2023 Canadian Electric Vehicle Owner

Charging Experience Survey

January 2024

Implementing Partners:

Pollution Probe

Mobility Futures Lab

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Pollution Probe

Pollution Probe is a Canadian charitable environmental organization that is a leading agent of change at the intersection of communities, health and environment. Since 1969, we have been defining environmental problems through research, promoting understanding through education and pressing for practical solutions through advocacy. Pollution Probe has a proven track record of working in successful partnership with industry and government to develop practical solutions for shared environmental challenges.

Pollution Probe is one of Canada's leading independent transportation solution providers. Our work supports aggressive actions to address climate change and reduce air pollution while promoting job creation and economic growth. In addition to projects we actively contribute to expert transportation committees and working groups at local, regional, national and global levels. We are technology neutral and work collaboratively with a wide variety of stakeholders to develop transportation decarbonization solutions across all modes.

Mobility Futures Lab

Mobility Futures Lab is a leading sustainable transportation consulting firm that is at the forefront of innovation and research in the field of mobility. The firm's services are designed to help clients navigate the complex landscape of sustainable transportation, with a focus on proprietary software tools and data-driven solutions. Our approach is based on a deep understanding of the interconnections between transportation, energy, and the environment.

Acknowledgements

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Table of Contents

List of Acronyms

AC – Alternating Current
BEV – Battery Electric Vehicle
CCS – Combined Charging System
DC – Direct Current
DCFC – Direct Current Fast Charger
EV – Electric Vehicles
EVSE – Electric Vehicle Supply Equipment
GHG – Greenhouse Gases
ICEV – Internal Combustion Engine Vehicle
ISED – Innovation, Science, and Economic Development Canada
iZEV – Incentives for Zero Emission Vehicles
km – Kilometers
kW – Kilowatts
kWh – Kilowatt Hour
MURB – Multi-Unit Residential Building
NACS – North American Charging Standard
NRCan – Natural Resources Canada
PHEV – Plug-in Hybrid Electric Vehicle
RFID – Radio Frequency Identification
TOU – Time of Use
V2G – Vehicle to Grid
ZEV – Zero-Emission Vehicle
ZEVIP – Zero-Emission Vehicle Infrastructure Program

Executive Summary

Canadian EV Market Trends

The outlook of the electric vehicle (EV) market in Canada is positive and trending in the right direction, fueled by a wide range of federal and provincial incentives for purchasing EVs and installing EV charging stations. EV sales in Canada in 2022 increased by 44% compared to 2021 and exceeded 120,000 for the first time. This increase in EV sales was complemented by the installation of new level 2 public EV charging stations at 1,990 locations and DC fast charging EV stations at 341 locations across Canada in 2022.

EV Owner Charging Experience Survey

The growing EV market has led to numerous stakeholders individually investing in the installation and operation of charging stations. Consequently, a decentralized public charging station ecosystem has emerged, comprising diverse networks managed separately by provincial and local governments, private charging station operators, electrical utilities, and vehicle manufacturers. Despite the industry rapidly maturing thanks to the adoption of several strategic partnerships, the charging experience of Canadian EV owners can vary significantly based on multiple factors, including access to home charging, driving behavior, vehicle range, residential location and access to public charging networks, and socioeconomic status.
Natural Resources Canada (NRCan), under the Zero Emission Vehicle Awareness Initiative, and the University of Toronto's Positive Zero Transport Futures initiative funded Pollution Probe, in partnership with the Mobility Futures Lab to conduct EV owner charging experience yearly surveys for 2023 and 2024. This 2023 report presents the EV charging experience of 1,522 EV owners across the country and highlights their opinion on public charging infrastructure. The results of this study identify gaps and weaknesses in current charging infrastructure, as well as strengths that can be leveraged to maximize the benefits of future deployments.

EV owners' interaction with public charging infrastructure was divided into four categories, charging behavior, network coverage satisfaction, network service satisfaction and costs and payments.

Survey Respondent Characteristics

- Responses were collected across 11 provinces. The highest number of responses were from Ontario (40%), Quebec (26%), and British Columbia (17%), with the remaining provinces representing 17% of responses.
- 71% of respondents were above the age of 45, and 56% had a household income of more than $125,000 before tax.
- 64% of respondents owned at least one internal combustion engine vehicle in addition to their EV and 46% have owned an EV for less than 3 years.
- 87% of respondents reside in single-family houses with dedicated parking, while only 12% reside in Multi Unit Residential Buildings (MURBs).
- 38% of EV owners residing in MURBs did not have access to home charging, compared to only 2% for single-family homeowners.

EV Charging Behavior

- 80% of respondents owned an EV with a range of at least 300km. Yet, 67% of respondents reported driving an average of less than 60km per day, while only 10% traveled more than 100km on average.
- 38% of respondents reported undertaking long-distance trips of over 200km one way at least once per month using their EVs. Such journeys typically necessitate the use of public charging infrastructure.
- 96% of EV owners do use public charging stations to some extent, although 55% of them rely on public stations for a small portion of their charging needs (less than 10%)

Network Coverage Satisfaction

- EV owners in Quebec were more satisfied with the coverage of public charging stations compared to the other provinces as 40% felt that the number of public charging stations was adequate, compared to around 20% for both Ontario and British Columbia. EV owner satisfaction in the remaining provinces was worse as only 9% felt that there was an adequate number of public charging stations.
- 53% of EV owners stated that the availability of public chargers in areas they frequently travel influenced their decision to purchase an EV. This influence was more pronounced in Ontario (63%) and the other provinces (59%) compared to British Columbia (44%) and Quebec (39%).
- 40% of EV owners across Canada indicated the need to often take indirect routes to access charging infrastructure, while 37% indicated the opposite.
- EV owners preferred level 2 public chargers at retail centers (22%), hotels/motels (20%), and common recreational destinations (19%), while level 3 charging stations were preferred at gas stations and highway rest stops (28%).

Network Service Satisfaction

IMPEDIMENTS AND WAIT TIME:

- 45% of EV owners reported instances of people remaining plugged in to charging stations after they have fully charged or having gas powered cars occupy EV charging spaces.
- EV owners were mostly satisfied with the wait times at charging stations (27% dissatisfied) and winter access (16% dissatisfied). Wait time satisfaction varied significantly between Tesla owners (16% dissatisfied) and non-Tesla owners (37% dissatisfied).

RELIABILITY:

- EV owners in Quebec were more satisfied with the reliability of public charging infrastructure, as only 19% complained about stations being out of service and 30% were concerned about being stranded due to stations being out of service, compared to 44% and 48%, respectively, in the remaining provinces. Similarly, Tesla owners were less concerned about charging stations being out of service (30%) compared to owners of other EVs (53%).
- 56% of EV owners felt that the power supply at public charging stations was not consistent.

USER FRIENDLINESS:

- 44% of respondents across Canada felt that the signage of public EV charging stations was not clear and 31% experienced difficulties charging due to the length, weight and position of charging cables.
- 63% of respondents in Ontario felt that public charging stations were located near useful amenities, compared to around 47% in other provinces.
- 73% of respondents never felt unsafe while charging in public. However, respondents that did express safety concerns indicate remote isolated locations (16%) and poor lighting at night (14%) as the main reasons for feeling unsafe.

DISABILITY ACCESSIBILITY:

- 14% of respondents felt that public EV charging stations were not accessible to individuals with disabilities and 38% were not sure.

Payments and Costs

PAYMENT:

- 76% of survey respondents indicate being a member of at least two networks. Furthermore, 37% of survey respondents are not aware of any roaming agreements between network operators, with EV owners in Quebec being more informed about agreements (48%) than other provinces (36%)
- 48% of respondents indicate that the payment options at public EV charging stations are adequate and convenient while 30% indicate the opposite. EV owners in Quebec are also more satisfied with the payment options (62%) than in other provinces (41%).
- 71% of Tesla owners currently pay through the ‘plug and charge’ payment method that is specific to the Tesla public charging network, but current payment methods were more distributed for non-Tesla owners, with 29% paying through network mobile apps (i.e., using their smartphone), 29% through multiple methods, 15% using network RFID cards and 19% using physical credit/debit cards.
- 73% of Tesla owners indicate preferring to pay for charging with their network mobile app (i.e., plug and charge payment system) compared to only 24% for non-Tesla owners (i.e., using their smartphone). The preferred method of payment for non-Tesla owners was using credit/debit cards (55% of respondents).

COST:

- 48% of EV owners agreed that the cost of charging EVs at public charging stations is reasonable based on the electricity consumed and the time required to charge, whereas 28% disagreed with the statement. Satisfaction with charging cost was also slightly more pronounced in Quebec (61%) and British Columbia (50%) compared to the other provinces (40%).

- 51% of EV owners felt that public EV charging pricing was inconsistent across different locations. In Quebec, the dissatisfaction with pricing consistency across locations was relatively lower, with 40% of EV owners expressing concerns, as opposed to other provinces where the figure stood at 56%

- 52% of respondents indicate willingness to pay more for faster charging. Willingness to pay for faster charging is less pronounced in Quebec (41%) compared to other provinces (55%).

- A significant majority of respondents (60% - 79%) showed willingness to participate in time-of-use pricing, smart charging, or vehicle-to-grid (V2G) charging programs, which offer potential cost savings.

Recommendations

PUBLIC CHARGING INFRASTRUCTURE DEPLOYMENT

Strategically position level 2 charging stations at retail centers, hotels, and recreational spots, especially where EVs stay parked for extended periods. Additionally, deploy level 3 DCFC charging stations along highways and gas stations for long-distance travel convenience, and in areas with numerous Multi-Unit Residential Buildings (MURBs) to serve residents without home charging access.

CHARGING STATION CONSTRUCTION STANDARDS

Develop universal construction standards for public EV charging stations, emphasizing clear signage and proper lighting to enhance user safety and experience. Integrate accessibility considerations to cater to individuals with various mobility needs and conduct further research on EV charging accessibility's impact on adoption among people with disabilities, assessing Canada's current EV network's accessibility and potential improvements.

NETWORK OPERATOR REGULATION

Introduce regulations mandating network operators to maintain a minimum station uptime to reduce station outages. Implement a standardized billing format in energy units (kWh) across locations for transparent and consistent charging costs, potentially attracting private sector investments. Consider enforcing financial penalties to prevent EVs remaining plugged after having fully charged under kWh-based billing, and encourage or mandate operator partnerships for universal access.

EV OWNER CHARGING EXPERIENCE EVOLUTION

Conduct regular surveys to monitor the evolving charging experiences of EV owners across provinces and demographics. Use survey data to shape policy decisions and infrastructure development, ensuring the charging ecosystem adapts to user needs. Analyze the provincial-level public charging infrastructure landscape to compare EV owner experiences with local public charging station operator practices, regional policies, and regulatory frameworks.

1 Background

Electrifying the transportation sector is a key component in the Canadian government's commitment to achieving net zero greenhouse gas (GHG) emissions by 2050[1]. As part of its decarbonization path, the federal government is considering a 100% zero-emissions vehicles (ZEV) sales mandate for all light-duty vehicles by 2035[2]. Proposed regulations aim to ensure that 20% of new passenger vehicles available for sale in Canada starting from the 2026 model year are ZEVs, increasing to 60% by 2030 and 100% by 2035[3].

Despite supply chain disruptions in 2022, Canada's EV market is trending in the right direction. Electric vehicle (EV) sales, including battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), reached a record high in 2022, exceeding 120,000 vehicles sold for the first time[4]. The rise in EV sales has been paralleled by substantial investments in charging infrastructure from both the public and private sectors. Throughout 2022, there has been a notable surge in the number of EV charging stations at the national level. It is important to sustain EV sales growth through a simultaneous deployment of EV charging infrastructure. The lack of public charging infrastructure has consistently been identified as one of the top three barriers to increased EV adoption, alongside purchase prices and vehicle range[5]. Additionally, the presence of conveniently located public charging stations significantly influences consumer awareness and perception of the feasibility of EV usage[6].

1 Canadian Institute for Climate Choices (2021). Canada's net zero future - Finding our way in the global transition. Retrieved from: https://climatechoices.ca/wp-content/uploads/2021/02/Canadas-Net-Zero-Future_Summary_FINAL.pdf

2 Environment and Climate Change Canada (2022). 2030 Emissions Reduction Plan - Canada's Next Steps for Clean Air and a Strong Economy. Retrieved from: https://climate-laws.org/document/2030-emissions-reduction-plan-canadas-next-steps-for-clean-air-and-a-strong-economy_75c2

3 Battery electric (BEV), plug-in hybrid electric (PHEV), and fuel cell electric vehicles (FCEV) are all classed as ZEVs for the purposes of the regulation.

