Public Uptake of Electric Vehicles in Newfoundland and Labrador

Barriers and Policy Solutions

by

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Abstract

The province of Newfoundland and Labrador (NL) is encountering challenges in decreasing greenhouse gas emissions, principally in the private road transportation sector. Even though NL is one of the major renewable energy producers across the Canadian provinces, it still depends greatly relies on petroleum products for fuel consumption, which shows a clear contrast between having plentiful capacity in renewable energy and maintaining reliance on fossil fuel. This thesis investigates the reasons behind NL's low electric vehicle (EV) uptake rates and suggests policy solutions. Using a cross-sectional survey methodology, this study examines public opinions on transportation decarbonization, explores the experiences of existing EV drivers, and reviews factors that affect the adoption of EVs. The results suggest seven barriers that may be preventing wider adoption of EVs in NL. These barriers include financial concerns, limited charging infrastructure, technology-related issues, government incentive inadequacies, EV knowledge gaps, market effectiveness, as well as NL-specific challenges. The study underlines the disproportionate impact of financial barriers on middle- to lower-income families, stressing the need for targeted government interventions. The challenges related to charging infrastructure, technology, and market effectiveness require strategic planning and collaborative efforts to overcome. Because of NL's unique environmental and geographical characteristics, EV adoption is complicated, requiring tailored infrastructure developments and awareness-raising programs. Other policy recommendations include financial incentives, infrastructure development, and education initiatives, as well as collaboration between government bodies, manufacturers, and local communities.

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This thesis is dedicated to the courageous individuals who have borne the heavy burden of oppression and persecution as a result of their involvement in the revolution of Women, Life, Freedom in Iran from 2022 to present—to those who have tragically lost their lives, sustained injuries, endured unjust imprisonment, faced execution, or been forced into exile. This dedication stands as a solemn tribute to their unwavering commitment to justice and equality. Their sacrifices have not gone unnoticed, nor will they be forgotten.

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List of Abbreviations and Symbols

AC	Alternating Current
BEV	Battery Electric Vehicle
CO_2	Carbon Dioxide
CO_2-eq	Carbon dioxide equivalent
DC	Direct Current
DCFC	Direct Current Fast Charging
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
FCEV	Fuel Cell Electric Vehicle
GHG	Greenhouse Gas
GWP	Global Warming Potential
HDV	Heavy Duty Vehicle
HEV	Hybrid Electric Vehicle
ICE	Internal Combustion Engine
ICEV	Internal Combustion Engine Vehicle
IEA	International Energy Agency
IPCC	Intergovernmental Panel of Climate Change
IRA	The Inflation Reduction Act
LCFS	Low-Carbon Fuel Standard
LDDT	Light Duty Diesel Truck
LDDV	Light Duty Diesel Vehicle
LDGV	Light Duty Gasoline Vehicle
LDGT	Light Duty Gasoline Truck
LDT	Light Duty Truck
LDV	Light Duty Vehicle
NDC	Nationally Determined Contribution
NGV	Natural Gas Vehicle
NIR	National Inventory Report
NL	Newfoundland and Labrador
PCF	Pan-Canadian Framework on clean growth and climate change
PHEV	Plug-in Hybrid Electric Vehicle
PMR	Perceived Mobility Restriction
PV	Propane Vehicle
RD&D	Research, Design and Development
RVG	Resale Value Guarantee
SUV	Sport Utility Vehicle
TCO	Total Cost of Ownership
UNFCCC	United Nations Framework Convention on Climate Change
V2G	Vehicle-to-grid
ZEV	Zero Emission Vehicle

Chapter 1: Introduction and Problem Statement

1.1. Background

Greenhouse gases (GHGs) trap heat in the atmosphere and warm the planet enough to make it habitable. Carbon dioxide, methane, nitrous oxide, water vapour, and fluorinated gases are the primary gases responsible for the greenhouse effect. Human activities such as burning fossil fuels and deforestation have increased the concentration of greenhouse gases in the atmosphere, resulting in more trapped heat and higher global temperatures (Denchak, 2019).

The Intergovernmental Panel on Climate Change (IPCC) was established in the 1980s to quantify and understand GHG emissions and climate change. Since 1990, the IPCC has released five reports, all of which have unequivocally determined that global warming is unavoidable and human activities undeniably influence the issue (IPCC, 2013, as cited in Reynolds, 2019). IPCC in 2018 reported human activities have caused approximately 1.0°C of warming over pre-industrial levels, and with high confidence, this increase will likely reach 1.5°C between 2030 and 2052 if the trend continues. It is also indicated that several ecosystems on land and in the oceans, including humans and natural systems, have already been adversely affected by climate change (IPCC, 2018). Heat stress, storms and severe precipitation, inland and coastal floods, landslides, air pollution, drought, water shortages, sea-level rise, and storm surges are all expected to raise hazards for people, assets, economies, and ecosystems in urban areas as a result of climate change with very high confidence (IPCC, 2014a). These dangers are magnified for individuals who lack basic infrastructure and services or live in vulnerable locations. For rural areas, with high certainty, water availability and supply, food security, infrastructure, and agricultural earnings are all likely to be impacted, including changes in the production areas of food and non-food crops across the

world (IPCC, 2014a). Climate change not only threatens plants and wildlife; it also poses risks to humans through insects that carry illnesses like dengue fever and Zika (Denchak, 2019). It is also concluded by Denchak (2019) that heat waves are becoming stronger and more dangerous. As a result of droughts and floods, our food supply can be diminished, and people could go hungry. Food insecurity can also lead to mass migration and political instability.

It will be essential to make considerable efforts to reduce greenhouse gas emissions at the global, national, and local levels. The IPCC's 2018 Special Report makes it abundantly obvious that the world cannot avoid warming of more than 1.5°C unless global CO_2 emissions begin to fall as soon as feasible. In particular, the report concludes that avoiding a 1.5°C temperature increase needs a 45% reduction in CO_2 emissions from 2010 levels by 2030, with net-zero emissions by 2050. This will necessitate significant reductions in the usage of coal, oil, and gas (IPCC, 2018).

The IPCC identified five economic sectors as sources of anthropogenic GHG emissions: electricity and heat production, agriculture, forestry and other land use, industry, buildings, and transportation (IPCC, 2014a). In accordance with the IPCC fifth assessment report (2014b), the transportation sector emitted 23% of the total energy-related emissions (7.0 Gt CO_2eq[1], including non-CO_2 GHGs) in 2010, twice its share in 1970. The report elaborates that road vehicles have contributed around 80% of this increase. Even though there have been increases in fuel technologies efficiency and the adoption of policies, reducing the greenhouse gas emissions of the transportation sector remains one of the most challenging issues facing global climate change efforts (IPCC, 2014b). Due to the increase in passengers and freight

[1]According to eurostat (2017), CO_2eq is a unit of measure used to determine and compare the global warming potential (GWP) of greenhouse gases. It is calculated by converting the amount of other gases into the same amount of CO_2.

carrying activities in the sector, emission trends are rising, offsetting the reductions that have taken place in other sectors (IPCC, 2014b); these subsectors requires greater attention from policymakers (IEA, 2021a). Transportation needs are higher in developed countries than in developing countries, due to rapidly increasing in income and the development of infrastructure, especially as forecasted for the 2020s (IPCC, 2014b). As a result, it is crucial to develop, implement, maintain, and improve aggressive mitigation policies, particularly in industrialized countries. In a business-as-usual scenario, greenhouse gas emissions from transportation will grow at a faster rate (compared to other sectors of energy consumption) and by 2050, with 70% growth, it will reach 12 Gt CO_2eq (IPCC, 2014b).

The shift of transportation from fossil-fuel-based products (coal, oil, and natural gas) to electricity generated from low emission sources can reduce direct (tank-to-wheel) greenhouse gas emissions, decarbonizing transportation (IPCC, 2014b). Recognizing the necessity of this action, the International Energy Agency (IEA) suggests a coordinated and integrated set of policies for the deployment of energy-efficient technologies for vehicles and their fuels (e.g. electrification) while also increasing the availability and use of low-carbon fuels (IEA, 2021a).

1.2. Total GHG Inventory of Canada and in Transportation Sector

Environment and Climate Change Canada published and submitted its latest National Inventory Report titled "NIR 1990-2020, Greenhouse Gas Resources and Sinks in Canada to the United Nations Framework Convention on Climate Change (UNFCCC)" in 2022. This report documents that Canada generated 672 mega tonnes of carbon dioxide equivalent (Mt CO_2eq) in 2020, 80% of which were emitted from sources associated with the energy sector, including combustion, transportation, and fugitive emissions (Environment and Climate Change Canada, 2022a). According to the report, the greenhouse gas emissions of Canada for

2020 decreased by 8.9% from 2019 and 9.3% from 2005; however, the COVID-19 pandemic in 2020 contributed to the decline in emissions from several sectors. For instance, the reduction in kilometres driven during 2020, resulted in a decrease in transport emissions of approximately 27 Mt CO2eq (12%) compared to 2019. Nevertheless, Canada is similar to other industrialized nations, as 80% of its emissions are CO_2 and originate from fossil fuel combustion. According to the IPCC sectors, 190 mega tonnes (28%) of GHG emissions were from transportation in 2020 in Canada, mainly from personal transportation and freight transportation (heavy-duty trucks). Based on the categorization of GHG emissions for each economic sector, it is concluded in the report that this number was 159 Mt CO2eq (24%), making it the second-most polluting economic sector in 2020 in Canada, following oil and gas with 179 mega tonnes (27%) (Environment and Climate Change Canada, 2022a).

As shown in Figure 1, 69% of Canada's transportation GHG emissions came from road transportation in 2020. The 69% figure reflects a total of 24% natural gas-fueled and propane transportation, 7% heavy-duty transport, and 38% (about 71 Mt CO_2eq) diesel and gasoline-powered personal transportation. Personal transportation consists of light-duty vehicles (LDV) and light-duty trucks (LDT) of both gasoline and diesel types. The definition of light-duty trucks covers most sport utility vehicles (SUVs), most pickup trucks, and all minivans as well. Light-duty diesel vehicles (LDDVs) and Light-duty diesel trucks (LDDTs) in Canada are estimated to be significantly less numerous than light-duty gasoline vehicles (LDGVs) and light-duty gasoline trucks (LDGTs) in the country; as a result, they produce significantly less emissions overall (1.5 Mt CO2eq, as opposed to 70 Mt CO2eq). As per Environment and Climate Change Canada (2022a), in spite of the decrease in the number of traveled kilometers in 2020, the emissions of LDTs increased by approximately 124% compared to 2019, demonstrating Canadians preferred using LDTs for their personal transportation.

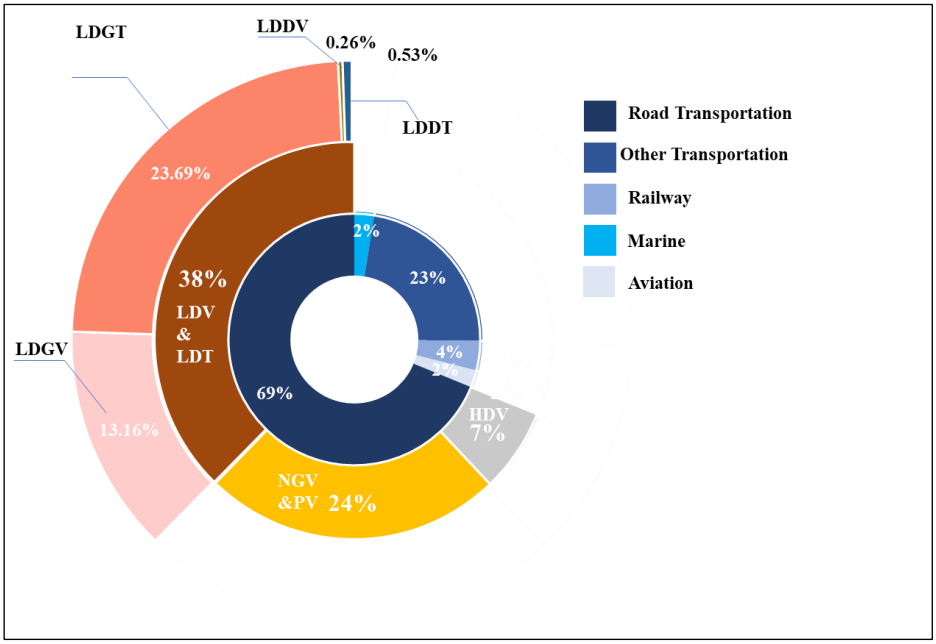


Figure 1: Canada's GHG Emission in Transportation-IPCC Sector in 2020 (Source: Adapted from Environment and Climate Change Canada, 2022a)[2]

Although total vehicle kilometers driven in 2020 decreased from the previous year, the steady increase in vehicle fleet from 1990 to 2020 resulted in a 61% increase in 2020 compared with 1990.

1.3. Cost of Inaction in Canada and Coastal Provinces Such as Newfoundland and Labrador

Social, economic, and political systems are threatened by climate change, primarily because of rising sea levels, thawing permafrost, and extreme weather events such as water shortages, floods, heatwaves, and droughts. Due to its high latitude, Canada is expected to

[2] LDV: Light Duty Vehicle,
LDT: Light Duty Truck,
LDGV: Light Duty Gasoline Vehicle,
LDGT: Light Duty Gasoline Truck,
LDDV: Light Duty Diesel Vehicle,
LDDT: Light Duty Diesel Truck,
HDV: Heavy Duty Vehicle,
NGV: Natural Gas Vehicle,
PV: Propane Vehicle

experience higher rates of warming than other countries (Pollution Probe & The Delphi Group, 2018). It is widely recognized that communities along low-lying coasts and rural communities that are heavily dependent on fishing, aquaculture, or tourism are highly vulnerable to the impacts of climate change, which can include sea level rise, erosion of coastlines, storm surges, as well as ocean acidification (TransCoastal Adaptations Centre, n.d.). About 6.5 million Canadians live close to marine coasts. The marine coastlines of Canada are divided into three major regions: the East Coast, the North Coast, and the West Coast. The East Coast (and in particular Newfoundland and Labrador (NL), which is the scope of this study) is home to several large cities, as well as many smaller towns and rural areas. Coastal resources play a significant role in the economy of this region. Almost all sectors in Canada's coastal regions will be impacted by changing climate, but the fisheries, tourism, transportation, energy, and infrastructure sectors are especially vulnerable to climate change (Lemmen & Warren, 2016). Figure 2 illustrates some examples of how climate change impacts these sectors.

Fisheries	***Infrastructure***	***Tourism***	***Transport***	***Energy***
• Impact of sea level rise and storms on coastal infrastructure for fisheries. • Fish kill; altered physiological development, growth, and migration patterns; loss of habitat for bottom-dwelling fishes; and habitat compression due to decreased dissolved oxygen.	• Less usable due to increased tides, storm surges, and erosion. • Extreme precipitation and storm surges cause costly infrastructure damage.	• Sea-level rise and more extreme weather threaten tourist infrastructure (e.g., wharves, coastal properties, etc.). • Algal blooms and water quality declines associated with warmer waters might reduce beach popularity.	• Isolation of coastal communities because of over-flooded highways due to storm surges and storm waves. • Storm-related delays and cancellations of ferries, as well as damage to ferries. • Warm winters and more fog affecting coastal airports.	• Storms and sea-level rise may create unsafe conditions for shipping along the coast. • Snowstorms and windstorms can harm energy transmission facilities.

Figure 2: Sectoral Impacts Associated with Climate Change on the East Coast (Source: Adapted from Lemmen & Warren, 2016)

A 2011 study by the National Round Table on the Environment and the Economy estimated that climate change will impose an economic burden on Canada of $21-43 billion per year by 2050 (Pollution Probe & The Delphi Group, 2018). As evidence, a hurricane (i.e., Hurricane Igor) on September 21, 2010, was cited by the Canadian Disaster Database as one of the most costly extreme events occurring due to climate change in NL. As a result of the severe weather, wind speeds in some areas exceeded 170 km/hour, washed-out roads caused the isolation of approximately 90 communities, and 22 communities declared states of emergency. There were 300 evacuations and one fatality; estimated total costs were $51 million (Lemmen & Warren, 2016). Boris Worm (2017) remarks that a 2016 study by the National Oceanic and Atmospheric Administration suggests sea levels may rise by 2.5 metres by 2100, indicating that coastal communities, including those in NL, are at risk of permanent flooding before the end of the century.

1.4. Transport Electrification and its Environmental Benefits

Many experts believe that the transportation sector provides the most potential for achieving Canada's GHG emissions reduction target, considering that emissions from sectors such as electricity generation, buildings, heavy industry, agriculture, and waste have decreased or stabilized in recent years (Pollution Probe & The Delphi Group, 2018).

Governments throughout the world are increasingly interested in introducing electrification into transportation systems as a means of achieving climate change targets (Council of Ministers Responsible for Transportation, 2018). If policymakers want to fight climate change, replacing fossil fuels with electricity may be one of the only technologically realistic solutions (Zhang & Fujimori, 2020).

The term "electrification of transportation" refers to transitioning from fossil to electric power for all types of vehicles, including personal cars, commercial fleets of vans and trucks,

and public transportation such as buses and trains (Western Resource Advocates, 2022). Governments worldwide are taking steps to speed up the transition to electric vehicles (EVs) to reduce transportation carbon emissions, energy consumption, and local air pollution (Slowik & Lutsey, 2018). Indeed, due to the low noise output and zero exhaust emissions, EVs are an attractive option for greening the transportation system, and now with the continuous improvement of lithium-ion batteries and fast charging technologies, we witness their widespread use globally (Raveendran, Alvarez-Bel, & Naira, 2020; Tan, Ramach and Ramamurthy, & YingYong, 2016). Additionally, transport electrification allows Canada to take advantage of its massive renewable energy resources and reduce the country's dependence on imported oil (Natural Resources Canada, 2017; Palmer, Tate, Wadud, & Nellthorp, 2018). Of course, to deliver above mentioned benefits[3], mass adoption of EVs is needed.

1.5. Canada's International Climate Change Commitments and Action Plans

Nationally Determined Contributions (NDCs) are long-term climate actions that signatories of the Paris Agreement are undertaking (or have undertaken). According to the 2015 Canadian National Development Plan, it is the goal of the Government of Canada to reduce its GHG emissions by 30% below 2005 levels by 2030, and by 80% by 2050 (Pollution Probe & The Delphi Group, 2018). Both the federal and provincial governments have instituted climate policies to achieve these objectives (Council of Ministers Responsible for Transportation, 2018). It was in 2021 that Canada formally submitted its revised and enhanced NDC to the United Nations, committing to cut GHG emissions by 40-50% below

[3] The researcher acknowledges that there are some ongoing debates about environmental impacts and sustainability of EVs. These debates include concerns such as environmental impacts of mining metals required for EV manufacturing, as well as difficulties linked with disposal or recycling these components once an EV's life ends. It is crucial to understand that this discussion is complicated and changing. The main assumption in this thesis is that shifting to EVs, when compared with ICEVs, benefits the environment. However, it is important to note the wider discussion on EV sustainability, which could influence future research as well as decisions related to policies.

2005 levels by 2030 and to net-zero by 2050. In light of this new target, the enhanced NDC represents a significant upgrade to the previous one, submitted in 2015, which was a reduction in emissions in 2030 of 30% below 2005 levels (Government of Canada, 2021; Environment and Climate Change Canada, 2022a).

In close collaboration with the provinces, territories and Indigenous peoples, Canada is pursuing its commitment to meet the Paris Agreement through various initiatives, such as the Pan-Canadian Framework on Clean Growth and Climate Change (2016), the Strengthened Climate Plan (2020), and the enactment of the Canadian Net-Zero Emissions Accountability Act (2021) (Environment and Climate Change Canada, 2022a).

Through these initiatives, comprehensive actions for reducing emissions across the economy are being considered, especially in the transportation sector, which includes improving vehicle emission standards, increasing the number of zero emissions vehicles, providing infrastructure for the transition to lower emission models of transportation, using cleaner fuels, and providing clean, affordable electricity and transportation for all communities (Environment and Climate Change Canada, 2022a).

Climate change policies are largely implemented at the provincial level in Canada (Center for Climate and Energy Solutions, n.d.). NL, like most Canadian provinces, has implemented market-based programs to reduce greenhouse gas emissions, promote zero-emission electricity, and introduce zero-emission vehicles (Center for Climate and Energy Solutions, n.d.). A Climate Change Action Plan was established greenhouse gas targets for NL. As part of the objectives, the emissions must be reduced by 10% below 1990 levels by 2020, and by 75% to 85% below 2001 levels by 2050 (Climate Change Branch of Newfoundland and Labrador Government, n.d.).

1.6. Case Description and Justification: Newfoundland and Labrador EV Uptake and Policies

The province's greenhouse gas emissions in 2020 reached 9.5 Mt CO_2eq, a decrease from 2019 primarily due to the COVID-19 pandemic. In 2020, transportation remains the most polluting sector in NL (i.e., in comparison to oil & gas, electricity, heavy industry, buildings, and agriculture), accounting for 41% of emissions. Since 1990, there have been similar trends in NL, which means among other economic sectors, the transportation sector has always been the most polluting (Environment and Climate Change Canada, 2022b). To be more precise, total GHG emission of the transportation sector in 2020 was measured as 3.9 Mt of CO_2eq, 44% of it comes from private road transportations (i.e., cars, passenger light trucks, off roads, and motorcycles (Environment and Climate Change Canada, 2022b). According to Natural Resources Canada (2020), until 2018, electricity consumption for transportation purposes in NL was zero and the primary fuels used were motor gasoline (52.2%), diesel fuel oil (24.1%), aviation turbo fuel (22.9%) and heavy fuel oil (0.8%), respectively. Again in 2019, refined petroleum products were the largest fuel type consumed in NL in 2019. While the province is the 5th-largest producer of electricity in Canada with a significant generating capacity (Canada Energy Regulator, 2022), including 96% from renewable sources (Canada Energy Regulator, 2022), we face the question of why the main reliance of fuel consumption is still on petroleum products.

When it comes to EV adoption rates, in 2021, 93.4% of zero emission vehicles [4] (ZEVs) (i.e., battery electric vehicles[5] or BEVs and plug-in-hybrid electric vehicles[6] or PHEVs)

[4]An electric vehicle (EV) that does not emit any tailpipe emissions when driving is called a zero-emission vehicle (ZEV) (Electric Car Home, n.d.).
[5] Battery Electric Vehicles (BEVs) have a battery and an electric motor, instead of a gas-powered engine. They run entirely on electricity and do not produce any exhaust from the burning of fuel (Electric Car Home, n.d.).
[6]Plug-in Hybrid Electric Vehicles (PHEVs) have an electric motor AND a gas-powered engine. They run both on gas and electricity. Their battery can be charged by plugging in. Once the battery is used up, a gasoline engine or generator takes over (Electric Car Home, n.d.).

registrations occurred in British Columbia (23,850), Ontario (19,726) and Quebec (36,800) (Statistics Canada, 2022). However, as of January 11, 2023, there are only about 430 battery electric vehicles on NL's roads (takeCHARGE!, n.d.), which is among the lowest uptake of ZEVs in Canada even though charging infrastructure has been installed widely in the province.

In terms of electrical power availability, as per statistics published by the Canada Energy Regulator (2022), NL was the fifth-largest electricity producer in Canada in 2018, 95% of it from renewable energy sources. The current situation with the infrastructure and potential for electricity generation makes viable the electrification of the transportation system in the province with few concerns regarding extreme pressure on the grid.

The above-mentioned facts demonstrate the importance of focusing on reducing emissions from the transport sector, and particularly road private passenger transport as the most polluting component of the transportation sector in NL. It is a promising opportunity for a ZEV strategy that the NL provincial government can take advantage of to combat climate change. However, questions remain: what are the reasons for this lowest uptake rate and how can the province make advances in this realm?

The purpose of this study is to identify the current barriers to public EV adoption in the province of NL, an area that has earned limited attention in the literature. Despite its significance, there is a noticeable gap in scholarly research regarding the specific challenges faced in NL. This thesis contributes to the literature by filling this gap and aims to identify potential policy solutions to increase NL's EV uptake rate, thereby offering novel insights into the field of EV adoption.

In this respect, the present study develops a qualitative and quantitative analysis of the perception of the general public toward EV adoption utilizing an online survey. This study is

primarily focused on light EVs, which are defined as cars and light trucks (not motorcycles, off-road vehicles, or medium- or heavy-duty trucks) that can be plugged in and recharged. These EVs include BEVs and PHEVs, which are the most common types of EVs currently on the market and face the numerous barriers to adoption. On top of that, EV development is more advanced in lighter vehicles than in heavier ones, so road freight transport (medium and heavy-duty trucks) are not included in the scope of this study.

More specifically, the following research questions need to be addressed:

A: What are the barriers to public EV adoption?

B: What are possible policy options for policymakers to overcome negative public perception and improve the current low rate of uptake?

This thesis is structured as follows: the second chapter provides definitions of key terms related to transport electrification as well as an overview of the EV market in Canada and NL, along with a comprehensive summary, comparison, and categorization of academic research that has been conducted in relation to identification of EV adoption barriers by other scholars. In Chapter 3, a description of the conducted study will be presented, as well as information regarding how the survey questions were selected in order to obtain useful results for an evaluation of the barriers in NL. Moreover, it explains how the results of the survey were analyzed quantitively and qualitatively. In Chapter 4, the survey analysis and the results are outlined. The discussion of the findings is depicted in Chapter 5 along with recommendations to promote the adoption of EVs. In the final section, conclusions are presented, and suggestions are summarized.

