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Identification of Current and Future Infrastructure Deployment Gaps

2021

Provided to Natural Resources Canada

ChargeHub

By Mogile Technologies Inc.

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About Mogile Technologies Inc:

Mogile Technologies Inc.
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Mogile Technologies Inc. maintains the ChargeHub database, the only independent, curated, user-enriched and commercially available database of public electric vehicle (EV) charging stations in North America. This unique perspective on public EV charging serves our commercial and institutional customers – public utilities, governments and automakers – with the necessary EV charging and driver insights and analytics solutions to apply a data-driven approach to public charging development, including the ChargeHub Central EV Charging Management System.

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List of Abbreviations

BEV	Battery Electric Vehicle
CA	Census Agglomeration
CMA	Census Metropolitan Area
CSCI	Charging Site Commercial Index
DCFC	Direct Current Fast Charger, same as level 3 charger
DXI	Driver Experience Index
EV	Electric Vehicle
FCEV	Fuel Cell Electric Vehicle
GHG	Greenhouse Gas
ICE	Internal Combustion Engine
kWh	Kilowatt-hours
L1, L2, L3	Level 1, 2 or 3 (types of EV chargers)
LD	Light Duty
MHV	Medium and Heavy Vehicle
MURB	Multi-unit Residential Building
NRCan	Natural Resources Canada
OCPP	Open Charging Point Protocol
PHEV	Plug-in Hybrid Electric Vehicle
RFID	Radio Frequency Identification
StatCan	Statistics Canada
SOW	Statement of Work
ZEV	Zero-emission Vehicle

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SUMMARY

This report identifies three categories in the Canadian electric vehicle (EV) charging infrastructure in which gaps occur: cities, highways, and customer experience. It is based on data in the ChargeHub database, an independent, curated, user-enriched and commercially available database of public EV charging stations in North America, augmented by data from stakeholder interviews and demographic census data and geographic data.

Generally, cities in British Columbia and Quebec have more public charging ports relative to their population than cities in other provinces, and city EV drivers use them more than drivers outside cities. As for major highways, coverage is at 61%, with most of the gaps in the Prairies. For customer experience, EV drivers consider range anxiety (a vehicle issue: “Will I be able to get where I am going?”) a less serious concern than charging anxiety (an infrastructure issue: “Will I be able to charge at this site?”).

Although the geographic coverage of the EV charging infrastructure is relatively good, the charging capacity is stretched in many areas, resulting in a suboptimal customer experience. Fast charging sites tend to be larger in cities, and Tesla fast charging sites are, on average, four times larger than non-Tesla sites. Meeting the increasing charging needs of EV drivers and promoting adoption of EVs will need to account for existing capacity utilization in the immediate area where new sites are considered, especially at peak driving times such as Fridays before a long weekend.

Interviewees stated that public charging sites generally have a challenging intrinsic economic case for their operators and site owners, which is constraining expansion. A large portion of charging sites is currently only financially undertaken when subsidized in some way, whether by governments, by utilities, by automakers or by site owners. Business owners likely justify supporting public charging sites based on the possible indirect benefits they may bring, such as attracting drivers and customers or improving public image. In this context, stakeholders see the financial support from NRCan’s infrastructure deployment programs as essential.

Optimizing future EV charging infrastructure deployment will need to account for not only coverage but also capacity needs. For example, adding ports to an existing site or adding a new site in the vicinity may be highly beneficial for EV drivers if there is regular congestion and if the new capacity can be demonstrated to relieve current or upcoming congestion. Furthermore, because of the low levels of satisfaction with customer experience for public charging, we recommend that NRCan make the driver experience a key measure in assessing the performance of the EV charging infrastructure.

INTRODUCTION

This final report is a deliverable in NRCan Statement of Work (SOW) 160512. The report aims to identify gaps in how the EV charging infrastructure has been deployed and how these gaps can be best filled in the future.

Largely thanks to some federal and provincial policies, deployment of the public EV charging infrastructure in Canada is impressive, with the result that Canada has relatively more public charging ports than the United States. With a population 8.6 times larger than Canada, the United States have only 5.5 times more public level 2 ports and 6 times more level 3 ports, according to the ChargeHub database.

Indeed, this report is largely based on data in the ChargeHub database, an independent, curated, user-enriched and commercially available database of public EV charging stations in North America, augmented by data from stakeholder interviews, demographic census data, geographic data, search engine data and Transport Canada scenarios. The interviewed stakeholders were selected from utilities across Canada, large cities, the main charging operators/manufacturers in Canada, and EV and utility associations. The interviewees depicted a broad perspective on the state of the Canadian EV infrastructure and enabled the identification of perceived gaps in public charging infrastructure.

In addition to site-specific information, such as the number and characteristics of charging ports, the ChargeHub database also includes session-level data for a significant share of charging stations, primarily in British Columbia and Quebec. Session-level data is used by charging network operators with a mandate to foster EV adoption through strategically planned deployment of public charging, such as Hydro-Québec and BC Hydro, to assess the level of congestion and to plan for infrastructure investments. Congestion and, more generally, site availability is becoming the most important issue for EV drivers now that the level of coverage is improving.

Natural Resources Canada

The Electric Vehicle and Alternative Fuel Infrastructure Deployment Initiative (the Program) ($182.5 million over 6 years) seeks to establish a coast-to-coast network of fast-charging stations along the national highway systems; natural gas refuelling stations along key freight corridors; and hydrogen refuelling stations in major metropolitan areas. The investments also support the demonstration of next generation and innovative electric vehicle charging and hydrogen refuelling technologies, as well as the development and alignment of Canadian and American codes and standards for electric and low-carbon-fuelled vehicles and refuelling infrastructure.

For the Deployment Component ($96.4 million), in summer 2020, the Program administered its last request for proposals (RFP). With the results of this RFP, NRCan will commit all program funds and meet or exceed the overall six-year program targets, supporting the establishment of

- A coast-to-coast network of 1,108 fast chargers against a target of 1,000
- Twenty-two natural gas stations against a target of 21
- Fifteen hydrogen stations against a target of 15

To date, the Demonstration Component ($76.1 million) has resulted in implementation of six fast chargers and 163 level-2 chargers across Canada in real-world demonstration projects. These projects have provided innovative solutions in the urban environment (e.g. at multi-unit residential buildings and for EV owners without dedicated parking) and at workplaces.

The Codes and Standards Component ($10 million over 4 years) supports the development and revision of codes and standards for low-carbon vehicles (e.g. electric, natural gas, and hydrogen) and refuelling infrastructure to ensure there is an alignment between Canada and the US. This addresses a barrier to the operation of these vehicles across jurisdictions and provides assurance that consumers can drive and refuel where and when required. It also ensures cleantech companies in both countries can design products to a single set of technical specifications, reducing the time to market and saving them money on certification.

To date, there are agreements in place that will result in more than 27 codes, standards, and best practices developed by March 2021, exceeding the target of six per year.

The Zero Emissions Vehicle Infrastructure program (ZEVIP) investments go beyond the establishment of fast chargers on the national highway system and focus on EV level 2 charging at workplaces, commercial and multi-unit residential buildings, and projects for fleets (e.g. taxis, car sharing), mass transit and inner-city delivery.

Budget 2019 provided NRCan with $130 million (over five years) to further expand Canada’s zero-emission vehicle infrastructure and deploy 20,000 new recharging and hydrogen refuelling stations in more focused locations where Canadians live, work and play, including:

- Multi-unit residential buildings
- Workplaces
- Commercial spaces
- Street-charging and public parking spots
- Remote areas
- Commercial fleets

METHODOLOGY

The data collection and augmentation methodology that was developed aims to identify gaps in how EV charging infrastructure has been deployed in Canada and how these gaps can be filled in the future.

Light-duty passenger EV drivers charge their vehicle at home, at their workplace or at public sites, or a combination of these. Home charging is, by far, the most popular use case, with around 80% of charging occurring at individual homes. However, home charging is often not possible for tenants of multi-dwelling buildings, either because on-premise parking is not wired for EV charging or because it is expected that tenants park on the street. Workplace charging is increasing in popularity, as it is seen as a good benefit for employees, but it remains rather marginal.

Public charging is therefore a key enabler of broader EV adoption, as it is very visible to the public and a necessity when going away from home. Much of this report thus focuses on public EV charging. The public EV charging infrastructure serves a small set of use cases. The taxonomy of public EV charging use cases includes:

1. *At a destination, where one can expect the vehicle to be parked for at least a few hours, such as for street parking, at hotels, and at shopping centres*. These are typically level 2 chargers. They may or may not be in cities, and they may or may not be along highways, but they must be at a site with points of interest requiring parking for at least a couple of hours, or near the residence or the workplace of the EV driver.
2. *On-the-go charging, where drivers may expect to stay a few minutes, such as at a highway service are*a. These are much like legacy gas stations, often collocated with a convenience store or a cafe, with access to restrooms. They are level 3 fast chargers intended to quickly charge an EV, either to a full charge or just for a top up while out. It is also useful to distinguish two use sub-cases for on-the-go charging:

    a. *Community fast charging*, typically in cities, for drivers who do not have access to home or workplace charging

    b. *Charging along highways*, for intercity travellers and long-haul heavy-duty vehicles

For this analysis, only pure battery EVs are considered, and not plug-in hybrid EVs, as pure EVs are the ones most likely to use public charging.

Comments submitted by drivers in the ChargeHub app show that the infrastructure at many charging sites does not match its use case. For example, some level 2 chargers identified as destination sites do not provide access to points of interest, leading to poor usage. Similarly, some sites with level 3 chargers do not provide access to the amenities one would expect to find when reaching on-the-go charging sites, such as restrooms, leading to poor customer experience.

The methodology to identify EV charging gaps combines the ChargeHub database with a series of interviews with key stakeholders in the Canadian EV charging ecosystem.

Interviews With Stakeholders

Video interviews were conducted with stakeholders across Canada to better understand the perceived barriers to the adoption of EVs, the obstacles to the deployment of public EV charging infrastructure, and the best practices that stakeholders would like the industry to follow.

A total of 21 interviews with 29 stakeholders (some interviews involved more than one individual) were conducted from December 2020 to February 2021. Interviewees included representatives from the following stakeholder groups: Canadian utilities (17 individuals), large cities (5), charging operators/manufacturers (7), and EV and utility associations (3). Three of these individuals represented two stakeholder groups. Nine of these individuals, or 31%, are EV drivers themselves. Some interviewees requested anonymity.

The interviews enabled the identification of perceived gaps in public charging infrastructure. Generally, stakeholders identified gaps in the following three categories:

- *City gaps*. This category refers to the charging challenges that city dwellers face, particularly EV drivers who cannot charge at home [such as garage or driveway "orphans" or those living in a multi-unit residential building (MURB)] and who do not have access to workplace chargers. In addition to home and workplace charging, the weekly charging needs of city dwellers may depend on a combination of level 2 chargers at destinations (use case 1 above), such as curbside chargers, and level 3 chargers in the city (use case 2a above).
- *Highway gaps*. This category refers to the challenges EV drivers may face when driving long distances, often in rural areas. Their charging needs depend on a combination of level 2 chargers located at their destination (use case 1 above), such as a cottage or a resort area, and level 3 chargers accessible along highways (use case 2b above).
- *Customer experience gaps*. This category refers to the need to address the numerous problems drivers encounter with the existing EV charging infrastructure, such as charging sites without amenities, blocked access to chargers, broken equipment and the variability of the service charging experience across the various operators.

With these categories identified, the ChargeHub database (linked with external sources) was used to quantify the gaps.