4 Statistics Canada. Table 20-10-0024-01 New motor vehicle registrations, quarterly. https://doi.org/10.25318/2010002401-eng .

5 Newmotion (2020). EV Driver Survey Report. Retrieved from: https://assets.ctfassets.net/ulfvrpf1itxm/1Qid6yJBwkLoAoTSgr9kYt/9c11d5bdc97b994d1e8772e929e46f57/0729NM04_EV_driver_survey_report_2020_EN_FINAL.pdf

6 Sandia National Laboratories (2017). Impact of Public Electric Vehicle Charging Infrastructure. Retrieved from: https://www.osti.gov/servlets/purl/1416695

A recent survey conducted among EV owners in Canada revealed that 44% of respondents expressed concerns about the inadequacy of public charging stations and were worried about their uptime and reliability[7]. The differences in opinions among EV owners across Canada regarding their charging experience can be attributed to the varying coverage and service of public charging stations nationwide. The low penetration of the EV market has been one of the factors that have contributed to numerous stakeholders individually investing in the installation and operation of charging stations. Consequently, a decentralized public charging station ecosystem has emerged, comprising diverse networks managed separately by provincial and local governments, private charging station operators, electrical utilities, and vehicle manufacturers. However, the industry is progressing towards maturity, thanks to the adoption of several strategic partnerships.

The charging experience of EV owners can vary for different segments of the population based on factors such as access to home charging, vehicle range, residential location and charging networks available, driving behavior, and socioeconomic status of the EV owner. To comprehensively assess these charging experiences and identify strengths and limitations in Canada's EV charging infrastructure, continuous monitoring of various aspects of EV charging is essential.

In this context, Natural Resources Canada (NRCan), under the Zero Emission Vehicle Awareness Initiative, and the University of Toronto's Positive Zero Transport Futures initiative funded Pollution Probe, in partnership with the Mobility Futures Lab to conduct EV owner charging experience yearly surveys for 2023 and 2024. This 2023 report presents the EV charging experience of 1,522 EV owners across the country and highlights their opinion on public charging infrastructure. The 52-question survey was designed based on interviews with over 20 leading EV experts from both the public and private sectors, as well as an extensive review of the existing literature.

The results of this study aim to identify gaps and weaknesses in current charging infrastructure, as well as strengths that can be leveraged to maximize the benefits of future deployments. Based on the results of the national survey, this report categorizes consumer interaction with charging infrastructure under four categories, namely: charging behaviour, network coverage satisfaction, network service satisfaction, and network payment systems. A descriptive analysis of the survey results attributed to each category is presented in the body of the report.

The remainder of the report is structured as follows: **Section 2** provides a summary of the current EV market in Canada, including provincial and federal EV incentives, EV sales and number of charging stations. **Section 3** presents the characteristics of the survey respondents, including demographics, driving behavior, and charging behavior. **Sections 4**, **5** and **6** summarize the satisfaction of EV owners in terms of network coverage, network service and network costs and payments respectively. Finally, a list of recommendations is included in the report's **final section**.

7 Canadian Automobile Association (2023). The Voice of the Canadian Electric Vehicle Driver. Retrieved from: https://www.caa.ca/app/uploads/2023/06/CAA-Canadian-EV-Driver-Study_FINAL_EN.pdf).

2 Trends and Developments in the Canadian EV Market

To ensure a comprehensive understanding of the EV owner charging experience, it is essential to closely examine the recent market developments in terms of incentives, sales trends, and the installation of charging infrastructure. By monitoring the interplay between these various aspects of the EV market, both at the federal and provincial levels, we can identify the most effective pathways that lead to increased EV adoption while achieving high satisfaction among EV owners regarding public charging infrastructure.

2.1 Provincial and Federal incentives

EV sales growth has benefited from advancements in battery range and cost, as well as financial incentives for EV purchases and the installation of charging infrastructure. Federal rebate and incentive programs, such as the Incentives for Zero-Emission Vehicles (iZEV[8]) program and tax write-offs for businesses, help make EVs more financially accessible. The iZEV program, for instance, offers incentives of up to $5,000 for the purchase of BEVs and long-range PHEVs. Furthermore, the Zero Emission Vehicle Infrastructure Program (ZEVIP) introduced in 2019 aims to support the deployment of 84,500 EV chargers in public spaces, on-street locations, multi-unit residential buildings, and workplaces by 2029[9].

In addition to federal incentives, several provinces have implemented their own incentive programs to encourage EV adoption and the installation of charging stations. These provincial incentives, summarized in **Table 1**, encompass various benefits for purchasing EVs, installing public charging stations, and setting up home charging infrastructure.

8 Transport Canada (2023). Incentives for purchasing zero-emission vehicles. Retrieved from: https://tc.canada.ca/en/road-transportation/innovative-technologies/zero-emission-vehicles/light-duty-zero-emission-vehicles/incentives-purchasing-zero-emission-vehicles.

9 Natural Resources Canada (2023). Zero Emission Vehicle Infrastructure Program. Retrieved from: https://natural-resources.canada.ca/energy-efficiency/transportation-alternative-fuels/zero-emission-vehicle-infrastructure-program/21876.

Table 1. Summary of Provincial EV Incentives.
Note: All provincial EV sales incentives and rebates can be obtained as an addition to the federal incentives

Province	Light-Duty Zero Emission Vehicle Purchase and Lease Programs	Public Charging Infrastructure Programs	Home and Workplace Charging Programs
Alberta	No Provincial Incentives	Rebates up to $10,000 for level 2 chargers and $150,000 for fast chargers (only for municipalities)[10]. Funded by the Municipal Climate Change Action Centre.	No Provincial Incentives
British Columbia	Rebates up to $4,000[11]	Rebates up to $7,500 for level 2 chargers and $130,000 for fast chargers[12]	Multiple rebate options for installation of level 2 chargers in single homes and apartment/condo buildings and level 2 and 3 chargers in workplaces[11]
Manitoba	No Provincial Incentives	No Provincial Incentives	Loans up to $3,000 per charger[13]
New Brunswick	Rebates up to $5,000[14]	No Provincial Incentives	Rebates up to $750 for level 2 chargers[14]
Newfoundland & Labrador	Rebates up to $2,500	No Provincial Incentives	No Provincial Incentives
Northwest Territories	Rebates up to $2,500[16]	No Provincial Incentives	Rebates up to $500 for level 2 chargers at home locations[16] and up to $5,000 for level 2 chargers and $75,000 for fast chargers in workplaces[17]
Nova Scotia	Rebates up to $3,00018	No Provincial Incentives	Rebates up to $10,000 per apartment building[19]
Nunavut	No Provincial Incentives	No Provincial Incentives	No Provincial Incentives
Ontario	No Provincial Incentives	Rebates up to $7,500 per level 2 port and $150,000 per level 3 port[20]	Loans up to $125,000 for level 2 chargers (only for single homes in Toronto) [21]
Prince Edward Island	Rebates up to $5,000[22]	No Provincial Incentives	Rebates up to $750 for level 2 chargers[22]
Quebec	Rebates up to $7,000[23]	No Provincial Incentives	Multiple rebate options for installation of level 2 chargers in single homes and apartment/ condo buildings and level 2 and 3 chargers in workplaces[23]
Saskatchewan	No Provincial Incentives	No Provincial Incentives	No Provincial Incentives
Yukon	Rebates up to $5,000	No Provincial Incentives	Rebates up to $750 at residences and $7,500 per charger at businesses

10 Municipal Climate Change Action Centre (2023). Electric Vehicle Charging Programs. Retrieved from: https://mccac.ca/programs/electric-vehicle-charging-program/.

11 CleanBC Go Electric (2023). Passenger Vehicle Rebates. Retrieved from: https://goelectricbc.gov.bc.ca/personal-rebate-offers/passenger-vehicle-rebates/.

12 CleanBC Go Electric (2023). Program guide for CleanBC Electric Charger Program. Retrieved from: https://pluginbc.ca/wp/wp-content/uploads/2023/03/ProgramGuide_GoElectricBC_Public_Charger_20230401v4.pdf.

13 Manitoba Hydro (2023). Home Energy Efficiency Loan. Retrieved from: https://www.hydro.mb.ca/your_home/residential_loan/.

14 New Brunswick Power (2023). Electric Vehicle Rebates. Retrieved from: https://www.nbpower.com/en/products-services/electric-vehicles/plug-in-nb/electric-vehicle-rebates/.

2.2 Provincial and National EV Sales Trends

EV sales in Canada witnessed a remarkable growth of 44% in 2022 compared to the previous year. EV sales accounted for 8% of total vehicle sales in 2022 compared to 5% in 2021 (**Figure 1**). Breaking down the sales figures, BEVs comprised 80% of total EV sales in 2022, experiencing a substantial surge of 68% compared to 2021. On the other hand, PHEVs saw a slight decline of 8.5% in sales during the same period and accounted for 20% of EV sales.

This upward trend in EV sales was evident across all provinces in Canada that reported EV sales data, albeit to varying degrees. Quebec and British Columbia, which have the most generous EV sales and EV charging stations incentives, stood out with significantly higher EV market shares compared to the national average. Quebec achieved a remarkable 12.3% market share, while BC exceeded that at 16.2%. These figures align closely with the global EV market share of 14%[26]. Conversely, other provinces reported lower market shares, such as 6.5% in Ontario, 4% in Prince Edward Island, and approximately 2% in Manitoba, New Brunswick, and Saskatchewan. The three largest provinces of Ontario, Quebec and British Columbia alone accounted for 92% of all EV sales in Canada.

Despite the relatively lower market shares in Ontario, Manitoba, New Brunswick, and Saskatchewan, it is encouraging to note that EV sales are moving in the right direction. These provinces witnessed substantial growth in 2022, building on the significant progress observed in 2021. Specifically, Ontario experienced an impressive 96% increase in EV sales compared to the previous year, while New Brunswick, Manitoba, and Saskatchewan saw growth rates of 82%, 66%, and 47%, respectively.

These increasing trends show the effectiveness of government incentives in encouraging EV uptake as provinces with the most aggressive EV incentives (Quebec and British Columbia) witnessed the largest EV market shares.

15 Newfoundland and Labrador Hydro (2023). Electric Vehicle Rebate Program. Retrieved from: https://nlhydro.com/electric-vehicles/ev-rebate/.

16 Arctic Energy Alliance (2023). Electric Vehicles. Retrieved from: https://aea.nt.ca/program/electric-vehicles/.

17 Government of the Northwest Territories (2022). Electric Vehicle Infrastructure Program. Retrieved from: https://www.inf.gov.nt.ca/en/services/energy/electric-vehicle-infrastructure-program

18 EV Assist Nova Scotia (2023). Electrify Nova Scotia Rebate Program. Retrieved from: https://evassist.ca/rebates/.

19 Efficiency Nova Scotia (2023). Electric vehicle charging station rebates for your apartment or condo building. Retrieved from: https://www.efficiencyns.ca/evcharging/

20 Government of Ontario (2023). Electric Vehicle (EV) ChargeON Program. Retrieved from: https://www.ontario.ca/page/ev-chargeon-program#section-1

21 City of Toronto (2023). Home Energy Loan Program. Retrieved from: https://www.toronto.ca/services-payments/water-environment/environmental-grants-incentives/home-energy-loan-program-help/.

22 Prince Edward Island Environment Energy and Climate Change (2023). Electric Vehicle Incentive. Retrieved from: https://www.princeedwardisland.ca/en/information/environment-energy-and-climate-action/electric-vehicle-incentive.