Chapter 2: Literature Review and Research Hypothesis

2.1. Transport Electrification Key Terms

2.1.1. Electric Vehicle Types

Electric vehicles (EVs) are classified into four different types, based on their electricity dependence (see Figure 3).

1. A battery electric vehicle (BEV) refers to a vehicle that runs entirely on electricity. BEVs use an external electrical charger for power. They are powered by electricity and do not have a gasoline engine, fuel tank, or exhaust system (Samsara, 2021). As such, there is no engine, hardly any belts or pulleys, and the only parts that move are an electric motor, the wheels, and the cooling fluid pump (Pollution Probe & the Delphi Group, 2020). They are charged by plugging them into an EV charger, and depending on their size and make, they can travel anywhere from 100 to 580[7] kilometers on a single charge. BEVs do not produce any emissions while driving, and even the electricity supplied may have low emissions if generated from wind or other renewable energy sources (Axsen, Goldberg, & Melton, 2016).
2. Plug-in-hybrid electric vehicles (PHEVs) are electrically powered vehicles that can run on gasoline and electricity, meaning that, depending on the make and model, they can run on electricity for the first 20 to 70 kilometers and then on gasoline for 500 to 900 kilometers (Axsen, Goldberg, & Melton, 2016). Their high-capacity batteries can be charged by plugging them into an electrical outlet or charging station, so they can store sufficient electricity to reduce their gas use significantly under usual driving conditions (U.S. Department of Energy, n.d.a).

[7] This upper limit is constantly increasing with the development of technology.

3. Hybrid electric vehicles (HEVs) use both gasoline and electricity to power them (i.e., they have a gas engine and a small electric motor). They differ from PHEVs because, when driving, they use their electric motor for charging, which is supplemented by the gasoline engine (Samsara, 2021; U.S. Department of Energy, n.d.b). A HEV runs primarily on gas and does not plug in, generating electricity from regenerative braking, so there are minimal fuel savings (U.S. Department of Energy, n.d.b).
4. Fuel-cell electric vehicles (FCEVs) use hydrogen fuel cells instead of batteries to power an electric motor. Unlike gasoline-powered vehicles, fuel-cell electric vehicles produce no tailpipe emissions, only vaporized water and warm air. A FCEV is powered by a propulsion system similar to an EV, in which hydrogen stored as fuel is converted into electricity. FCEV technology and the hydrogen infrastructure to fuel them are in their infancy (Pollution Probe & The Delphi Group, 2018; U.S. Department of Energy, n.d.c).

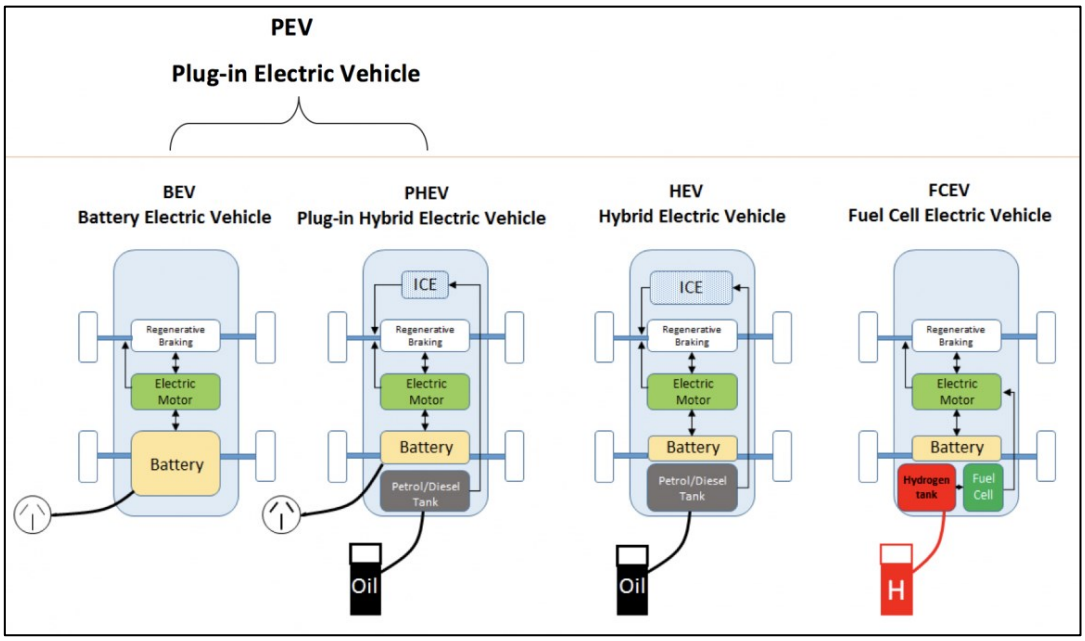


Figure 3: Different propulsion technologies employed by EVs (Source: Reproduced from Gaton, 2018)

2.1.2. Zero-Emission Vehicles (ZEVs)

An EV that does not emit any tailpipe emissions when driving is called a zero-emission vehicle (ZEV). It can still have an internal combustion engine but must also be able to operate without it (Transport Canada, 2020). According to Transport Canada‘s (2020)classification, Zero-Emission Vehicles (ZEVs) include BEVs, PHEVs, and FCEVs, but not HEVs. Compared to a conventional gasoline vehicle, an EV (depending on the type) can reduce emissions by 45% to 98% in Canada, depending on the current sources of electricity generation; obviously, the use of EVs contributes more to GHG reductions as provinces shift towards greener sources of electricity (Axsen, Goldberg, & Melton, 2016). This study focuses primarily on BEVs and PHEVs as ZEVs of interest.

2.1.3. Cost of Ownership

Considering the vehicle’s cost is an essential element of any discussion regarding the purchase of a vehicle. Consumers are likely to consider an EV if they understand the total cost of ownership (Stropp, 2022). In the context of transport electrification, the total cost of ownership (TCO) is an indicator of net costs over time. There are several factors considered in TCO estimates, including capital expenditures (vehicle purchase and taxes), operating costs (fuel, maintenance, repair, annual registration, and insurance), as well as the depreciation and resale value (Parker et al., 2021). Despite having higher up-front purchase prices than conventional cars, EVs can save consumers much more on operating costs (Harto, 2020). Since electricity is less expensive than gasoline[8] (and is also taxed less than gasoline), and because EV service and maintenance costs are about a third lower than internal combustion

[8] Comparing energy costs per km, EVs, with an average electricity cost of 10 cents per kWh in the U.S., typically incur around 2.05 cents per kilometer, whereas gasoline vehicles, at USD 0.92 per liter, generally cost about 9.88 cents per kilometer (Idaho National Laboratory, n.d.).

engine[9] (ICE) cars, the TCO for EVs is not more than internal combustion engine vehicles (ICEVs). Experts anticipate that the cost of EV batteries may drop between 19% and 37% by 2027, which may further reduce the TCO for EVs (Umicore, 2021).

Recent studies in the US comparing the TCO for EVs with ICEVs have shown that when considering government subsidies and other operating costs, the most recent generation of common EVs typically cost less than their gas-powered counterparts. Thus, consumers choosing EVs may benefit greatly from new developments in the auto industry (Harto, 2020).

2.1.4. EV Chargers

BEVs and PHEVs both require EV chargers to keep their batteries charged, just like any other chargeable electronic device. An EV charger works by connecting a plug to the port on the vehicle, and then connecting the other end to an electrical outlet (EVConnect, 2019). As the name implies, electric vehicle supply equipment (EVSE), commonly known as an EV charger or EV charging station, is the equipment that is used to connect a power source to the vehicle's charging port. Cables, connectors, and other components of the EVSE unit are used to safely transmit power and allow information to be exchanged between the electric circuit and the vehicle (Pollution Probe & the Delphi Group, 2020). There are three types of chargers according to the power of charging, suitable for both BEVs and PHEVs.

1) The Level-1 charger, which is included with the vehicle as a portable cord, utilizes standard electrical outlets, alternating current (AC), and a standard 3-prong household plug. As the slowest type of charging, level-1 chargers take eight to thirty hours to fully recharge an EV battery (only 8 kilometers per one hour of charging), making them most suitable for long-term parking (Chargehub, n.d.; Pollution Probe & the Delphi Group, 2020).

[9] Definition of internal combustion engine (ICE) vehicles: these are vehicles powered by gasoline, diesel, biofuel, or even natural gas and are the most prevalent type of engine on the road today (Canadian Fuels Association, 2016).

2) Level-2 chargers are sold separately, powered by 240V, and plugged into an AC outlet similar in electrical specifications to those of a clothes dryer or a stove, which can be installed by any certified electrician. These chargers are capable of charging 3 to 7 times as fast as a Level-1 charger. A full charge can take between 4 and 10 hours, with an average increase in range per hour of 30 km to 50 km. Level-2 charging stations, if installed, are suitable for use at home, at the workplace, and in public places (Chargehub, n.d.; Plugndrive, n.d.; Pollution Probe & the Delphi Group, 2020).

3) The fastest charging speeds among current chargers are provided by direct current fast chargers (DCFC), also known as Level-3 chargers. In EVs, direct current (DC) charging allows for faster charging, since DC can supply power directly to the battery at higher voltages than AC charging. In the DCFC system, 480V direct current is supplied via a special plug that for example allows a BEV to charge up to 80% in approximately 25 to 30 minutes (shorter for PHEVs). This adds more than 100 kilometers per hour to the range. These chargers are typically used in public charging stations (Electrificyamerica, n.d.; Pollution Probe & the Delphi Group, 2020).

2.2. Overview of Global EV Market

There has been a continuing growth in the sales of EVs all around the world. Governments worldwide at all levels support the market to achieve energy, climate change, air quality, and industrial development objectives (Slowik & Lutsey, 2018).

There is a wide range of regional and national variations in the sales of EVs around the world. China and Norway are leading the way in switching to EVs (Axsen, Goldberg, & Melton, 2016). By the end of 2020, there were 10 million EVs on the road worldwide (a 4.6% sales share), and Europe overtook China as the world's largest EV market for the first time (IEA, 2021a). The number of EVs on the global roads exceeded 16.5 million by 2021, a

threefold growth in just three years, representing about 10% of total vehicle sales in that period (IEA, 2022a).

Norway has the highest market share of ZEVs amongst other countries in 2021 (65% BEVs and 22% PHEVs, 87% of total sales) (IEA, 2022a; Klesty, 2022). Norway began selling EVs in 2010, and by 2021, there were 585,337 EVs on the road, of which 412,155 were BEVs and 173,182 were PHEVs. Considering the population of 5.4 million in Norway, it has highest adoption rate per capita in the world as well (IEA, 2022b).

There was a major increase in the number of EVs sold in 2021, with more than half of the growth (3.3 million EV registrations) being attributed to China (IEA, 2022a). After the boom in 2020, EV sales in Europe have continued to grow rapidly (2.3 million EV registration), while in the U.S. they increased in 2021 after two years of decline (630,000 EV registration). Similarly, worldwide sales continued to rise during the first quarter of 2022, but much more needs to be done to sustain this progress (IEA, 2022a). Rapid development in technology is enhancing the performance of EVs' batteries, and manufacturers are introducing new EV models to attract new customers. EV designs are evolving, and better batteries are being developed to speed their adoption (Khandakar et al., 2020). As a result of a fivefold increase in available EV models over 2015, the number of EV models on the market has increased to approximately 450 in 2021, enhancing their appeal to consumers (IEA, 2022a). But it remains the case that the adoption rate of EVs still varies around the world (Khandakar et al., 2020).

2.3. Overview of EV Market in Canada

The ZEV market in Canada has experienced considerable growth in recent years, which is encouraging for the future (Pollution Probe & The Delphi Group, 2018) but it is still well below global average (IEA, 2022a). In Canada, the sale and registration of EVs began in 2011

(Logtenberg, Pawley, & Saxifrage, 2018), and by the end of 2021, there were 286,967 ZEVs on the roads of Canada, of which 177,713 were BEVs and 108,984 were PHEVs (Statistics Canada, 2022). Across Canada, EVs are gaining market share and are expected to continue to grow (IEA, 2022b). Despite the worldwide slowdown in automobile sales and difficulties in the supply chain caused by the COVID-19 pandemic, ZEV registrations increased by 60% in 2021 in Canada (compared to 2020) (IEA, 2021a; Statistics Canada, 2022). More precisely, from the data obtained from Statistics Canada (2022), the market share of ZEVs in Canada was below 0.6% until the end of 2016. There has been an increase in the market share of these vehicles since 2017 and at the end of 2023 they accounted for 10.80% of the total market (see Figure 4). In other words, one out of every 10 cars registered in Canada was a ZEV.

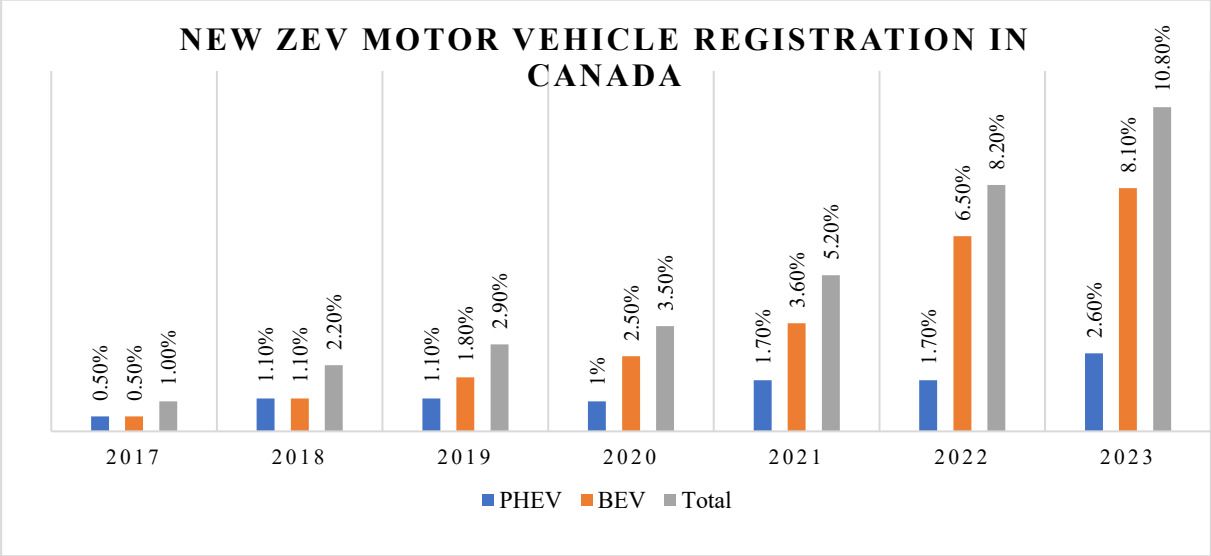


Figure 4: Percentage of New ZEVs registered in Canada (Source: Adapted from Statistics Canada, 2024)

BEVs accounted for two-thirds of new ZEVs registered in 2021, exceeding PHEVs. It is noteworthy that the number of BEVs registered increased by approximately 50% over the previous year, while the number of PHEVs registered increased by approximately 77%.

In comparison with other provinces in Canada, Quebec has a record of being the largest market for ZEVs, as shown in Figure 5. About 45% of Canada's ZEVs are registered in Quebec. There is no doubt that since two-thirds of the country's population resides within the

three provinces of Quebec, Ontario, and British Columbia, most of the registered zero-emission vehicles are located within these three provinces (close to 97%) (Axsen, Goldberg, & Melton, 2016; Statistics Canada, 2022). In other words, based on the average population until the end of 2021, for every 100 people, one and a half ZEVs have been registered in Quebec, 1.40 in British Columbia and 0.5 in Ontario. In other provinces (i.e., Manitoba, Saskatchewan, New Brunswick, and Prince Edward Island), the rate ranged between 0.09 and 0.18 (Statistics Canada, 2021; Statistics Canada, 2022).

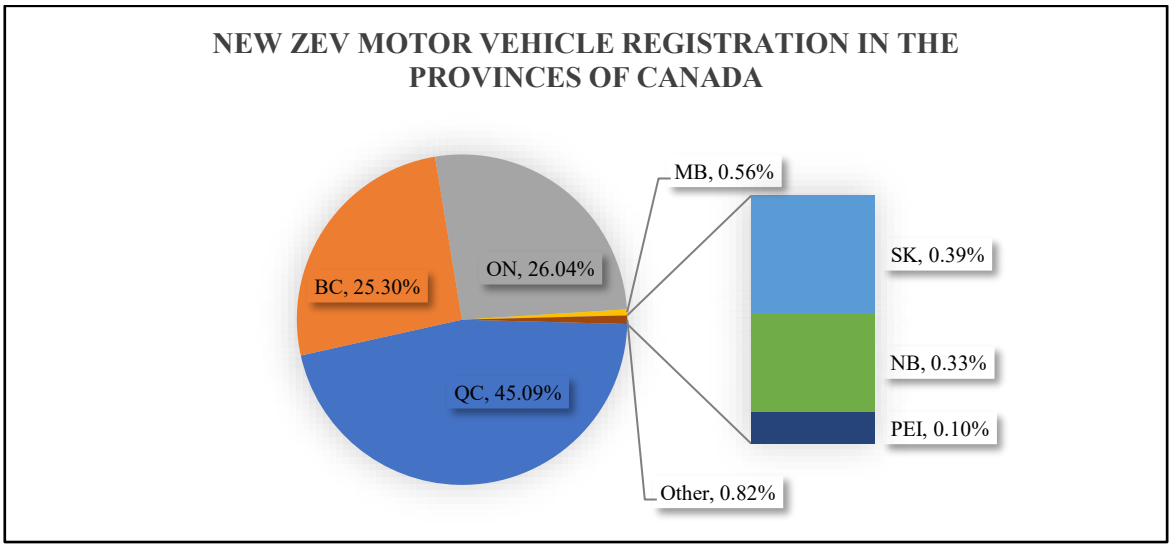


Figure 5: Total New ZEVs registered in Canadian Provinces from 2011 to 2021 (Source: Adapted from Statistics Canada, 2022)

2.4. EV Market in Newfoundland and Labrador

NL has seen an increase in the number of EVs. However, on an overall basis, the number remains relatively low, lagging behind the rest of the country (CBC, 2022). To have a precise look at this market, there are some limitations. It has been stated by Statistics Canada (2022) that due to "contractual limitations" of the existing data sharing agreement in NL, they are unable to estimate details of the ZEVs market; however, these details are included in the Canadian total discussed earlier. Another limitation we encountered is that the provincial

government does not categorize plug-in hybrids differently than other hybrids, and there is no good insight into the number of registered plug-in hybrids in statistics.

According to statistics released by the provincial government's department of finance, 4949 hybrid (HEV and PHEV) and all-electric (BEV) vehicles have been registered in the province as of the end of 2021 (see Figure 6), less than half a percent of the country's total registrations (Government of NL, n.d.a). As such, out of every 217 registered vehicles, one is all-electric or hybrid (Government of NL, n.d.a), while in Quebec, 9 of every 100 cars were ZEVs in 2021[10] (Statistics Canada, 2022).

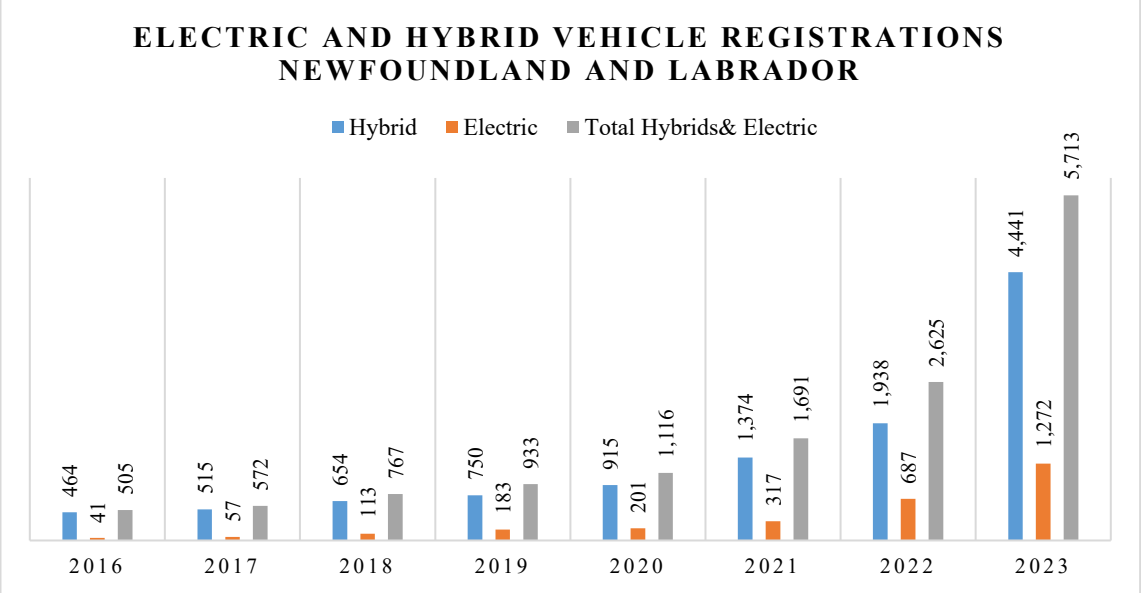


Figure 6: Number of Hybrid (All Types) and Electric Vehicles Registered in NL (Source: Adapted from Government of NL, n.d.a)

Between 2016 and 2023 (as depicted in Figure 6), the number of registered all-electric vehicles (BEVs) surged 31-fold, whereas the annual registrations of hybrid vehicles (all types) rose by 9.5 times. This trend highlights a substantial shift towards electric and hybrid vehicle adoption within the automotive market during the specified timeframe (Government of NL, n.d.b).

[10] This is ignoring the discrepancy regarding the method of measuring the statistics of hybrid vehicles between the provincial government and the federal government. That is, the NL rates may include HEVs, while the Canadian rates do not.

2.5. Identification of Factors Contributing to Electric Vehicle Adoption

Although the prospects for the growth of the ZEV worldwide market seem to be promising, there are still a variety of barriers that are preventing their widespread adoption. A significant increase in EV sales could be expected if governments accelerate their efforts toward achieving their climate change goals (Xue, Zhou, Wu, Wu, & Xu, 2021; Christidis & Focas, 2019). However, the barriers to carbon-neutral transportation differ between regions. In particular, as it is indicated by IPCC (2014b), the characteristics of motorization[11], current infrastructure, and the various processes involved in urban development differ from one region to another. Therefore, to develop policies for decarbonization of the transport sector, policymakers must examine the regional, financial, sociological, cultural, and legal factors that affect the actual EV market within their jurisdiction.

The growth of the EV market involves a variety of actions taken by various stakeholders (Slowik & Lutsey, 2018). But the International Energy Agency points out that governments are the main driving force behind the growth of EV adoption, and their policies are the tools they use to accomplish this (Xu, Wang, Li, & Zhao, 2020). Nevertheless, the design of these policies requires input from several organizations, turning the development of EV adoption into a complex policy problem (IEA, 2021b). Local conditions and regional changes mainly contribute to the decision to adopt EVs. Accordingly, government policies for promoting the use of EVs should be tailored to local conditions and regional specifications (Christidis & Focas, 2019). Policymakers are better equipped to formulate appropriate policies if they identify the local and regional factors that influence EV adoption (Christidis & Focas, 2019).

[11] Adoption and use of motor vehicles as an essential component of the economy and daily life is known as motorization (Gorham, 2017).

As part of its long-term commitment to accelerating ZEV adoption, the Canadian federal government has established a mandatory target of 100 percent ZEVs for light-duty vehicle sales by 2035. As part of the new national emissions reduction plan, one in five new vehicles sold by 2026 must be zero-emission vehicles. By 2030, the target is to be 60 percent zero-emission vehicles (EKOS, 2021). Increasing the demand for EVs will not happen on its own. To reduce the carbon footprint of the transportation system, the federal, provincial, and territorial governments of Canada will need to collaborate on the implementation of policies and initiatives that encourage the adoption of EVs (Pollution Probe & The Delphi Group, 2018; Dunskey Energy Consulting, 2020). Axsen and colleagues (2016) concluded that while policy support for EVs should be considered at the national, provincial, and municipal levels, policies at the provincial level are the most effective ones. Quebec, British Columbia, and Ontario have shown that provincial policies have a marked impact on adoption in the Canadian context (Dunskey Energy Consulting, 2020).

The adoption of EVs has been hampered by various barriers that prevent them from being widely accepted worldwide even though they provide a lot of environmental benefits. Many studies demonstrate that there are obstacles to EV adoption in different regions of the world (Khandakar et al., 2020). In order to gain a better understanding of factors generally contributing to EV adoption, I conducted a review of 36 similar studies. A number of studies focus exclusively on psychological determinants, whereas others concentrate primarily on socioeconomic determinants. A large number of similar studies were systematically reviewed in two studies which are briefly discussed below. Coffman et al. (2017) conducted a systematic literature review which reviewed 50 peer-reviewed studies about the factors that contribute to the adoption of EVs and determined that there are two groups of factors that have an impact on this adoption (See Figure 7). The first group is related to EV technological performance and attributes such as driving range, vehicle ownership cost, and charging time.