ChargeHub Database

The ChargeHub database includes public charging ports in approximately 6,600 sites in Canada as of January 2021. In addition to longitude and latitude, each site provides details on charging ports at the site (number, types, charging rates, etc.); the list of charging operators; and user comments and ratings, as well as replies from the operator, as the case may be. Session-level charging information is available for some sites, mostly in Quebec and British Columbia. The session-level information is owned by the charging operators and may only be used with their permission. The report used the data in the database as of January 2021.

To identify gaps for the use cases, the ChargeHub database was augmented by linking it to the secondary sources outlined below.

City Gaps

- *Linked secondary source: Boundaries of Census Metropolitan Areas (CMA) and Census Agglomerations (CA) from Statistics Canada (StatCan)*. With this, the CMA or CA can be found for each charging site location.
  - For reference, the plain language definitions of CMAs and CAs are areas defined by StatCan and consist of one or more neighbouring municipalities situated around a core population area. A CMA must have a total population of at least 100,000. A CA must have a core population of at least 10,000. To be included in the CMA or CA, adjacent municipalities must have a high degree of integration with the core, as measured by commuting flows derived from place of work data of commuter surveys. This makes CMAs and CAs useful for identifying gaps within cities and neighbouring areas.
  - Using the CMA and CA data, the charging sites can be correlated with demographic data, such as population.[1]
  - Charging sites can also be correlated with vehicle fleet information per CMA and CA and EV forecast per province, as provided by NRCan.[2]

1 Statistics Canada. 2017. Population and Dwelling Count Highlight Tables. 2016 Census, Statistics Canada Catalogue no. 98-402-X2016001. Ottawa. Released February 8, 2017.

2 EV fleet and forecast information extracted from Transport Canada's internal Zero Emission Vehicle Forecast Model (the 2020 version).

With the CMA and CA data, the number of level 2 (use case 1 above, destination charging) sites and level 3 (use case 2a above, on-the-go community charging) sites can be compared to population and number of vehicles (electric and internal combustion) to identify city gaps. Areas outside CMAs and CAs can also be examined to see how they compare.

Highway Gaps

- *Linked secondary source: Road Network File*. This is used to assess which charging sites are along highways and to look for fast charging gaps along highways.
    - Street rank codes 1 (Trans-Canada Highway), 2 (National Highway System not ranked 1) and 3 (Major Highway not ranked 1 or 2) were considered as highways.[3]
    - All charging sites within 3 km of a highway were counted, as highway drivers seeking a charging site are likely to avoid sites further away for on-the-go charging.

With the above data, stretches of highways that are more than 50 km from an on-the-go charging site were considered to be gaps. Tesla superchargers were excluded from this analysis. Tesla is a major EV automaker that deployed its own network; only Tesla EVs can use it, although Tesla EVs can also use non-Tesla chargers. Since non-Tesla EVs cannot use Tesla Superchargers, the most significant gaps are for non-Tesla EVs.

Customer Experience Gaps

In addition to linking the ChargeHub database to secondary sources, Mogile built a consolidated Driver Experience Index (DXI) per charging site based on all comments and ratings left by drivers on the ChargeHub app. The result is a ratings index akin to “stars” in Tripadvisor. The DXI was then correlated with various site attributes and surrounding demographics.

- *Linked secondary source: Programming interface for point-of-interest searches using Google*.
    - Mogile developed a Charging Site Commercial Index (CSCI) for destination charging sites (use case 1 above, level 2 charging), based on the Google points of interests around a site, such as various types of shops and lodging within walking distance of a charging site. Using proprietary data, the CSCI was shown to be correlated with an increased number of charging sessions and overall duration, as well as an increase in a more positive customer experience. In other words, this tool estimates the commercial attractiveness of destination sites (level 2 charging sites). Although causation is identified, further refinement to the index is preferred in the future.
    - Similarly, amenities near on-the-go charging sites (use cases 2a and 2b above, level 3 charging sites), such as access to restrooms, were assessed. The absence of amenities may lead to unsatisfactory customer experience and direct EV traffic to other charging sites with better services, therefore reducing charging sessions at sites with poor amenities and leading to inefficiencies in the charging infrastructure.

[3] See https://www150.statcan.gc.ca/n1/pub/92-500-g/92-500-g2017001-eng.htm, accessed 20210209.

A very large number of potential EV destination charging sites (use case 1 above, level 2 charging), with appropriate points of interest in the vicinity, exist within Canada. Identifying them all is not practical. However, CSCI statistics for existing destination charging sites in Canada, especially outside major centres, may be derived to see how efficient their deployment has been thus far.

Similarly, statistics on existing on-the-go charging sites (use case 2 above, level 3 charging) in Canada can be derived, to see how efficient their deployment has been thus far.

Taken together, the DXI, the CSCI of destination charging sites (use case 1 above, level 2 charging), and the presence of amenities for level 3 charging sites will point toward customer experience gaps with the existing infrastructure.

CITY GAPS

This section is presenting gaps within CMAs and CAs, correlating with pertinent demographic metrics.

We will also be commenting on how the public charging infrastructure may complement fleet charging for medium and heavy-duty (MHD) vehicles for local deliveries and activities.

Regional Perspective

Most EVs and charging ports are in CMAs. There are almost twice as many EVs per 100,000 inhabitants in CMAs than outside CMAs – see Table 1.

Table 1. Number of EVs and Charging Ports in and out of CMAs

	EVs	EVs/100,000 people	L2 ports	L3 ports
CANADA	**115,911**	**330**	**13,174**	**2,257**
CMA	95,175	382	9,406	1,243
CA	8,928	208	1,360	396
Non CMA/CA	11,808	200	2,408	618

Note that Canada has relatively more public charging ports than the United States. With a population 8.6 times larger than Canada, the United States have only 5.5 times more public level 2 ports and 6 times more level 3 ports, according to the ChargeHub database.

As shown in Table 2, in all regions of Canada, the largest share of EVs is in CMAs rather than in CAs or rural areas. There are also more EVs per port in CMAs across Canada, with a much higher ratio found in British Columbia and Quebec, the provinces with the highest adoption of EVs. Apparently, the larger number of EVs per port has not slowed down EV adoption in regions with greater EV adoption: the higher ratio of EVs per port in B.C. and Quebec appears to be a result of an increased number of EVs, and not delays in deploying chargers.

Table 2. Regional Charging Site Statistics

	EVs/ 100,000 people	EVs/L2 port	EVs/L3 port
BRITISH COLUMBIA	**784**	**16**	**93**
CMA	965	20	151
CA	341	10	40
Non CMA/CA	450	5	22
PRAIRIES	**59**	**6**	**19**
CMA	80	8	49
CA	29	3	3
Non-CMA/CA	18	2	4
ONTARIO	204	7	30
CMA	229	7	41
CA	79	5	7
Non CMA/CA	102	4	8
QUEBEC	**580**	**8**	**76**
CMA	613	10	110
CA	522	7	46
Non CMA/CA	488	6	37
ATLANTIC	**38**	**2**	**7**
CMA	54	2	14
CA	41	2	7
Non CMA/CA	20	1	3

Table 3 lists the 20 largest CMAs and CAs by the total number of charging ports in each. The CMAs with the most ports are Montréal, Toronto and Vancouver.

Table 3. Top 20 CMAs and CAs Based on the Number of Charging Ports

CMA	Total ports
Montréal, Quebec	2,962
Toronto, Ontario	2,279
Vancouver, British Columbia	1,316
Québec, Quebec	526
Ottawa, Ontario – Gatineau, Quebec	422
Victoria, British Columbia	294
Hamilton, Ontario	242
Kingston, Ontario	214
Kitchener, Cambridge, Waterloo (Ontario)	212
Calgary, Alberta	211
St. Catharines, Niagara (Ontario)	202
Sherbrooke, Quebec	182
London, Ontario	154
Trois-Rivi res, Quebec	133
Barrie, Ontario	127
Edmonton, Alberta	123
Saguenay, Quebec	105
Windsor, Ontario	91
Granby, Quebec	87
Halifax, Nova Scotia	86
Rest of Canada	5,463
Total Canada	**15,432**

Differences in Charging Infrastructure and Usage In/Out of CMAs

CMAs have more charging ports than non-CMA areas but there are even more EVs in CMAs by population. As a result, there are two to three times more EVs per public port in CMAs than outside of CMAs – see Table 4.

Table 4. Number of EVs per Level 2 and Level 3 Ports in Different Types of Agglomerations

	EVs/L2 port	EVs/L3 port
CANADA	**9**	**51**
CMA	10	77
CA	7	23
Non CMA/CA	5	19

A higher number of EVs per port seems to be reflected in port usage, for both level 2 and level 3 ports. Looking at the usage data available in the ChargeHub database,[4] ports in CMAs are used significantly more than ports outside CMAs, with more sessions and longer average plug-in times – see Table 5.

Table 5. Sessions and Plug-in Time in Different Types of Agglomerations

	Level 2 ports		Level 3 ports	
	Sessions per month per L2 port	Average L2 plug-in time (hours)	Sessions per month per L3 port	Average L3 plug-in time (minutes)
CMA	72	3.3	277	26.5
CA	56	2.6	191	22.3
Non CMA/CA	28	3.0	149	22.7

Although EVs are mostly charged at home, drivers in CMAs appear to use public charging significantly more than drivers outside CMAs. While there are no data in the ChargeHub database to ascertain why CMA drivers use public charging more, it may be that they more often live in multi-unit residential buildings (MURB) without access to residential charging.

Looking at the average size of charging sites in CMAs and outside, it appears that charging operators and site owners have built larger sites in cities – see Table 6. The smaller sites outside of CMAs may have been deployed with coverage as the primary consideration, while sites in cities may also have grown over time to address capacity issues or were pre-built with extra capacity to meet future demand. In other words, charging operators and site owners may have installed these smaller sites outside of CMAs to provide geographic coverage, perhaps without expecting high usage rates, while building larger ones in cities to respond to increasing peak demands. Interestingly, Tesla – the largest level 3 charger operator in Canada through its Supercharger network and being the largest EV automaker – has, on average, built much larger sites than other operators, both in and out of CMAs.

Table 6. Average Sizes of Charging Sites in Different Types of Agglomerations

	L2 ports per site	L3 ports per site	Tesla L3 Superchargers
CANADA	**2.2**	**2.3**	**9.5**
CMA	2.6	2.7	12.2
CA	1.7	2.0	6.6
Non CMA/CA	1.7	2.0	6.9

4 One should be careful with the usage data. The ChargeHub database includes session data for 1,421 of the 6,567 charging sites in Canada, primarily in British Columbian and Quebec. Average usage in those sites could be different than Canada-wide averages, as British Columbian and Quebec averages should be representative of jurisdictions with higher EV adoption. Canada-wide planning would benefit from more comprehensive data collection.

Perspectives of Interviewees on Charging in Cities

Sixty-four percent (64%) of utility, city and operator interviewees cited a lack of convenient home charging as a barrier to EV adoption. It was the second most often cited barrier to EV adoption, after EV cost of ownership (74%), and ahead of range anxiety (54%). It is essentially a CMA issue, given that lack of access to home charging is largely related to living in MURBs.

Interviewees offered several potential solutions, including some that do not imply public charging, such as changing building codes for MURBs and initiating new electricity rate designs for workplace charging. The most mentioned public charging solutions included:

- Curbside level 2 chargers
- Level 2 chargers in community places, such as libraries, arenas, and community centres
- Level 2 and 3 chargers at commercial destinations such as shopping malls

Interviewees also mentioned barriers specific to public charging in cities, such as the difficulty of finding suitable public charging sites, the very high costs of building sites in cities, permitting issues (including long delays), public perception, and the difficulty of coordinating all stakeholders.

HIGHWAY GAPS

This section is presenting gaps along highways. It looks at both geographic coverage and capacity.