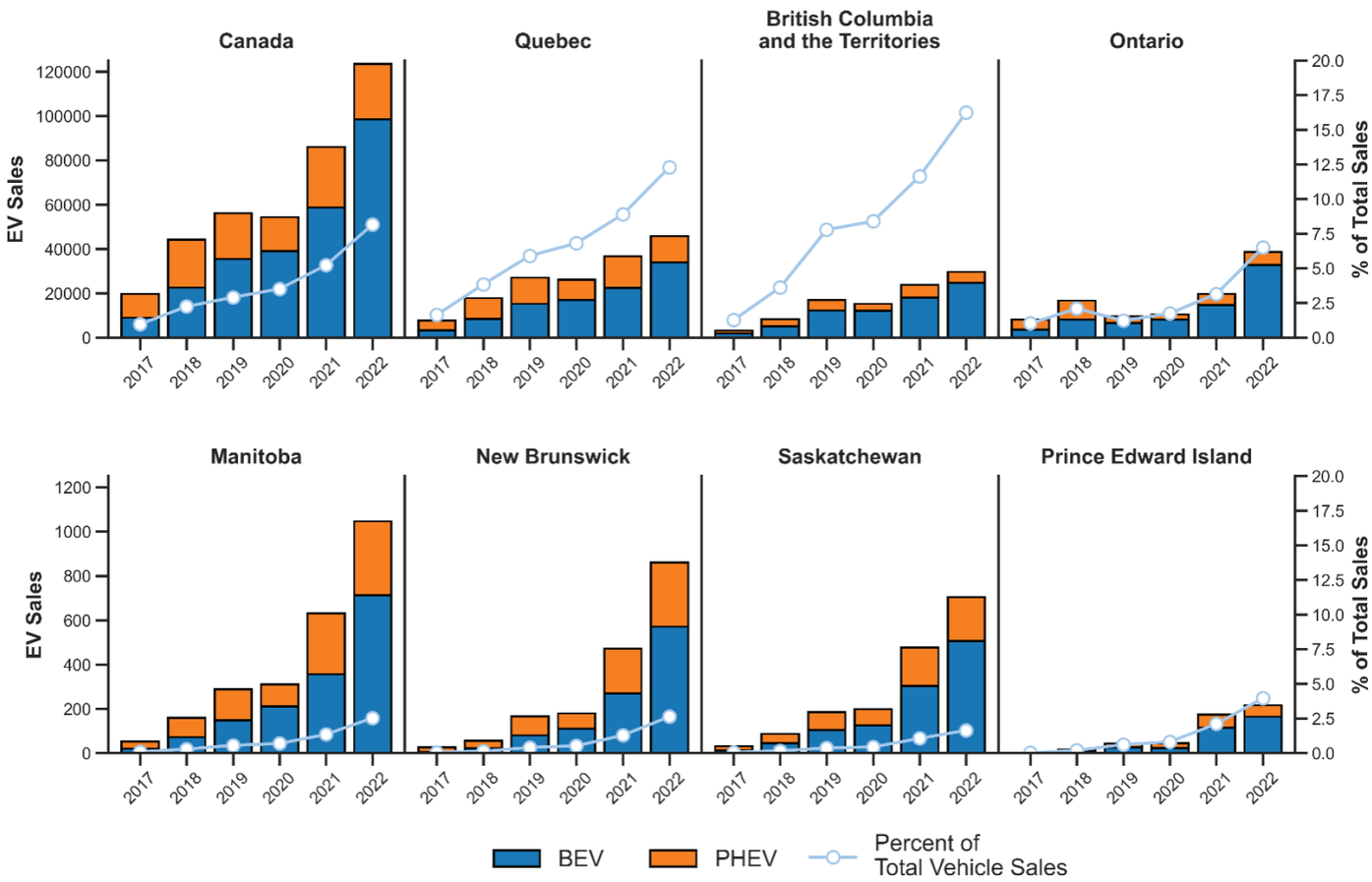
23 Gouvernement du Quebec (2023). Financial Assistance for a New Electric Vehicle. Retrieved from: https://www.quebec.ca/en/transports/electric-transportation/financial-assistance-electric-vehicle/new-vehicle.

24Yukon (2023). Apply for a rebate for a new zero-emission vehicle. Retrieved from: https://yukon.ca/en/driving-and-transportation/apply-rebate-new-zero-emission-vehicle.

25 Yukon (2023). Apply for a rebate for a level 2 electric vehicle charger. Retrieved from: https://yukon.ca/en/driving-and-transportation/clean-energy-rebates/apply-rebate-level-2-electric-vehicle-charger-0

26 International Energy Agency (2023). Global EV Outlook 2023 - Catching up with climate ambitions. Retrieved from: https://www.iea.org/reports/global-ev-outlook-2023.

Figure 1. Yearly EV sales for different provinces. Bars and left axis show EV sales per year, whereas the white dots and the right axis show the percentage of EV sales from the total vehicle sales.
Note: EV sales were not available for the remaining provinces but are accounted for in the total EV sales for Canada.



2.3 Provincial and National EV Public Charging Trends

Charging stations in North America are categorized into three levels: level 1, level 2 and level 3 (also known as DC fast chargers, abbreviated as DCFC). **Table 2** provides an overview of the key features of each type of charging. Due to their low power and lengthy charging times, level 1 charging is inadequate for public charging and is rarely used. There are currently only 136 public charging stations in Canada equipped with level 1 chargers. Consequently, this section primarily focuses on level 2 and level 3 DC charging stations and electric vehicle supply equipment (EVSE) ports. EVSE ports refer to the individual chargers capable of charging one vehicle at a time, while charging stations denote physical locations that can accommodate multiple EVSE ports.

Table 2. Summary of Charging Station Types

	Level 1 AC	Level 2 AC	Level 3 DCFC
EVs supported	All PHEVs and BEVs	All PHEVs and BEVs	Most BEVs and some PHEVS
Requirements	120-volt AC (alternating current) standard electrical outlet	240-volt AC (alternating current) connection	480-volt DC (direct current) connection
Average BEV charging time	8 to 30 hours	4 to 10 hours	25 to 45 minutes (to 80% of full charge)
Power delivered	~1.6 kW	3.3 – 19.2 kW	50 – 450+ kW
Range added per hour (approximate)	5 – 8 km	30 – 40 km	240 – 400+ km
Hardware and installation costs	$1,000 in new building $2,000 during renovation	$1,500 in new building $5,000 during renovation	$50,000 - $120,000
Applications	Long-term parking (home, work, overnight, etc.)	Long- and short-term parking (home, work, retail, etc.)	Long-distance travel (highways) and retail

Source: Adapted from Framework for Municipal Zero Emission Vehicle Deployment[27]

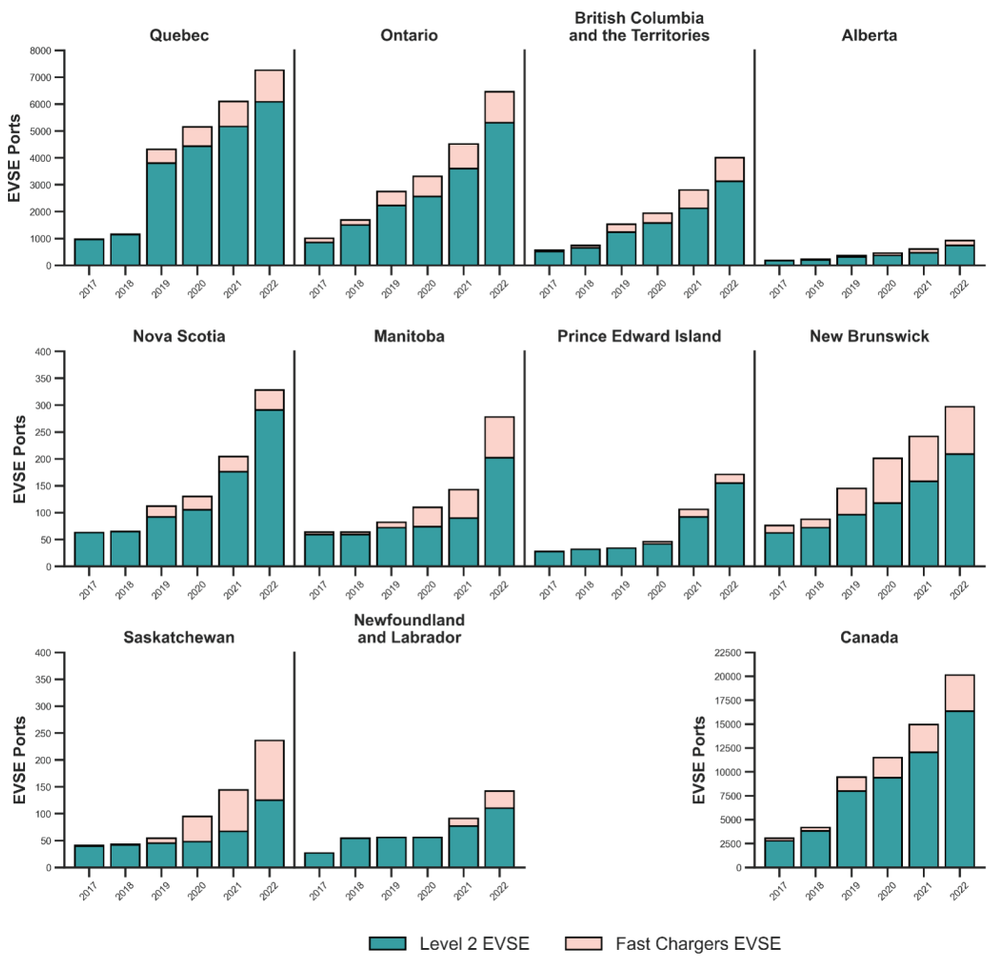
The number of EV charging stations has seen a significant increase in Canada, both at the national level and across all provinces and territories. According to Transport Canada, there were 7,388 public charging locations with level 2 charging as of the end of 2022, up by 37% from the previous year (equivalent to the installation of 1,990 new charging stations). Additionally, there were 1,427 public charging locations with DCFC chargers, representing a 31% increase from the previous year (equivalent to the installation of 341 new charging stations) . In terms of EVSE ports, Canada had a total of 16,363 public level 2 ports at the end of 2022, reflecting a yearly increase of 36% (a total of 4,337 level 2 ports installed in 2022). Similarly, there were 3,752 DCFC ports, demonstrating a 28% yearly increase (a total of 831 DCFC ports installed in 2022) (**Figure 2**)[28].

27 Pollution Probe and The Delphi Group. (2019). Framework for Municipal Zero Emission Vehicle Deployment. Retrieved from: https://www.pollutionprobe.org/wp-content/uploads/Probe-Delphi-Municipal-ZEV-Framework-Report.pdf

28 Transport Canada (2023). Zero-emission vehicle charging stations. Retrieved from: https://tc.canada.ca/en/road-transportation/innovative-technologies/zero-emission-vehicles/zero-emission-vehicle-charging-stations#/find/nearest?country=CA.

Quebec, Ontario, and British Columbia account for a combined 83% and 84% of all level 2 and DCFC EVSE ports installed in 2022. However, when considering trends relative to 2021, Manitoba and Saskatchewan observed the largest increases in level 2 EVSE ports at 124% and 87%, respectively. Conversely, Newfoundland and Labrador experienced the largest relative increase in DCFC EVSE ports at 129% compared to 2021, followed by a 44% increase in both Manitoba and Saskatchewan. Although the outlook for public EV charging stations in Canada appears promising and trending in the right direction, the ratio of EVs on the road to EVSE ports is approximately 20, which is twice as high as the world average of 10[26]. This ratio remained the same compared to 2021[29], indicating a consistent growth in the development of public charging infrastructure in proportion to EV sales[30]. While studies have found that high availability of charging stations does not necessarily lead to higher EV adoption, low availability was found to result in lower EV adoption rates[31].