The other group comprises external factors such as consumer characteristics, fuel price, charging network reliability and availability, and public visibility. In the other systematic literature review, Singh et al. (2020) evaluated 211 studies in this area and identified four categories of factors: demographic, situational, contextual, and psychological (See Figure 8).

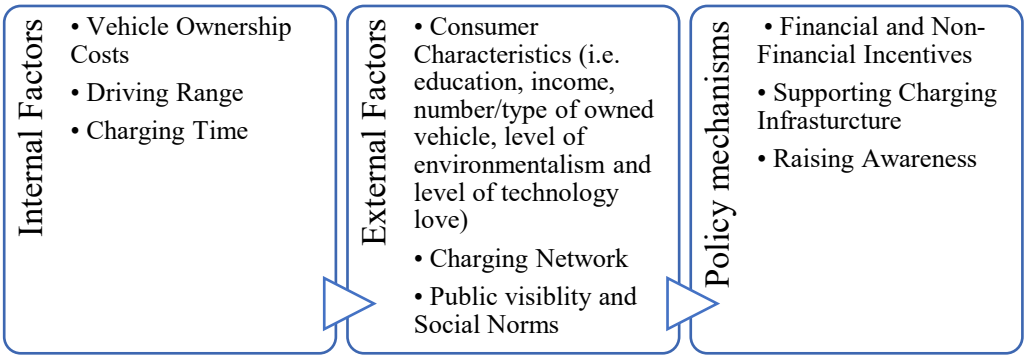


Figure 7: Classification of Factors Influencing EV Adoption (Source: Adapted from Coffman et al. 2017)

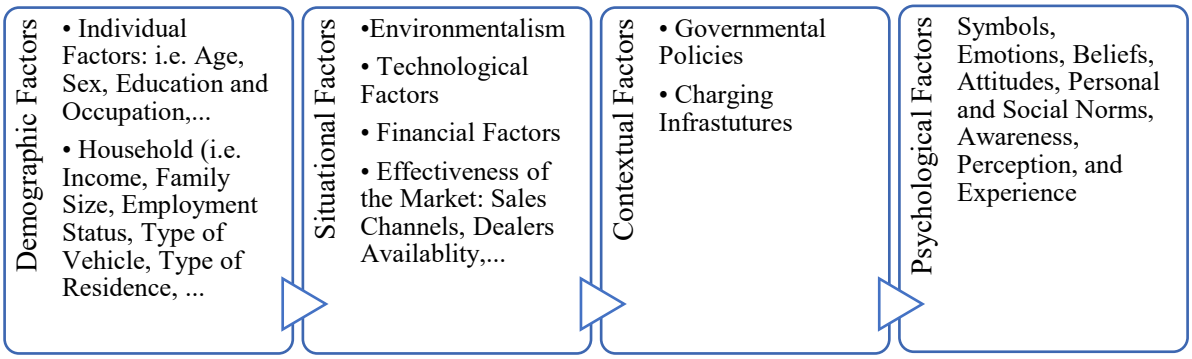


Figure 8: Classification of Factors Influencing EV Adoption (Source: Adapted from Singh et al. 2020)

For the purpose of conducting a literature review in this thesis and identifying the critical and strong influencing factors on EV adoption, the classification used by Singh and colleagues is used as a basis; their classification has been derived from a review of a substantial body of scholarly work (211 studies). Additionally, their classification is much more comprehensive than Coffman et al.'s classification because it considers a broader range of factors, such as market conditions and human-related factors, such as psychological factors and demographic factors. The following sections provide an overview of the results of previous studies, based on Singh et al.'s classification.

2.5.1. Demographic Factors

According to Singh et al. (2020), the demographic characteristics of buyers have been categorized at two levels, individual and household. At the individual level, sex, age, education, occupation, and marital status have been examined. Factors associated with a household include household income, employment status, home ownership and type of residence, household composition (i.e., family size, number of members in the house, number of children), number of vehicles, vehicle types, population density.

Studies on the role of demographic factors in EV adoption have yielded inconsistent results, and it is unclear which factors play significant roles and which do not make a difference. For instance, a consumer's income, education, and age have varying degrees of significance in determining whether they will consider purchasing an EV (Coffman, Bernstein, & Wee, 2017).

In terms of level of education attainment, several studies concluded that the more educated a person is, the more likely they are to purchase EVs (Carley et al., 2013; Hackbarth & Madlener, 2013; Hidrue et al., 2011, as cited in Coffman, Bernstein, & Wee, 2017). Similarly, according to a study conducted in Sweden, 77% of those who have purchased EVs hold higher education degrees or have attended some kind of higher education (Vassileva & Campillo, 2017, as cited in Christidis & Focas, 2019). The adoption of EVs is also heavily influenced by demographic characteristics such as education level, as evidenced in a study by She et al. (2017). In more precise terms, individuals who possess a high level of education and have a thorough understanding of the advantages of EVs tend to prefer EVs over vehicles with a gasoline engine (She et al., 2017).

Several studies have suggested that economic variables such as income, employment level, and employment status can significantly influence adoption intentions. A study

conducted in Sweden observed that owners of EVs typically have a high degree of purchasing power, and wealthier countries adopt EVs earlier (Vassileva & Campillo, 2017). As reported by Xue and colleagues (2021), national income per capita, the prices of gasoline, and electric power are strongly associated with the adoption of EVs. But on the other side, a number of studies have reached completely opposite conclusions. Therefore, understanding the complexities of economic factors in shaping EV adoption intentions requires careful consideration of divergent perspectives within the literature. Based on the findings of Hidrue et al. (2011), a higher income is not associated with a higher likelihood of being "EV-oriented" among the U.S. respondents. It is stated even in another study that there is no correlation between the market share of EVs and per capita income (Lévay, Drossinos, & Thiel, 2017, as cited in Christidis & Focas, 2019).

However, one remarkable aspect of the affordability of EVs is that low income still presents an obstacle to their popularity, as EVs are currently more expensive than ICEVs despite the various incentives offered to reduce their purchase price. In many countries, this contributes significantly to their low market share (Christidis & Focas, 2019; Xue, Zhou, Wu, Wu, & Xu, 2021). There is, however, a possibility that income will play a less significant role in the adoption of EVs in the future. This is because they become more readily available and technological advances lead to a reduction in vehicle prices (ibid).

In addition to other demographic factors, the number of vehicles in a family has been found to be one of the determinants of adopting EVs. This is based on almost identical results reported in different studies. Hidruea et al. (2011) and Zhang et al. (2018) found that families with more than one vehicle were less likely to adopt EVs.

The level of urbanization of a person’s place of residence can also influence their uptake of EVs. Javid and Nejat (2017) proved in their research that density (level of urbanization)

has a significant impact on the demand for EVs, meaning that with a 1% increase in density, demand for EVs increases multi-fold. As a result of a study conducted by Christidis & Focas (2019), among 26,500 respondents in the Europe, it has been determined that the desire to adopt EVs is strongly correlated with income, education, and urbanization level. Another analysis of six large European countries identified that young people and urban residents are the most likely demographic to purchase EVs (Vilchez et al., 2018). Vassileva & Campillo (2017) argue that in Sweden although 40% of all EVs are registered within Stockholm County, only 8% are located within the city and the remainder in the suburbs.

As a whole, the literature on the demographic characteristics of potential adopters of EVs is far from conclusive, and demographic factors may or may not significantly affect a decision to purchase an EV. The reviewed literature recognizes the fact that demographic characteristics can matter for the purchasing intentions of consumers (Christidis & Focas, 2019; Singh, Singh, & Vaibhav, 2020) and most research findings, however, emphasize the impact of income, education level, place of residence, and urban level among other demographic factors. But all in all, it is noteworthy that according to Mohammed et al. (2016), socioeconomic and demographic factors alone are not sufficient to provide a comprehensive analysis of the EV market; additional factors must also be taken into account.

2.5.2. Situational Factors

As classified by Singh et al. (2020), the situational factors that influence the choice to use EVs include environmental factors, technological factors, financial factors, and the effectiveness of the market.

a) Environmental Factors

Environmental factors are those factors that are derived from a concern for the preservation of the environment and may impact the decision of purchasers. The effects of

reducing air pollution, greenhouse gas emissions, climate change, environmental impacts from the manufacturing process, and the electricity consumed by these cars and their origin, as well as sustainability and the consumption of natural resources, are included among these factors (Singh, Singh, & Vaibhav, 2020). Environmental factors were found to be a determinant of consumer decision but not as strong as the financial factors and charging infrastructure. For instance, as determined in a survey conducted by Natural Resources Canada among 3,449 Canadians in 2021, the majority of Canadians believe ZEVs are environmentally friendly and in the opinion of 61% of respondents, ZEVs reduce GHG emissions but this point has not been so decisive to encourage them to use ZEVs because they still believe that ZEVs are not affordable and difficult to charge (EKOS, 2021). In addition, the performance of EVs has raised consumer concerns more than their environmental benefits meaning that consumers have not yet been sufficiently captivated by environmental benefits (Hidruea, Parsons, Kempton, & Gardner, 2011; Muslim et al., 2018, as cited in Yang, Zhang, Fu, Fan, & Ji, 2018; Rowe et al., 2012, as cited in Coffman, Bernstein, & Wee, 2017). The findings of a survey that was conducted in Hong Kong indicate that respondents acknowledge that EVs have positive effects on the environment, but they are reluctant to purchase them since they are quite expensive (Delang & Cheng, 2013). While the environmental benefits of EVs do not appear to be primary motivators for purchasing EVs in the research described above, it seems that this factor may be influential. As Jensen et al. (2013) concluded in their research, there is a positive relationship between environmental values and the preference for EVs.

b) Technological Factors

An essential aspect of EVs affecting purchase decisions is their operational characteristics (Christidis & Focas, 2019). These factors were classified by Coffman et al. (2017) as non-financial internal barriers relevant to the properties of vehicles. In their

literature reviews, Singh et al. (2020) and Khandakar et al. (2020) identified several factors including driving range, speed, automatic transmission, battery life, reliability in various climate conditions, safety, charging time, overall performance and power of the vehicle, design, and style of EVs. Besides financial concerns, which will be discussed in the following section, a limited driving range and a lengthy charging time are cited as the main obstacles to the use of EVs (Coffman, Bernstein, & Wee, 2017; Hoen & Koetse, 2014; Tiwaria, Aditjandra, & Dissanayake, 2020).

Potential purchasers of EVs express a common fear due to the limited driving range. More precisely, they worry that they will be left without transportation and electricity to recharge their empty batteries. This fear is commonly called “range anxiety” (Christidis & Focas, 2019; Yang, Zhang, Fu, Fan, & Ji, 2018). The literature regarding driving range anxiety contains some inconsistencies and some authors regard it as a psychological phenomenon. For instance, White et al. (2022) reported that range anxiety is a psychological construct that is characterized by a feeling of the stress associated with the expectation that an EV might not be able to operate within its range. They instead developed the term perceived mobility restriction (PMR) to describe the level of mobility conferred by a battery EV. The concept of mobility refers to the extent and type of travel that can be accomplished. As a result, the authors concluded that PMR differs from range anxiety; whereas range anxiety identifies worry which is related to the emotions associated with an EV, PMR refers to level of satisfaction with the range of an EV.

Driving range has demonstrated to be a critical factor for consumer intention when purchasing an EV. In a survey conducted by Carley et al. (2013), over 70% of respondents considered the limited range a disadvantage. It is noteworthy that this survey was conducted only in urban areas, a group less likely to be concerned about driving range than those in suburban or rural settings. Based on the results of the survey, the authors concluded that

limited driving range negatively correlates with purchase intentions. Castrol Corporation (2020) conducted a survey of nearly 10,000 consumers worldwide in 2020; eight out of ten respondents considered range to be one of the most important factors in purchasing an EV. An EV capable of travelling 469 kilometers between charges would be attractive to consumers, according to this survey. Khandakar et al. (2020) cited a survey by Coffman et al (2015) indicating that 70% of customers prefer plug-in hybrids over battery cars, proving that consumers place a high value on the range of their cars. Essentially, if the consumer is given the option of choosing between more range and greater environmental efficiency, they will prefer the former and place a lesser emphasis on the latter. In light of this research, it has been concluded that EVs will be more widely used in the future when cars with a longer range and a shorter charging time are available (Khandakar et al., 2020).

Scholars have suggested that appropriately planned and installed charging stations could maximize the functional range of EVs and reduce concerns about range and charging time (Yang, Zhang, Fu, Fan, & Ji, 2018; Newmotion, 2020; Tiwaria, Aditjandra, & Dissanayake, 2020). On top of that, many recent technological advances have improved the driving range to about 830 kilometres, dedicated to Lucid Air, the Dream Edition by the American EV manufacturer, Lucid Motors, sold in 2022 (Wallace & Irwin, 2022). Therefore, it is expected that technological advancements in the near future will alleviate concerns about range. Also, many owners of EVs have attested to the fact that the range of their cars is sufficient for their daily needs (Newmotion, 2020). So, the dissemination of information regarding the adequacy of battery ranges for daily use may also have an influential impact on reducing the level of concern regarding car ranges in the future. Newmotion (2020) emphasizes that according to the current range of EVs for daily commuting, only 20% of the battery is used and, if charging facilities are provided at work and home, there should be little concern about low battery range.

Other technological specification like reliability, safety, comfort, and maintenance-related issues, take major consideration over automatic transmission or brand, as investigated by O'Neill et al. (2019) in Ireland. Another research carried out in Thailand showed that people placed more weight on safety and performance aspects as opposed to financial factors (e.g. the purchase cost, fuel costs, and operation costs) when making a purchase decision (Thananusak, Rakthin, Tavewatanaphan, & Punnakitikashem, 2019).

Another common hesitation that people have when it comes to EVs is the performance of the cars in cold weather, which is just as important as range anxiety (Pratt, 2021). When it comes to climate-related reliability, 79% of respondents in the NRCan survey in 2021 indicated that they would be willing to purchase or lease a ZEV if it could be proved to be reliable under Canada's cold conditions (EKOS, 2021). A survey conducted by KPMG (2022) asked over 2,000 Canadians about their concerns regarding EVs, and one of the most interesting findings was that 64% of surveyed Canadians believed that EVs would not withstand the winters in the country.

A study conducted by the Norwegian Automobile Federation, as cited by Pratt (2021), demonstrated that EVs could suffer a 20 percent reduction in range during cold weather, particularly if the temperature is -7 °C or lower. There can also be a longer process of recharging during the summer months due to the heat. Thanks to the advancements in battery technology, many EVs have battery ranges exceeding 322 kilometers, and this number tends to increase from model year to model year (Pratt, 2021). Some vehicle manufacturers, such as General Motors, Ford, and Toyota Canada, have cold-weather test facilities in Canada to test ZEV cold-weather performance (Pollution Probe & The Delphi Group, 2018). However, this is still a serious concern when dealing with an older EV that has lost some of its range with age (Pratt, 2021). It might be more advantageous to consider a plug-in hybrid if, for example,

the climate is too harsh for an EV, due to combining electric power with an internal combustion engine to cover long distances and extreme temperatures (Pratt, 2021).

As outlined in the Castrol survey (2020), respondents ranked charging time as the second-greatest obstacle to the mainstream adoption of EVs. Again, a well-designed charging infrastructure also contributes to consumer expectations regarding charge times and the location, timing, and method of charging. Education is essential with regard to how consumers can integrate EV charging into their daily lives.

c) Financial Factors

Various studies have examined the financial factors that influence the uptake of EVs (also known as consumer economics), such as the purchase cost, the operation cost, the fuel cost, the battery cost, the technology cost, and the overall savings.

The high purchase prices of most BEVs are cited in consumer surveys as a major barrier to adoption, even with government subsidies (Parker et al., 2021). The purchase price of a typical BEV remains approximately $7,000 to $16,000 more expensive than an equivalent ICEV, despite the declining battery prices (Parker et al., 2021). Total Ownership Cost (TCO) is a metric that researchers use to compare the costs of EVs and ICEVs. Purchase prices and fuel savings are not the only factors to consider when considering ownership costs. There are also significant costs that are associated with vehicle ownership, such as maintenance, insurance, taxes, and resale value (depreciation). TCO encompasses the overall costs involved in owning a vehicle for a set duration, covering initial purchase costs, ongoing operational costs, and the resale value (Parker et al., 2021).

Logtenberg et al. (2018) conducted a study comparing the fuel and maintenance costs of EVs and ICEVs in Canada. Based on their findings, BEVs in most of Canada are significantly more expensive than ICEVs in terms of up-front costs. EVs, however, become more cost-

effective when maintenance costs are taken into account. Because BEVs have fewer moving parts than ICEVs, they do not require oil changes or timing belts, and their regenerative brake system prolongs the life of their brake pads, so they require less maintenance than ICEVs. Logtenberg and colleagues (2018) concluded that BEVs offer lifetime savings of $32,052 compared to ICEVs on average in Canada, considering that the average car life expectancy is 250,000 kilometers. Therefore, BEVs are more appealing investments due to their reduced maintenance requirements and lower fuel costs (electricity versus gasoline).

In light of the above-mentioned facts, Pollution Probe & the Delphi group (2018) reports that upfront purchasing costs are among the most important factors for Canadians when making decisions and that these higher capital costs can be a deterrent. There is a tendency among consumers to be more concerned about the initial cost of a vehicle than the total cost of ownership. It is the initial price that should be considered the barrier, not the operating costs (Castrol, 2020; Dunskey Energy Consulting, 2020). Consequently, Castrol (2020) proposes that for achieving widespread EV adoption, the discussion of cost should be shifted to the total cost of ownership rather than the upfront cost of the vehicle. Nevertheless, the fact remains, however, that many consumers cannot afford the initial cost of EVs, and regardless of their perception, this is a simple matter of affordability. Several income classes do not possess such savings or qualify for a loan. This issue is expected to be addressed by government subsidies and low-interest loans in the future to alleviate the pressure.

Additionally, as stated by Ewing and Boudette (2022), most analysts believe that the popularity of EVs will not occur until the up-front cost of EVs is comparable to that of gasoline vehicles. So that, many governments throughout the world are providing or extending fiscal incentives to support and promote EV purchases (IEA, 2021a).

The resale value of an EV is another factor that prevents consumers from buying one, as reported by 57% of respondents in the Castrol survey (2020). Due to the rapid pace of technological advancement, consumers are becoming increasingly concerned about technology discontinuity (Castrol, 2020). The resale value of a vehicle can be affected by a number of factors, including its specification, range, brand and model, condition, and cost of maintenance (Wróblewski & Lewicki, 2021). As a result of their high battery replacement costs, EVs, however, tend to lose value more rapidly than ICEVs. In addition, resale values for EVs are unclear in their early stages of adoption, which makes the ownership of EVs more uncertain than that of ICEVs (Alotaibi, Omer, & Su, 2022). The resale value guarantee (RVG) strategy has been implemented by some EV manufacturers to reduce consumer resale anxiety. An RVG strategy offers EV consumers the opportunity to return their used vehicles to the manufacturer at a fixed price through a product return program (Zhang & Zhao, 2021).

Prices of fuel play an important role in determining market share of different types of vehicles as well as consumer preference when it comes to purchasing vehicles with lower emissions. A higher fuel price results in a faster return on the up-front investment for consumers, while a lower fuel price will require longer times to recover the initial cost increase associated with fuel saving technologies due to reduced fuel consumption (Environment and Climate Change Canada, 2018). There is no doubt that the unprecedented high gas prices in 2022 have prompted many individuals to consider purchasing EVs. According to AutoTrader.ca, the number of car shoppers requesting information about purchasing an EV jumped 567 percent in March of 2022 as compared to March of 2021 (Redekop, 2022).

d) Market Effectiveness

Several aspects of the sales chain, including sales channels, after-sales service, advertising and promotion, dealer inventory, as well as the range of available models and brands, contribute to the widespread adoption of EVs (Castrol, 2020; Singh, Singh, & Vaibhav, 2020). A major factor contributing to the growth of EV uptake is the expansion of model availability. To continue development of the EV market, there is a need for more EVs in more segments of the broader auto market, particularly vehicles with lower costs and a longer range (Slowik & Lutsey, 2018). As a promising factor for the EV market, the automotive industry is contributing to the effort. In 2020, a number of major manufacturers announced that they have begun ZEVs' mass-producing in a variety of models (Dunsky Energy+Climate Advisors, 2021) in order to satisfy the needs of a wide range of consumers. Throughout the years, battery prices have decreased at a remarkable rate, and it appears that they may continue to do so, leading to more models with low prices in the future (Loveday, 2021). Castrol (2020) demonstrates a positive statistical correlation between model diversity and EV adoption through the study, indicating that over half of consumers intend to switch to EVs provided that EV of equal quality is available to them as their favourite ICEV. EV adoption in Nova Scotia is outlined in Dunskey Energy Consulting's (2020) study. The limited stock availability of EVs at local dealerships in 2020 as well as the long waiting times (for instance, 10 months for the Hyundai Kona) are recognized significant barriers in the above mentioned study in Nova Scotia, evidenced by the fact that only 1 out of 10 dealerships have EVs to purchase, as well as a complete lack of certain models. Upon conducting research on 3,500 EV owners, Plug in America (2021) concluded that most of the respondents (85%) had adequate access to internet resources for finding information about purchasing or leasing EV. Among respondents surveyed about their buying experiences from dealerships, only 40%

considered the dealers to have sufficient knowledge in selling these cars, which indicates the importance of improving dealer knowledge and experience.

Pollution Probe & the Delphi Group (2018) reports that purchasing experience management also plays a vital role in the market for EVs. They emphasize that Canadians perform research before making a vehicle purchase, and this research usually includes online reviews, discussions with colleagues and dealers, as well as test drives. Clearly, in many cases (in that Canadian study), people cannot get information from dealers about the advantages and disadvantages of these cars due to insufficient dealer knowledge, and on the other hand, there are no cars for demonstration . An automobile dealership must obtain a license to sell these cars, which involves a significant investment in training staff, providing specialized tools, and providing charging infrastructure. Although the situation has improved in the leading provinces since then, it is still a challenge in emerging markets such as the Priarie and Atlantic provinces.

2.5.3. Contextual Factors

According to Singh et al. (2020), contextual factors cover governmental policies and charging infrastructure. The government can stimulate the uptake of EVs with a variety of policies that fall into either the supply-side or demand-side category (Axsen, Goldberg, & Melton, 2016). Policy measures designed to increase the demand for EVs are known as demand-focused policies. The development and sale of EVs are encouraged or required by supply-focused policies such as those affecting auto manufacturers and dealerships. Most common policies cited in the literature are illustrated in Figure 9.

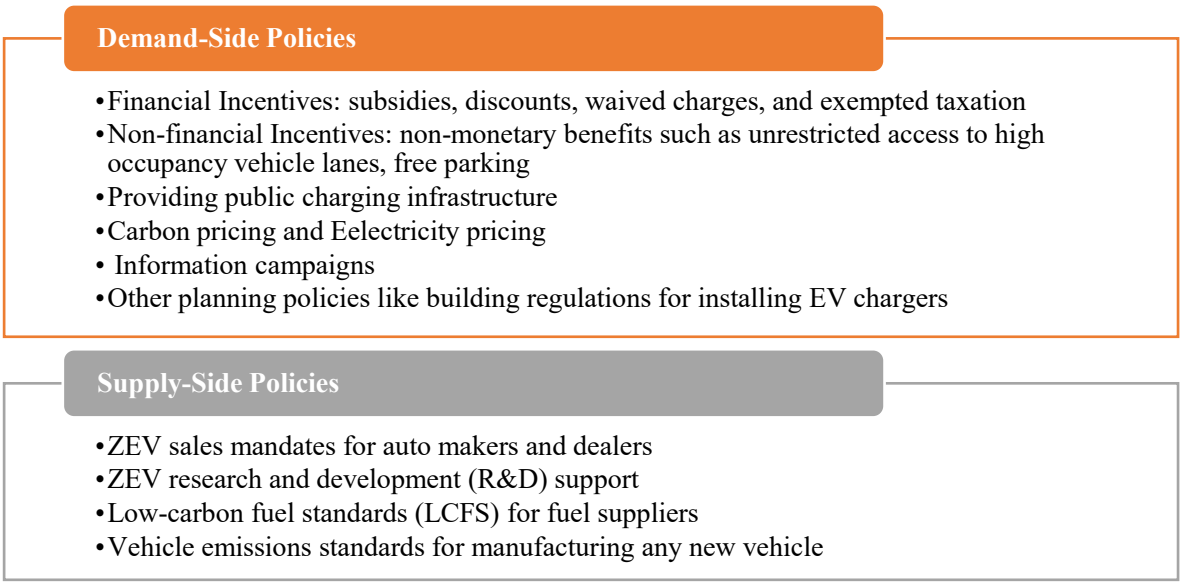


Figure 9: Most Common Policies Cited in Literature (Source: Adapted from Axsen, Goldberg, & Melton, 2016; Clean Energy Canada, 2020; Coffman, Bernstein, & Wee, 2017; Xue, Zhou, Wu, Wu, & Xu, 2021; IEA, 2021a)

The influence of actions to support the uptake of EVs on user choice has been studied extensively by many scholars (e.g. Christidis & Focas, 2019). The uptake of alternative energy in transport can be enforced through regulations or wider public promotional measures (IPCC, 2014b). In many countries, a combination of monetary and non-monetary measures has been used to promote the adoption of EVs (Christidis & Focas, 2019; Xue, Zhou, Wu, Wu, & Xu, 2021). As the country with the highest percentage of EVs in Europe, Norway has invested heavily in promoting the demand for EVs through strong financial incentives (i.e., tax exemption, road toll exemption, free ferry tickets, free parking, and access to bus lanes). Combined with financial penalties for ICEVs, the EV purchase price was reduced by 50% and extensive public charging systems have been implemented (Axsen, Goldberg, & Melton, 2016; Christidis & Focas, 2019). In a study comparing PHEVs policies across 13 countries from 2008 to 2014, Wesseling (2016, as cited in Xue, Zhou, Wu, Wu, & Xu, 2021) concluded that infrastructure investments; sales incentives; and research, design, and development (RD&D) subsidies play key roles in promoting PHEVs. In Wee and colleagues' (2018) study,

they examined different policies in 50 U.S. states and found that different mixes of policies in the form of subsidies contribute to an increase in EV registrations in those states.