We will also be commenting on how the public charging infrastructure may complement fleet charging for long-haul medium- and heavy-duty (MHD) trucks and how future hydrogen fuelling stations may complement charging stations.

Geographic Coverage

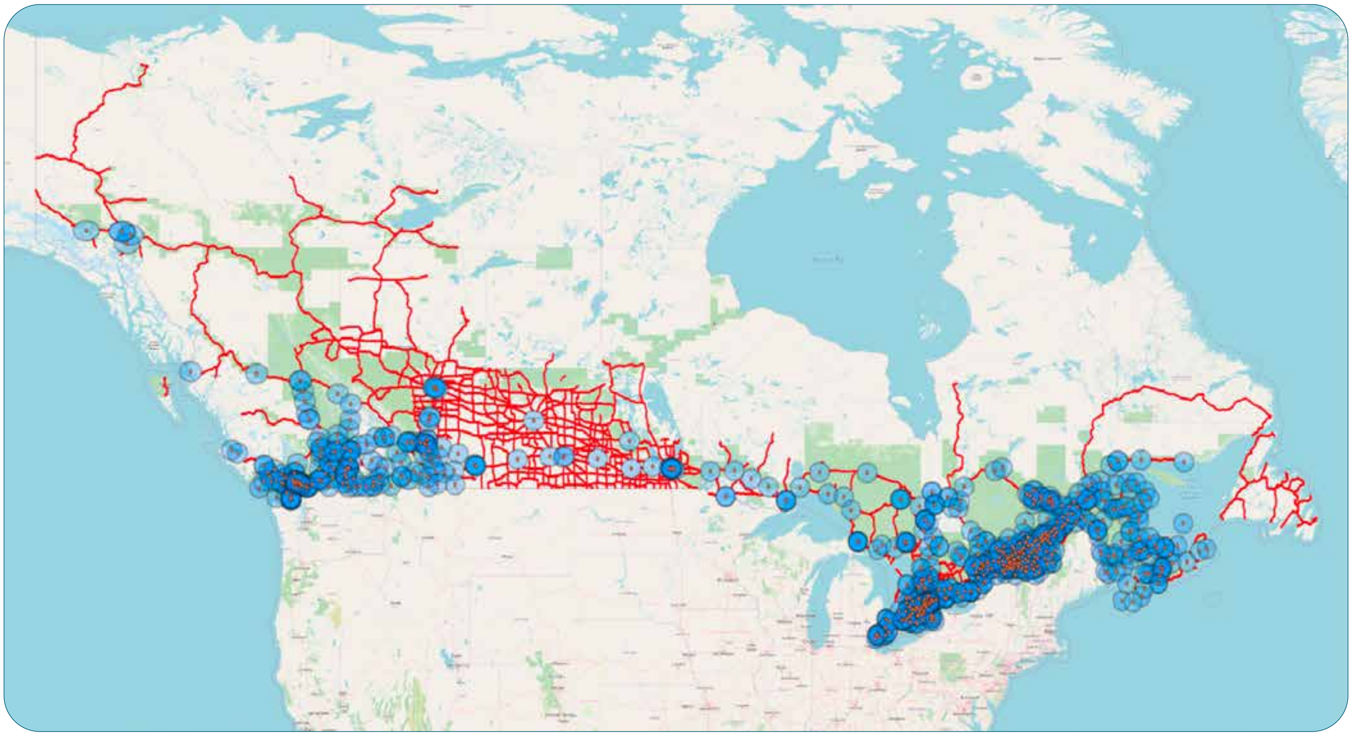
Coverage of Canada's highway network was assessed by determining segments of highways that are within 50 kilometres of level 3 charging sites (see Highway Gaps methodology above). A radius of 50 km from level 3 sites was selected, with the maximum distance between level 3 stations then becoming 100 km (50 km either way). One hundred kilometres (100 km) is the preferable maximum distance because of the following rational:

- Modern long-range EVs commonly have about 300 km of range in the winter.
- When plugged in at level 3 direct current fast chargers (DCFC), charging tends to slow down once the battery reaches a state of charge of about 80%, depending on the car model; this corresponds to about 250 km of winter range.
- Experienced drivers typically start looking for charging stations once their range is down to about 50 km, which is a common safety margin. Therefore, drivers may go up to about 200 km (i.e. 250 km minus 50 km) between on-the-go charging sessions.
- If charging sites are less than 100 km apart, a driver can go close to the optimal 200 km between recharges.
- If charging sites are more than 100 km apart, one must stop at every site or risk driving 200 km or more and hitting the safety margin.
- Only level 3 charging sites within 3 km of highways are considered to be along a highway, as sites further away would require too much detour.
- Tesla Superchargers have been excluded from the highway gap analysis as they are not compatible with vehicles from other automakers.

This hypothesis is not meant to be a design rule to decide on where to install new charging stations, as many other factors come into play. However, it can be used to assess the level of coverage of the public charging infrastructure for intercity driving.

Figure 1 is a map of Canada's highway system, rank 1 to 3, overlaid by circles of 50 km radius from level 3 charging sites in operations along those highways, as of January 2021.

Figure 1. **Canadian Highways (Ranks 1 to 3) with a Level 3 Charging Stations Overlay**

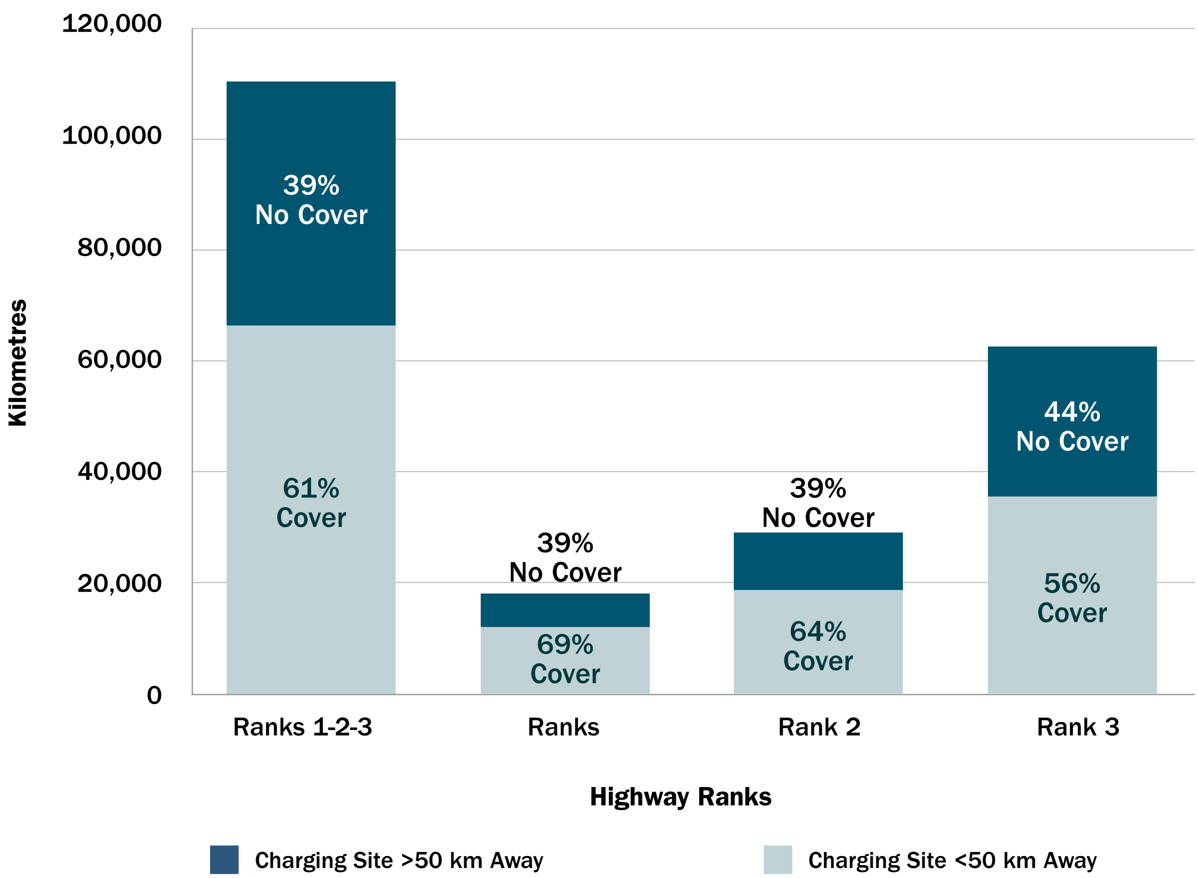


As can be seen, coverage is high along the Trans-Canada highway, in the Fraser and St. Lawrence valleys, as well as along the shores of the Erie and Ontario lakes. However, there are significant gaps in the Prairies and in the more northern parts of the country. Detailed regional maps are included in Appendix 1. Regional Maps.

Kilometre Coverage

Figure 2 shows the total length of highways ranked 1, 2 and 3 in Canada, along with the percentage of highways covered by level 3 charging sites along highways and the percentage that is not (using the 50-km radius from level 3 charger approximation). For reference, rank 1 is the Trans-Canada Highway, rank 2 is other national highways, and rank 3 is major highways.

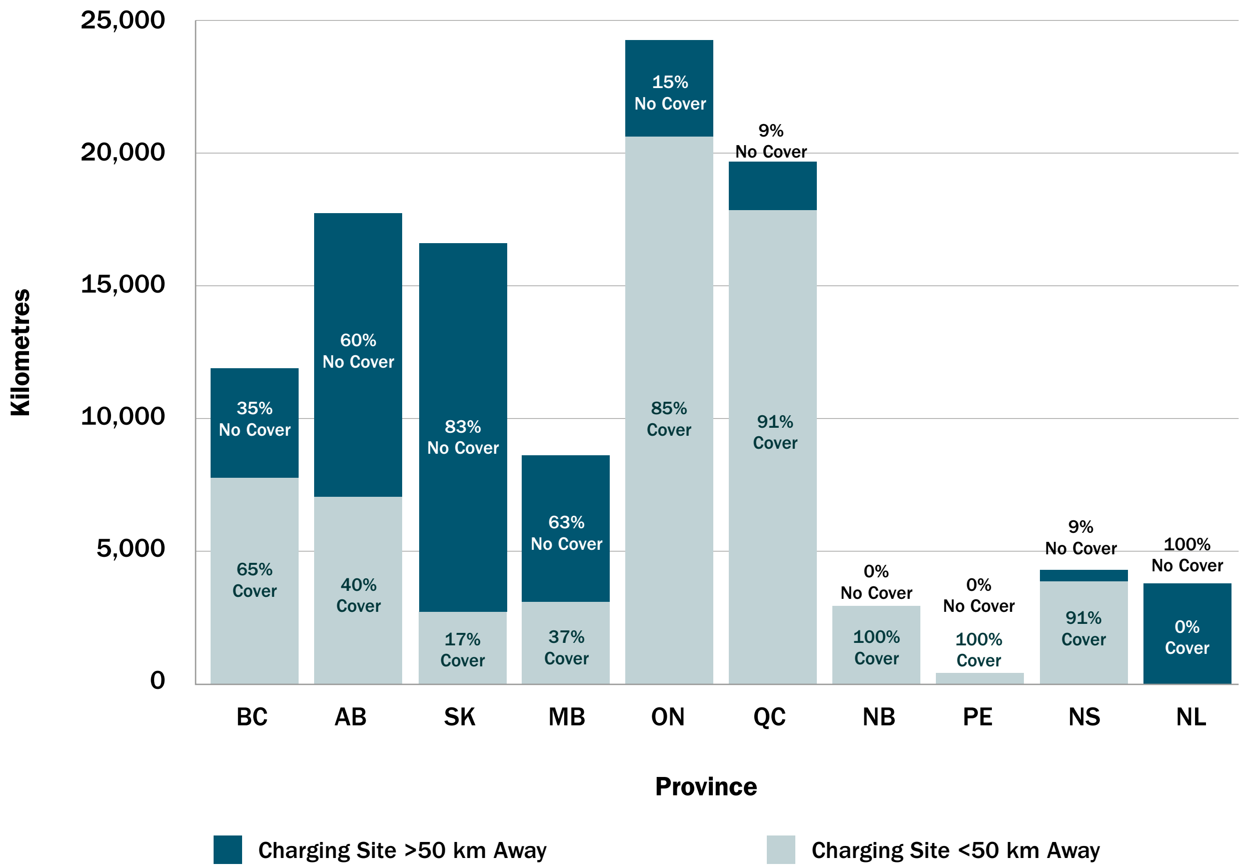
Figure 2. Canada's Highways: Level 3 Charging Sites Coverage by Rank



Overall, 61% of the highways are covered using our criteria. Rank 1 highways are better covered than rank 2 highways, which are better covered than rank 3.