Figure 2. Total number of level 2 and DCFC EVSE ports in different provinces

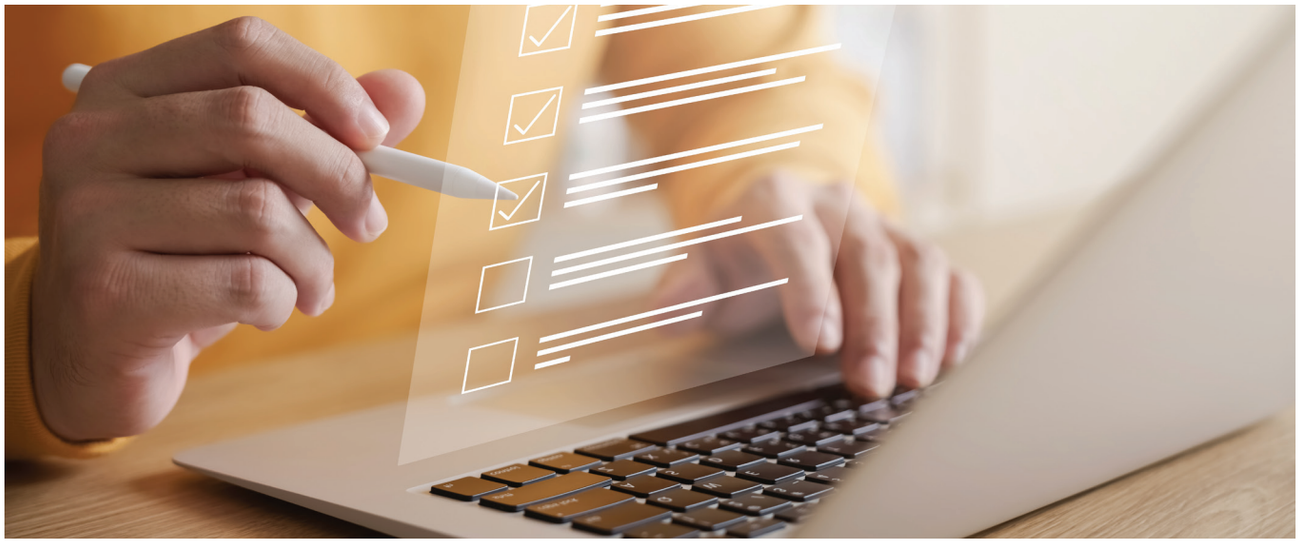


29 International Energy Agency (2022). Global EV Outlook 2022 - Catching up with climate ambitions. Retrieved from: https://www.iea.org/reports/global-ev-outlook-2022.

30 The project team acknowledges that this ratio will vary significantly from country to country based on urban planning policy and land-use, which dictates access to home charging. The importance of the metric in the Canadian context is still being evaluated.

31 Spöttle, M., Jörling, K., Schimmel, M. & Staats, M. (2018). Research for TRAN Committee - Charging infrastructure for electric road vehicles. Retrieved from: https://www.europarl.europa.eu/RegData/etudes/STUD/2018/617470/IPOL_STU(2018)617470_EN.pdf.

3 Survey Respondent Characteristics



3.1 Demographic Characteristics

The online survey was hosted on dedicated webpages in both English and French from March to July 2023. The survey received generous promotion from various stakeholders in the EV ecosystem, including municipalities, vehicle manufacturer associations, non-profit and for-profit organizations, and EV society groups. In particular, the efforts of Electric Mobility Canada and the Canadian Vehicle Manufacturers' Association are appreciated. A total of 1,522 responses were collected from across Canada, with the highest number of responses coming from Ontario, Quebec, and British Columbia, accounting for 40%, 26%, and 17% of the total responses, respectively (**Figure 3**).

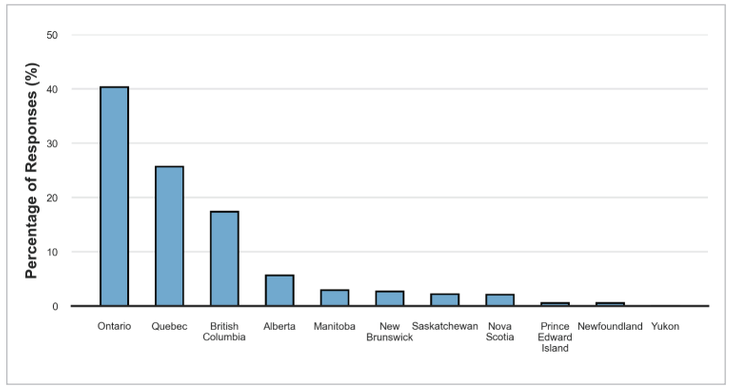


Figure 3. Responses per Province

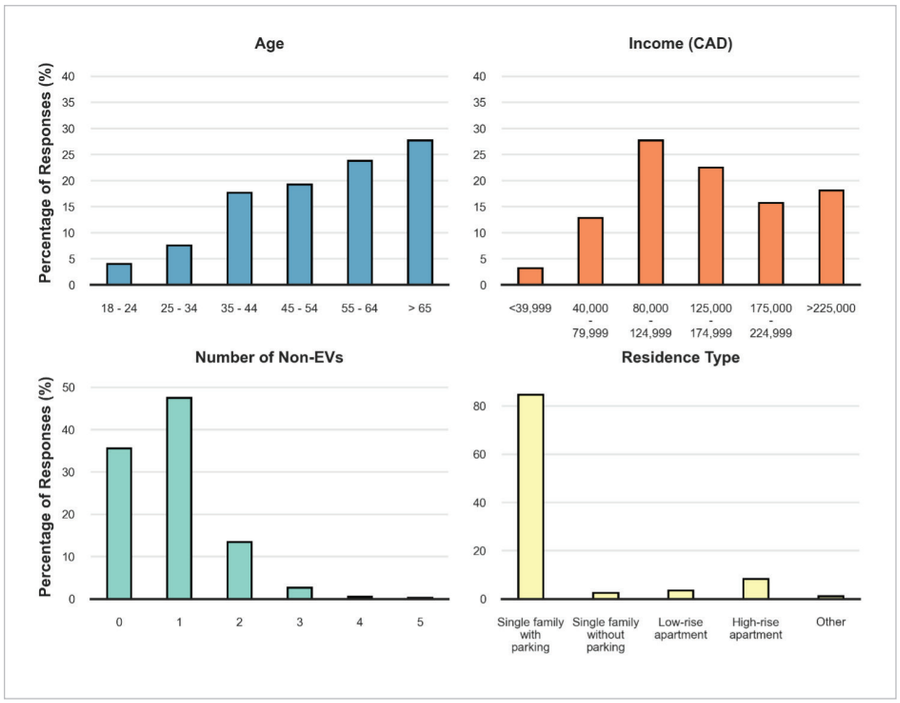
As part of the survey's demographic section, EV owners were asked about their age, income, number of non-EVs owned, residence type, household size, and whether they owned or rented their current residence. These questions aimed to explore potential variations in experiences and concerns with public charging infrastructure across different segments of the population.

About 71% of respondents were above the age of 45, and 56% had a household income of more than $125,000 before tax (**Figure 4**). 29% of households in Canada have an income higher than $125,000 based on the latest census data[32]. These findings are consistent with earlier studies that demonstrate how individuals with higher incomes tend to be early adopters of EVs[33]. Furthermore, the initial higher cost of EVs can create obstacles for lower-income groups, despite the overall cost of ownership over the vehicle's lifetime being favorable for most EV models with access to home charging, particularly in provinces with the lowest electricity rates[34].

64% of respondents owned at least one internal combustion engine vehicle (ICEV) in addition to their EV. Owning a non-EV has previously been associated with reduced EV range anxiety, as the non-EVs are typically used for longer trips[35]. Additionally, 87% of EV owners were found to reside in single-family houses/townhouses with dedicated parking, while only 12% resided in multi-unit residential buildings (MURBs)[36]. This is noteworthy considering that approximately 34% of all Canadians live in MURBs[37].

These demographic results align with findings reported elsewhere[38,39] and emphasize the need to consider diverse segments of the population when evaluating experiences and concerns related to public charging infrastructure.

Figure 4. Demographic characteristics of survey respondents



32 Statistics Canada (2023). Table 98-10-0055-01 Household total income group by household characteristics: Canada, provinces and territories, census metropolitan areas and census agglomerations with parts. Retrieved from: https://doi.org/10.25318/9810005501-eng.

33 Plug'N Drive (2017). Driving EV Uptake in the Greater Toronto and Hamilton Area. Retrieved from: https://www.plugndrive.ca/wp-content/uploads/2017/07/EV-Survey-Report.pdf.

34 Clean Energy Canada (2022). The true cost. Retrieved from: https://cleanenergycanada.org/wp-content/uploads/2022/03/Report_TheTrueCost.pdf.

35 Liao, F., Molin, E. & van Wee, B. (2017). Consumer preferences for electric vehicles: a literature review. Transp Rev 37, 252–275.

36 MURBs are defined in the survey as residents of condominiums/strata, and rental apartments in low-rise and high-rise buildings.

37 Statistics Canada (2021). Table 98-10-0040-01 Structural type of dwelling and household size: Canada, provinces and territories, census metropolitan areas and census agglomerations with parts. Retrieved from: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=9810004001.

38 Haugneland, P. & Kvisle, H. H. (2015) Norwegian electric car user experiences. International Journal of Automotive Technology and Management 15, 194–221.

39 Visaria, A. A., Jensen, A. F., Thorhauge, M. & Mabit, S. E. (2022). User preferences for EV charging, pricing schemes, and charging infrastructure. Transp Res Part A Policy Pract 165, 120–143.

3.2 EV Characteristics and Driving Behavior

The satisfaction of EV owners with public charging infrastructure depends on the characteristics of their EVs and their driving patterns. For instance, owners of EVs with shorter ranges who have long daily commutes might rely heavily on public charging stations, while those with longer EV ranges and shorter daily commutes may have less interaction with public charging infrastructure. In this context, survey respondents were asked about their EV type, EV range, length of daily commutes, and frequency of long trips (over 200 km one way) using their EVs.

Among the survey respondents, 92% identified as BEV users, while the remaining 8% owned PHEVs[40]. **Figure 5** presents information on the length of time survey respondents have owned their EVs, the range of their EVs, the average daily distance traveled using EVs, and the frequency of long-distance trips with their EVs. The results provide insights into the evolving landscape of EV adoption and usage patterns within the Canadian market.

25% of respondents have been EV owners for more than 5 years, classifying them as early adopters. Conversely, 46% of respondents have owned an EV for less than 3 years, representing the recent growth of the Canadian EV sector.

Vehicle range plays a significant role in shaping charging behavior and consumer perceptions regarding public charging infrastructure. The survey revealed that 80% of respondents owned an EV with a range of at least 300km. Additionally, 67% of respondents reported driving an average of less than 60km per day, while only 10% traveled more than 100km on average. These findings suggest that the vast majority of EV owners can comfortably complete their daily commutes with a single full charge.

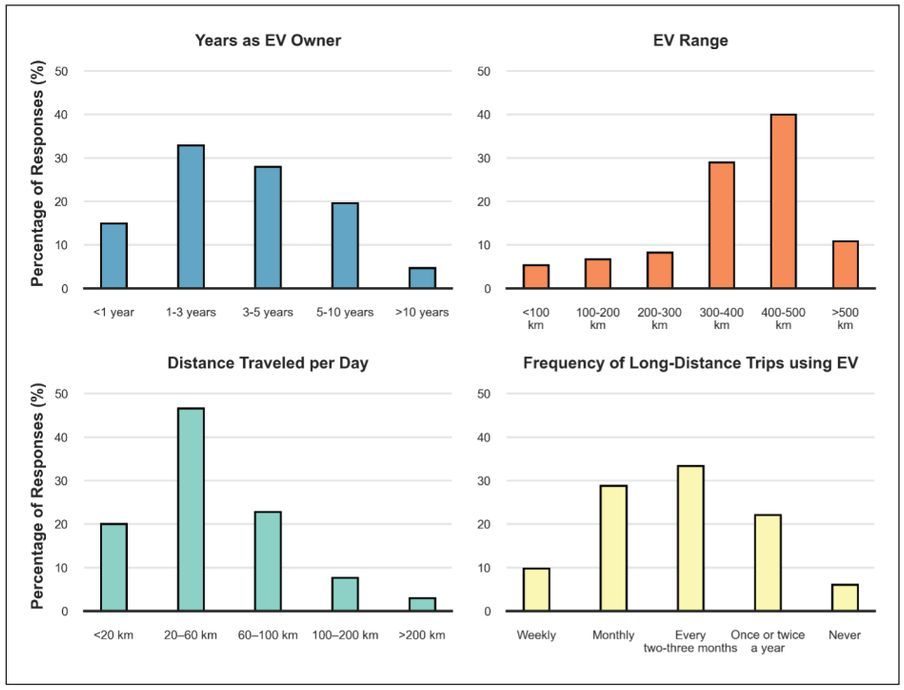


Figure 5. Demographic characteristics of survey respondents

In addition, 38% of respondents reported undertaking long-distance trips of over 200km one way at least once per month using their EVs. Such journeys typically necessitate the use of public charging infrastructure. In contrast, only 6% of respondents stated that they never use their EVs for long-distance trips.

These findings underscore the diverse driving patterns among EV owners in Canada. The high percentage of EVs with ample range indicates that most owners can confidently rely on a single full charge for their daily travel needs. However, even though long-distance trips represent a smaller portion of total travel, the availability of charging for these occasional trips has been previously found to play a substantial role in driving EV adoption rates[41].