In terms of designing policies for EV promotion, Xue et al. (2021, p. 4) in their study elaborate that a country or a territory must have "a stable policy framework and adequate incentive mechanisms in order to experience long-term and reliable market conditions for EVs" but for this framework to succeed, the socio-economic factors within the region must be taken into account. For instance, while the government has the option of reducing the purchase costs of EVs by offering financial incentives, low income still remains a barrier to widespread adoption of EVs. Therefore, financial policies can be developed based on income levels in order to increase the likelihood of EVs becoming more popular in the future. The high rate of correlation of income levels for EV uptake is one of the most overlooked factors for the formulation of EV policies (Xue, Zhou, Wu, Wu, & Xu, 2021).

Developing public charging infrastructure for EVs is a popular policy instrument (White, Carrel, Shi, & Sintov, 2022). IEA (2021a) agrees that the increasing number of EVs will require convenient and affordable public chargers. By investing directly in charging infrastructure or providing incentives to EV owners, governments have helped to address this issue. According to a survey by Khandehkar et al. (2020), more people will transition to EVs if charging infrastructure is easily accessible. The majority of respondents want charging stations to be available in a variety of locations, including offices, residences, and highways. The findings of White et al. (2022) indicate that the more public charging infrastructure a region has, the more likely it is to adopt EVs, and it increases EV purchases when more public charging stations are made available. Maintenance of this public service is also critical, as most EV owners commented in Plug in America's (2021) survey that they have encountered frequent frustrations with charging stations that do not function properly because they are damaged or out of order.

2.5.3.1. Exploring Electric Vehicle Promotion Policies: Case Examples from Different Jurisdictions

A) Demand-side policies play a significant role in encouraging the adoption of EVs, particularly through purchasing incentives aimed at both individual consumers and businesses (Gaede, Nippard, Haley, & Linders, 2022). Recent study by Canada Efficiency Center (2022) highlights the efficiency of these incentives when they extend beyond the conventional scope, covering not only new vehicles but also encompassing used vehicles and non-automotive options like e-bikes. This more comprehensive approach not only ensures fairness and equity but also maximizes the impact of such policies.

Taking a closer look at the Canadian landscape, rather the federal government incentives, various provinces are offering incentive programs, each with its own characteristics for both new and used EVs (Plug 'N Drive, n.d.). Used EV incentives are available in provinces and territories such as Quebec, Yukon, Prince Edward Island, British Columbia, Nova Scotia, New Brunswick, and NL (Gaede et al., 2022). For instance, Quebec leads the way by providing substantial support for used EVs, with incentives of up to $3,500 (Gouvernement du Québec, 2023; Plug 'N Drive, n.d.). In contrast, Yukon's incentive of up to $1,500 is designed to encourage used EV adoption (Government of Yukon, n.d. a). When it comes to new vehicles, Quebec again offers one of the most significant incentives, reaching up to $8,000 per vehicle (Gaede et al., 2022). Similarly, Yukon and Prince Edward Island provide attractive incentives of up to $5,000 for new EVs (Government of Prince Edward Island, 2023; Government of Yukon, n.d. b), while New Brunswick and Nova Scotia and NL offer up to $5,000 (Énergie NB Power, n.d.), $3,000 (EVAssist Nova Scotia, n.d.), and $2500 (Newfoundland and Labrador Hydro, n.d. a) respectively. Currently, Ontario's incentive program is on temporary hold (Jabakhanji, 2022; Plug 'N Drive, 2018), underscoring the dynamic nature of policy implementation.

When EV purchase incentives include income eligibility criteria, they are more effective, ensuring financial aid reaches those who need it most (Clean Energy Canada, 2022; Thorn, 2022). Research by Sheldon & Dua (2019) suggests that programs that target households with lower incomes benefit households twice, compared to those that do not take income into account. A clear example of this policy comes from British Columbia, where, in 2022, the government introduced income requirements for their EV rebate program (BC Gov News, 2022). Certain incentives for the purchase of EVs were not available to individuals and households earning more than $100,000 per year (individuals) and $165,000 (households) (BC Gov News, 2022). Similarly, the U.S. has revised its federal EV policy through the Inflation Reduction Act (IRA), which replaces the standard rebate with a USD 7,500 tax rebate that includes income thresholds of USD 75,000 per year for individuals and USD 150,000 for households (Clean Energy Canada, 2022).

Clean Energy Canada in its 2022 report recommended the adoption of a revenue neutral feebate system for Canada (Clean Energy Canada, 2022). Wappelhorst (2022) defines this system as an innovative concept, often referred to as “bonus-malus programs”, which charge the owners of high CO_2 emission vehicles and allocating the receiving funds to incentivize the purchase of low or zero emission vehicles. Wappelhorst (2022) brought France as a leading example, with this approach more than 14 years ago, incorporating CO_2 emissions and vehicle weight for passenger cars into their bonus-malus system. In a parallel move, Sweden introduced a comparable system in 2018, encompassing a diverse range of vehicle types.

As previously discussed, creating a network of EVs charging stations is another vital policy step after providing purchase incentives. This network ensures that people can confidently travel all over the country, from highways and cities to remote and rural areas (IEA, 2021a). Efficiency Canada in its 2022 analysis suggests two important factors for planning where to put chargers: how many chargers there are per capita and how many there

are for every kilometer of road (Gaede et al., 2022). Gaede and their colleagues (2022), by looking at charging stations in the U.S. reported having stations about 70 miles (112 kilometers) apart is enough for EV drivers to feel comfortable taking long trips. This translates to roughly one charging station for every 100 kilometers. Applying this idea, Quebec has around 6.5 chargers for every 100 kilometers of road, while Newfoundland and Labrador have 0.9 chargers. When it comes to per capita basis, Quebec has 7.5 chargers for every 10,000 people, compared to Newfoundland and Labrador's 1.8 chargers (ibid).

Since the majority of EV charging, around 80%, takes place at home, offering incentives for home EV chargers can play a significant role in motivating people to make the switch to EVs (ChargeHub, 2022). While the NL government has not yet introduced incentives for home EV charger installations, businesses and owners of public service centers can benefit from incentives ranging from $5,000 to $15,000, depending on the charger type (Newfoundlad and Labrador Hydro, n.d.b). In contrast, provinces like Quebec and British Columbia offer some encouraging programs to promote home charger installations among EV owners, and municipalities provide supplementary incentives that complement provincial efforts (ChargeHub, 2022).

Governments can boost the adoption of EVs by requiring EV charging infrastructure in new homes through building codes and enabling local governments to mandate such provisions in new developments via zoning bylaws (IEA, 2021a). This integration aligns transportation and building infrastructure, enhancing energy efficiency policies. Provinces can further support municipalities through legislation, model bylaws, and best practices sharing (Gaede et al., 2022). The Governments of British Columbia and Québec have empowered municipalities to create their own rules for EV chargers (ibid). Vancouver, for example, has integrated EV charger requirements into its parking bylaws (City of Vancouver, 2021), while the City of Québec's 2018 electricity code amendment mandates essential wiring for EV

charging in dwellings with garages (Electric Autonomy, n.d) signifying their commitment to support EV adoption and charging infrastructure. Additionally, Québec also gives municipalities the power to set their own EV regulations, customizing them to their unique urban settings and needs (Gaede et al., 2022). However, NL have not made changes in this regard so far (Kozelj, 2023).

B) Supply side policies: To maintain a balanced and accessible ZEV market, comprehensive supply-side measures like the ZEV sale mandate are essential (Gaede et al., 2022). As defined by Bhardwaj and McBain (2023), these mandates demand a minimum portion of new vehicle sales as ZEVs, promoting electric personal transportation. California was the first jurisdiction that began this mandate in 1990 (Moawad & Wolinetz, 2019).

Similar to California, Quebec as the first Canadian province and British Columbia have already taken progressive steps by implementing ZEV mandates that exceed federal targets (Clean Energy Canada, 2022). Quebec's Zero-Emission Vehicle Act, initiated in 2016 and effective since 2018, utilizes a credit system requiring manufacturers to accumulate ZEV credits based on a rising percentage of vehicle sales (Moawad & Wolinetz, 2019). Similarly, British Columbia's Zero-Emission Vehicles Act, established in 2019, employs a credit system compelling manufacturers to achieve increasing annual ZEV sales percentages (Government of British Columbia, n.d. a). Both provinces have also introduced further initiatives, with Quebec aiming to ban new gasoline-powered vehicle sales after 2035 (Gyulai, 2020) and British Columbia aiming to raise ZEV targets towards 100% by 2035 as part of their CleanBC climate strategy (Government of British Columbia, n.d. b). As of 2022, NL has not introduced any legislation regarding ZEV mandates (Kanduth, 2022).

2.5.4. Psychological Factors

There are several psychological factors influencing the adoption of EVs, which are reviewed in several studies, including symbols, emotions, beliefs, attitudes, personal and social norms, awareness, perception, and experience (Coffman, Bernstein, & Wee, 2017; Singh, Singh, & Vaibhav, 2020).

Many studies have identified the lack of awareness as well as misperception as important obstacles to the uptake of EVs. This lack of awareness is evident in the limited information or even misinformation about EVs, their performance, their charging time, their safety, and also their total cost of ownership (Dunskey Energy Consulting, 2020). According to the surveys on general knowledge about EVs, most people hold inaccurate perceptions about EV purchases (Castrol, 2020; Khandakar et al., 2020). Furthermore, many of the respondents indicated that they were unaware of the incentives available for EVs (Khandakar et al., 2020; Xu, Wang, Li, & Zhao, 2020). A common misconception exists regarding the daily travel range. In their study, Castrol (2020) demonstrated that many people misperceive the distance they travel each day because they do not drive more than the estimated range of an EV on a daily basis. As reported by Jin & Slowik (2017), a consumer survey conducted by the Consumer Federation of America in 2015 found that there was a clear and significant correlation between EV knowledge and a positive perception of EV technology, ultimately leading to the purchase of an EV.

In terms of public visibility, a survey of 8,027 U.S. residents found that people are more likely to purchase EVs if they see more of them in their neighborhoods (Consumer Reports, 2022).

Additionally, social norms and trends can also play a role in influencing EV adoption. Several public transport systems, government vehicle fleets, as well as more EVs on the road

in general can increase EV visibility. Social norms may be seen as an effect of a network, family, friends, coworkers, and also neighbours (Coffman, Bernstein, & Wee, 2017). A survey of more than 500 Australians, led by Davidson (2019), shows that social norms and attitudes toward EVs are the key to encourage greater adoption. According to their study results, the purchase price, operating costs, driving range, emissions, and acceleration time are all factors that influence purchase decisions. The scholar added a noteworthy point that consumers act on the basis of social norms and popular attitudes, such as what their friends and family think, resulting in the need for policymakers and industry to work more closely together to change consumer perception and social acceptance of EVs. When friends and family support a vehicle, it will make a big difference, no matter how good it is or how much it costs.

2.6. Research Objectives and Approach

A significant body of research has been assembled to explore the adoption of EVs. There is a vast array of factors that may influence the adoption of EVs. A number of factors have been implicated in the adoption of EVs by consumers, including the characteristics of the vehicle, sociodemographic characteristics, vehicle preferences, driving habits, market structure and even social trends.

Based on the literature review, Table 1 summarizes the effects of the four categories of factors (demographic, situational, contextual, and psychological) on EV adoption, highlighting the factors with greater emphasis and stronger effects.

Table 1: Summary of Influential Factors in EV Adoption According to the Literature Review

Category	Factors	Possible Effect	Reference
Demographic	Education	People with a higher level of education are more likely to adopt EVs.	(Christidis & Focas, 2019)
	Number of vehicles	Families with more than one vehicle are less likely choose an EV.	(Hidruea, Parsons, Kempton, & Gardner, 2011; Zhang et al., 2018)
	Type of vehicles	If EVs offer similar performance and size to their current ICEVs, people will be more inclined to consider them	(Sierzchula, Bakkerb, Maat, & Wee, 2012)
	Income	The lower a person's income, the lower their EV interest.	(Xue, Zhou, Wu, Wu, & Xu, 2021)
	Population density (level of urbanization)	Living in a more urban location leads to more EV interest.	(Javid & Nejat, 2017; Christidis & Focas, 2019)
Situational	Technological concerns	Limited driving range and lengthy charging time negatively correlate with purchase intentions.	(Tiwaria, Aditjandra, & Dissanayake, 2020)
		Vehicle performance in cold and harsh weather is a barrier to EV adoption, especially in areas with long or intense winters.	(EKOS, 2021)
	Financial concerns	Higher up-front costs lead to a decrease in EV interest	(Castrol, 2020; Dunskey Energy Consulting, 2020)
	Market effectiveness	Economy-wide, there is a positive statistical correlation between model diversity of EVs and their adoption.	(Castrol, 2020)
Contextual	Policies	Pro-EV policies, especially subsidies, contribute to an increase in EV purchases in those jurisdictions.	(Wee, Coffman, & La Croix, 2018)
	Charging infrastructure	Greater availability of EV chargers increases interest in EVs.	(White, Carrel, Shi, & Sintov, 2022)
Psychological	Public visibility	The more that EVs are visibly used and charging stations are visibly available, the greater the increase in further EV interest.	(Consumer Reports, 2022)
	Peer effect and social norms	Social norms and attitudes toward EVs affect EV adoption rates.	(Davidson, 2019)
	Awareness and perception	A consumer's level of knowledge affects their interest in EVs	(Jin & Slowik, 2017)

However, these factors in isolation cannot provide a comprehensive picture of the EV market in a jurisdiction, since designing a framework of policies for widespread uptake requires considering regional circumstances and local changes. In recognition of the above need, this thesis is intended to provide an understanding of consumer insights and the barriers of adoption of EVs in NL. Using insights from different perspectives, this thesis presents a set of possible policy options for improving the low uptake rate in NL.

Chapter 3: Methodology and Research Design

As specified in Chapter 1, the purpose of this study is to investigate the current barriers to public interest in EVs in the province of NL and identify potential policy solutions to increase NL's EV uptake rate. In this section, a brief overview of the research design, data collection, analytical plan, and methodological limitations is presented.

3.1. Research Design

This project employs an exploratory research design utilizing mixed methods. George (2022) defines exploratory research as an investigative process that seeks to gain insights into a research problem. They go on to say that mixed methods are especially useful when it comes to exploratory research, as they can provide a more holistic understanding of the research problem. Combining quantitative and qualitative data allows the researcher to gain insights into the problem from both a numerical and a narrative perspective. Finally, they state that this can help researchers identify patterns and relationships that may not have been evident from one method alone (George, 2022). A mixed-method approach was used to analyze the perceptions of the general public in the province of NL, focusing on both ICEV owners and EV drivers, in order to identify the barriers to widespread EV adoption in NL. This approach was chosen to gain a better understanding of the potential factors that could be inhibiting the uptake of EVs in the province, and how these issues can be addressed. Details of the methodology and research design are summarized in Table 2.

Table 2: Details of Methodology and Research Design

Research Questions	A: What are the barriers to public EV adoption?	B: What are possible policy options for policymakers to overcome negative public perception and improve the current low rate of uptake?
Methodological Approach	Exploratory	

Question Type	Explanatory	Prescriptive
Research Approach	Case Study	
Case	Newfoundland and Labrador	
Data Collection Method	Survey of general public (social media survey)	
Type of Data Required	Mixed qualitative (open-ended questions in the survey) and quantitative data (close-ended questions in the survey)	
Data Analysis Method	Mixed: qualitative (inductive thematic analysis) and quantitative analysis (descriptive and correlational statistics)	

The selection of the case study as the research approach for this study is based on its acknowledged effectiveness in social science research. According to Zainal (2007) it serves as a powerful tool in social science research, offering a closer look at real-world problems. A case study approach involves exploring a specific event or circumstance deeply (Williams, 2022). By examining a case in detail, researchers can identify patterns and relationships. This helps to provide a better understanding of the underlying causes and potential solutions to a given problem. Williams (2022) also added that case studies are especially valuable when dealing with complex topics, such as socio-environmental issues, where multiple factors interact. Running case studies can generate valuable lessons and make research findings more relatable and understandable by using real-life stories.

As described in Chapter 1, the selection of NL as the case study location for this research is driven by several key considerations. A significant amount of greenhouse gas emissions originates from the transportation sector in NL, causing environmental concerns. Despite NL's abundant renewable energy sources, there remains a substantial reliance on petroleum-based fuels for transportation. Furthermore, NL exhibits one of the lowest rates of EV adoption in Canada despite its electricity generation potential and grid readiness. This gap

between infrastructure readiness and EV adoption in NL, considering abundant renewable energy resources, presents an ideal opportunity for exploring public interest in EVs, a field in which limited research has been conducted. Therefore, NL represents an ideal setting to better understand EV adoption barriers.

This research was conducted through a general public survey for several reasons. As it is explained by Kelly et al. (2003), a survey instrument can be used to examine different aspects of a situation or to discover explanations while obtaining valuable data for hypothesis testing. The authors also added that random sampling is typically used in research that collects data through questionnaires. The use of random sampling makes it possible to generalize research findings to the whole population later, ensuring that the sample represents the entire population fairly and accurately.

However, in the specific context of this case study, the utilization of a random sample was not possible due to the inaccessibility of driver contact information held by the Motor Registration Division of Service NL. Therefore, a voluntary sample was recruited through social media channels as an alternative approach. The process of volunteer sampling involves actively seeking volunteers through personal invitations, online recruitment (e.g., social media), public announcements, etc. (Moss, Rosenzweig, & Litman, n.d.).

A combination of quantitative and qualitative data is suitable for this particular case study as it enables a comprehensive grasp of the research issue. In testing hypotheses, quantitative data can be valuable, but it may overlook context-related factors (Jehanne, 2023). This is why qualitative data is useful when exploring a context or case, such as NL for this thesis. According to Tenny and colleagues (2022), qualitative data allows the researcher to gain a deeper understanding of individuals' attitudes, beliefs, and experiences. By incorporating both qualitative and quantitative data, the researcher can triangulate their

findings and attain a more thorough understanding of the research problem. This will minimize the bias that is more likely to occur when using only a single research method (Bhandari, 2023).

3.2. Primary Data Collection

3.2.1. Research Hypotheses

The literature review conducted in the previous chapter led to a series of hypotheses based on some of the influential factors identified in Table 1. These hypotheses were considered in order to empirically test whether there is a meaningful or significant correlation between probable influential factors and the level of interest in purchasing EVs in NL. Based on the outcomes, legislators and EV industry stakeholders may be able to formulate a more strategic approach for the province. More comprehensive policies could be devised if the key correlations between the most influential factors and the level of interest in purchasing EVs (hereafter EV interest) are taken into account. The following hypotheses are proposed:

- Hypothesis 1: Revealed EV knowledge/awareness correlates positively with interest in purchasing an EV.
- Hypothesis 2: Living in urban areas correlates positively with EV interest.
- Hypothesis 3: Income level correlates positively with EV interest.
- Hypothesis 4: Driving frequency/length (i.e., kilometres driven per week) correlates positively with EV interest.
- Hypothesis 5: Environmental concern correlates positively with EV interest.
- Hypothesis 6: The main type of ICEV vehicle driven affects EV interest (i.e., driving a smaller vehicle correlates positively with EV interest).

Each hypothesis will be explored with a statistical test between two or more sets of survey answers/data. All sets of survey answers/data will also be summarized descriptively, with

basic percentages and averages (see Section 4.1), before the statistical tests (see Section 4.2). However, the thesis also has goals, stemming from the research questions, that are entirely descriptive and do not involve statistical tests. These goals will require some simple descriptive data (see Section 4.1) and/or qualitative data (see Section 4.3). Diverse goals ensure a comprehensive approach to the research questions and help to inform the survey design.

- From the perspective of ICEV drivers in NL

  ICVE Descriptive 1: Collect perceived barriers to EV purchase/use.

  ICEV Descriptive 2: Collect overall level of EV interest, overall perception of ICEVs vs EVs, overall familiarity with EV initiatives, and overall level of environmental concern.

  ICEV Descriptive 3: Collect characteristics of prospective EV drivers among ICEV owners in terms of urbanization, vehicle type, average weekly driving length, age, gender, education, income and household size.

  ICEV Descriptive 4: Collect ideas for policy approaches to increase EV adoption.

  ICEV Qualitative 1: Collect potential reasons for choosing EVs.

  ICEV Qualitative 2: Collect reasons for not choosing EVs as EV adoption barriers.

  ICEV Qualitative 3: Collect ideas for policy approaches to increase EV adoption.

- From the perspective of EV drivers in NL

  EV Descriptive 1: Collect perceived barriers to EV purchase/use.

  EV Descriptive 2: Collect ideas for policy solutions for EV growth.

  EV Descriptive 3: Find the level of satisfaction of owning an EV.

  EV Descriptive 4: Identify the trends in EV market of NL (e.g. which makes are popular).

  EV Descriptive 5: Identify the range of urbanization among current EV drivers.

EV Descriptive 6: Understand charging habits of current EV drivers.

ICEV Qualitative 1: Collect reasons for choosing EVs.

ICEV Qualitative 2: Collect perceived reasons for why others do not choose EVs, as a proxy for EV adoption barriers

ICEV Qualitative 3: Collect ideas for policy approaches to increase EV adoption.

These summaries capture both the perspectives and characteristics of ICEV and EV drivers. It is essential to understand the factors that influence EV adoption to recommend potential policy solutions. Firstly, by gathering information on the perceived barriers to purchasing and using EVs in Descriptive 1, this research gains insights from real-world experiences and concerns providing data that can identify obstacles. Secondly, including summaries that assess levels of interest in EVs, perceptions between ICEVs and EVs, familiarity with EV initiatives, and general environmental concerns (in Descriptive 2 of ICEV Drivers) will provide a view of respondents' attitudes and preferences. This will shed light on the role played by perception, awareness, and environmental responsibility, offering a broader context for understanding adoption decisions.

The collection of data on the characteristics of prospective EV drivers (ICEV Descriptive 3) will also help identify target groups that would benefit from EV adoption campaigns and tailored policies. It is also crucial to gather ideas for policy solutions that can support EV adoption growth. This includes seeking input from both ICEV Descriptive 4 and EV Descriptive 2. By gathering these insights researcher can create suggestions that tackle obstacles to the adoption of EVs and encourage their use in NL. The information obtained from these targets will be further enhanced by the integration of qualitative data.

3.2.2. Key Considerations in Survey Design

Prior to developing the questionnaire, several key points were considered (see Appendix A for a full version of the survey). It was essential to guarantee that the questionnaire covered the variables related to the research hypotheses. This ensures that the questionnaire is designed to collect all the data needed to test the hypotheses. By structuring the questionnaire around the research hypotheses, it guarantees that the questions are focused on the relevant variables and that the data collected can be analyzed in a way that is meaningful to the research.

Secondly, demographic indicators were taken into consideration to determine the demographic profile of the sample. Demographic questions provide a better understanding of the sample, ensuring that the sample is representative of the population. This allows researchers to draw more accurate conclusions from the data collected. For instance, the questionnaire included questions regarding age, gender, education level, and income level, which also helped to identify any potential demographic differences between respondents. However, demographic questions were placed at the end of the survey to avoid unintended priming effects (Dobosh, 2018).

A further consideration was that the questionnaire should examine both the perceptions of ICEV drivers and the lived experiences of EV drivers. This approach can lead to a better understanding of the market and identify differences between those who own EVs and those who own ICEVs. Surveying EV drivers can also reveal as the motivations behind their own purchases (for instance, the relative importance across saving money, protecting the environment, and charging convenience) as well as unique insights into the EV market and help to inform policy and business decisions on a range of topics, such as refuelling and charging infrastructure, environmental impact, and cost savings.

In terms of designing questions, using both closed-ended and open-ended questions should elicit more detailed responses. Close-ended questions can allow for hypotheses to be tested statistically and facilitate straightforward quantitative summaries. Open-ended questions allow participants to provide more detailed answers and express their thoughts freely, which can yield valuable insights that closed-ended questions may not be able to obtain. This can be especially helpful when trying to uncover the motivations behind a certain behavior or opinion. Additionally, open-ended questions can be used to explore topics that may not have been anticipated. All questions must also be designed to be clear and unambiguous so that respondents can understand the meaning and intent of the questions. The questions must be carefully worded so that they are not leading or biased, and the order in which the questions are asked must be planned so that the responses are meaningful. Additionally, the length of the questionnaire must be taken into consideration to ensure that participants are not overwhelmed with too many questions.