Figure 3 shows the total length of highways (ranked 1, 2 or 3) in each province, along with the percentage of highways covered by level 3 charging sites.

Figure 3. Canada's Highways: Level 3 Charging Sites Coverage by Province



Ontario, Quebec, and British Columbia have the highest coverage, when measured in kilometres.

New Brunswick and Prince Edward Island have 100% coverage using our criteria, and Nova Scotia has 91% coverage, but this high coverage is explained by their small surface area. While the Maritime provinces have a high coverage percentage, they have relatively few EVs, as shown in Table 2. Regional Charging Site Statistics.

Coverage is less in the Prairies and, as of January 2021, 0% in Newfoundland and Labrador. There were no active public level 3 sites in Newfoundland and Labrador in January 2021; however, a network of 14 fast chargers along the Trans-Canada Highway is set to open in 2021.[5] If these 14 sites were counted, coverage in Newfoundland and Labrador would be approximately 40%.

[5] See https://nlhydro.com/electricvehicles/, accessed 20210310.

Capacity and Perspective of Interviewees

While many provinces have a significant highway coverage by level 3 charging sites, this depicts only one of the many components in measuring the success of public charging infrastructure. Capacity (measured by the number and type of ports) and the business case for charging sites are both important components to factor in when aiming to reduce highway gaps.

Through Mogile's collaboration with BC Hydro and Hydro-Québec, the ChargeHub database has included, with their permission, session-level data for the majority of the EV charging infrastructure of their respective provinces. Expanding such ecosystem data sharing would help understand gaps across Canada far beyond what would be available to the individual stakeholder in the deployment of the public charging infrastructure. Although there is not enough session-level data in the ChargeHub database to harness a panoramic view of current usage (or congestion) level in charging sites across all of Canada, it still provides insight that can help reduce gaps in the charging infrastructure. Furthermore, many insights may be derived from the current number of ports at level 3 charging sites and from information provided by this report's interviewees.

Table 7 compares the number of level 3 ports at charging sites in Canada with the market penetration of EVs in each province. The table distinguishes between Tesla and non-Tesla sites.

Table 7. Number of Ports at Level 3 Sites, With Tesla and EV Penetration

	Number of L3 ports per non-Tesla site	Number of L3 ports per Tesla site	% of EVs in the fleet
CANADA	1.4	9.6	0.46%
B.C.	1.5	11.1	1.04%
Alta.	1.2	6.2	0.09%
Sask.	1.7	6.3	0.04%
Man.	1.4	5.8	0.07%
Ont.	1.4	10.5	0.29%
Que.	1.5	10.2	0.83%
N.B.	1.2	8.0	0.05%
P.E.I.	1.0	NA	0.09%
N.S.	1.4	8.0	0.05%
Nfld.	NA	NA	0.02%

As can be seen in this table, Tesla level 3 charging sites are, on average, much larger than non-Tesla sites (9.6 vs. 1.4 ports per site). Tesla sites are even larger in the three provinces with the largest market share of EVs: British Columbia, Quebec and Ontario. Based on this, one can infer that Tesla first targets charging site coverage, at least along major highways, then site capacity once a certain threshold of EV adoption is reached. Given Tesla's first mover status in manufacturing EVs and deploying public charging infrastructure, this is an emerging strategy to consider with great interest.

Some interviewees have confirmed the soundness of focusing on capacity once a certain level of coverage is achieved:

- All interviewees from charging operators mentioned finding good sites and challenging business cases as top obstacles when deploying charging sites.
- Ninety percent of utility interviewees confirmed that public charging sites have a challenging business case.
- Larger sites (rather than more small sites) were seen as a solution to the problems of finding good sites and challenging business cases (by reducing costs per port). In particular, high-power level 3 chargers

(DCFC), such as 250-kW ports, often require a power container serving a number of ports, the size of which disqualifies small sites. However, availability of power also constrains large sites.

- Larger sites can be built over time, starting with a few ports and adding more in a cost-effective manner as the initial ports show signs of approaching congestion levels.
- The initial building of a site may take up to 2 years, while adding capacity to an existing site is much faster.
- Larger sites are also more efficient, as, statistically, the risk of congestion at a large site is less than the risk of congestion at multiple smaller sites with the same total number of ports.[6]
- Some charging operator interviewees highlighted the need for sizing charging sites for peak times, such as Friday evenings before a long weekend. For example, level 3 charging sites around Kingston, Ontario, midway between Toronto, Ottawa and Montréal, apparently see lineups at peak times.
- Kingston is already well covered. It ranks 8th in the number of ports among cities (see Table 3) although the Kingston CMA ranks 26th in population and ranks even lower in number of EVs in the city. Nevertheless, network operators would like to see even more ports in the vicinity of this critical location in order to serve EV drivers travelling between Toronto, Ottawa and Montréal.
- Among interviewees who are EV drivers, the top problem with public EV charging is charging anxiety (an infrastructure issue: “Will I be able to charge when I get to a charging station or will there be a problem such as a broken charger, blocked access, a long waiting line or an ICE vehicle in the stall? How long will it take to charge?”) rather than range anxiety (a vehicle issue: “Will I have enough charge in the battery to get where I want to go?”).

MHD and Hydrogen FCEV Vehicles

While this report focuses primarily on public charging of light-duty battery electric vehicles (LD BEV), it is also important to consider the impact of medium- and heavy-duty (MHD) vehicles and hydrogen fuel cell electric vehicles (FCEV).

MHD vehicles include large trucks and buses. These vehicles are used for local deliveries or routes and for long-haul transportation, resulting in different vehicle and charging (or fuelling) requirements.

For local deliveries and routes, charging or refuelling is expected to occur mainly at a fleet depot and not at public sites. BEVs dedicated to local work will have enough battery capacity for a worst-case day and will be recharged overnight. In some cases, vehicles could also be recharged at the depot around midday after a morning route and before the afternoon route. While depot charging may have a large impact on the local distribution electrical grid, it is not public and outside the scope of this report.

For long-haul trucks and buses, some charging or fuelling may occur at a fleet depot before beginning a journey but recharging or refuelling along the way will be required. For the current MHD diesel fleet on long-haul routes, refuelling typically occurs at truck stops. In addition to a refuelling area, many truck stops have maintenance and wash facilities for heavy trucks, as well as restaurants, stores and lodging facilities. Most trucking companies have accounts with specific truck stop chains and, after negotiating a specific price for diesel, require their drivers to fuel exclusively at supported locations.

Given the industry structure and services available at truck stops, it is likely that recharging and refuelling of MHD trucks on long-haul routes will continue to occur at truck stops. The ChargeHub database includes DCFC ports at 23 sites defined as truck stops in Canada. All of them have only one or two DCFC ports, except one truck stop in

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[6] This is a statistical effect. For example, a site with 8 ports would have a lesser chance of congestion than, say, 4 sites with only 2 ports each serving the same area. With 2 ports, a third driver will often get to a site already fully occupied while other sites nearby may still empty, requiring the driver to go around until they find an available port.

Ontario that has 8 Tesla Superchargers. Clearly, the current charging infrastructure was not deployed for long-haul trucking, even before we consider the power requirements for larger capacity batteries that heavier electric vehicles would require.

According to NRCan's Electric Charging and Alternative Fuelling Stations Locator,[7] there are currently 4 public hydrogen public fuelling stations open in Canada: 3 in the Vancouver, B.C. area and one in Quebec City. Given the 5,000 km distance between these two cities, these fuelling stations likely serve local fleets and were not installed for long-haul trucking.

To enable long-haul BEV or FCEV trucking, charging or fuelling ports dedicated to trucks would need to be installed every few hundred kilometres at existing truck stops, with priority given to the Trans-Canada Highway.

[7] See https://www.nrcan.gc.ca/energy-efficiency/energy-efficiency-transportation-and-alternative-fuels/electric-charging-alternative-fuelling-stationslocator-map/20487#/find/nearest?fuel=HY&hy_nonretail=true&country=CA, accessed 20210222.

CUSTOMER EXPERIENCE GAPS

This section presents gaps in customer experience, focusing on amenities surrounding charging stations and driver feedback in the ChargeHub app, and then compares, where pertinent, across geographic measures.

All charging sites in Canada for which data was available were assessed based on the points of interest around them. Some charging sites were also assessed based on session-level data or driver feedback.

Charging Site Commercial Index (CSCI) for Level 2 Charging Sites

For all Canadian level 2 sites (destination charging), a preliminary Charging Site Commercial Index (CSCI) was designed, based on the Google points of interest around the sites, such as various types of shops and lodging within walking distance (300 m) of a charging site. More points of interest with high dwell time[8] and frequent visits lead to a higher CSCI. For example, a transit station has a dwell time of many hours and an EV driver may charge there twice a week. This is better than a movie theatre (dwell time of about 2 hours, perhaps monthly) and much better than a convenience store. We consider that the CSCI, as currently defined, is still preliminary and further refinement to the index may be appropriate in the future.[9]

All level 2 charging sites were ranked according to their CSCI and grouped in quartiles. Top quartile sites ("top sites") have the most points of interest visited frequently and with longer dwell time, while bottom quartile sites ("bottom sites") have the least. The quartiles were then compared to various charging statistics from a sample of 1,421 sites where we have charging session data and 2,940 sites for which we received feedback from drivers. This enables an assessment of the impact of a strong commercial offering at a destination (see Table 8. Impacts of the Charging Site Commercial Index (CSCI)).

Table 8. Impacts of the Charging Site Commercial Index (CSCI)

	Charging Site Commercial Index (CSCI) for L2 sites				
Averages at the sites	**Bottom quartile sites**	**3rd quartile**	**2nd quartile**	**Top quartile sites**	
Plug-in time (hours)	3.00	2.99	3.53	3.40	13% higher in top vs. bottom quartile
Number of sessions per month	95	103	105	129	36% higher in top vs. bottom quartile
Charging hours per month	284	307	371	439	54% higher in top vs. bottom quartile
Number of L2 ports	2.1	2.1	2.2	2.5	17% more in top vs. bottom quartile
ChargeHub Driver Experience Index (DXI)	87.0%	89.7%	89.3%	89.3%	More negative in bottom quartile

[8] Retail dwell time, or how long a consumer stays at a store, is a key metrics in retail commerce. Some EV charging analyses have used "dwell time" to describe time spent at a charging site after a vehicle is fully charged. We are using dwell time in its retail definition here.

[9] A possible area of improvement is to include non-commercial points of interest that may contribute to a site being a good "destination." For example, curbside chargers, which are starting to be installed in core cities, may be surrounded by few shops but many dwellings, and therefore, are suitable for overnight charging by residents. Similarly, public charging sites in industrial parks and in office building parkades may be suitable for daytime charging, but often with few commercial locations in their vicinity.