40 BEVs are powered by a battery pack and rely entirely on access to a charging station or an electricity outlet to be recharged. PHEVs have smaller battery packs that are coupled with an internal combustion engine (ICE) that is activated whenever the battery is depleted.

41 Haustein, S., Jensen, A. F. & Cherchi, E. (2021). Battery electric vehicle adoption in Denmark and Sweden: Recent changes, related factors and policy implications. Energy Policy 149, 112096.

3.3 EV Charging Behavior

Charging of EVs typically takes place at four main locations: (1) at-home (typically overnight), (2) at the workplace, (3) at other publicly available locations and (4) on travel corridors for long-distance trips[42]. While charging at home is the most common and convenient charging location, this option is not available at all residences, especially in MURBs where parking spaces are limited. This pushes these portions of the population to rely on other locations to charge.

The charging locations and patterns of EV owners were explored by asking them about their access to home charging, the type of available home charger, their access to workplace charging, their frequency of use of public charging and public fast charging and the charging compatibility of their EVs.

Figure 6 shows the access to home charging for different residence types. Almost all EV owners residing in single family homes with dedicated parking had access to home charging (98%), whereas 26%, 42% and 35% of respondents residing in single family homes without dedicated parking, low-rise apartments and high-rise apartments did not have access to charging at home, which makes them more reliant on public charging infrastructure. Out of all the EV owners that have access to home charging, 85% had a level 2 charger, whereas 15% relied on level 1 charging. Additionally, out of the EV owners that commuted to work, 43% had access to a workplace charger.

Survey results indicate that 96% of EV owners do use public charging stations to some extent, although 55% of them rely on public stations for a small portion of their charging needs (less than 10%) (**Figure 7**). Similar patterns were observed for public fast charging, with approximately 11% of respondents never using fast public chargers and 53% relying on them for less than 10% of their charging needs.

Figure 6. Access to home charging per residence type

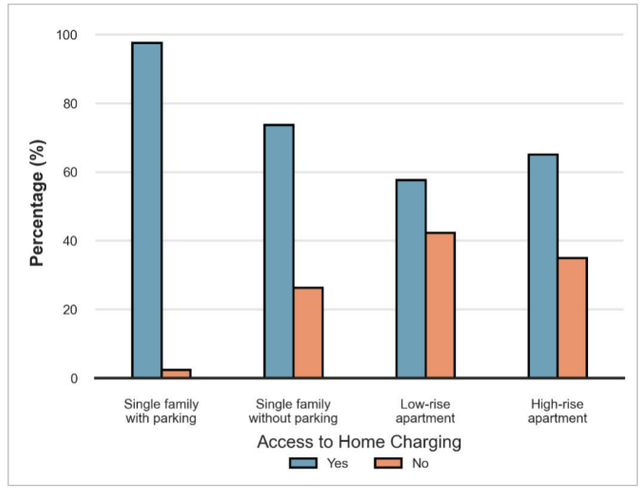
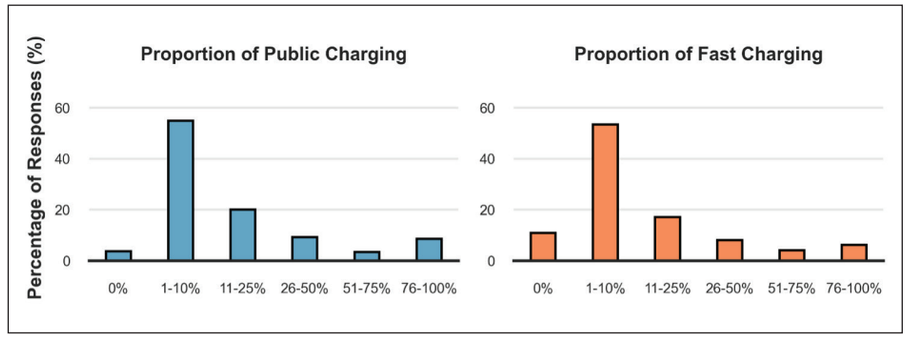


Figure 7. EV charging behavior



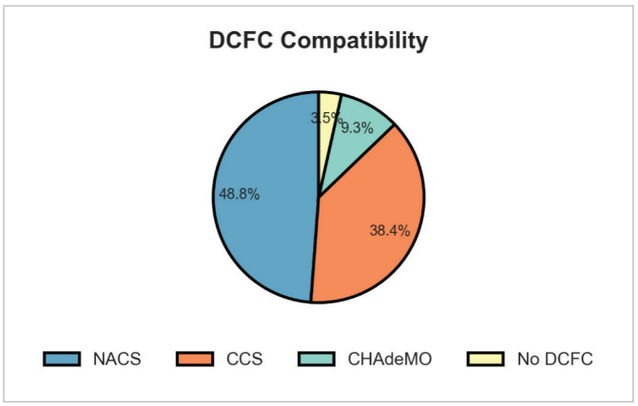
Not all types of EVs are compatible with public DC fast charging stations. There are currently three types of DCFC connectors – Combo Charging System (CCS), CHAdeMO, and North American Charging Standard (NACS) (previously known as Tesla Supercharger). Up until early 2023, the CCS plug was the most popular plug equipped on vehicles by European and North American vehicle manufacturers, while the CHAdeMO was the favoured option for Japanese and Korean manufacturers. However, the NACS network, which used to be exclusive to Tesla vehicles, has been opened for use to other manufacturers in 2023 and is gaining unprecedented support in North America.

42 Hardman, S. et al. (2018). A review of consumer preferences of and interactions with electric vehicle charging infrastructure. Transp Res D Transp Environ 62, 508–523.

Major automotive manufacturers including Ford, General Motors, Mercedes-Benz, Volvo, and others have recently made commitments to adopt the NACS plug in newer EV models and will gain access to the existing Tesla NACS public charging network. NACS equipped vehicles will still be able to access CCS stations with an adapter, taking advantage of existing CCS charging infrastructure that is not retrofitted[43].

The availability of different connector types adds complexity to the EV charging experience and can make charging stations less accessible. However, the recent convergence of multiple EV manufacturers towards the NACS may help alleviate this issue. The survey results indicated that 48.8% of respondents had EVs that were compatible with NACS (all consisting of Tesla vehicles when the 2023 survey was conducted), while 38.4% and 9.3% had EVs that were compatible with CCS and CHAdeMO respectively (**Figure 8**).

Figure 8. DCFC Compatibility



43 Yakub, M. (2023). Seven major automakers in joint venture to launch 30,000-charger network across North America. Retrieved from: https://electricautonomy.ca/2023/07/28/seven-automakers-30000-chargers-north-america/.

4 Network Coverage Satisfaction

Figure 9 presents the Likert scale responses to statements related to charging infrastructure coverage broken down by province. British Columbia, Quebec and Ontario were considered separately, whereas the remaining provinces were clustered together due to their lower EV uptake and less mature public charging infrastructure network.

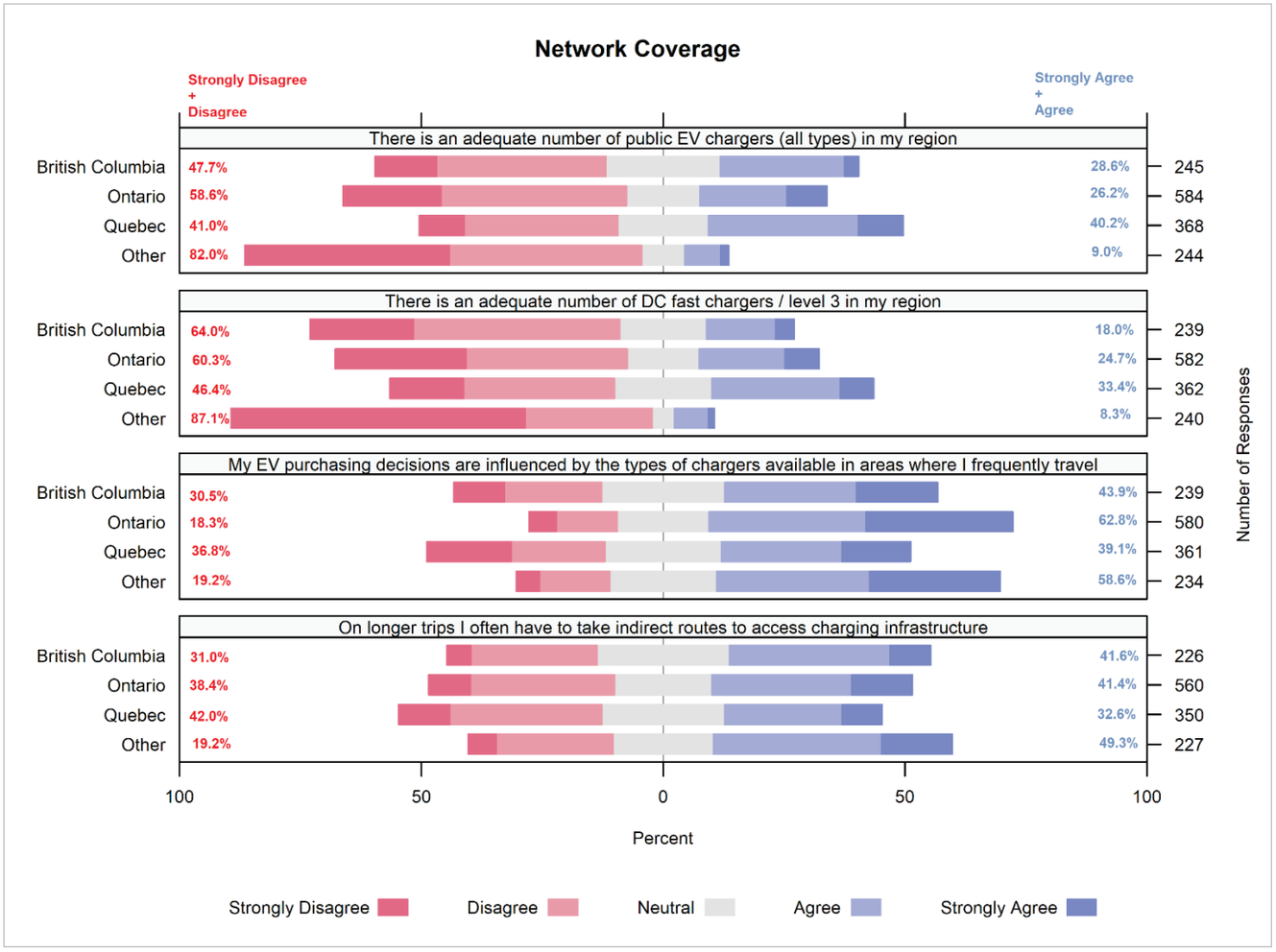
EV owners across all provinces were generally dissatisfied with the number of public charging stations and fast charging stations. EV owners in Quebec were slightly more satisfied with the coverage of public charging stations compared to the other provinces as 40% and 33% felt that the number of public charging stations and fast charging stations was adequate, compared to around 20% for both Ontario and British Columbia. EV owner satisfaction in the remaining provinces was worse as only 9% felt that there was an adequate number of public charging stations and fast charging stations. Furthermore, 53% of EV owners across all provinces stated that the availability of public chargers in areas they frequently travel influenced their decision to purchase an EV. This influence was more pronounced in Ontario (63%) and the other provinces (59%) compared to British Columbia (44%) and Quebec (39%).

Regarding coverage on long distance trips, 40% of EV owners across Canada indicated the need to often take indirect routes to access charging infrastructure, while 37% indicated the opposite. Quebec had the highest level of satisfaction compared to other provinces, with only 33% of respondents expressing dissatisfaction with coverage on long distance trips.

EV owners generally express dissatisfaction with the number of public charging stations in their respective regions. However, they demonstrate slightly higher satisfaction with the availability of charging infrastructure along longer routes, suggesting improved accessibility of charging stations along highway corridors compared to population clusters. Overall, public charging infrastructure coverage will benefit from recent significant investment commitments from automakers to expand the North American charging network[44].

44 Yakub, M. (2023). Seven major automakers in joint venture to launch 30,000-charger network across North America. Retrieved from: https://electricautonomy.ca/2023/07/28/seven-automakers-30000-chargers-north-america/.

Figure 9. Network coverage satisfaction Likert plot. Percentages on the left refer to the proportion of disagree and strongly disagree responses whereas percentages on the right refer to the proportions of agree and strongly agree responses.