3.2.3. Survey Structure

The survey consisted of four blocks: mandatory eligibility in block 0, questions for ICEV drivers in block 1, questions for EV drivers in block 2, and demographic questions (for both types of respondents) in block 3. Separating the questions in this way allows for more accurate responses from participants by providing specific questions for each type of car drivers. It also allows for more accurate demographic data to be collected (i.e., comparing ICEV drivers to EV drivers).

Through block 0 of the survey, two questions determine whether respondents qualify to participate. These questions act as a filter to confirm if the respondent's main residence is in NL and if they have a motor vehicle they use regularly (see Appendix A). By including this section at the beginning of the survey the researcher could make certain that the subsequent

data collected is relevant to the research context and aligns with the objectives of the study. Table 3 and Table 4 describe ICEV drivers and EV drivers blocks. The final blocks on demographic questions are described in the following section.

Table 3: ICEV Drivers Block Structure in the Survey

Topic	Question	Objective
Urbanization	How would you describe the area where you live?	• independent variable of Hypothesis 2 - assessing surrounding population density of residence • ICEV Descriptive 3
Vehicle Type	Of the vehicles your household has, what is the main type of motor vehicle that you drive?	• independent variable of Hypothesis 6 - determination of the primary vehicle type of the respondents • ICEV Descriptive 3
Weekly Driving Range	On average, how much do you drive this vehicle each week?	• independent variable of Hypothesis 4 - determination of participants' average weekly driving distances and their driving habits • ICEV Descriptive 3
Environmentalism	(six Likert-scale questions)	• independent variable of Hypothesis 5 - aggregate measurement of a participant's attitude towards environmental issues • ICEV Descriptive 2
EV Perception	(six Likert-scale questions)	• independent variable of Hypothesis 1 - aggregately assessing participants' perception of EVs versus ICEVs • ICEV Descriptive 2
EV Familiarity	(three Likert-scale questions)	• independent variable of Hypothesis 1 - aggregately assessing participants' knowledge about EVs and relevant initiatives • ICEV Descriptive 2
EV Interest	How likely is it that their next car will be an electric vehicle?	• dependent variable for all hypotheses - assessing level of interest in EVs among participants. • ICEV Descriptive 2, 3
	An open-ended and a multiple-choice question: the main reasons you might choose an electric vehicle	• understanding the factors contributing to EV interest (ICEV Qualitative 1 and EV Qualitative 1)

Topic	Question	Objective
EV Adoption Barriers	An open-ended and a multiple-choice question: the main reasons you might *not* choose an electric vehicle?	• gathering insights into the primary factors or concerns that may discourage individuals from choosing EVs (ICEV Qualitative 2) • ICEV Descriptive 1
EV Promotion Suggestion	An open-ended question of: how can the government better manage the issue of electric vehicles?	• public input through identification of current policy gaps (ICEV Qualitative 3) • ICEV Descriptive 4

Incorporating questions related to environmentalism[12] in the survey serves a twofold purpose. Firstly, it provides valuable insights into how people in the region perceive climate change, fossil fuels, collective action for climate change mitigation, and climate change-related issues specific to NL. This type of question can help to identify areas where people may need more education. Secondly, it can also help to identify areas of agreement and disagreement among the population, which can inform public policy decisions. By understanding the public's opinion, policy makers and other stakeholders can better identify potential areas of public support for green initiatives and help to promote environmental education and awareness.

Additionally**,** measuring people's ICEVs vs EVs perception gives a better understanding of how people view these two types of vehicles in terms of their overall performance, cost, environmental benefits, the affordability of the initial purchase, affordability of maintenance and running costs, driving range, function in winter weather, limiting air pollution, environmentally responsible manufacturing and disposal practices. Information such as this

[12] The concept of environmentalism asserts that humans have a moral and ethical duty to respect and conserve the environment, to act sustainably, and to avoid irreversible environmental damage. It is based on the idea that the Earth is a common home for all living organisms, and that humans have a duty to protect it for future generations (Lovelady & Shrestha, 2019).

assists in identifying potential areas of concern or misconception. Such data is essential for developing strategies to promote EV adoption and address misconceptions in the community.

Furthermore, three topics were covered in the question block on familiarity with EVs: respondents' familiarity with the different types of EVs, their knowledge of available rebates and EV purchasing by the federal and the provincial governments and, finally, whether they are familiar with "takeCHARGE", which is a provincial initiative, promoting and supporting the adoption of EVs throughout the province. Quantifying respondents' familiarity with EV-related information allows the researcher to gain a clearer picture of their knowledge about EVs. Similarly, questions about EV interest and the reasons for this interest (through an open-ended question and multiple choice) give a sense of how the community accepts EVs. The likelihood of respondents considering an EV as their next vehicle and the reasons behind their choices provide valuable insight into EV adoption strategies. Lastly, for EV adoption barriers, through open-ended and multiple-choice questions, participants can express their reasons for not opting for an EV. This approach captures a wide range of barriers, whether they are related to cost, infrastructure, knowledge gaps, or other factors.

Table 4: EV Drivers Block Structure in Survey

Topic	Question	Relevant Objectives
Urbanization	How would you describe the area where you live?	To compare the level of urbanization among ICEV and EV drivers (EV Descriptive 5)
EV Type and Length of Ownership	What type of electric vehicle does your household have?	Identify the trends in EV market of NL (which makes are popular) (EV Descriptive 4).
Level of Satisfaction	How satisfied have you been with this electric vehicle?	Identify variations in satisfaction levels between current EV drivers (EV Descriptive #3)
Charging habits	What types of chargers they generally have access to?	Understanding charging habits and identifying the ways of

Topic	Question	Relevant Objectives
	What percentage of the time do you usually charge your EV at home?	improving the charging infrastructure (EV Descriptive 6)
	How do you plan long trips with their EV?	
Reason for Choosing an EV and Adoption Barrier	Two open-ended questions regarding their reasons for choosing an EV as well as their perceptions of what may prevent other people from purchasing an EV	• To discover the factors that influenced them to adopt EVs and the barriers adopt EVs from their perspective (EV Qualitative 1 &2) • EV Descriptive 1
EV Promotion Suggestion	An open-ended question of: how can government better manage the issue of electric vehicles?	Insights from EV drivers for policy gaps about EVs (EV Qualitative 3) • EV Descriptive 2

The demographic questions in the survey were the same for both types of drivers. The survey asked for age, gender, first three digits of home postal code, education level, household income level, and number of household members. Demographic questions were used for multiple purposes. Their primary purpose was to ensure the representativeness of the survey sample. Additionally, income level was also used as the independent variable of hypothesis 3, along with the postal code information which was used to verify respondent eligibility.

3.2.3. Sampling Strategy, Ethics Approval, and Data Collection

The survey was distributed to the drivers in NL as widely as possible, through social media platforms such as Facebook “Classified” groups (e.g. “Corner Brook Classified”) throughout the province. Posts including the survey invite were made only with the permission of group administrators. The survey was conducted on a volunteer basis and remained anonymous and confidential. The questionnaire was accessed by participants through a shared link and the data gathered using Qualtrics platform. Eligibility was assessed

using pre-screening questions in the online survey. Potential participants included residents of NL that were 19 years of age or older and drove a vehicle.

To determine the appropriate sample size, the Qualtrics sample size calculator was employed. Considering that population of NL aged 19 or over was estimated at 421,810 in 2021 according to the 2021 NL Census profile published by the NL Statistics Agency (2022) and using a confidence level of 95% and a margin of error of 5%, at least 384 is the ideal number for the sample size (Qualtrics, 2020). Hence, the ideal sample size of this survey would be at least 384 participants (i.e., enough to serve as a statistical sample for the population of NL).

However, it is important to note that the sample was not truly random, and response bias may have been influenced by the distribution of the survey through social media. A thorough representativeness analysis in the next chapter will allow for an assessment of how representative the sample is.

A list of potential distribution channels was developed including 73 Facebook "Classified" pages or groups from various communities. It was expected to receive at least 384 usable responses collectively from distribution channels associated with the largest communities and municipalities in NL: Bay Roberts, St. George, Clarenville, Conception Bay, Corner Brook, Deer Lake, Gander, Mary's Town, Massy Drive, Norris Point, Paradise, Pasadena, Peninsula, Placentia, Port Aux Basques, Portugal Cove and St. Philips, St. George, Rocky Harbour, St. Anthony, St. John's, Stephenville, Windsor, and Woody point.

Participants for the survey were invited through the following process: first, the survey invitation was sent to all groups' drivers for permission to post it on their group page; then, the invitation was posted, asking individuals who fit the criteria (i.e., residing in NL, driving a vehicle, at least 19 years of age) to fill out the questionnaire (see the "Recruitment Text" in

Appendix B and “Consent Form” which is the first page of the questionnaire in Appendix A). Two weeks after the date of each initial post, one reminder was posted/requested for that post.

All the filled questionnaires were combined into the Qualtrics database, which is accessible to the researcher through the MUN “Qualtrics Survey Tool” website.

As the research involved human participants, the researcher had to obtain clearance from the Grenfell Campus Research Ethics Board (GC-REB) before distributing the survey. This was done to ensure that the rights and welfare of the participants would be protected. Following the approved procedure, the survey was conducted ethically and in accordance with the principles of informed consent, confidentiality, and anonymity. The survey was distributed in April 2022, following receipt of ethics approval in March 2022 (see the letter of ethics approval in Appendix C).

3.3. Data Analysis Plan

In early May 2022, the survey was closed after two weeks of running, with 1202 respondents. A description of the procedures for data cleaning and verifying the representativeness of the data, as well as a quantitative and qualitative analysis of the data, will be provided in the sections below.

3.3.1. Cleaning the Data

After exporting the data from Qualtrics to Excel format, four main steps were taken to clean the data, as listed in Table 3. The first condition involved removing all questionnaires that had not been finished, followed by removing all respondents whose main place of residence was outside of NL and then those without a motor vehicle. Essentially, this was done to ensure that only respondents from the target population were included in the analysis

and the analyses were not skewed by including data from respondents who did not fit the criteria of the target population.

Following this, the data had to be verified for consistency. This step involved verifying that the responses provided were consistent and that there were no discrepancies between answers to the same questions asked differently. By using the postal code as a verification tool (based on the question asked to participants about their residential postal code), all questionnaires with invalid NL postal codes were removed from the respondents. In the end, 1032 questionnaires were available for analysis, of which 943 belonged to drivers of ICEVs and 89 to drivers of EVs.

Table 5: Data Cleaning Steps

Step	Filtered Column	Selected Filter	Variables	Remaining Responses	Reason of Specific Filter Applied	Remark
1	Finished	1	{0, False} {1, True}	1059 out of 1202 respondents finished the survey	Removing incomplete surveys	-
2	Q2: Is your main place of residence (household) located in Newfoundland and Labrador?	1	{1, yes} {2, No}	1057 out of 1059	Removing respondents not residing in NL	-
3	Q3: Does your household have a motor vehicle that you drive regularly?	1	{1, yes} {2, No}	1051 out of 1057	Removing respondents who do not drive a vehicle regularly	-
4	Q30: first digits of postal code	Keep the "not answered" ones, then test the validity of postal codes: valid pattern: Letter Alphabet-Digit-Letter Alphabet.	{1, the first three digits of my postal code} {2, Unsure or prefer not to say}	1032 out of 1051 (this includes 72 people who answered unsure or prefer not to say)	Testing consistency and removing respondents who did not provide an eligible NL postal code even though they answered earlier that they reside in NL (i.e., potentially spoof responses).	Invalid answers to Q30 were also removed: AKO, Ar0, A8H, 709, 6t5, L7M, 816, 840, 894, 2r0, Aja, 900, 600, 5R9, 010, 331, 751

3.3.2. Representativeness of the Sample

Representativeness of the sample is an essential factor to consider when analyzing data. Doing so helps assess whether the data collected (i.e., survey respondents) represents the population being studied (i.e., drivers in NL). The sample is considered representative if it has similar attributes to the population (e.g., comparable age distribution). To ensure accurate representation, researchers often use sampling techniques such as random sampling. This helps to make sure that all members of the population have an equal chance of being included in the data set. However, as discussed above, this study could not pursue a true random sample, since only the provincial government has access to the contact information for all drivers in NL (which they understandably could not share with us, to protect privacy and confidentiality). To consider representativeness of the voluntary sample used out of necessity by this study, we directly compared demographic information, such as age, gender, level of education, income, and household size, between the sample and the population (using census data for the entire population as a proxy for data about the population of drivers). The results of this comparison are included in Appendix D, to provide context and demonstrate potential limitations of extrapolating any trends in the sample to the entire population.

3.3.3. Quantitative Analysis Plan

The data obtained from Qualtrics was exported to Microsoft Excel for further examination and statistical evaluation. The exported data comprised responses from participants across multiple variables. Utilizing the functionalities and tools available in Microsoft Excel, descriptive statistics like pie charts and histograms were constructed to summarize the responses. Initially, the data underwent some cleaning and organization to ensure consistency and precision. Subsequently, pertinent variables were selected, and suitable formulas and functions were employed to compute frequencies, percentages, and

other descriptive metrics. These data points were then employed to generate summary pie charts or histograms illustrating the distribution of variables. Such summaries are reported in the following chapter.

To assess the hypotheses with the survey data, the statistical software SPSS was utilized to perform a multivariate ordinal logistic regression analysis. This analysis aimed to investigate the relationship between multiple independent variables and an ordinal dependent variable (i.e., interest in purchasing an EV, ranked on a Likert scale).

The choice of conducting a multivariate ordinal logistic regression analysis is justified for several reasons. Firstly, as per Laerd Statistics (n.d.), assumption #1 is met, since the dependent variable is ordinal, with multiple ordered categories representing varying degrees of EV interest. This makes ordinal logistic regression an appropriate choice. In addition, again according to Laerd Statistics (n.d.), assumption #2 is met as several continuous and ordinal independent variables are considered for this study, such that multivariate analysis can assess the effects of several independent variables simultaneously on the dependent variable. Lastly, multicollinearity was checked in this analysis to confirm no strong correlation existed among the independent variables. Laerd Statistics (n.d.) explains that confirming a lack of multicollinearity is a crucial step in this analysis, since multicollinearity can make it challenging to identify the individual effects of variables to the dependent variable and can create technical issues in ordinal regression. As a result, multivariate ordinal logistic regression is a suitable choice for this study, as opposed to many individual tests.

Before conducting the regression analysis, necessary data preparations were carried out, ensuring proper coding and formatting of variables. Subsequently, the ordinal logistic regression model was specified in SPSS, analyzing all of the identified independent variables

relevant to the hypotheses simultaneously. The results of this analysis are also included in the next chapter.

3.3.4. Qualitative Analysis Plan

The answers to open-ended questions were analyzed using an inductive qualitative analysis method, which is commonly used in exploratory research. This method involves searching for patterns in the data after it has been collected, without hypothesizing anything in advance. It is helpful in uncovering themes and underlying structures in the data. Inductive analysis was conducted using Microsoft Excel in four steps. (1) familiarization with data based on reading responses; (2) generating initial categories or "codes"; (3) identifying themes within text data by mapping initial codes to text; (4) analyzing the themes and extracting meaningful information. Through this process, the researcher was able to identify patterns and relationships in the data that may not have been immediately evident. By generating the codes and mapping them to text, the researcher can group similar ideas together, which allows for more in-depth analysis and interpretation of the data. The themes and frequency of each provide additional insight into the data, allowing the researcher to pinpoint which topics are more prominent than others. The results of this analysis comprise the final section of the following chapter.

3.4. Methodological Limitations

An online survey may be subject to some methodological limitations, one of which is that the sample may be skewed toward a specific demographic, resulting in a reduced level of representativeness. This is because the participants of an online survey are self-selected, meaning that only those who actively choose to participate will be included in the sample. As a result, the sample may be biased toward those who use Facebook, those who join community groups, those living in communities with more active community groups, those

who are more willing to take surveys, and those who are interested in the subject. For instance, elderly people, on average, are less likely to use online platforms like Facebook, and it is probably that the survey has not been made available to many of them. This means that the survey results will be skewed in favour of specific demographics, such as young and middle-aged people, and that the data may not accurately reflect the opinions of the general population.

Chapter 4: Results

Reducing emissions from the private passenger transportation sector in NL is important in mitigating the effects of climate change, because it is the most polluting sector in the province. The government has an opportunity to address the issue by implementing a zero-emission vehicle strategy. The primary focus of this research is to identify the barriers hindering the widespread adoption of EVs in NL, using an online questionnaire (see Chapter 3 for details). The data gathered from the survey will enable the recommendation of possible policy solutions based on existing conditions. This chapter presents the findings of the study, organized into three parts: discussion of sample descriptive statistical summaries, followed by statistical results of hypothesis testing, and qualitative evaluations of open-ended questions. Supplemental demographic and representativeness analysis are presented in Appendix D.

4.1. Descriptive Statistical Summaries

The study examined the representativeness of its survey sample compared to the demographic distribution of NL. While these biases may limit generalizability, the sample size and coverage offer valuable insights, suggesting a need for future research to enhance diversity and representativeness through random sampling methods.

This section presents descriptive summaries of survey results related to urbanization level, vehicle type, driving habits, environmentalism, perceptions of ICEVs vs EVs, familiarity with EVs and EV initiatives in the province, and interest in adopting EVs among ICEV drivers. Note that the total number of complete responses from ICEV drivers is 943, but individual subsections below often use a different (lower) number because not all participants answered every question. Additionally, this section includes descriptive summaries for EV drivers in terms of urbanization level, their EV types, driving habits, satisfaction with EV ownership, access to chargers, and charging habits.

4.1.1. ICEV Drivers Summaries

Figure 10 shows the urbanization level of participating ICEV drivers. Of the ICEV drivers surveyed, the highest percentage (35%) reside in small cities or large towns, followed by small towns (23%), suburbs of large cities (18%), and rural areas (14%). Only 9% of the participating ICEV drivers reside in the city center of a large city. Level of urbanization is also an important independent variable in the next section on hypothesis testing.

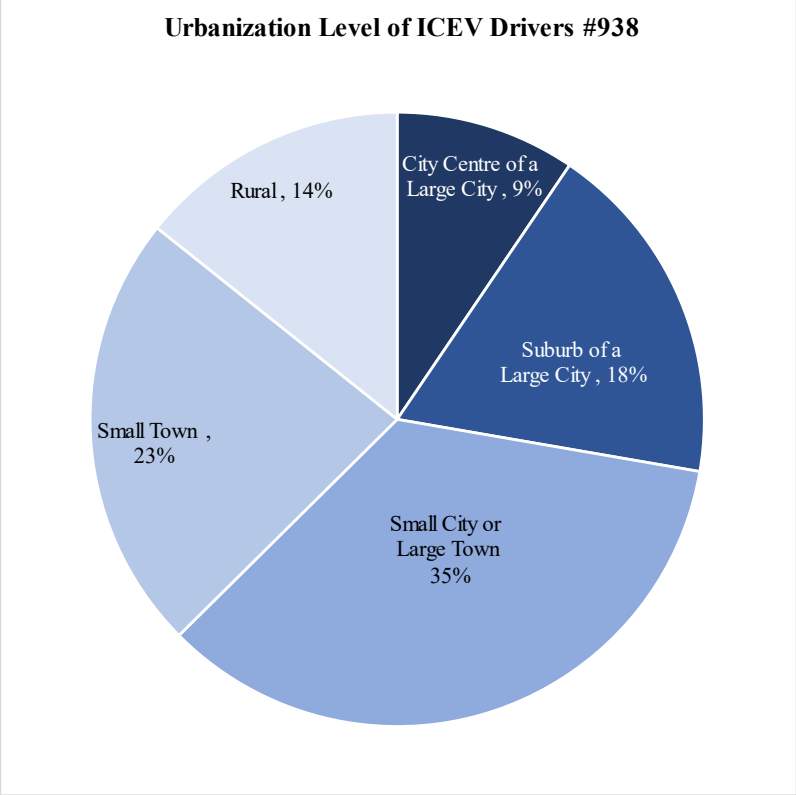


Figure 10: Distribution of Urbanization Level across ICEV Drivers (938 Responses)

Figure 11 represents the distribution of the types of vehicles used by participating ICEV drivers. The most commonly owned type of vehicle was SUVs or crossovers, which represented 49% of the sample, followed by four-door cars (31%) and four-door trucks (14%). Other types of vehicles were much less common in the sample; minivans or vans representing 3%, followed by two-door cars (2%) and two-door trucks (1%).

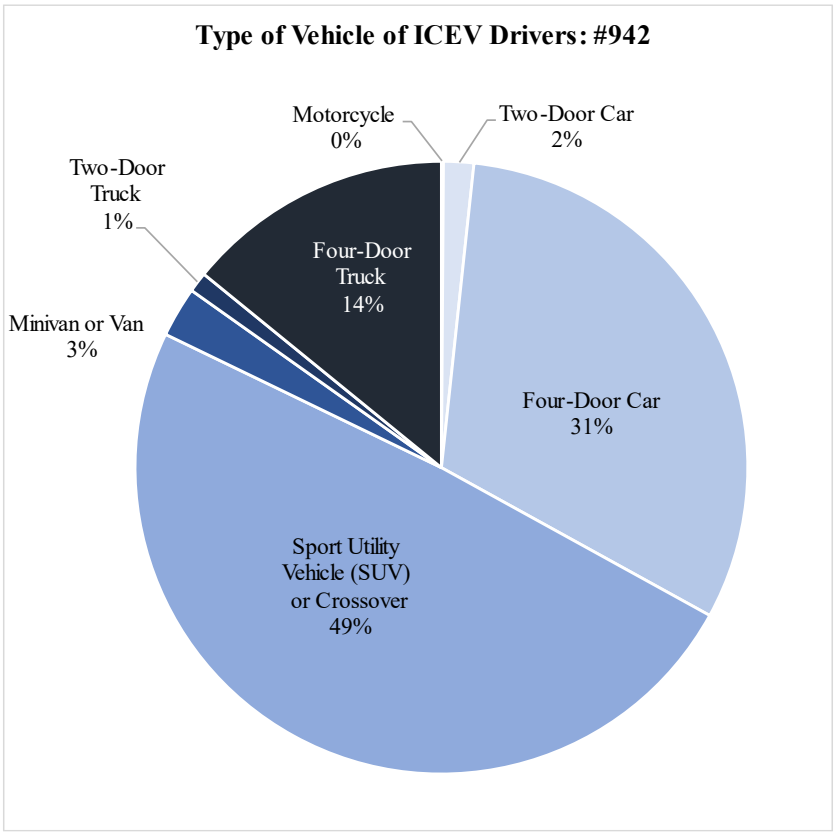


Figure 11: Distribution of Vehicle Type across ICEV Drivers (942 Responses)

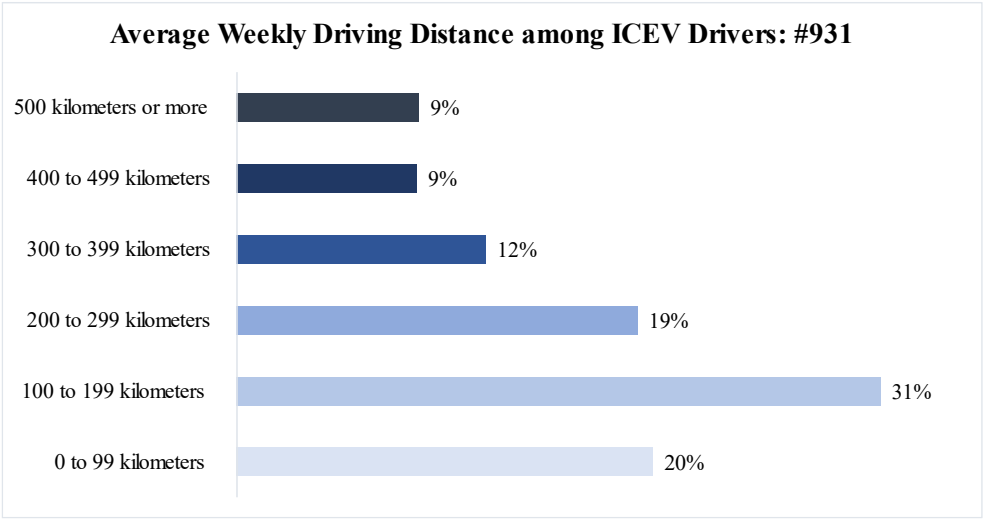
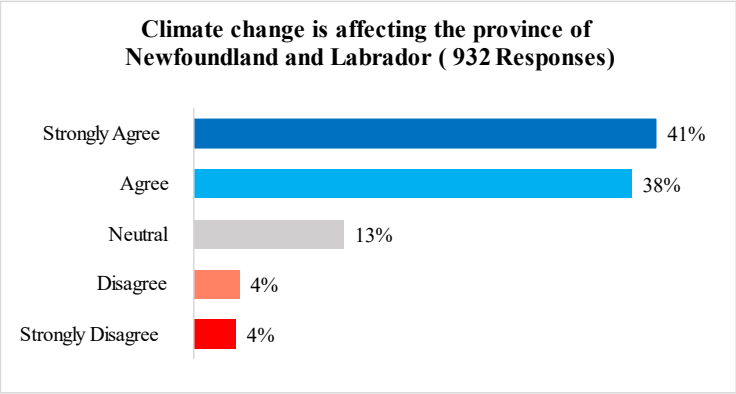


Figure 12: Distribution of Average Weekly Driving across ICEV Drivers (931 Responses)

As Figure 12 shows, participating ICEV drivers most commonly (31%) estimated that they drive between 100 and 199 kilometers per week, followed by 0-99 km (20%), 200-299 km (19%), 300-399 km (12%), 400-499 km (9%), and 500+ km (9%). Overall, the distribution suggests that most ICEV drivers do not typically drive very long distances on a weekly basis, with the majority falling into the 0-to-199-kilometer range.