Plug-in Time (hours)

On average, top sites have 13% higher plug-in time (i.e. duration of charging session) than bottom sites. This is not surprising as there is simply more to do at those sites, making them better "destinations."

Number of Sessions per Month

Top sites also see 36% more drivers coming to charge their vehicles. Drivers appear to prefer sites with more points of interest.

Charging Hours per Month

The combination of longer charging session duration and higher number of sessions means that charging hours at top sites are 54% higher than at bottom sites.

Number of Level 2 Ports

Presumably, the greater number of charging hours recorded at top sites has induced charging operators to install more ports: top sites have 17% more level 2 ports than bottom sites. Overall, there is 38% more utilization per port at top sites than at bottom sites. This likely has an impact on the economics of those ports. Furthermore, larger sites have better statistical efficiency, leading to reduced chances of congestion. Knowing this, EV drivers may also prefer larger sites with more amenities, resulting in a positive feedback loop.

ChargeHub Driver Experience Index (DXI)

Based on comments and ratings on the ChargeHub app, top quartile CSCI sites receive more positive feedback than bottom sites, despite their higher utilization. Negative feedback (the difference between 100% and the DXI) is 10.7% at top sites but 13.0% at bottom sites; in other words, sites with a low CSCI get 1.23 times more negative comments than top ones.

Urban vs. Rural Sites

The quality of basic (short-term) amenities around level 3 charging sites was assessed by looking at the following subset of Google locations within 300 m: car repair shops, convenience stores, gas stations, restaurants, shopping malls and supermarkets. These Google locations were selected as appropriate for short, 30-minute stops while fast charging at a level 3 site—analogous to a refuelling stop with an ICE vehicle. We, therefore, excluded locations requiring longer dwell time, such as movie theatres and transit stations. We also compared them to the ChargeHub driver experience index (see Table 9).

Table 9. Short-term Amenities and the DXI Across Charger Level and Urban/rural Settings

	% of sites with amenities within 300 m of a charger	
	L2 only	With L3
CMA	79%	92%
CA	79%	90%
Rural	69%	90%
Overall	77%	91%
	Average DXI	
	L2 only	With L3
Overall	89%	86%

In general, charging sites with level 3 ports, suitable for on-the-go charging, have better short-term amenities than level 2-only sites. This is likely because level 3 charging sites are more carefully selected, being more expensive to deploy than level 2. Urban (CMA and CA) sites also tend to have better amenities than rural ones.

Interestingly, level 3 charging sites have better amenities, yet their ratings through the ChargeHub Driver Experience Index (DXI) are overall found to be worse. Clearly, EV drivers have issues with level 3 charging sites that are unrelated to the surrounding amenities.

Generally, the stakes and the expectations are higher for a level 3 charging session than for a level 2 charging session. Expectations for a level 2 charging session are rather low: the driver knows that charging is slow, with power typically in the 5-to-7-kilowatt range. Either the driver leaves the vehicle parked for a long time for a full charge, such as overnight at a curbside charger, or for a couple of hours for just a top-up, such as while shopping.

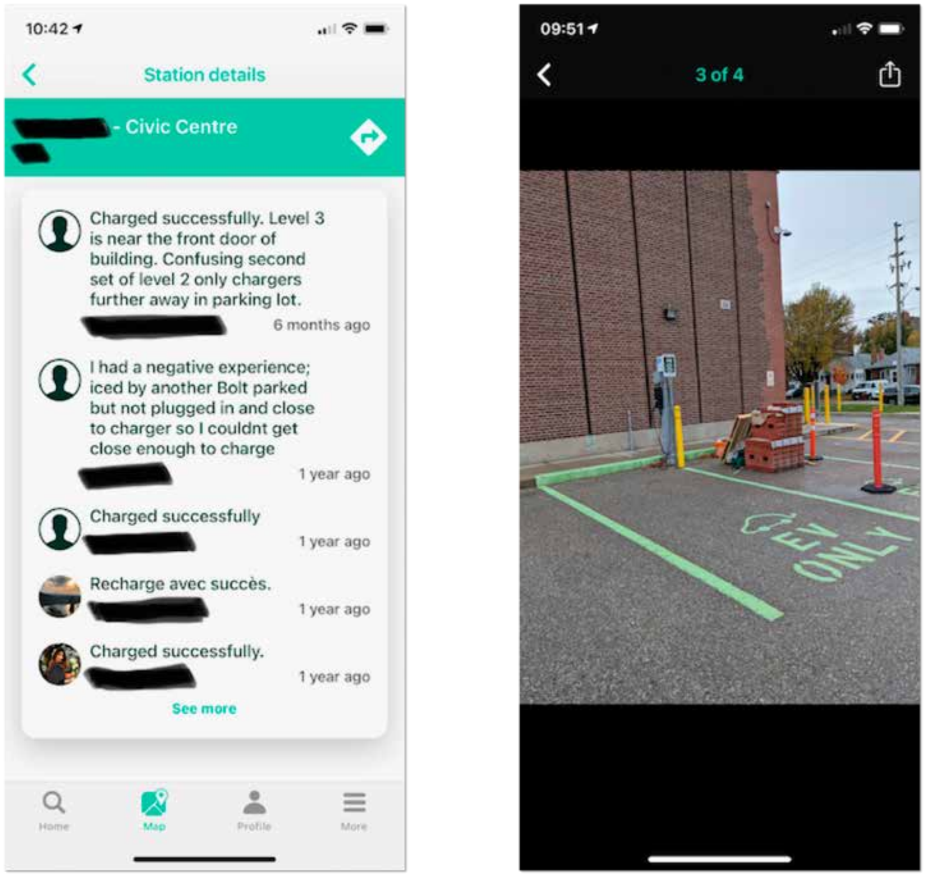
Expectations for level 3 charging are higher: the driver expects to stay a few minutes and gain enough range for hundreds of kilometres, with power measured in the tens or hundreds of kilowatts. Drivers going to a level 3 station will often be in a rush, sometimes arriving with a significantly depleted battery but expecting to depart quickly and be on their way. Unfortunately, how long a driver might have to wait and the quality of the driver experience depends on several factors with which drivers may not be familiar:

- A level 3 station that is busy, broken or inaccessible may represent a significant inconvenience for a driver.
- The rate of charge, in kilowatts, is limited both by the on-board power electronic module and the level 3 supply equipment at the site. Many vehicles have power electronics limited to 50 to 100 kW; a 150-kW port will not supply more than what the vehicle electronic module is able to take. Conversely, some vehicles can take 200 kW or more; however, connected to a 25-kW charging port, these vehicles will only charge at 25 kW.
- A level 3 charger rated to a given power may also be unable to supply its full rated power because it is either electronically limited to avoid high demand charges or physically limited because of sub-sizing of its supply equipment.
- The rate of charge is further limited by factors such as the temperature of the battery and its state of charge. Typically, a battery temperature that is too high or too low, as well as a state of charge exceeding 70 or 80%, limit the power that a battery can absorb.

In other words, timely completion of a specific charging event at a level 2 charging session may less often be a make-or-break moment in an EV driver's day than at a level 3 station. Therefore, one should not conclude that driver experience is better at level 2 charging stations than level 3, but rather that subpar user experience at a level 3 station is more likely to push an EV driver to report the bad experience.

In the ChargeHub app, drivers often offer criticisms for public chargers, such as slower than expected charging rates and inaccessible or broken stations. Figure 4 provides some examples of comments and a picture left by a user.

Figure 4. Examples of Driver Feedback on the ChargeHub Smartphone App



Stakeholder Perceptions

Interviewees were asked what they thought were the main issues that EV drivers (as opposed to potential EV buyers) have regarding public charging. Responses were grouped into four main categories:

- *Charging anxiety.* An infrastructure issue: "Will I be able to charge when I get to a charging station or will there be a problem such as a broken charger, blocked access, a long waiting line or an ICE vehicle in the stall? How long will it take to charge?"
- *Range anxiety.* A vehicle issue: "Will I have enough charge in the battery to get where I want to go?"
- *Complex payments, apps.* An awareness issue: "Why do all these charging stations have different pricing scheme? How do I pay?"
- *Lack of amenities.* A customer experience issue: "Is there a restroom and a place to get coffee at this charging station?"

Overall, charging anxiety was considered as the main category EV drivers regard as the most pressing issue when it comes to public charging, followed by range anxiety. Responses varied against local context and stakeholder type (a utility, a city or a charging operator) and whether they were themselves an EV driver or not. Table 10 summarizes how often an issue was mentioned by various stakeholder categories.

Table 10. Driver Issues With Public Charging as Perceived by Interviewees

	Percentage of interviewees stating a driver issue with public charging				
	Type of stakeholder			Driving status	
	Utility	City	Charging operator	EV drivers	EV drivers
Charging anxiety	80%	25%	100%	100%	46%
Range anxiety	60%	75%	50%	63%	54%
Complex payment, apps	30%	0%	67%	63%	15%
Lack of amenities	20%	25%	17%	25%	15%

Charging operators and EV drivers attached less importance to range anxiety, some even stating that this was a perceived issue just for non-EV drivers. Many added that the coverage of charging sites was already adequate in most regions, although more drive planning might be required than when driving an ICE vehicle. However, site capacity (i.e. the number and type of chargers) during peak periods (such as before a long weekend) may be lacking and blocked access or broken chargers are major obstacles to a fluid public charging experience.

In general, charging operators and EV drivers aligned on the complexity of purchasing for charging, with each charging operator having its own app or a membership card. EV drivers regard this as inhibiting customer experience satisfaction, much more so than the lack of amenities. Nevertheless, charging operators stated that they try to select sites with proper amenities. Neither utilities nor city interviewees saw these driver experience aspects to be as significant. However, surveys have shown that EV drivers are not satisfied with the existing public charging infrastructure, and drivers who do most of their charging at home or work are much happier than those who rely on public chargers.[10]

[10] For example, see this survey of Tesla Model 3 drivers: https://www.bloomberg.com/graphics/2019-tesla-model-3-survey, accessed 2021-03-15.

BARRIERS AND OPPORTUNITIES

This section provides an analysis of current barriers and an overview of how applying best practices might present new opportunities for expanding electric vehicle charging infrastructure.

Table 11 shows the percentages of interviewees who identified the following specific barriers to the expansion of the public charging infrastructure.

Table 11. Barriers to EV Public Charging According to Interviewees

	Barriers to EV Public Charging According to Interviewees			
	All interviewees	Type of stakeholder		
		Utility	City	Charging operator
Challenging business case	76%	90%	25%	100%
Siting issues; finding good sites	48%	30%	75%	100%
Grid costs; unfair utilities	38%	30%	50%	83%
Utilities can't rate base stations	24%	40%	0%	0%
Unfavourable provincial policies	19%	10%	0%	33%
Negative public perception	19%	20%	25%	17%
Technology risks	14%	20%	0%	33%
Can't price charging by kWh	14%	10%	0%	33%
Too many stakeholders	10%	10%	25%	0%

The barriers listed in Table 11 are discussed below, as are potential opportunities to overcome them.

Challenging Business Case

Overall, the challenging business case of public charging sites is seen as the largest barrier, with three quarters (76%) of all interviewees, including most utilities and all charging operators, identifying it. This is now well documented: energy sales at any reasonable price, whether charged by units of energy or time, do not cover the operating and capital costs of charging stations, especially for level 3 (DCFC) chargers. The difference between potential revenues and costs is too large, resulting in consistent negative Net Present Value (NPV) for these projects. For example, an analysis of the profitability of DCFC in eight US states showed them to have negative NPV around $30,000 to $40,000 per port, meaning that they never reach a breakeven point.[11]

Therefore, public chargers end up being subsidized in some ways, either by government policies (federal, provincial, or municipal, often to reduce GHG emissions or pollution), by utilities (which make it up with revenue from home and workplace charging), by automakers (to remove a barrier to the sale of EVs), or by site owners (to draw customers to their stores). Many interviewees stated that the NRCan's financial support through its infrastructure deployment programs is essential to establish a viable business case.