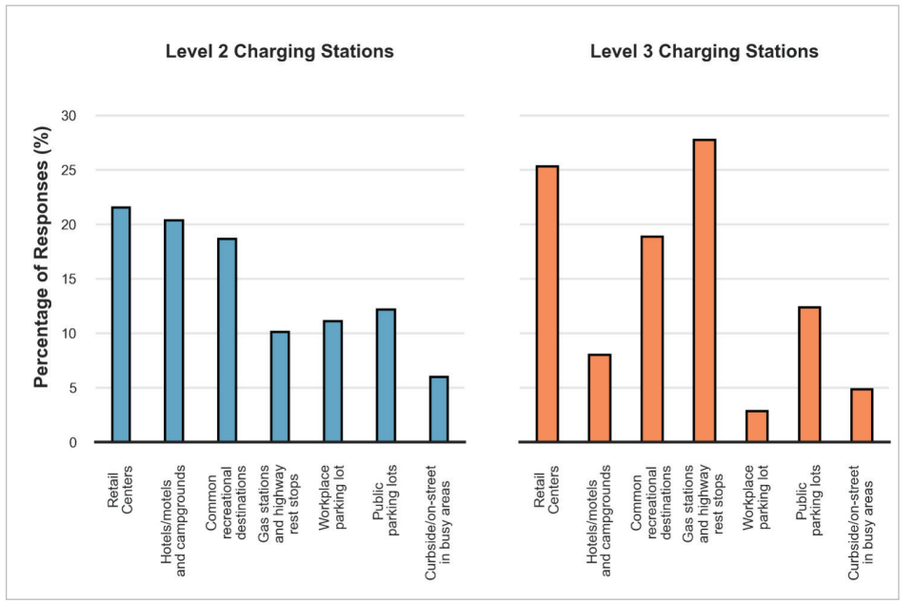


Network coverage satisfaction responses were contrasted between EV owners based on their access to home charging, income level, residence type, and Tesla vs non-Tesla EV ownership. Among the trends observed, the decision of lower-income EV owners to purchase an EV was significantly less influenced by charger availability compared to higher-income EV owners (47% for low-income vs 62% for high-income). Additionally, 33% of Tesla owners reported having to take indirect routes to access charging infrastructure on long trips, compared to 47% for owners of other EVs, justifying the recent announcements of major automakers to adopt the NACS plug and gain access to the Tesla charging network.

A recent study estimated that by 2030, Canada will require around 4,000 DCFC chargers and 50,000 level 2 chargers[45]. While the number of public charging stations has significantly increased in recent years with the support of federal government funding[46], strategic placement of these charging stations is crucial to maximize their utility and improve satisfaction among EV owners.

The majority of survey respondents identified retail centers (22%), hotels/motels and campgrounds (20%), and common recreational destinations (19%) as their preferred locations for level 2 chargers. These are locations where EV owners typically park for extended periods. On the other hand, gas stations and highway rest stops (28%) were identified as preferred locations for level 3 DC fast charging, in addition to retail centers (25%) and common recreational destinations (19%) (**Figure 10**).

Figure 10. Preferred locations of level 2 and level 3 charging stations



45 Dunsky (2022). Canada's Public Charging Infrastructure Needs. Retrieved from: https://natural-resources.canada.ca/sites/nrcan/files/energy/cpcin/2022-ev-charging-assesment-report-eng.pdf.

46 Natural Resources Canada (2023). Zero Emission Vehicle Infrastructure Program. Retrieved from: https://natural-resources.canada.ca/energy-efficiency/transportation-alternative-fuels/zero-emission-vehicle-infrastructure-program/21876.

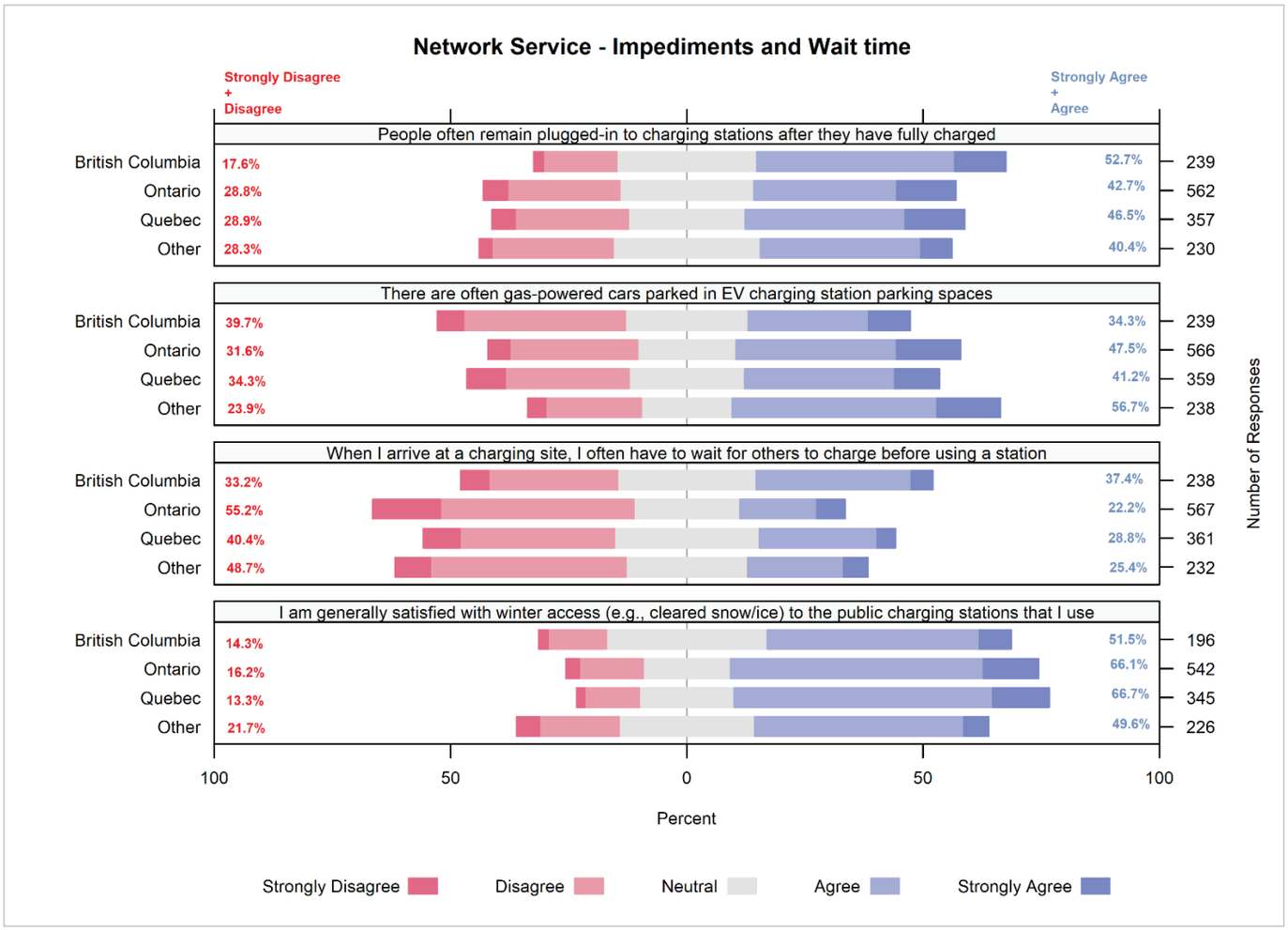
5 Network Service Satisfaction

Network service satisfaction refers to the level of approval experienced by users of public charging stations with the services provided. It was broken down into four categories, namely (1) impediments and wait times, (2) reliability, (3) user friendliness and (4) disability accessibility.

5.1 Impediments and wait times

Figure 11 illustrates the Likert scale responses to statements related to impediments and wait times broken down by province. Overall, 45% of EV owners across all provinces reported instances of people remaining plugged in to charging stations after they have fully charged. Remaining plugged in is an issue because other EV owners won't find an available charging port to charge. This behavior was the most prevalent in British Columbia, with 53% of respondents agreeing with the statement. Additionally, 45% of EV owners felt that gas-powered cars often occupy parking spaces designated for EV charging stations. This issue was more pronounced in the remaining provinces, with 57% of respondents agreeing with the statement. EV owners across Canada were mostly satisfied with the wait times at charging stations (27% dissatisfied) and winter access (16% dissatisfied). However, wait time satisfaction varied significantly between Tesla owners and non-Tesla owners as only 16% of Tesla owners were dissatisfied with the wait times to access a station compared to 37% for non-Tesla owners.

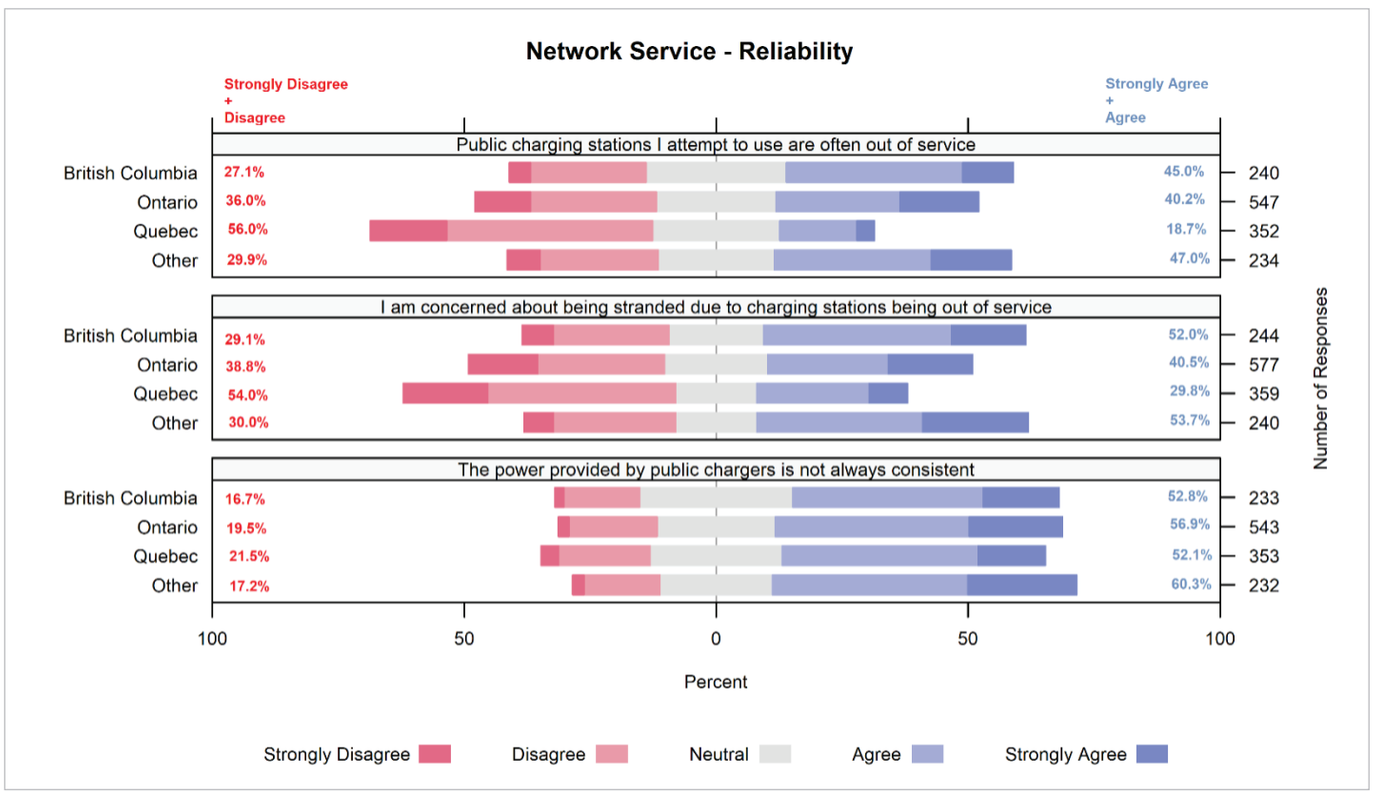
Figure 11. Network service – Impediments and wait time Likert chart. Percentages on the left refer to the proportion of disagree and strongly disagree responses whereas percentages on the right refer to the proportions of agree and strongly agree responses.