Figure 13 presents the distribution of responses from participating ICEV drivers to six environmentalism questions. The results indicate that a majority of this group believed that: every individual needs to pay their part in addressing climate change (90%), NL has a low rate of EV adoption (90%), climate change is affecting NL (80%), emissions from burning fossil fuels are one of the main causes of climate change (75%), and EVs are beneficial for the province's environment (70%). In contrast, only 30% of respondents agreed (correctly) that NL has a higher rate of GHG emissions compared to other provinces, although that question also had the highest percentage of "neutral" responses (32%), leaving only 38% in the "disagree" categories. In general, these results suggest a high level of environmentalism among ICEV drivers in the sample, which could be an encouraging sign for the promotion of EVs as a more sustainable alternative.



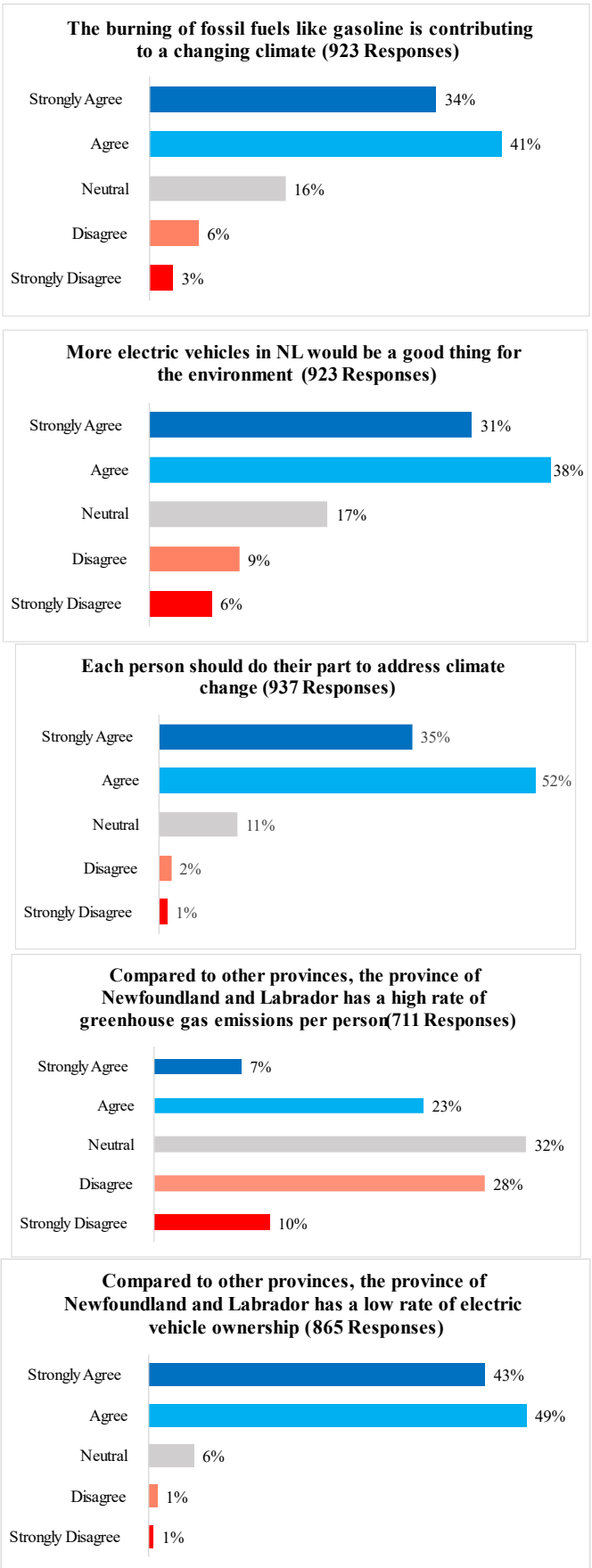
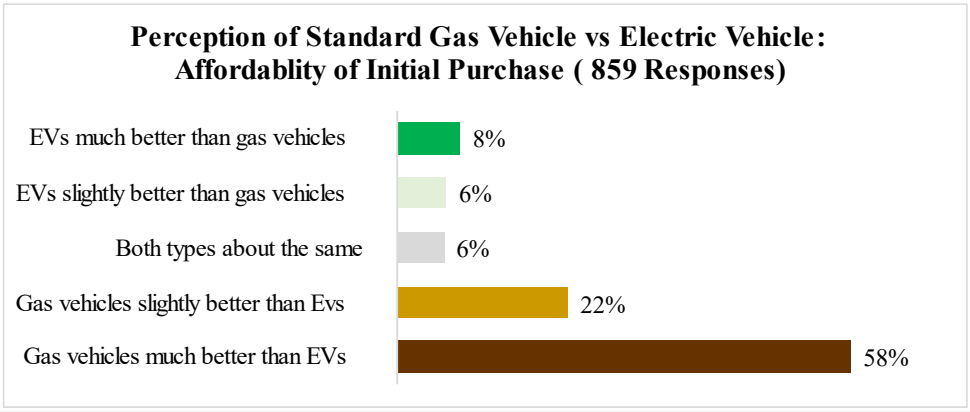
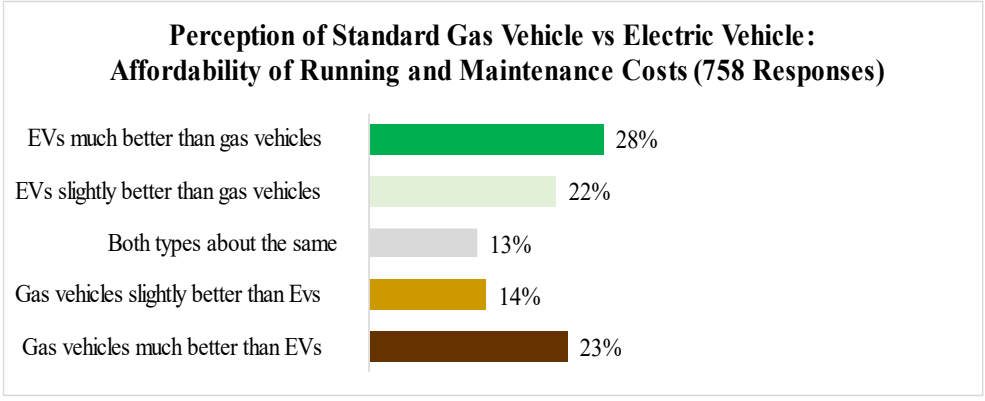


Figure 13: Distribution of Responses to Environmentalism Questions across ICEV Drivers

Figure 14 reveals perceptions of participating ICEV drivers on various characteristics of EVs versus ICEVs. The respondents rated their opinions on a Likert scale. The most favourable result for EVs was perceptions around air pollution (90% thought EVs were better vs. only 3% who thought ICEVs were better) followed by slightly favourable perceptions around environmentally responsible construction and disposal (43% EVs; 18% ICEVs; many neutral responses) as well as running and maintenance costs (50% EVs; 37% ICEVs). Other results were more favourable for ICEVs, including perceptions around driving range (8% thought EVs were better vs. an overwhelming 82% who thought ICEVs were better), affordability of initial purchase (14% EVs; 80% ICEVs), and function in winter weather (3% EVs; 77% ICEVs). Overall, the survey suggests that ICEVs are currently very commonly perceived to be superior in terms of initial purchase cost, driving range, and winter function, while EVs are currently very commonly perceived to be superior in terms of limiting air pollution as well as somewhat commonly perceived to use more environmentally friendly materials and offer more affordable operational costs.





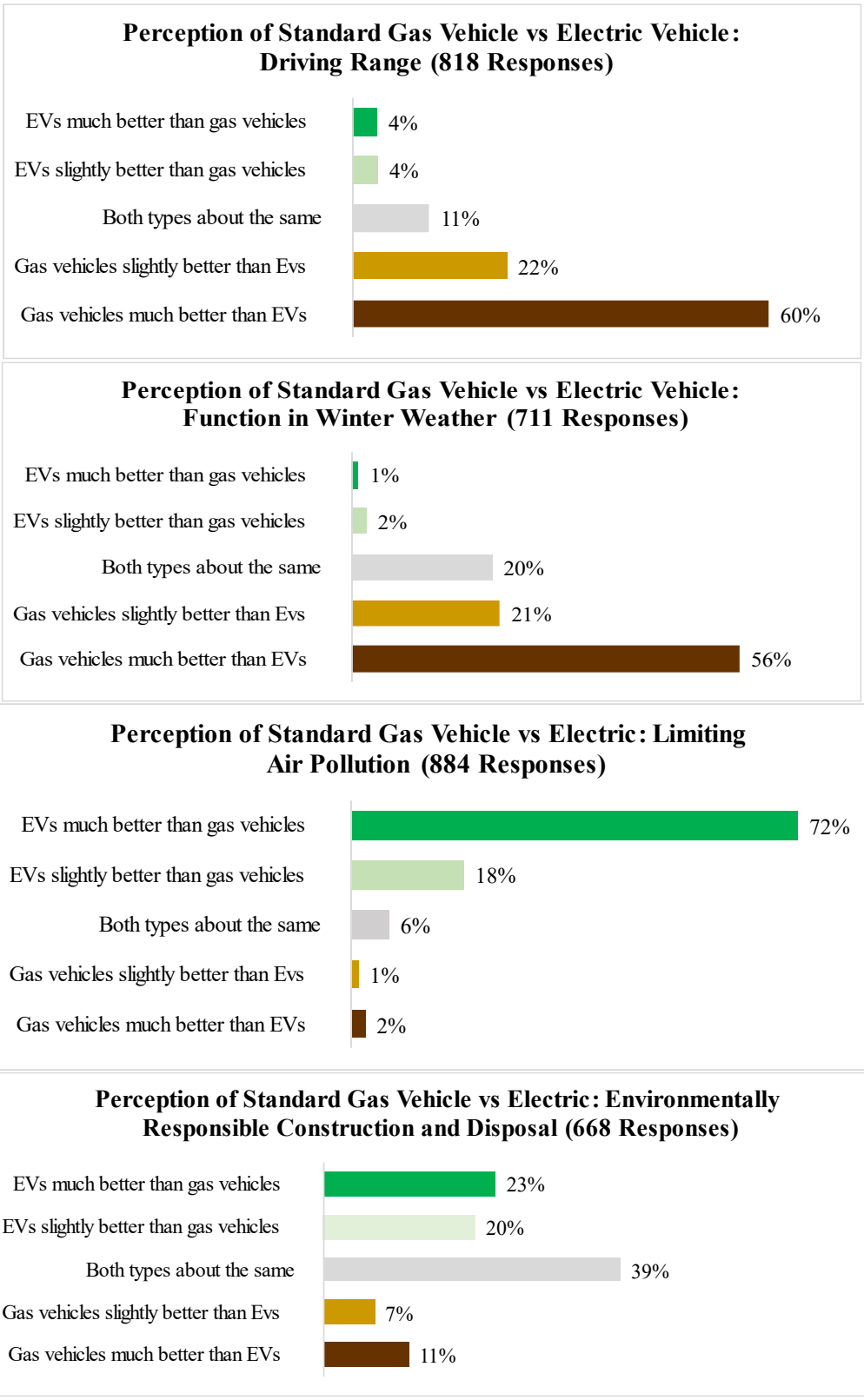
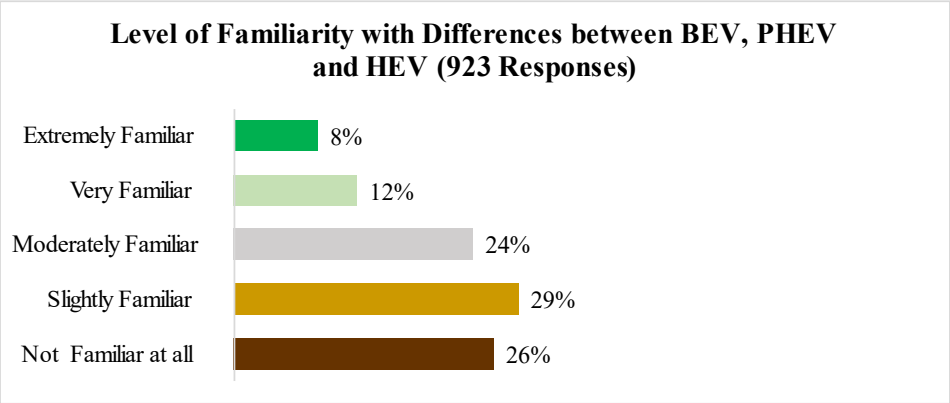


Figure 14: Distribution of Responses to the Questions of EV vs ICEV Perception across ICEV Drivers

Figure 15 represents the responses of participating ICEV drivers to the survey question regarding familiarity with EVs and current EV initiatives in the province. The question consisted of three parts. The results show that 26% of respondents were not at all familiar with the different types of EVs, 29% were slightly familiar, 24% were moderately familiar, 12% were very familiar, and 8% were extremely familiar. These results suggest that a significant portion of the sample is still not familiar with EVs, so there is still a clear opportunity for more education and awareness programs to increase overall familiarity with EVs and promote their adoption.

This second part of this question also assessed the familiarity of participating ICEV drivers with current initiatives aimed at promoting EV adoption in NL. Most respondents were not particularly familiar with government rebates for purchasing EVs (29% not familiar at all; 27% slightly familiar; 26% moderately familiar; 12% very familiar; 6% extremely familiar). Regarding the takeCHARGE website, familiarity was roughly comparable to that of government rebates (22% not familiar at all, 29% slightly familiar, 30% moderately familiar, 13% very familiar, 7% extremely familiar). As with the results for general EV familiarity, these results suggest an opportunity for greater outreach and education to increase awareness about government EV initiatives.



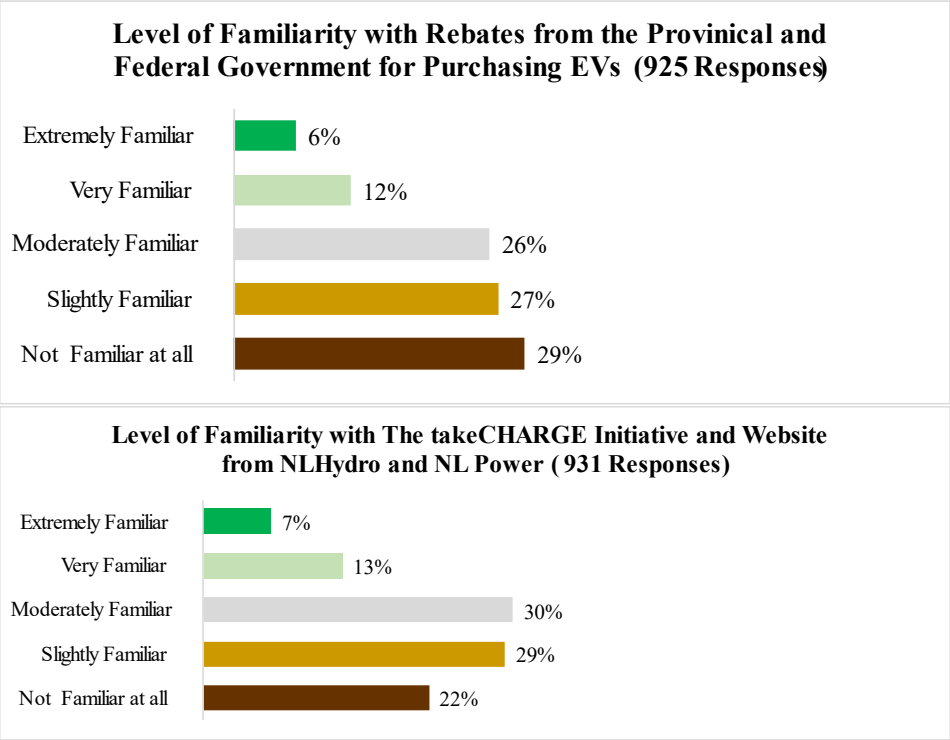


Figure 15: Distribution of Responses about Familiarity with EVs and Government Initiatives across ICEV Drivers

The next survey question asked respondents about their overall interest in purchasing an EV versus a standard gas vehicle. The results show that among participating ICEV drivers, around 60% expressed a preference for buying a standard gas vehicle, 10% were equally likely to choose either type, or 33% were more likely to buy an EV (See Figure 16). Overall, the finding suggests that there is still a significant preference for standard gas vehicles among the ICEV respondents. However, a substantial proportion of respondents reported being somewhat or much more likely to buy an EV, indicating a growing interest in EVs.

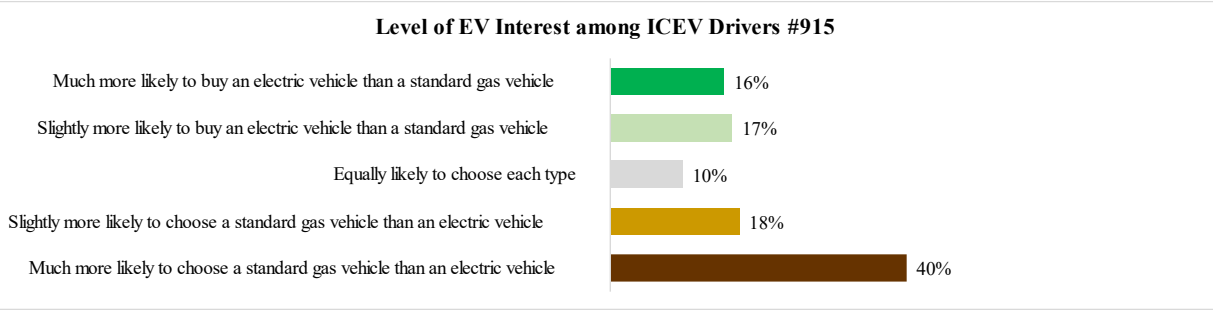


Figure 16: Distribution of Interest in EV Adoption across ICEV Drivers (915 Responses)

As presented in Figure 17, among the 792 participating ICEV drivers who responded to the survey question about their possible reasons for choosing an EV, the most commonly cited reasons were their lower environmental impact (89% of respondents selected this reason) and money saved on fuel and maintenance (79%). Less common reasons were availability of government incentives (44% of respondents selected this reason), interest in technological innovation (40%), availability of public charging stations (28%), convenience and style (21%), and that they are fun to drive (21%). Overall, these findings indicate that environmental benefits and potential cost savings of are the most important factors for ICEV drivers when considering a switch to an EV, but availability of government incentives and public charging infrastructure as well as the general appeal of EVs also play a role in their decision-making.

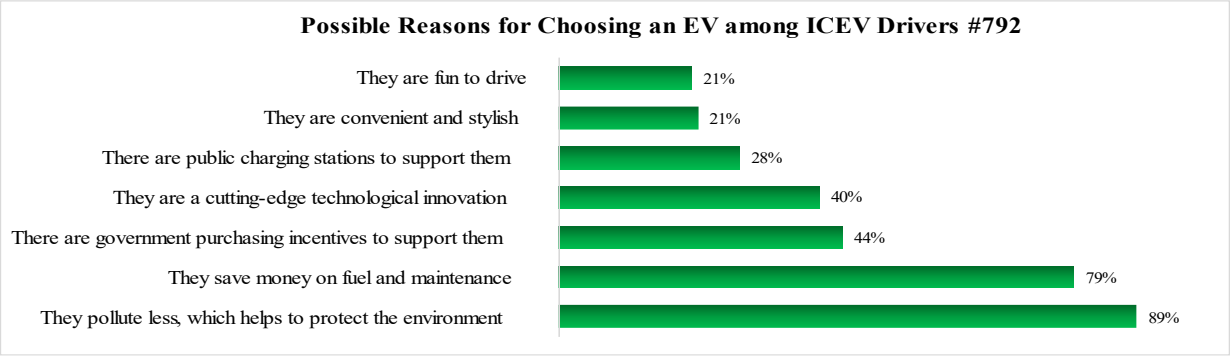


Figure 17: Distribution of Possible Reasons for Choosing an EV across ICEV Drivers (792 Responses)

As presented in Figure 18, among the 943 participating ICEV drivers who responded to the survey question about their possible reasons for not choosing an EV, 84% of respondents indicated that EVs are expensive to purchase. The lack of public charging infrastructure was another significant factor, with 75% of respondents citing this as a reason not to choose an EV. The lack of public charging infrastructure was another significant factor, with 75% of respondents citing this as a reason not to choose an EV (see Figure 18).

The limited driving range of EVs was also a concern for 66% of ICEV respondents, while 62% cited a limited selection of EVs at local dealerships. About 57% of respondents mentioned charging time as a factor, with 34% citing difficulty charging at home. Other reasons, such as a lack of government incentives, unfamiliarity with the technology, and concerns about safety, were cited by smaller percentages of respondents.

As a whole, the results show concerns around initial vehicle cost, infrastructure, and practicality are the main reasons why ICEV drivers are hesitant to switch to EVs. These findings suggest the need for continued investment in charging infrastructure and incentives, as well as efforts to raise awareness and address misconceptions around EV technology and its practicality in daily use.

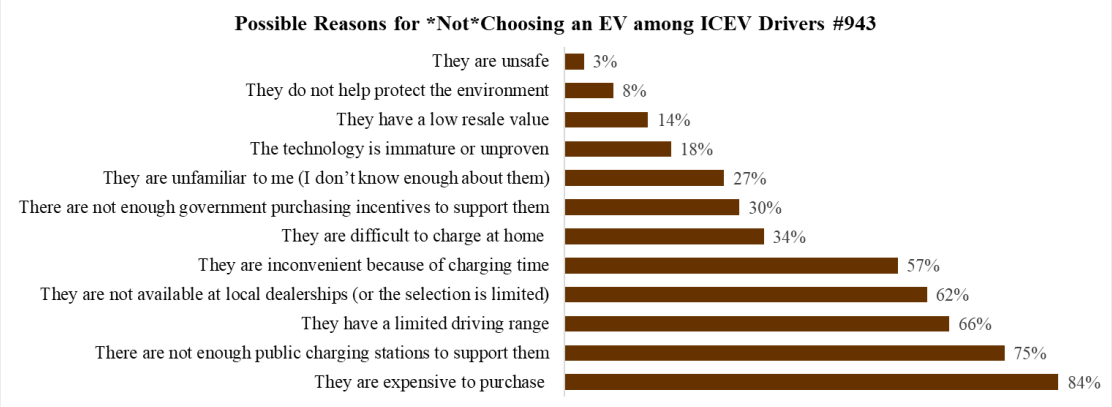


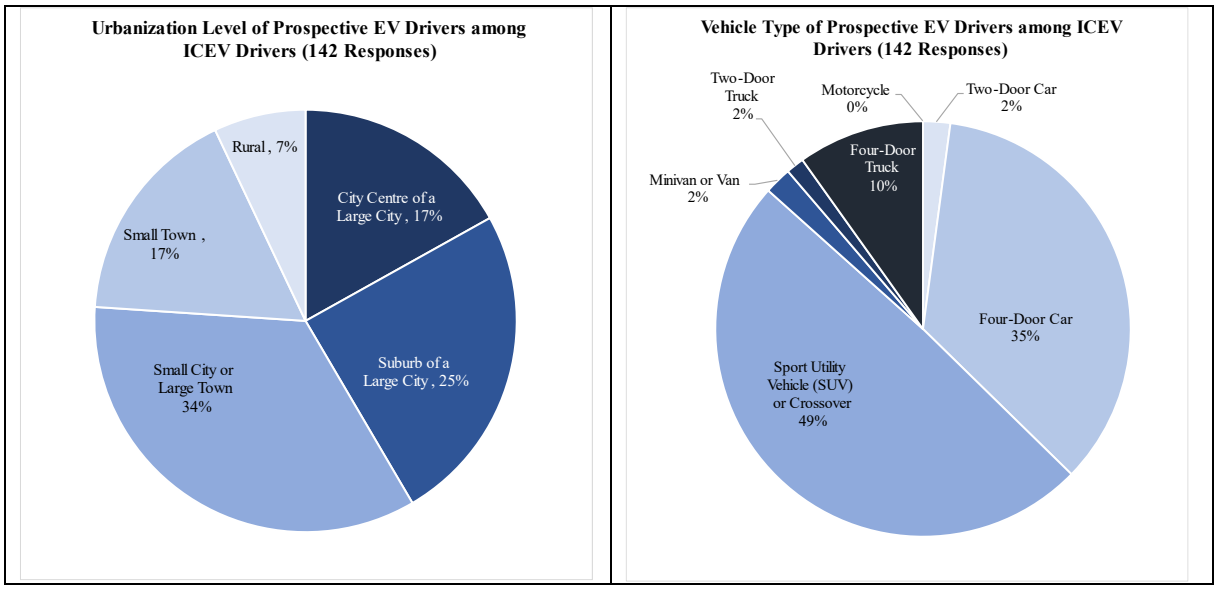
Figure 18: Distribution of Possible Reasons for Not Choosing an EV across ICEV Drivers (943 Responses)

4.1.2. Prospective EV Drivers among ICEV Drivers

The below graphs collectively present the characteristics and factors associated with individuals who have expressed a much higher likelihood of choosing an EV over a standard gas vehicle, based on their responses. Considering respondents classified as "much more likely" to choose an EV (rather than the combination of "much more likely" and "slightly more likely") offers a more precise image of a subgroup with a most possible strong

preference for EV adoption. By analyzing the characteristics of individuals who exhibit highest level of interest in EVs, significant patterns and factors that strongly influence decision-making can be identified.