[11] Établissement d'un service public de recharge rapide pour véhicules électriques, HQD-1, document 1, dossier R-4060-2018 à la Régie de l'énergie du Québec, 2018-08-16, page 39.

In addition to delivery charges (for usage of the local electricity grid) and energy consumption charges (measured in kilowatt-hour, or kWh), charging operators and site owners usually pay for electricity demand charges (measured in kilowatts, or kW). Demand charges are based on the maximum load drawn from the grid at some point during a month or a year.[12] Given that charging sites are not used many hours per month in comparison to typical commercial or industrial loads, they pay relatively more for the demand charges than for delivery or energy charges. Demand charges then become a salient cost for operators and site owners, especially since demand charges do not align well with their revenue model, especially for DCFC sites that have high power requirements. There are many discussions within energy regulators to adapt electricity rates to the particularities of charging operators. For example, Hydro-Québec has an experimental “BR” rate for EV charging sites.[13]

Siting Issues; Finding Good Sites

The next most significant barrier identified was the ability to find suitable sites (land) for charging stations. Criteria vary, but access, grid connections and amenities were mentioned. Additionally, in cities, finding curbside stalls for EV charging that do not raise resident ire may be problematic.

Grid Costs; Unfair Utilities

Independent charging operators have mentioned that grid connection costs place them at a disadvantage versus utility-owned operators, specifically citing the unfairness of this. This fairness assessment may partly result from a misunderstanding on utility regulations. Provincial or state commissions are responsible for electricity regulation in North America. Generally, utilities are regulated on a “rate base rate-of-return” basis, where the entirety of costs incurred by the utility, plus its regulated shareholder return on investments, constitute its “rate base” that is reimbursed by revenue from ratepayers (customers), with regulators scrutinizing for “prudent” utility costs and determining a “fair” return for shareholders.[14] Utility price regulation is necessary as they are “natural monopolies” that otherwise would be in a position to extract undue revenue from captive customers.

This is a complex environment: there are 145 utilities in Canada alone,[15] each with its own electricity rates approved by their provincial regulator. In practice, utilities often have their hands tied—what may appear to be unfavourable utility practices may in fact be the reflection of regulations and policies, especially where technology and markets are changing rapidly. Still, there is a clear opportunity to change utility rates to account for the peculiarities of EV charging sites for the benefit of all ratepayers.

Utilities Can't Include Stations in the Rate Base

On the other hand, some utilities are recognizing that EV charging—home, public or workplace—is exerting downward pressure on rates, with additional energy sales being significantly above incremental costs. These utilities would like to accelerate EV adoption by deploying a robust public charging infrastructure and adding it to their “rate base” (see the previous section for a definition of “rate base”).

Some regulators have previously denied adding chargers to utility rate bases. However, certain utilities have succeeded in petitioning their provincial regulators, most notably Hydro-Québec and BC Hydro. In Ontario, the Electricity Distributor Association is proposing that local distribution companies be able to base investments in EV charging infrastructure on rates.[16] During interviews, some utility participants wanted to know what arguments were presented to regulators to accomplish this, pointing to the need to improve knowledge sharing of EV charging among utilities.

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[12] Ontario also has a rate component called “global adjustment,” on top of demand charges; this rate component can be extremely expensive for large DCFC charging sites.

[13] See https://www.hydroquebec.com/business/customer-space/rates/rate-br-experimental-rate-fast-charge-stations.html, accessed 20210312.

[14] Some municipal utilities are regulated by cities or effectively run as a municipal service. Some provincial and state utilities, especially in Alberta and some US states, have performance incentives built into their regulatory regime.

[15] See http://benoit.marcoux.ca/blog/here-are-the-151-canadian-electric-utilities/ for the list of these utilities, accessed 20210219.

[16] See Charging Ahead: Electricity Distributors Association Position Paper on Electrified Transportation, December 2020.

Unfavourable Policies in Some Provinces

Some provincial governments have adopted policies to support EVs and EV charging, and others have not. These policies may include direct ones, such as EV and EV charging subsidies, and indirect ones through policies requiring utility regulators to approve EV rates and services.

Provinces who have not yet directly addressed EV-related issues through policy may see infrastructure deployment constrained. For example, NB Power had to stop its deployment of DCFCs following a decision by the New Brunswick Energy & Utilities Board. The Board deemed that EV charging stations are not within the core business of NB Power.[17]

However, some provincial governments are highly supportive of EVs. For example, the Quebec government is supporting EVs through multiple policy actions. These policies enabled the Quebec regulator to approve adding DCFC chargers to Hydro-Québec's rate base and enabling rates specifically for public charging.[18]

Negative Public Perception

Some city interviewees mentioned difficulties in siting public chargers, especially curbside chargers that may restrict on-street parking to EVs only. Other interviewees mentioned that if there is a perception that these charging sites are not often used, citizens may question the need for government support of EV-friendly policies. Such negative impressions may persist until EV adoption increases and more citizens become EV drivers themselves.

Technology Risks

Some utility and charging operator interviewees were concerned by the rapid evolution of charger technology, as it increases their risk of having stranded assets. This risk appears to be especially significant for DCFC, as increasingly powerful chargers become available, which could render existing ones obsolete. Other technologies, such as plug-and-charge[19] and Open Charge Point Protocol (OCPP),[20] could also mean costly retrofitting in the future. This suggests that sharing experience and information in government-sponsored forums might benefit the ecosystem.

Can't Price Charging by kWh

Some utilities and charging operators mentioned that EV drivers would prefer to buy charging services by units of energy (kilowatt-hours or kWh) rather than plug-in or parking time, as currently done. In the Canadian provinces, charging network operators cannot sell charging by kWh, as only utilities can sell electricity by the kWh, although Manitoba Hydro has proposed to its regulators to allow charging operators to sell kWh. It should be noted that those are provincial regulations, set by provincial policies and energy regulators. However, Measurement Canada would be involved in certifying whatever meters would be used, whether traditional electricity meters or using the chargers themselves as a metering device.

From comments on the ChargeHub app, EV drivers are often displeased by the plethora of pricing schemes among the various operators; a uniform kWh pricing across Canada might indeed be preferable. However, enabling kWh-based pricing only in some provinces might also contribute to driver confusion.

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[17] See https://nbeub.ca/uploads/2018%2007%2020%20-%20Decision%20-%20Matter%20375.pdf, accessed 20210312.

[18] See http://publicsde.regie-energie.qc.ca/projets/473/DocPrj/R-4060-2018-A-0035-Dec-Dec-2019_10_21.pdf, accessed 2021-03-15.

[19] Plug-and-charge refers to a technology where a driver simply plugs in their vehicle and walks away, with the vehicle and the charger exchanging payment information to initiate charging. This is already used by Tesla, and Electrify America is rolling it out at its DCFC charges, using the ISO 15118 standard, ahead of compatible EVs becoming available.

[20] Open Charging Point Protocol is a proposed (and still evolving) standard of communication to and from charging equipment.

Measurement Canada expects to allow existing and new electric vehicle (EV) charging stations that meet established technical standards to charge based on kilowatt-hours (kWh) consumed within the next year and a half.[21] However, allowing charging operators to sell electricity as kilowatt-hours would rest with provincial regulators.

That said, having only per kWh pricing is not necessarily the best approach for all cases. For example, at destination chargers, a per hour pricing may ensure that users do not plug in and park their vehicle longer than necessary, blocking access for other drivers for many hours.

Too Many Stakeholders

Some utility and city interviewees mentioned the large number of stakeholders to be a problem, given the lack of coordination among them. There are indeed many stakeholders in the EV charging ecosystem: utilities, cities, charging operators, provincial governments, federal government, regulators, automakers, charger manufacturers, associations, etc. This is especially confusing for newcomers. In fact, the interviewees citing this issue were not EV drivers. This again points to the need to share experience among stakeholders.

[21] See https://www.ic.gc.ca/eic/site/mc-mc.nsf/eng/lm04949.html, accessed 20210310

FUTURE INFRASTRUCTURE NEEDS

In general, DCFC deployment models assume that installation of charging ports precedes EV adoption. For example, Hydro-Québec assumes that the ratio of BEVs to level 3 ports will go from 125:1 in 2021, to 225:1 in 2025, and to 250:1 in 2030, when BEV penetration will achieve more than 10% of the LDV market and reach the provincial government target of 1 million EVs on the roads. According to the literature cited by Hydro-Québec,[22] a ratio of 250:1 is considered optimal over the long run.

In Canada, there were 113,000 BEVs[23] and 2,257 DCFC[24], for an average ratio of 50:1, at the end of 2020.[25] For 2030, Transport Canada forecasts that under the business-as-usual scenario there will be 1.0 M BEVs on Canadian roads;[26] assuming a 250:1 ratio, approximately 4,000 DCFC ports would be required, or 1.7 times more than in 2020. This can be considered a minimum number of DCFC ports as:

- The Transport Canada forecast includes policies/programs that were in place up to July 31, 2020, but does not account for any new initiative to accelerate BEV adoption after that time, such as the extension of the iZEV program. Furthermore, some provinces will lag others and require more than 1 DCFC port per 250 BEVs until BEV penetration approaches 10%.

DCFC deployment would cover use case 2a and 2b described in the Methodology section. Destination charging using level 2 public chargers (use case 1) complements DCFC chargers. Use case 1 is for public destinations where one can expect the vehicle to be parked for at least a few hours, such as on-street parking, at hotels, and at shopping centres. However, it is difficult to forecast future deployment in use case 1 as:

- Installation of chargers at commercial sites is primarily driven by business considerations, such as attracting customers, and not to ensure sufficient coverage or capacity for EV drivers. The decision is left to business owners.
- In the case of chargers installed on public land, such as curbside chargers, it is most efficient to deploy EV charging at the same time as other infrastructure works, such as building new curbs or repaving streets. In a city environment, citizens' and other stakeholders' perceptions of the work must also be considered. Timing of charger deployment is then constrained by many other considerations than only the needs of EV drivers.

In addition to the public use cases above, the charging needs of EV drivers are also served by home and workplace charging.

- Home charging will likely remain the most important method. Estimates vary; for example, the Hydro-Québec study cited above assumes that 80% of charging will occur at home in 2030. However, home charging is currently inaccessible for the vast majority of tenants in older multi-dwelling buildings. Retrofitting these buildings will take time, as the interests of many stakeholders (mostly building owners, condo or strata owners, and renters) and the evolution of building codes will need to be considered.

Workplace charging will likely increase in importance. However, many businesses rent their workplaces from real-estate owners, which can complicate infrastructure deployment. The business occupant and the real-estate owners must agree upon the costs of installing chargers, operating costs and employee pricing for charging (if any).

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[22] Energy+Environmental Economics, New Economic Model Report, Nancy Ryan et al., February 15th, 2018, presented in case 4060 before the *Régie de l'énergie*.

[23] Transport Canada (2020), internal ZEV model estimation

[24] ChargeHub Database, December 2020

[25] However, CMAs in British Columbia and in Quebec already have up to 151 EVs per DCFC port (see Table 4).

[26] Transport Canada (2020) internal ZEV model estimation

Conclusion

This report identified three categories of gaps in the current Canadian EV charging infrastructure: in cities, along highways, and in driver experience.