5.2 Reliability

Figure 12 presents the Likert scale responses to statements related to charging infrastructure reliability broken down by province. EV owners in Quebec were generally more satisfied with the reliability of public charging infrastructure, as only 19% complained about stations being out of service and 30% were concerned about being stranded due to stations being out of service, compared to 44% and 48%, respectively, in the remaining provinces. In other words, charging stations in Quebec are perceived to be more reliable than in other provinces. Similarly, Tesla owners were less concerned about charging stations being out of service (30%) compared to owners of other EVs (53%). Lastly, 56% of EV owners across all of Canada felt that the power supply at public charging stations was not consistent.

Figure 12. Network service – Reliability Likert chart. Percentages on the left refer to the proportion of disagree and strongly disagree responses whereas percentages on the right refer to the proportions of agree and strongly agree responses.

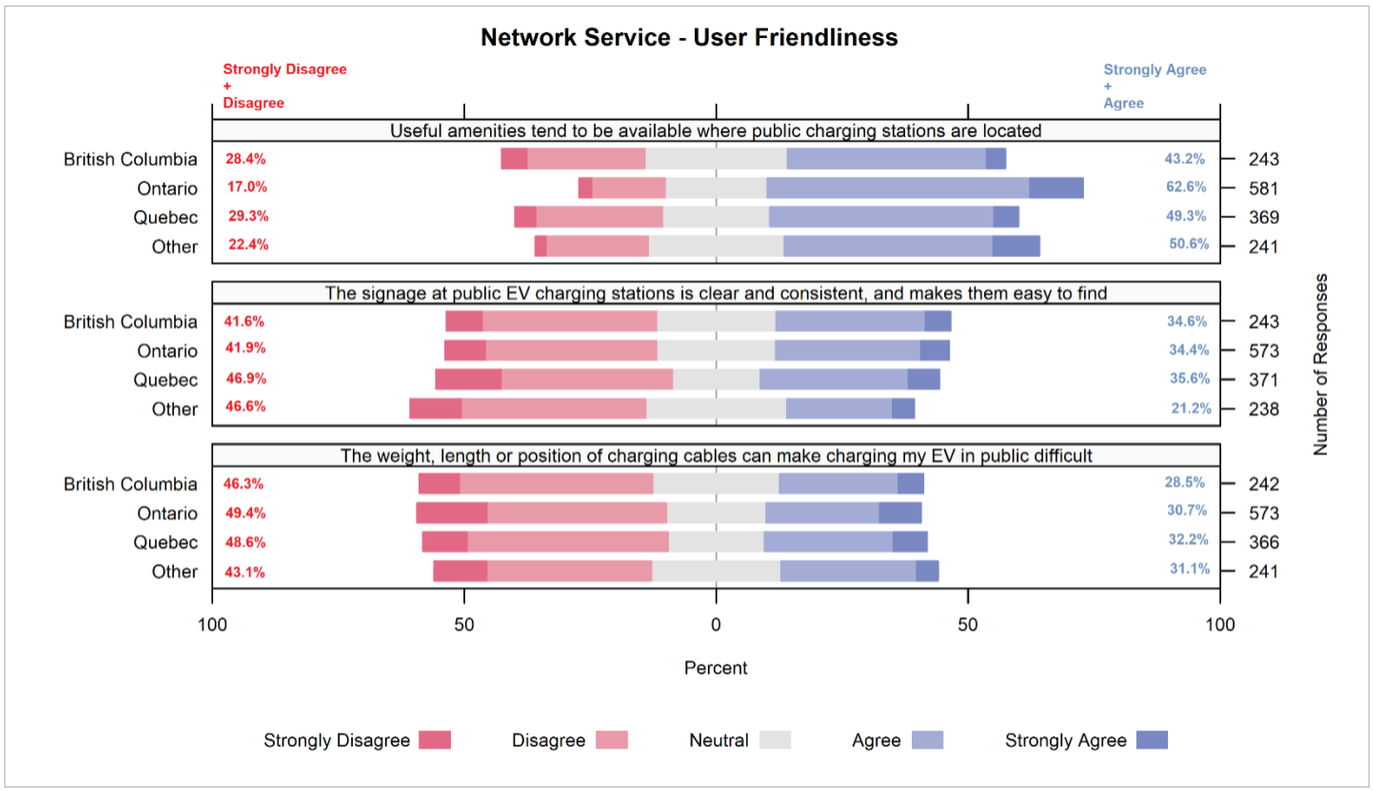


5.3 User friendliness

Figure 13 presents the Likert scale responses to statements related to charging infrastructure user friendliness broken down by province. Around 63% of respondents in Ontario felt that public charging stations were located near useful amenities, compared to around 47% in other provinces. Additionally, 44% of respondents across Canada felt that the signage of public EV charging stations was not clear and 31% experienced difficulties charging due to the length, weight and position of charging cables. These trends were consistent across provinces.

Additionally, around 73% of respondents never felt unsafe while charging in public. However, respondents that did express safety concerns indicate remote isolated locations (16%) and poor lighting at night (14%) as the main reasons for feeling unsafe.

Figure 13. Network service - User Friendliness Likert chart. Percentages on the left refer to the proportion of disagree and strongly disagree responses whereas percentages on the right refer to the proportions of agree and strongly agree responses.

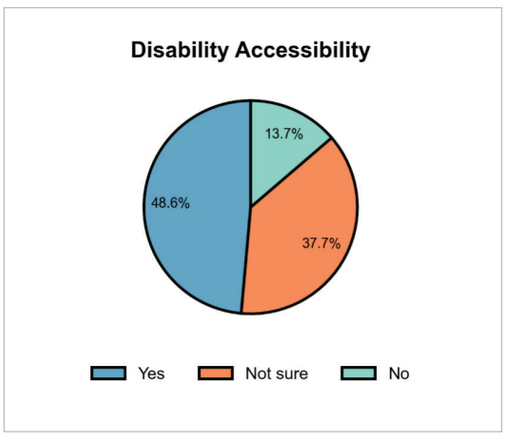


5.4 Disability accessibility

Addressing the accessibility needs of individuals with disabilities at EV charging stations is of utmost importance, necessitating a design approach that takes their specific requirements into account. Unlike gas stations, where attendants can be available to offer assistance with refueling, EV charging stations are typically unattended.

EV owners were asked about their perceptions of the accessibility of public EV charging stations for individuals with disabilities. The survey results revealed that approximately 14% of respondents felt that public EV charging stations were not accessible to individuals with disabilities whereas around 38% were unsure (**Figure 14**). However, it is important to note that we did not have any information on whether respondents had disabilities or not.

Figure 14. Disability Accessibility



In addition to the survey question, interviews were conducted with 7 EV owners across 5 provinces who expressed a desire to further discuss this topic. It is important to note that none of the interviewees had a disability themselves. The following key points were expressed:

- Spacing at public charging stations is typically sufficient for individuals with disabilities, provided that all charging ports are not in use, allowing for ample space between vehicles. However, certain locations may encounter obstruction issues caused by poorly placed bollards.

- In certain locations, charging stations are situated at the outskirts of parking lots, posing a considerable distance to access amenities. This can impact safety and accessibility for individuals with disabilities while waiting for charging. Additionally, the limited number of covered areas for charging stations presents an additional accessibility barrier for individuals with disabilities, especially during winter.

- Level 2 charging station cables are user-friendly and do not present accessibility barriers for individuals with disabilities. However, accessibility at DCFC stations varies depending on the plug type. CCS and CHAdeMO cables are heavy and challenging to handle, especially in winter conditions. In contrast, the NACS (formerly Tesla plug) is lighter and more user-friendly.

- Charging station screens that are used by EV owners to interact with the station are typically positioned at a height suitable for standing individuals, with some variations depending on the charging network. While certain networks enable users to manage the entire charging session through their smartphone app, other stations require users to interact with the screen directly.

In Canada, there is currently a lack of established accessibility standards in the context of individuals with disabilities for the installation of public EV charging stations[47]. The U.S access board accessibility guidelines mainly include the following considerations[48]:

1. Adequate Spacing and Unobstructed Surfaces:
- Ensure sufficient spacing between the parking space and charging port, with flat and unobstructed surfaces, allowing easy maneuvering.

2. Long and Lightweight Charging Cables:
- Provide charging cables that are long enough and lightweight, accommodating various parking orientations and locations of the EV charging inlet.

3. Access Ramps for Curbside Charging Stations:
- Install access ramps where charging stations are located on curbs to facilitate smooth wheelchair access.

4. Optimal Height for All Operable Parts:
- Ensure that all components of the charging station are positioned at an appropriate height, reachable by individuals with disabilities.

5. Strategic Placement of Accessible Charging Locations:
- Locate accessible public charging stations near entrances of amenities or other high-traffic areas, enhancing convenience and ease.

Additional research is required to determine the degree to which EV charging accessibility concerns may be hindering EV adoption among individuals with disabilities, the degree to which Canada's current EV network is accessible to individuals with disabilities and how improvements can be made. This additional research should be focused on accessibility issues and should seek input from a broad swathe of Canadians with disabilities – both EV owners and non-EV owners.

47 In 2022, B.C. Hydro announced it was working to ensure accessibility for its new and existing public fast chargers, noting this would "improve inclusiveness and safety at every location within the provincial network". Source: B.C. Hydro (2022), Improving accessibility at all BC Hydro EV fast charging network sites. Retrieved from: https://www.bchydro.com/news/press_centre/news_releases/2022/ev-accessibility.html

48 US Access Board (2023). Design Recommendations for Accessible Electric Vehicle Charging Stations. Retrieved from: https://www.access-board.gov/files/usab-evse-guide.pdf.

6 Costs and Payment Methods

6.1 Payment Methods

EV owners typically need to be a member of a charging network (or a partner network in the case of roaming agreements) to be able to access and pay for its charging stations. The decentralized state of the Canadian charging ecosystem often requires consumers to register with multiple networks to gain access to adequate public charging infrastructure. In fact, 76% of survey respondents indicate being a member of at least two networks. Furthermore, 37% of survey respondents are not aware of any roaming agreements between network operators, with EV owners in Quebec being more informed about agreements (48%) than other provinces (36%) (**Figure 15**).

Multiple European countries have passed legislation to guarantee payment interoperability for EV consumers. In Norway, the Norwegian EV Association introduced RFID cards that allow members to simultaneously register with all of the major charging providers and use their networks. Similar initiatives are being gradually implemented through agreements between major charging infrastructure providers and automakers (NACS adoption) in the Canadian context, and at the provincial level in British Columbia[49] and Quebec[50]. 48% of respondents indicate that they agree or strongly agree that the payment options for EV charging stations are adequate and convenient while 30% indicate the opposite. EV owners in Quebec are also more satisfied with the payment options (62%) than in other provinces (41%).

49 PluginBC (2022). Charging Card and Apps. Retrieved from: https://pluginbc.ca/charging/charging-cards-and-apps/

50 CAA Quebec (2022). Public electric charging stations. Retrieved from: https://www.caaquebec.com/en/on-the-road/public-interest/sustainable-mobility/public-electric-vehicle-charging-stations/

Figure 15. Payment Methods Likert Chart. Percentages on the left refer to the proportion of disagree and strongly disagree responses whereas percentages on the right refer to the proportions of agree and strongly agree responses.