The data reveals several noteworthy trends. Firstly, individuals residing in small cities or large towns are most likely (35%) to opt for EVs, followed by those in suburbs of large cities (25%). SUVs or crossovers are the preferred vehicle choice, accounting for 49% of respondents, while four-door cars are the second choice at 35%. The distribution of weekly driving frequency is fairly even, with the majority falling within the range of 0 to 299 kilometers per week. The age group most inclined towards EVs is 35-44 years old (32%), closely followed by individuals aged 25-34 (25%). Females are slightly more inclined towards EVs, constituting 54% of the respondents, compared to males at 46%. Education level also plays a role, with a higher preference for EVs among those with a postsecondary certificate, diploma, or degree (58%) and graduate or professional degree (30%). Income is a significant factor, as the majority (65%) of individuals earning $100,000 or more are much more likely to choose EVs.



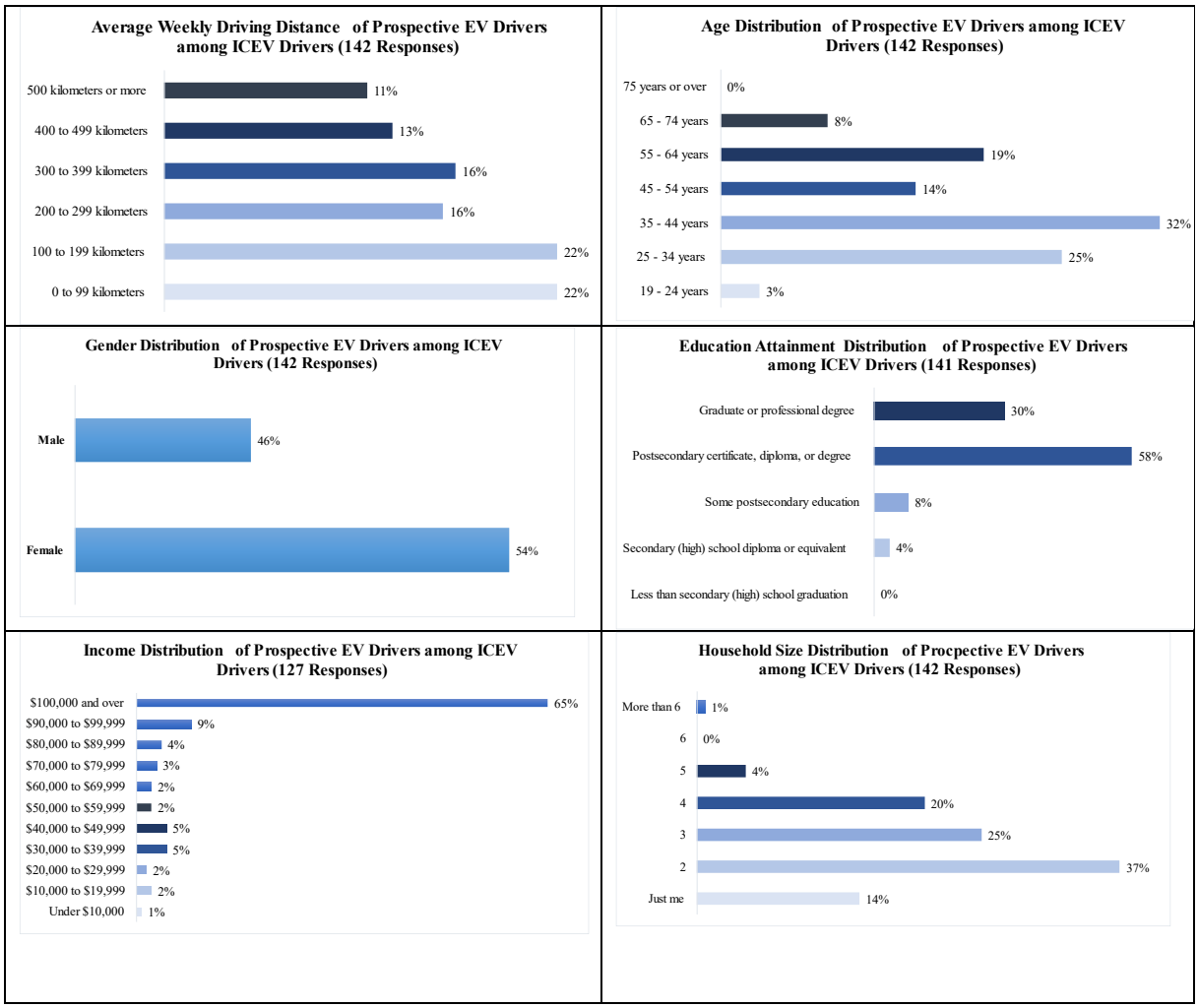


Figure 19: Characteristics of Prospective EV Drivers across ICEV Drivers

4.1.3. EV Drivers' Summaries

This section presents descriptive summaries of survey results related to urbanization level, vehicle type, driving habits, satisfaction level of owning an EV, length of ownership, access to different types of EV chargers, and level of charging at home among EV drivers participating in the survey. Note that the total number of complete responses from EV drivers is 84 but individual subsections below often use a different (lower) number because not all participants answered every question. Figure 20 shows the distribution of urbanization level among 84 EV drivers. The largest group of EV drivers live in suburbs of large cities (43%), followed by small cities or large towns (28%) and city centers of large cities (13%). Only 5% of EV drivers live in rural areas. This suggests that EV adoption is more prevalent in urban

and suburban areas with greater access to charging infrastructure and transportation options. However, the low percentage of EV drivers in rural areas indicates a need for increased efforts to promote and facilitate EV adoption in these regions. Overall, the distribution of urbanization level among EV drivers highlights the importance of considering geographic factors in the development of policies and initiatives aimed at promoting sustainable transportation.

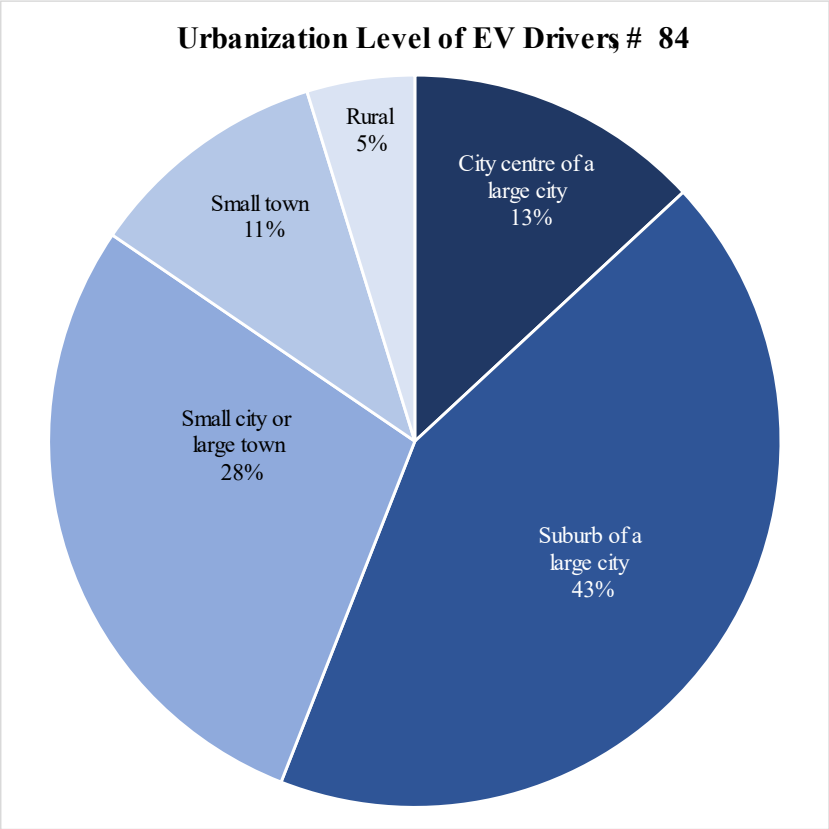


Figure 20: Distribution of Urbanization Level among EV Drivers (84 Responses)

Figure 21 shows the distribution of EV type among 84 EV drivers. The majority of EV drivers own Battery Electric Vehicles (61%), followed by Plug-in Hybrid Electric Vehicles (39%). This suggests that fully electric vehicles are the most popular choice among EV drivers, with plug-in hybrids also being a viable option for those who require longer driving ranges.

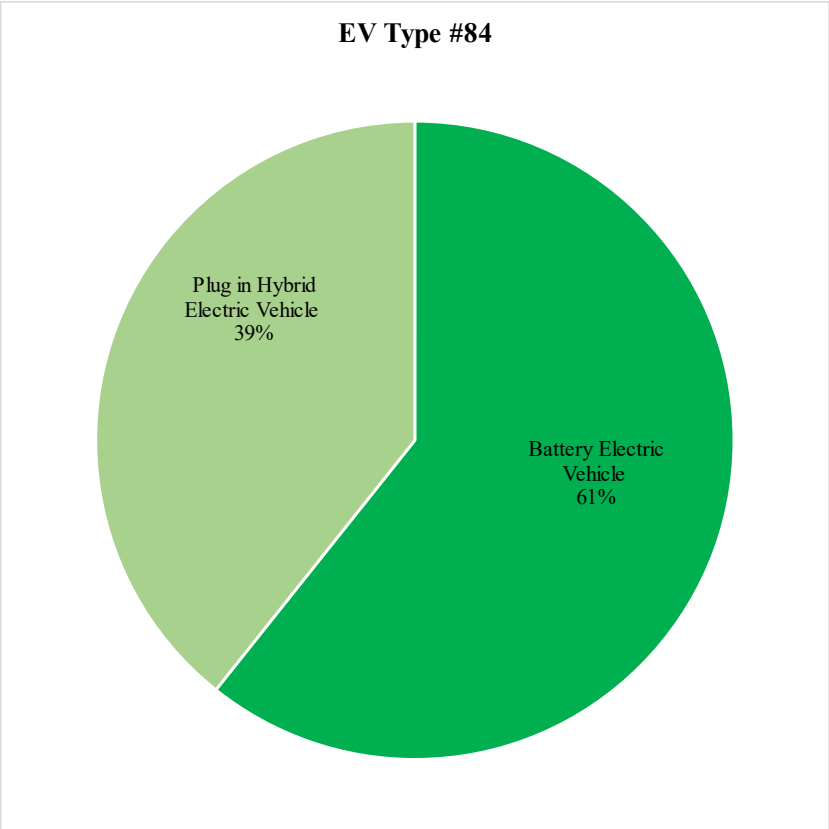


Figure 21: Distribution of EV Type across EV Drivers (84 Responses)

Figure 22 shows the distribution of average weekly driving distances among 83 EV drivers. The majority of EV drivers (29%) drive 200 to 299 kilometers per week, followed by 100-199 km (23%), 500+ km (17%), and 300-399 km (17%). Only a small percentage of EV drivers drive 0 to 99 kilometers per week (8%) or 400-499 km (6%). These results indicate that EVs are being used for a wide range of driving distances, with a significant portion of EV drivers driving more than 200 kilometers per week. This conclusion may have implications for the above perception that EVs are limited in terms of driving distance.

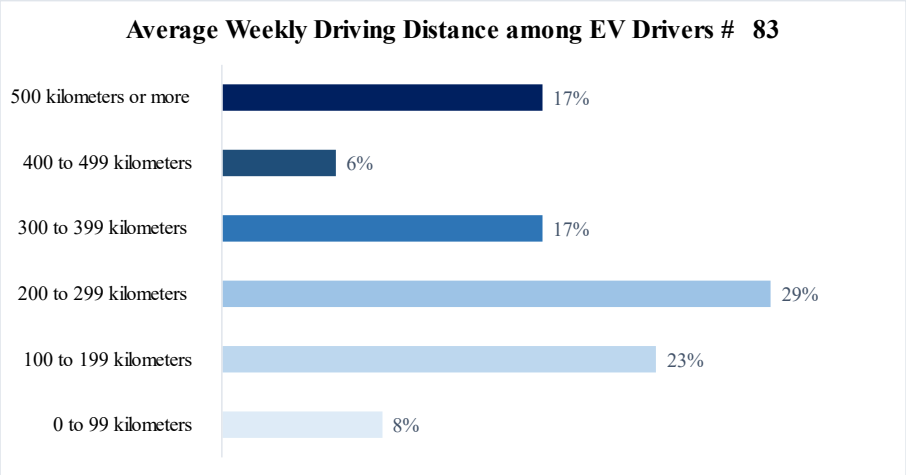


Figure 22: Distribution of Average Weekly Driving across EV Drivers (83 Responses)

Figure 23 demonstrates that a majority of the 84 EV drivers who responded to the survey are extremely satisfied with their EVs (61%), followed by smaller proportions who are very satisfied (17%), moderately satisfied (18%), or slightly satisfied (5%). None of the respondents reported being not at all satisfied. Overall, the reported satisfaction levels among EV drivers are quite high.

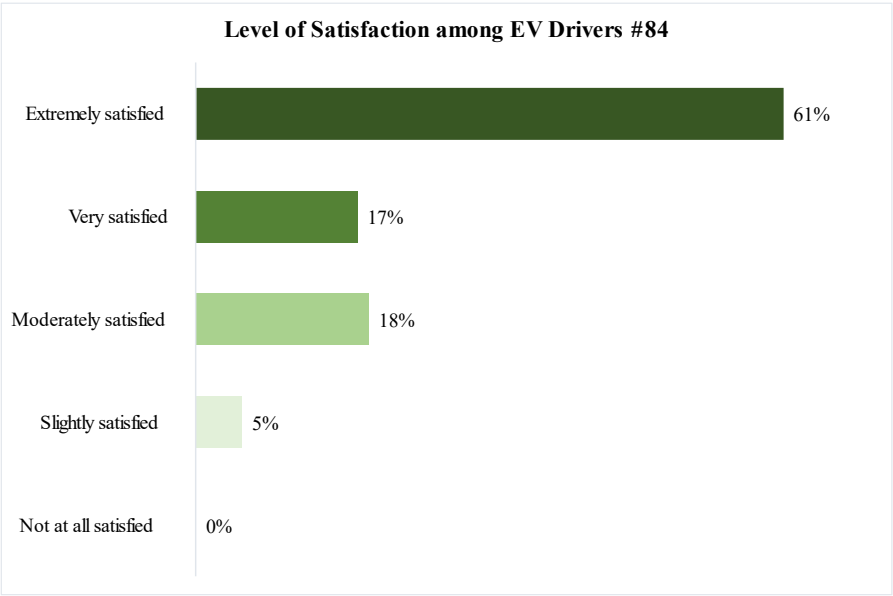


Figure 23: Level of Satisfaction across EV Drivers (84 Responses)

Figure 24 shows that most participating EV drivers have had their vehicle for two years or less (94%), with the most popular response within that group indicating a brand-new vehicle (39%). Only 6% reported driving an EV for three years or more. Overall, the data suggests that EV drivers purchased their EVs recently.

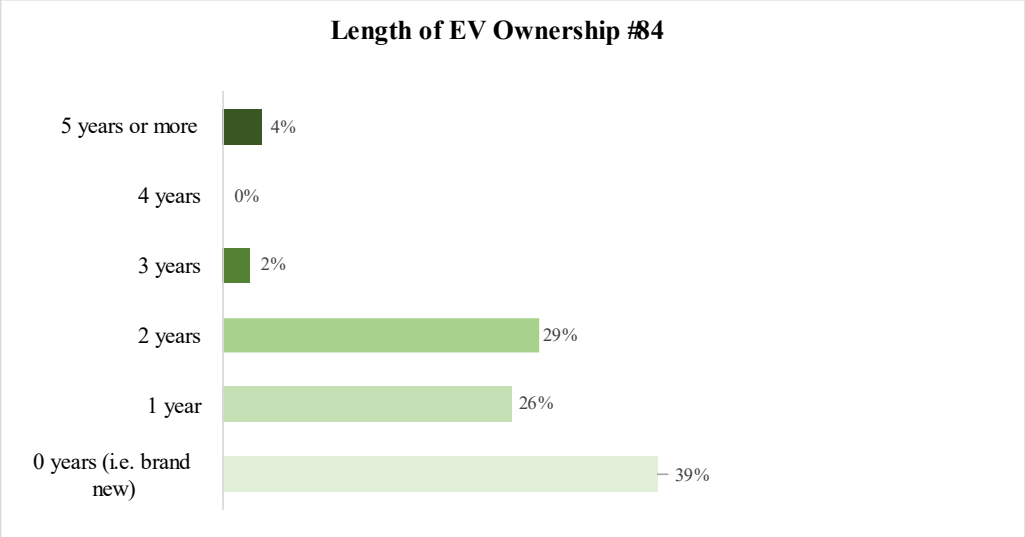


Figure 24: Length of EV Ownership (84 Responses)

As shown in Figure 25, a majority of participating EV drivers (56%) have access to an at-home Level-1 charger. Additionally, 64% of respondents reported having access to an at-home Level -2 charger, which can provide faster charging times than Level-1 chargers. In terms of workplace charging, 23% of respondents reported having access to a Level-1 charger, while 19% reported having access to a Level-2 charger. Only a small percentage of respondents (2%) reported having access to a Level-3 (fast) charger at their workplace.

In terms of public charging options, 40% of respondents reported having access to a public Level-2 charger, which can provide faster charging times than Level-1 chargers and are typically found in public parking lots or along the streets. Additionally, 32% of respondents reported having access to a public Level-3 (fast) charger, which provides the fastest charging times and is typically found along major highways or in other high-traffic areas. Overall, the

data suggests that while many EV drivers have access to at-home charging options, either at Level-1 or Level-2, public charging is more limited, with access to Level-3 (fast) chargers being the most restricted.

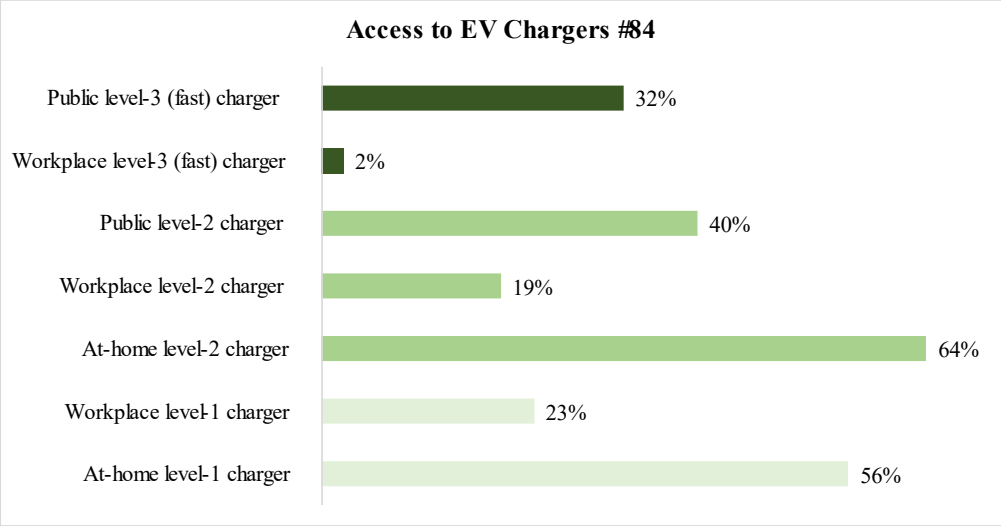


Figure 25: Distribution of Access to Different Types of EV chargers across EV Drivers (84 Responses)

The results reported in Figure 26 indicate that, out of the participating EV drivers, the largest percentage (56%) reported doing 80-100% of their charging at home. Other proportions of at-home charging have lower response rates: 17% reported 60-79% at-home charging, 13% reported 40-59% at-home charging, 10% reported 20-39% at-home charging, and 5% reported 0-19% at-home charging. In addition, a small percentage (6%) of respondents reported owning a regular hybrid vehicle that does not require charging. Overall, the data suggests that a majority of EV drivers are able to charge their vehicles to a high level at home, with only a small percentage of respondents reporting lower levels of home charging.

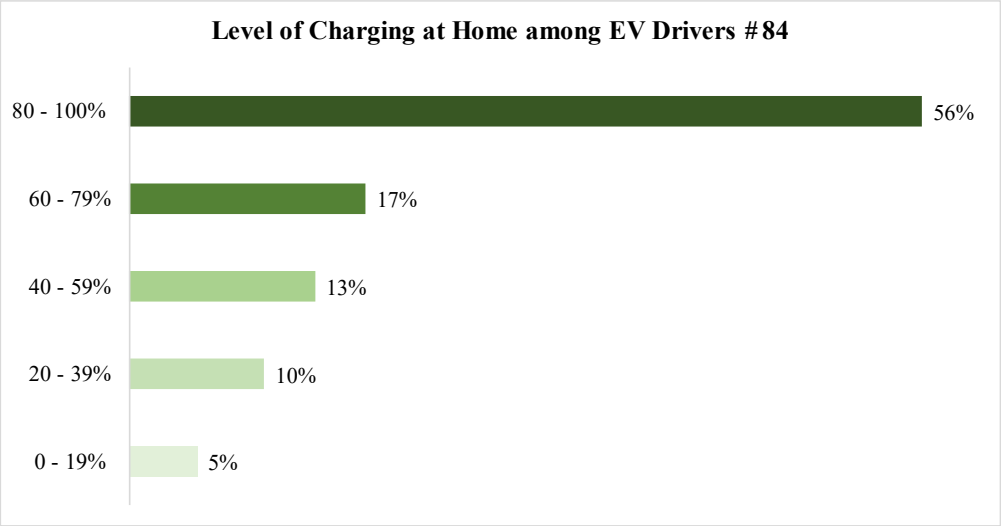


Figure 26: Level of Charging at Home among EV Drivers (89 Responses)

4.2. Hypotheses Testing

The primary focus of the hypotheses (see Chapter 3) is on the dependent variable "EV interest", which reflects the level of interest that participating ICEV drivers have in adopting EVs (see Figure 16). This variable is assessed using an ordinal scale, capturing the varying degrees of interest. As it was explained in Table 3, seven independent variables are taken into account, which are better explained in Table 6 in terms of range and type of measurement (see Appendix A for the actual questionnaire). The main objective of testing these hypotheses is to determine what factors are correlated with EV interest, which could have implications for EV promotion and policy.

Table 6: Independent Variables, Including Range and Type of Measurement

Hypo #	Independent Variable	Range	Type of Measurement	Descriptive Summary
H1	EV Perception	Aggregated Likert Scale 0-24 from the least level as 0 to 24 the most level	Continuous	Figure 14
H1	EV Familiarity	Aggregated Likert Scale 0-12 from the least level as 0 to 12 the most level	Continuous	Figure 15

Hypo #	Independent Variable	Range	Type of Measurement	Descriptive Summary
H2	Level of Ruralisation	From 1 as the most level to 5 the least level	Ordinal	Figure 10
H3	Income Level[13]	In three levels: 1 as under $59,999, 2 between $60,000 to $99,999, and 3 as $100,000 and over	Ordinal	Table 9
H4	Weekly Driving Length	From 1 (0-99 km) to 6 (500+ km)	Ordinal	Figure 12
H5	Level of Environmentalism	Aggregated Likert Scale 0-24 from the least level as 0 to 24 the most level	Continuous	Figure 13
H6	Vehicle Type[14]	In three levels: 1 as two- or four-door car; 2 as SUV, crossover, minivan or van; and 3 as two- or four-door truck	Ordinal	Figure 11

For the statistical analysis of this study, three variables were aggregated (environmentalism, EV perception and EV familiarity). According to Jacob (2016), aaggregated variables are combined measures derived from a respondent's individual responses, providing a comprehensive overview of their attitudes towards that variable. This aggregation was made to simplify interpretation, facilitate statistical analysis, and enhance the strength of conclusions drawn from the data. To derive the aggregate variables from the survey responses, a consistent approach was employed for each variable (i.e., environmentalism, EV perception and EV familiarity). For the level of environmentalism, encompassing six Likert scale questions where respondents rated their agreement from 1 to 5,

[13]Certain vehicle size categories were combined based on the observation of low data counts in most cells during cross-tabulation. Combining these categories, specifically grouping two-door cars with four-door cars, SUVs with crossovers, minivans, and vans, and two-door trucks with four-door trucks, was undertaken to address the issue of low observations, which could otherwise complicate statistical analysis and easily lead to hypothesis rejection.