There are large differences in the availability of EV charging infrastructure between large Canadian cities (CMAs). Generally, cities in British Columbia and Quebec have more charging ports relative to their population. However, since these two provinces also have greater than average EV adoption, there are more EVs per public charging port in British Columbia and Quebec than in other provinces—these provinces benefit from an economy of scale given their higher numbers of EVs on the road. Still, even there, EV adoption is in its early stages, and cities in these provinces have fewer than 250 EVs per DCFC port, a ratio cited as optimal in the long run.[27] Given that EV adoption will increase significantly in the years to come, EV charging infrastructure in all Canadian cities will also need to increase in capacity, ahead of EV adoption, as the public infrastructure is a driver of EV adoption.

Coverage of major highways is already at 61%, with most of the remaining gaps currently located in the Prairies, Newfoundland and Labrador,[28] and Canada's North. Experienced EV drivers know that there are usually charging sites wherever they want to go – range anxiety (a vehicle issue: "Will I be able to get where I am going?") appears to be a greater issue for non-EV drivers than for EV drivers.

However, capacity issues (overcrowding of chargers) are becoming apparent, especially in the provinces with the highest penetration of EVs. Capacity issues directly impact the driver experience and are the subject of much of the negative feedback on the ChargeHub app. Other negative feedback relates to issues such as blocked access to charging stalls and broken ports. For EV drivers, charging anxiety (an infrastructure issue: "Will I be able to charge at this site?") is a more serious issue than range anxiety.

Overall, the challenging business case of public charging sites is well documented: at current prices, revenue from charging sales does not cover the operating and capital costs of charging stations, resulting in consistent negative NPV for these projects. This is especially true for DCFC chargers. In most cases, future increase in a charging site usage over time will not overcome the cost deficit, as congestion levels at peak time are reached before a break-even may be achieved, requiring upgrades. Public chargers end up being subsidized in some way, either by government policies (federal, provincial, or municipal, often to reduce GHG emissions), by utilities (which make it up with revenue from home and workplace charging), by automakers (to remove a barrier to the sale of EVs), or by site owners (to draw customers to their stores). In this context, stakeholders see the financial support provided through NRCan's infrastructure deployment programs as essential.

While the ChargeHub database is extensive, it does not have much session-level charging data outside of British Columbia and Quebec, and this data cannot readily be used by third parties to assess congestion and to plan for infrastructure expansion because it is owned by network operators. Nevertheless, site utilization at peak periods (and not only averages over time) would be extremely useful in helping NRCan to prioritize investments where capacity is strained. For example, NRCan could require peak utilization data for the charging stations it subsidizes, or even all communicating stations of the charging operators it subsidizes, as part of the selection process. This could be achieved in the form of reports. An alternative that would not entail additional reporting by operators might be to link to the computer systems of the main charging operators, collecting utilization data automatically, and presenting it in consolidated, high-level dashboards and easy-to-view map-based congestion indexes.

[27] See Future Infrastructure Needs

[28] As of January 2021, there were no active public level 3 sites in Newfoundland and Labrador; however, a network of 14 fast chargers along the Trans-Canada Highway is set to open in 2021. See https://nlhydro.com/electricvehicles/, accessed 20210310.

Public charging is the aspect of owning an EV that EV drivers like the least. Public charging is also a key enabler for the adoption of EVs. Therefore, we recommend that NRCan encourage best practices by implementing merit criteria associated with driver experience in the selection process for EV charging subsidies. This can be done by monitoring overcrowding of chargers in the area, suggesting sharing of port status so that drivers may easily discover where they can charge, enabling drivers to share their experience, and suggesting that operators participate in streamlining the EV charging payment process.

Once congestion data and driver feedback are available, it could feed analytical systems to assess where best to increase capacity. These actions would make NRCan the “national conductor” to accelerate the adoption of EVs in Canada.

APPENDIX 1 Regional Maps

Figure 5. British Columbia Highways (Ranks 1 to 3) With a Level 3 Charging Stations Overlay

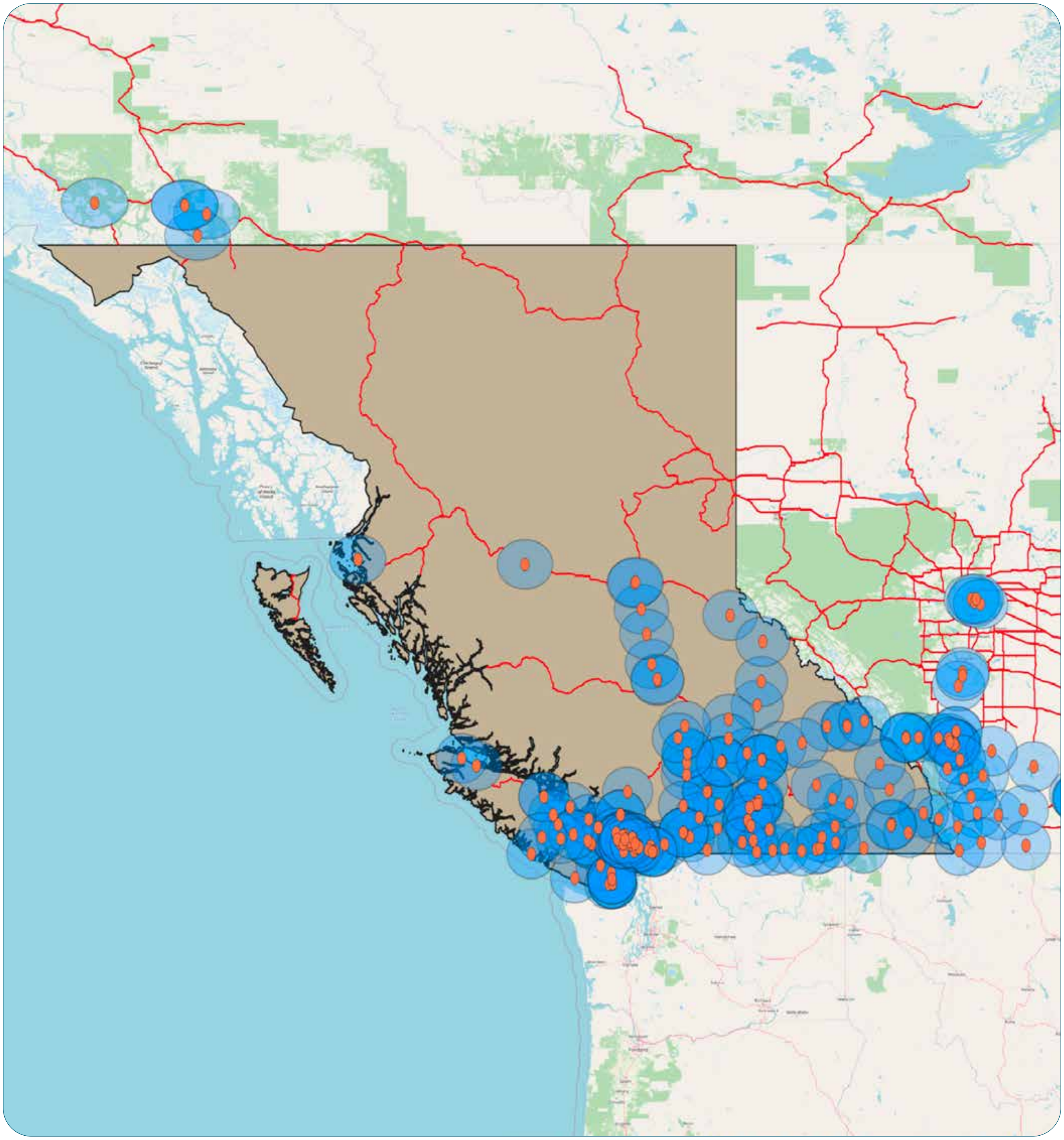

Figure 6. Prairies Highways (Ranks 1 to 3) With a Level 3 Charging Stations Overlay

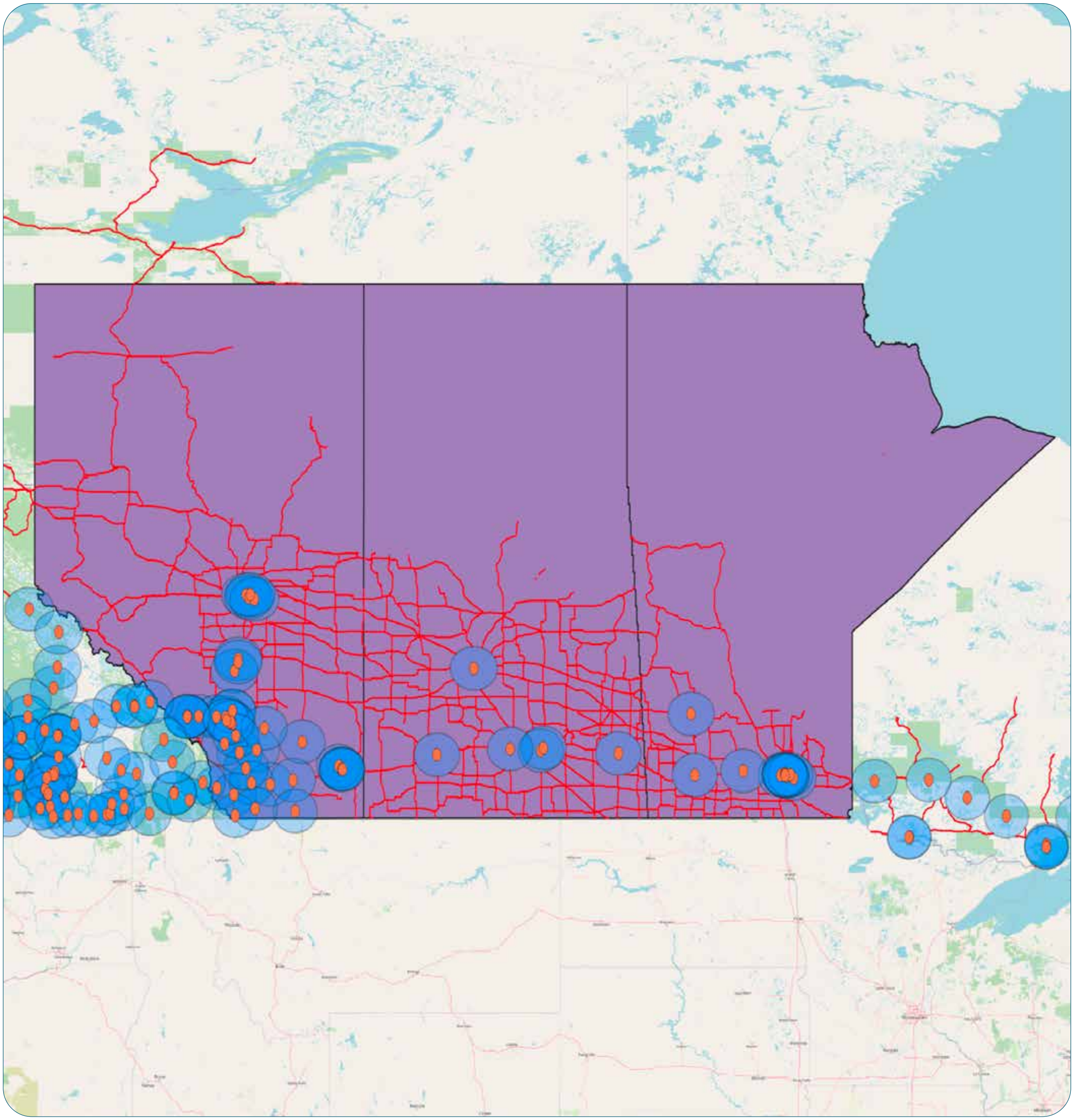

Figure 7. Ontario Highways (Ranks 1 to 3) With a Level 3 Charging Stations Overlay