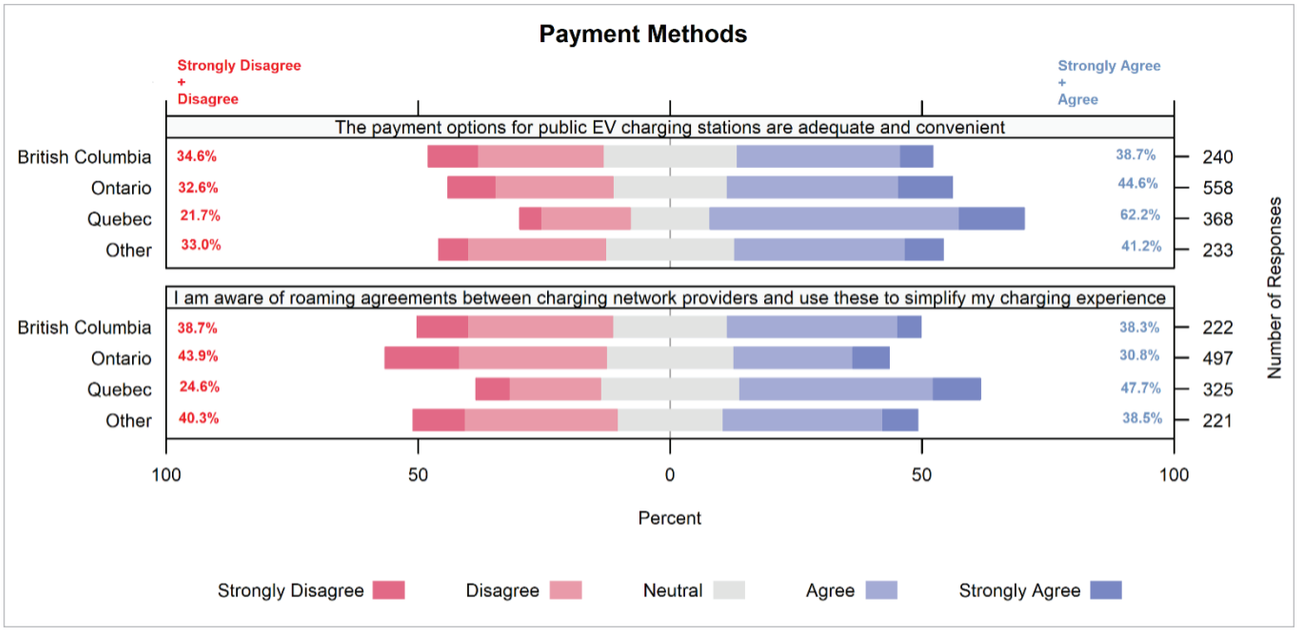
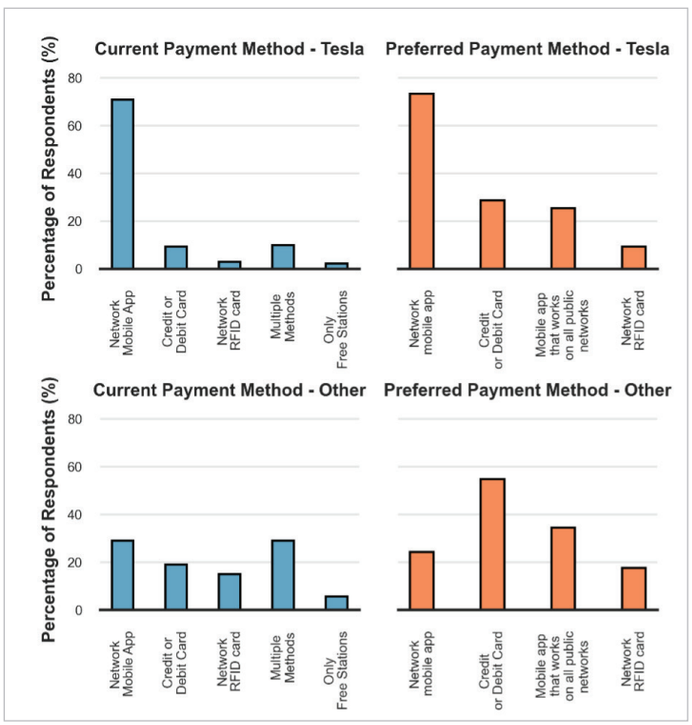


Figure 16 presents the current payment method of survey respondents and their preferred payment method. Respondents were allowed to select multiple options for their preferred payment option. Large differences were observed between Tesla and non-Tesla owners.

Figure 16. Current and Preferred Payment Methods for Tesla and non-Tesla owners



51 Yakub, M. (2023). Seven major automakers in joint venture to launch 30,000-charger network across North America. Retrieved from: https://electricautonomy.ca/2023/07/28/seven-automakers-30000-chargers-north-america/.

The Tesla 'plug and charge' payment method was included as part of the 'Network Mobile App' payment option in the survey. 71% of Tesla owners currently pay through the 'plug and charge' payment method that is specific to the Tesla public charging network. The Tesla 'plug and charge' payment method allows users to have a seamless charging experience without needing to use an app on their smartphone or any physical card. The charging station automatically identifies the vehicle and bills the EV owner on their credit card through their Tesla profile. The Tesla owner has the option of verifying the charging session on their smartphone app. On the other hand, current payment methods were more distributed for non-Tesla owners, with 29% paying through network mobile apps (i.e using their smartphone), 29% through multiple methods, 15% using network RFID cards and 19% using physical credit/debit cards.

When given the option to select their preferred method of payment, 73% of Tesla owners indicate preferring to pay for charging with a network mobile app (i.e plug and charge payment system) compared to only 24% for non-Tesla owners (i.e using their smartphone). These findings indicate that Tesla owners are very satisfied with the 'plug and charge' model offered to them, and the switch of most automakers to the NACS plug, which will allow other automakers to access 'plug and charge' billing, should be a positive to the charging payment experience in the industry.[51]

The preferred method of payment for non-Tesla owners was using credit/debit cards (55% of respondents) compared to only 29% for Tesla owners. These findings suggest that non-Tesla owners, who currently rely on smartphones or RFID cards for charging, are interested in having physical debit/credit card payment options similar to those available for gas refueling. To assess the persistence of these preferences, future surveys should investigate the payment charging experience once other automakers adopt the NACS plug and implement the 'plug and charge' payment system.

6.2 Charging Costs

Another concern related to charging is its costs. Lower operating and refueling costs are a major driver behind consumers' transition to EVs[52], particularly in provinces that have favorable electricity costs[53]. 48% of EV owners agreed that the cost of charging EVs at public charging stations is reasonable based on the electricity consumed and the time required to charge, whereas 28% disagreed with the statement. Satisfaction with charging cost was also slightly more pronounced in Quebec (61%) and British Columbia (50%) compared to the other provinces (40%). This finding is expected given that Quebec and British Columbia have the 1st and 3rd lowest electricity rates respectively in Canada[54].

52 Geotab Energy. (2020). EV driver insights: Understanding the experiences powering electric vehicle driver behaviour. Retrieved from: https://image.info.fleetcarma.com/lib/fe321171716404797c1674/m/1/14dc7fa3-567c-4b0b-85d9-a10e94a6b8fa.pdf

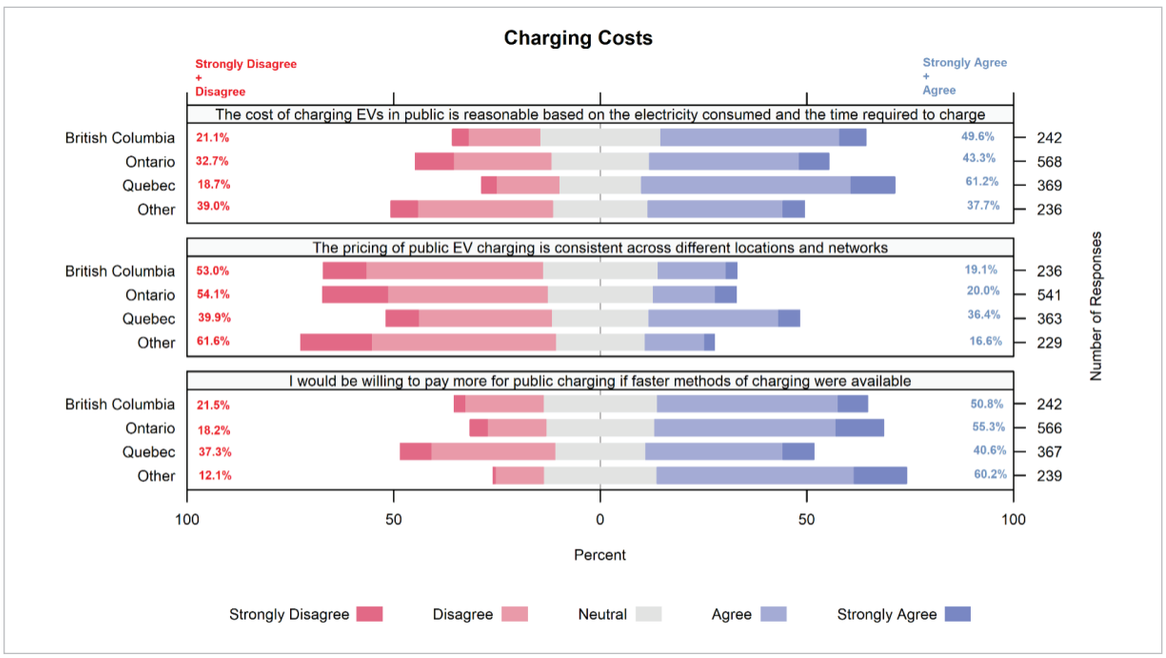
53 CAA Quebec (2022). 5 frequently asked questions about electric cars. Retrieved from: https://www.caaquebec.com/en/on-the-road/advice/tips-and-tricks/tip-and-trick/show/sujet/5-frequently-asked-questions-about-electric-cars/

54 Energy Hub (2023). Electricity Prices in Canada 2023. Retrieved from: https://www.energyhub.org/electricity-prices/

Nevertheless, a considerable proportion (51%) of EV owners have voiced their concerns regarding the inconsistency in public EV charging pricing across different locations. In Quebec, the dissatisfaction with pricing consistency across locations was relatively lower, with 40% of EV owners expressing concerns, as opposed to other provinces where the figure stood at 56%. A number of EV owners provided additional comments expressing a preference to be billed based per unit of energy in kilowatt-hours (kWh) instead of per unit of time, which is the prevailing practice in Canada. Responding to these concerns, charging station providers nationwide are gradually obtaining licenses to implement a kWh energy-based billing system following the recent approval of this billing approach by Innovation, Science, and Economic Development Canada (ISED).[55]

Lastly, more than half of respondents indicate they would be willing to pay more to charge if faster methods of charging were available. Provincial differences can be observed on willingness to pay for faster charging with EV owners in Quebec less willing to pay more for faster charging (41%) than in other provinces (55%). It is worth noting that this finding did not significantly differ by income level, as EV owners that have an income lower than $80,000 were less willing to pay more for faster charging (46%) compared to EV owners that have an income higher than $175,000 (54%). Demand management approaches such as time-of-use pricing and smart charging can play roles in further reducing charging costs for consumers. A clear majority of respondents indicated a willingness to participate in time-of-use pricing, smart charging or vehicle-to-grid (V2G) charging programs that would offer them cost saving, with favourable response rates of 60%, 79% and 70%, respectively. The trends were consistent across all provinces, except for Quebec, where EV owners were less interested in TOU pricing (47%) compared to the remaining provinces (63%).

Figure 17. Charging Costs Likert chart. Percentages on the left refer to the proportion of disagree and strongly disagree responses whereas percentages on the right refer to the proportions of agree and strongly agree responses.



55 Innovation, Science, and Economic Development Canada (2022). Electric vehicle charging stations. Retrieved from: https://ised-isde.canada.ca/site/measurement-canada/en/buying-and-selling-measured-goods/electric-vehicle-charging-stations

Recommendations

1. Public Charging Infrastructure Deployment:

- Strategically locate level 2 charging stations at retail centers, hotels/motels, and recreational destinations, particularly in locations where EV owners tend to park for over 3 hours.
- Deploy level 3 DCFC charging stations along highways and gas stations to facilitate long-distance travel.
- Deploy level 3 DCFC charging stations in areas with a high concentration of Multi-Unit Residential Buildings (MURBs) to cater to residents without access to home charging.

2. Charging Station Construction Standards:

- Define universal construction standards for public EV charging stations, ensuring adequate signage and lighting to improve user experience and safety.
- Incorporate disability accessibility considerations to accommodate individuals with diverse mobility needs, fostering inclusivity in the charging infrastructure.
- Conduct additional research to determine the degree to which EV charging accessibility concerns may be hindering EV adoption among individuals with disabilities, the degree to which Canada's current EV network is accessible to individuals with disabilities and how improvements can be made.

3. Network Operator Regulation:

- Establish a regulation that mandates network operators to maintain a minimum station uptime, reducing instances of out-of-service stations.
- Implement a universal billing standard in units of energy (kWh) across locations to offer transparent and straightforward charging costs. This standardization could enhance private sector investments by providing more dependable return on investment projections and mitigate pricing differences between locations through transparent competition. Allow financial penalties to ensure that EVs will not remain plugged in when fully charged under kWh-based billing.
- Encourage and/or mandate partnerships between operators that would enable EV owners to charge at any public charging station, regardless of their network membership.

4. EV Owner Charging Experience Evolution:

- Conduct regular and similar surveys to monitor how the charging experience of EV owners is evolving across provinces and demographics.
- Utilize survey insights to inform policy decisions and infrastructure development, ensuring the charging ecosystem evolves in response to user needs.
- Examine the public charging infrastructure stakeholder landscape at the provincial level to contrast the charging experience of EV owners to local charging station operator internal policies as well as provincial policy environments.