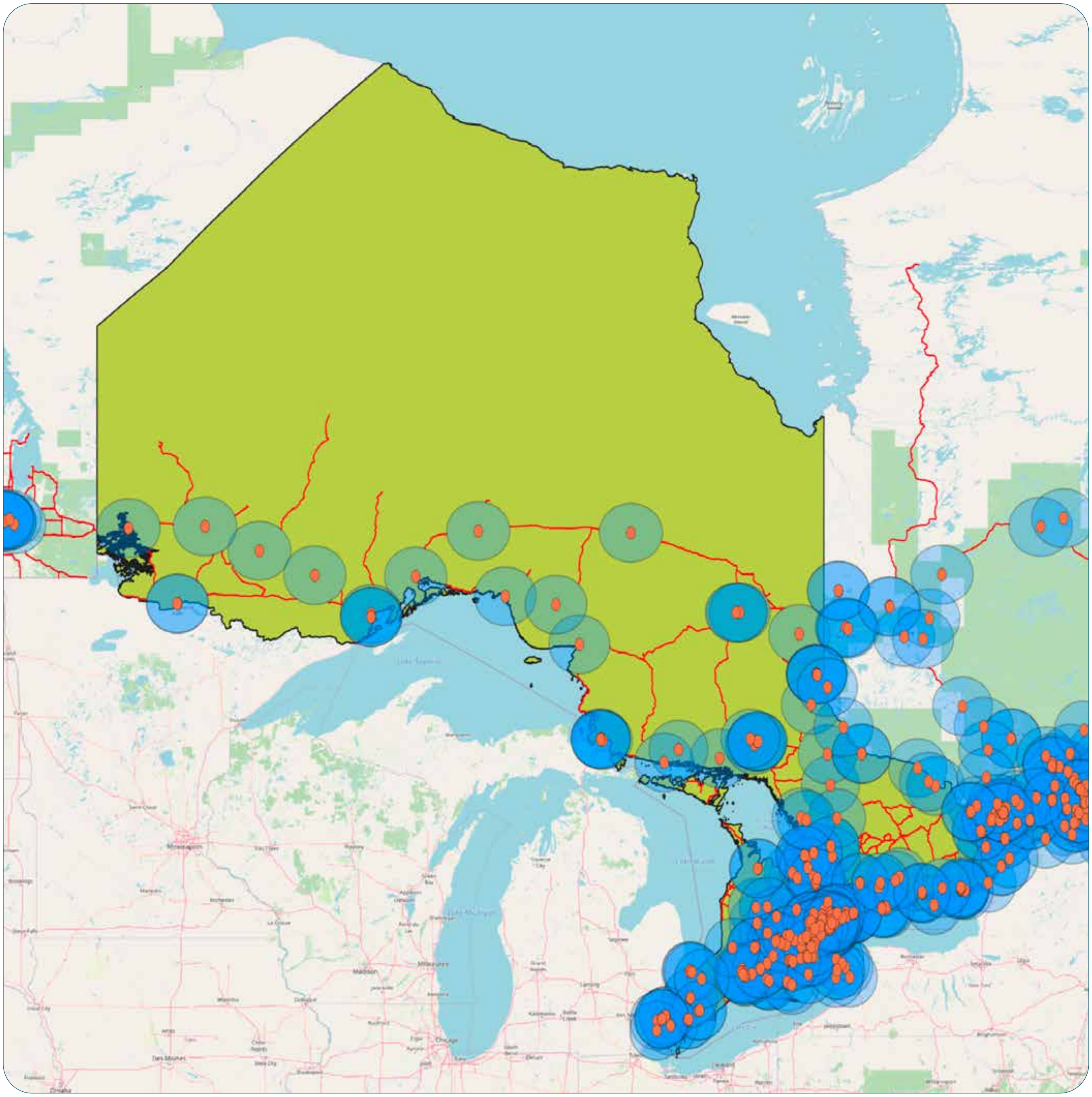

Figure 8. Quebec Highways (Ranks 1 to 3) With a Level 3 Charging Stations Overlay

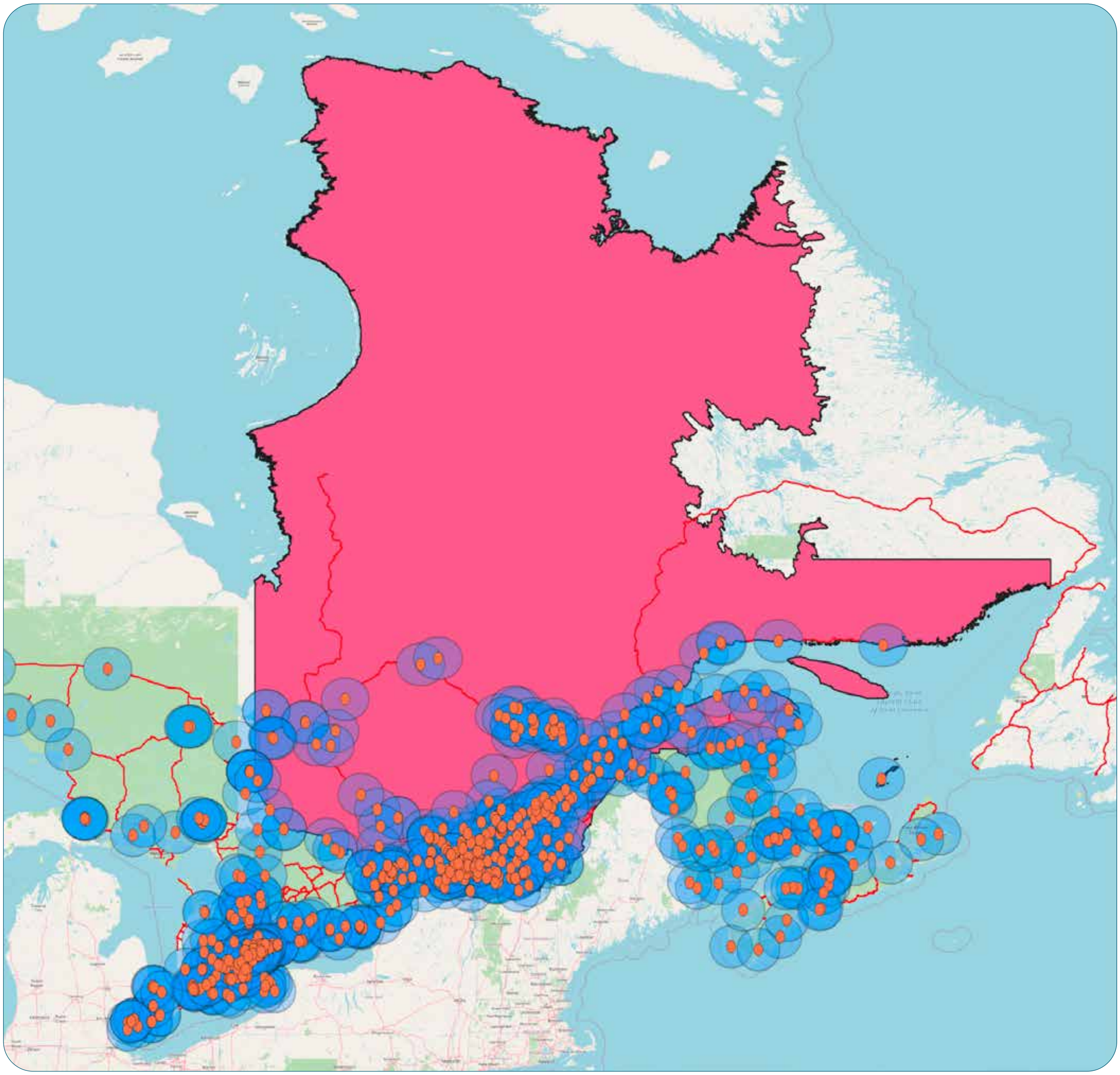

Figure 9. Maritime Highways (Ranks 1 to 3) With a Level 3 Charging Stations Overlay

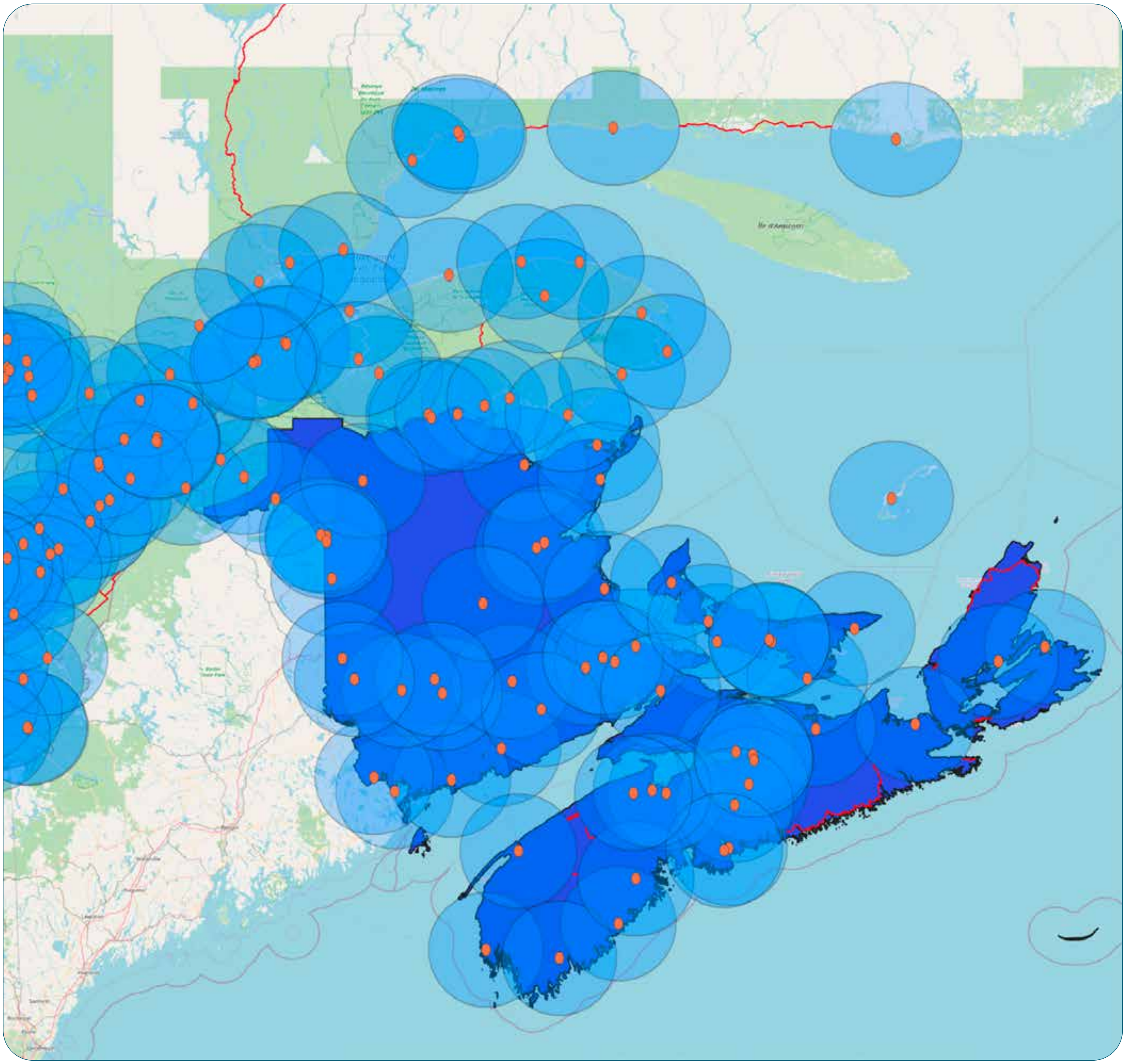

Figure 10. Newfoundland and Labrador Highways (Ranks 1 to 3) With a Level 3 Charging Stations Overlay