[14]For the same reason, it was decided to group certain income levels together. Specifically, income levels ranging from "Under $10,000" to "$59,999" were combined into a single category labeled "0 to $59,999". Similarly, income levels from "$60,000 to $99,999" were merged into the category "$60,000 to $99,999," while the highest income level remained "100,000 and over." This adjustment was made to ensure that each income category had a sufficient number of observations, as low counts can complicate data analysis.

the summation of these responses across the respondents was calculated and subsequently adjusted by subtracting 6 (this adjustment was made to set the lowest possible score at zero for easier comparison and interpretation), resulting in a scale ranging from 0 to 24. This way, the scale starts at 0, representing the lowest level, and goes up to the highest level (24), making it easier to interpret the scores. In the case of EV Perception, the six Likert scale responses were summed up after adjusting (subtracting 6 out of total) for the scale's range, resulting in a scale of 0 to 24. A score of 0 indicates a perception favoring ICEVs on all factors, while a score of 24 signifies a perception favoring EVs on all considered factors. Lastly, EV familiarity, composed of three Likert scale queries rating familiarity from 1 to 5, was aggregated by summing these responses and then subtracting 3, yielding a scale from 0 to 12. A score of 0 indicates extremely not familiar on all factors, while a score of 12 signifies a extreme familiarity on all considered factors. All in all, it is important to note that the aggregation of these variables made through a subjective decision, as multiple individual responses are combined into a single measure. Therefore, it is necessary to consider this subjectivity when interpreting the results. The individual questions that compose each aggregate variable are reported in the descriptive summaries section (see section 4.1.1), allowing readers to reference and interpret the detailed data alongside the aggregated measures. It is also worth to acknowledging the limitations and potential biases inherent in the use of aggregate variables.

To examine the relationships between the independent variables (EV Perception, EV Familiarity, Level of Urbanization, Income Level, Weekly Driving Length, Level of Environmentalism, and Size of Vehicle) and the dependent variable (EV Interest), a multivariate ordinal logistic regression analysis was done. This statistical approach allowed for the assessment of the impact of these variables on participants' levels of interest in EVs. The statistical analysis was performed using the IBM SPSS software.

Table 7: Multivariate Ordinal Logistic Regression Results (Correlation of 7 Independent Variables with the Dependent Variable of EV Interest)

Independent Variable	β Estimated Effect	EXP (β)	p-value	Std. Error
Level of Ruralisation	-0.180	0.84	0.040**	.0888
Vehicle Size	0.043	1.04	0.780	.1518
Driving Frequency	0.142	1.15	0.032**	.0665
Environmentalism	0.219	1.24	<0.001***	.0531
EV Perception	0.295	1.34	<0.001***	.0324
EV Familiarity	0.241	1.27	<0.001***	.0342
Income	0.439	1.55	0.001***	.1350

** significant at the 0.05 level *** significant at the 0.01 level

4.2.1. Results of Multivariate Ordinal Logistic Regression

In Table 7 above, β represents the coefficient or estimated effect size for each independent variable (IV) in the regression. The higher the value of β coefficient, the stronger the relationship between the independent and dependent variables (DV); the lower it is, the weaker the relationship between the independent and dependent variables (EasyMedStat, 2023). According to Laerd Statistics (2015), the coefficient in multivariate ordinal logistic regression represents the change in the log odds of being in a higher category of the dependent variable (DV) for a one-unit increase in the independent variable (IV), while holding all other variables constant. Log odds, on their own, are not practically very meaningful. Looking instead at the exponent of β (i.e. through use of the e^x function on a calculator), which is the next column to the right in the above table, means shifting from "log odds" to a more meaningful "odds ratio". For example, an EXP(β) value of 1.5 means that every one-unit increase in the IV increases the odds of the corresponding DV also being in a higher category by 50%, whereas an "odds ratio" less than 1 suggests a negative relationship.

The p-value is the probability that the observed correlation is due to randomness. The lower the p-value, the more likely it is that the observed correlation is due to an actual relationship between the variables instead of randomness. A p-value lower that 0.05 (i.e. 5% probability that the observed correlation is due to randomness) is considered statistically significant.

Hypothesis 1 - EV Perception: Perception toward EVs rather than ICEVs correlates positively with EV interest.

The variable "EV Perception" exhibited a statistically significant positive correlation with EV interest ($\beta = 0.295$, $p < 0.001$). A positive beta (in this case, 0.295) means that as the level of perception EVs vs ICEVs (i.e. aggregate perception score) increases, the odds of having a higher interest in EVs also increase. An odds ratio (EXP (β)) of 1.34 for the EV perception IV means that each shift up from one perception score to another (e.g. from 10 to 11) increases the odds of a person having a higher level of EV interest (the dependent variable) by 34%. A significance value where $p < 0.001$ means that the positive correlation between EV Perception and EV interest is statistically significant. This indicates that individuals with greater perception in favour of EVs tend to have a higher level of interest in them, consistent with Hypothesis 1 (in terms of EV perception), at least within the sample.

Hypothesis 1 (Part 2) - EV Familiarity: Familiarity with EVs and corresponding government incentives correlates positively with EV interest.

The variable "EV Familiarity" exhibited a statistically significant positive correlation with EV interest ($\beta = 0.241$, $p < 0.001$). A positive beta (in this case, 0.241) means that as the level of familiarity with EV (i.e. aggregate familiarity score) increases, the odds of having a higher interest in EVs also increase. An odds ratio (EXP (β)) of 1.27 for the EV familiarity IV means that each shift up from one familiarity score to another (e.g. from 6 to 7) increases the odds of a person having a higher level of EV interest (the dependent variable) by 27%. A

significance value where $p < 0.001$ means that the positive correlation between EV Familiarity and EV interest is statistically significant. This indicates that individuals with greater familiarity with EVs tend to have a higher level of interest in them, consistent with Hypothesis 1 (in terms of EV familiarity), within the sample.

Hypothesis 2 - Level of Urbanization: Living in urban areas correlates positively with EV interest.

Living in rural areas showed a statistically significant negative correlation with EV interest ($\beta = -0.180$, $p = 0.040$). The negative correlation suggests that rural living is associated with a decrease in EV interest and does support the hypothesis. An odds ratio (EXP (β)) of 0.84 for the "Level of Ruralisation" IV means that unit increase in ruralisation level (e.g. from "small city or large town" to "small town") decreases the odds of a person having a higher level of EV interest (the dependent variable) by 16%. The significance level of $p = 0.040$ indicates that this relationship is statistically meaningful. The effect size is relatively small, means that the impact of urbanization on EV interest, while present, may not be very large. In other words, the data suggests that urbanization has a quantifiable influence on EV interest, but the impact may not be substantial, even though it is statistically significant.

Hypothesis 3 - Income: Income level correlates positively with EV interest.

Income level was found to have a statistically significant positive correlation with EV interest ($\beta = 0.439$, $p = 0.001$). This implies that higher-income individuals are more likely to express interest in EVs, suggesting support for Hypothesis 3 The positive coefficient ($\beta = 0.439$) indicates that as income levels increase, the likelihood of having a higher interest in EVs also increases. An odds ratio (EXP (β)) of 1.55 for the income IV means that each shift up from one income category to another (e.g. from "$60,000 to $99,999" to "$100,000 or over") increases the odds of a person having a higher level of EV interest (the dependent

variable) by 55%. The very low p-value ($p = 0.001$) demonstrates that this relationship is statistically significant, providing strong evidence that higher income is associated with greater EV interest.

Hypothesis 4 - Driving Frequency: Driving frequency/length correlates positively with EV interest.

Driving frequency exhibited a statistically significant positive correlation with EV interest ($\beta = 0.142$, $p = 0.032$). Thus, individuals who drive more frequently or cover longer distances per week are more likely to have a higher level of interest in EVs, supporting Hypothesis 4. An odds ratio (EXP (β)) of 1.15 for the weekly driving length IV means that each shift up from one driving length category to another (e.g. from "200 to 299 km" to "300 to 399 km") increases the odds of a person having a higher level of EV interest (the dependent variable) by 15%. This suggests that the frequency of driving is an important factor in understanding various aspects of driving behavior and preferences, which could extend to an interest in EVs.

Hypothesis 5 - Environmentalism: Environmental concern correlates positively with EV interest.

Environmental concern demonstrated a highly statistically significant positive correlation with EV interest ($\beta = 0.219$, $p < 0.001$). This confirms that individuals with stronger environmental concerns are more interested in EVs, validating Hypothesis 5. The results strongly support Hypothesis 5. The positive coefficient ($\beta = 0.219$) indicates that as environmental concern increases, there is a significantly higher likelihood of having a greater interest in EVs. An odds ratio (EXP (β)) of 1.24 for the environmentalism IV means that each shift up from one environmentalism score to another (e.g. from 12 to 13) increases the odds of a person having a higher level of EV interest (the dependent variable) by 24%.

Hypothesis 6 - Vehicle Size: The main type of ICEV vehicle driven affects EV interest.

The type of internal combustion engine (ICE) vehicle driven, as represented by "Vehicle Size," did not show a statistically significant correlation with EV interest ($\beta = 0.043$, $p = 0.780$). This suggests that the size of the ICEV driven does not significantly influence interest in EVs, and support for Hypothesis 6 is insignificant.

In summary, the multivariate ordinal logistic regression results provide support for Hypotheses 1, 2, 3, 4, and 5. Hypothesis 6 also was not supported, as the type of ICEV driven did not significantly affect interest in EVs according to the analysis.

4.3. Qualitative Analysis

The following section presents the themes that emerged from the qualitative analysis of seven open-ended questions asked of respondents. Two questions were directed towards ICEV drivers, asking about their reasons for potentially choosing or not choosing EVs. Three questions were directed towards EV drivers, asking about their reasons for choosing EVs, potential reasons others might have for not choosing them, and how they plan long trips with their EVs. The final two questions asked both ICEV and EV drivers about their thoughts on how the government could improve policy around EVs. The themes that emerged from the analysis (see details of the process in Chapter 3) provide valuable insights into the motivations, concerns, and opinions of drivers, regarding EVs and the role of the government in supporting their adoption.

4.3.1. Qualitative Analysis Part 1: Potential Reasons for Choosing EV (Responses from ICEV Drivers)

A) Content Analysis

The word cloud in Figure 27 illustrates the most frequent keywords found in open-ended qualitative answers from ICEV drivers about reasons for potentially choosing an EV, which reveal a significant emphasis on maintenance, environment, gas, and cost. Words related to environmental protection, financial savings, fuel efficiency, cost-effectiveness, and charging accessibility were also recurring among the responses.

Figure 27: Word Cloud of Potential Reasons for Choosing EVs by ICEV Drivers

The emerged codes/themes and the frequency of each have been presented in hierarchy charts in Figure 28. Financial reasons, such as gas price, overall cost saving, and little or no maintenance, are the most commonly listed factors in the 576 answers, followed by the reason of environmental protection/lower emissions. The frequency of technology-related reasons, such as a better driving experience and performance, was notable but not nearly as common. Future-proofing investment, personal habits, and contextual reasons such as subsidies and availability of chargers were mentioned but only by a small number of respondents.

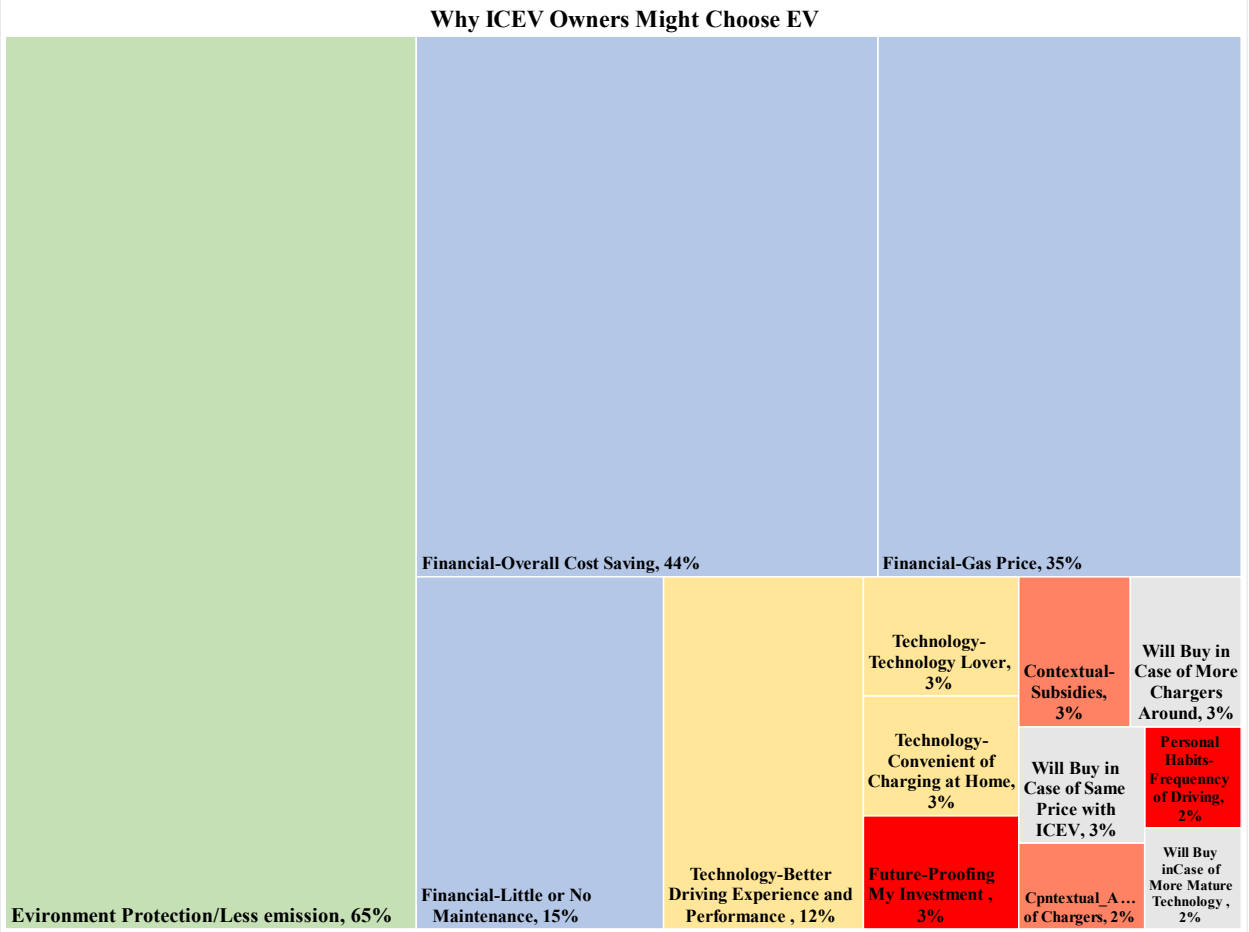


Figure 28: Hierarchy Chart of Reasons for Possibly Choosing EVs (Answers of ICEV Drivers)

B) Themes

The themes below are ordered by how frequently they were mentioned in the answers.

Theme 1 - Financial Reasons: Gas Price and Cost Savings: This theme includes reasons related to the financial benefits of owning an EV as opposed to a traditional gas-powered vehicle. Many respondents cited the high cost of gasoline and the instability of gas prices as a motivating factor to switch to an EV. One participant said, “Gas prices are unpredictable and volatile”, while another stated “Gas prices are ridiculously high.” Other financial reasons included the affordability of operating an EV, with one respondent noting that “A year of electricity for an EV is cheaper than a year of gas in a gasoline vehicle.”

Participants also highlighted the cost savings from reduced maintenance, as EVs have fewer moving parts and do not require oil changes or exhaust system replacements. However, some respondents expressed concerns about the cost of electricity and the potential for NL's energy utilities to raise their prices in response to increased EV adoption. This theme does not include responses related to the upfront cost of purchasing an EV (which was typically covered in the question about reasons not to adopt EVs), or financial incentives offered by the government or other organizations to promote the adoption of EVs (which was typically covered in the question on recommendations for government).

Theme 2 - Environmental Responsibility: This theme represents the reasons why ICEV drivers might choose an EV based on their environmental concerns. It includes a range of responses related to reducing carbon footprint, greenhouse gas emissions, and pollution. It also includes the desire to participate in the move toward sustainable transportation and contribute to provincial electrification.

Examples of responses that fall under this theme include a desire leave a smaller environmental footprint such as "lower emission" or "to know I am leaving smaller footprint", feeling a responsibility to do their part for the environment and being driven by climate change anxiety or guilt as one of them said "Moral consciousness". Some respondents also highlighted the benefit of using locally generated electricity rather than imported gasoline and the potential for a significantly lower carbon impact while driving, particularly if the provincial grid is running on renewables as one respondent mentioned. This theme also reflects the desire of some respondents to reduce noise pollution like one respondent mentioned "they [EVs] are quiet to drive and not polluting the environment", which is a unique benefit of EVs compared to ICEVs.

In summary, the environmental impact of ICEVs on the planet and future generations is a key concern for many ICEV drivers, motivating them to potentially choose EVs as a more environmentally responsible and sustainable transportation option.

Theme 3 - Technological Attractions and Better Performance: Many ICEV drivers are attracted to EVs for their technological advancements and better performance. The convenience of not visiting gas stations and being able to charge overnight is a major attraction. As one respondent put it, "able to charge overnight and wake up with a 'full tank'." This theme also encompasses the "fun" of driving high-torque EVs, and the potential longevity of EVs compared to gas vehicles. Additionally, EVs were perceived by some respondents to offer a quieter drive, better acceleration, stylish designs, and smart safety features.

The ICEV drivers also appreciated the easier maintenance of EVs and their spacious interiors, along with the plug-in hybrid options that offer the flexibility of not being dependent on one technology. EVs were also considered safer than traditional gas vehicles by some, as they do not carry large amounts of flammable fuel. Additionally, the ICEV drivers saw the benefits of EVs as they are getting better every year, are ready to go with no warm-up time, and offer a nicer driving experience based on test drives. Finally, some ICEV drivers recognized the performance benefits of EVs for towing and were interested in exploring this feature.

Theme 4 - Governmental Incentives and Charging Infrastructure: This theme centers on the availability of incentives and charging infrastructure provided by the government and other entities, which are key factors that influence the decision to switch to EVs. Participants expressed a range of views on the subject, with some highlighting the various incentives and benefits of owning an EV such as tax exemptions, rebates, and carbon

tax credits. Others mentioned the growing accessibility of charging stations in their areas, with some noting the availability of free charging at their workplaces.

For instance, one participant mentioned, “More charging stations are coming on the Island, and there are accessible charging stations on the GNP [Great Northern Peninsula], making it easier to travel and charge an EV.” Another stated, “I [can] get a tax exemption and a rebate on purchasing an electric vehicle, which helps offset the cost.” Overall, the availability of incentives and charging infrastructure emerged as an important theme, highlighting the need for further investment in these areas to support the growth of the EV market.

Theme 5 - Driving Habits and Range Suitability: Many of the respondents identified that their driving habits were well-suited for owning an EV, particularly for short commutes within the city. Some respondents also mentioned that an EV would be a suitable replacement for a secondary or in-town vehicle. However, others noted that their current driving habits may be partially but not fully compatible with an EV, particularly for longer trips. Examples of responses that fit within this theme include: “My driving habits are very suitable to an EV,” “better for my inner-city use,” “I don’t often travel long distances, so an electric vehicle would suit my range needed MOST of the time.”

Theme 6 - Future Proofing: This theme encompasses the idea that choosing an EV is a way to prepare for the future of transportation and technology. Many participants expressed interest in future-proofing their investment and being part of the change towards a more environmentally sustainable future. Examples of quotes from this theme include: “Future-proofing my investment,” “Being part of change as EVs are the future,” “the fact that most manufacturers are leaning towards producing only EVs in the future,” “Changing federal legislation in 2035,” and “EV’s become more common.”

Theme 7 - "I will buy if": Some ICEV drivers expressed interest in purchasing an EV, but price and technology concerns were holding them back. They believed that EVs were still too expensive and charging infrastructure is not yet widespread enough to make owning an EV a practical choice. They also feel that the technology is not yet mature enough to offer the same level of performance and reliability as ICEVs, especially in harsh climates like NL. They indicated that they would consider purchasing an EV in the future if the technology matures and becomes more affordable, or if charging infrastructure becomes more accessible. Some respondents also noted that they require certain features, such as 4x4 or high hauling power, which are not yet available in EVs. They believed that as EV technology advances and more models become available, they will be more likely to consider purchasing an EV. As one respondent put it, "Hopefully my next vehicle will be timed when things are better." They are hesitant to invest in an EV due to the initial cost difference. Examples of responses include: "I would choose an electric vehicle if it was the same price as a gas vehicle AND there were adequate charging stations," "Hopefully my next vehicle will be timed when things are better," and "I need 4x4 to get to my cabin- unless an EV offers 4x4 I am unwilling to buy."

4.3.2. Qualitative Analysis Part 2: Reasons for Choosing EV (Responses from EV Drivers)

The themes are ordered based on how frequently they were mentioned in the answers.

Theme 1 - Financial Reasons (Gas Price and Cost Saving): EV drivers in the survey expressed the financial benefits of owning an EV, both in terms of the price of gas (mentioned in 25 out of 71 answers and overall cost savings (mentioned in 32 out of 71 answers). Many cited the fluctuating and increasing price of gas as a key factor in their decision to switch to an EV. As one respondent stated, "Gas prices were the #1 factor in selling my truck and going

electric." Another mentioned that "The volatile and continually increasing price of gas was just not sustainable for me." Yet another responded, "I drive 50 minutes to work, so the cost of fuel was a big consideration."

In addition to the cost of gas, numerous EV drivers mentioned the long-term cost savings of owning an EV, including lower maintenance costs, no gas bills, and cheaper overall operating costs. Sample quotes include: "The Nissan Leaf spoke to us with the lower cost...and no really maintenance costs to incur after purchase. Our payment is our payment." and "Cheaper to operate and predictability of cost." Some drivers also noted the cost savings of driving an EV for long distances, with one stating, "We drive quite a good bit...it just didn't make sense for us not to switch with our 50-60,000 km annual commute."

Theme 2 - Environmental Responsibility: 23 out of 71 EV drivers who responded to this question mentioned their motivation for owning an EV was to help the environment and reduce emissions. They expressed a sense of conscious responsibility and concern about climate change. Sample responses include: "I wanted to reduce my carbon footprint and help the environment" and "I feel good knowing I'm not contributing to greenhouse gas emissions."

Theme 3 - Technological Attractions and Better Performance: The responses from EV drivers indicate that the technological attractions of EVs play a significant role in their decision making. 18 out of 71 respondents expressed their love for new technology and how it adds convenience, fun, and excitement to their driving experience. As one respondent stated, "I love the idea of an EV and I wanted to get in with the technology." Others mentioned being an early adopter, trying new things, and experiencing the auto-driving features of EVs.

In terms of performance, EV drivers highlighted the instant torque, smoother ride, and better handling of EVs compared to gas-powered cars. One respondent mentioned that

"Initially it was performance. Since owning it I have to say the entire driving experience is better". Respondents also appreciated the emissions-free aspect of EVs, as well as their ability to perform well in winter conditions. One driver mentioned, "It is the future, it is emissions-free, and also it is a lot cheaper and performs well in the winter as well." These responses indicate that EV drivers appreciate the superior performance of EVs compared to traditional gas-powered vehicles. They may also address some of the concerns of ICEV drivers about switching to EVs.

Theme 4 - Range Suitability and Driving Habits: A few responses from responding EV drivers (4 out of 71) revealed that the commuting and general driving needs of owners played a significant role in their decision to purchase an EV. Drivers cited the efficiency of EVs for small trips and daily commutes as a major factor in their decision. One owner mentioned, "The efficiency of small trips with an EV is what pushed us to go electric. On average, we were averaging close to 10L/100km in a 3-year-old Honda Civic with all the start and stop, small trips, it just didn't make sense for us not to switch with our 50-60,000 km annual commute."

Theme 5 - Subsidies: Subsidies played a role in the decision of some respondents (i.e., 2 out of 71) to purchase an EV. Two drivers cited the availability of subsidies as a factor that influenced their decision. One driver mentioned that "Subsidies are functionally free money," indicating that the financial incentives provided by the government were a significant factor in their decision to purchase an EV. Another driver mentioned receiving a "tax rebate for small business," indicating that the financial incentives provided by the government were not only appealing to individual drivers but also to small business owners who purchased EVs for their fleet.

4.3.3. Qualitative Analysis Part 3: Reasons for Not Choosing EV (Responses from ICEV Drivers)

A) Content Analysis

The word cloud in Figure 29 has been generated from the reasons why ICEV drivers do not choose EVs; it suggests that the most significant concerns are related to cost and charging infrastructure. The most frequently used words in the cloud – such as "charge," "cost," "lack," "charging," "stations," and "expensive," – indicate that the upfront cost of purchasing an EV, as well as the availability and accessibility of charging stations, are significant barriers for potential EV buyers. Furthermore, the next level of frequency includes words such as "winter," "range," "maintenance," "battery", "enough," and "gas", suggesting that ICEV drivers are also concerned about the practical aspects of owning an EV. The perception of limited range of EVs, especially during the winter season, and the maintenance costs of EV batteries are additional factors that might impact the adoption of EVs. These concerns may indicate that potential buyers need to be reassured about the practicality of EVs and how they can fit into their daily lives, or that technology and cost need further improvements before widespread adoption can be expected.

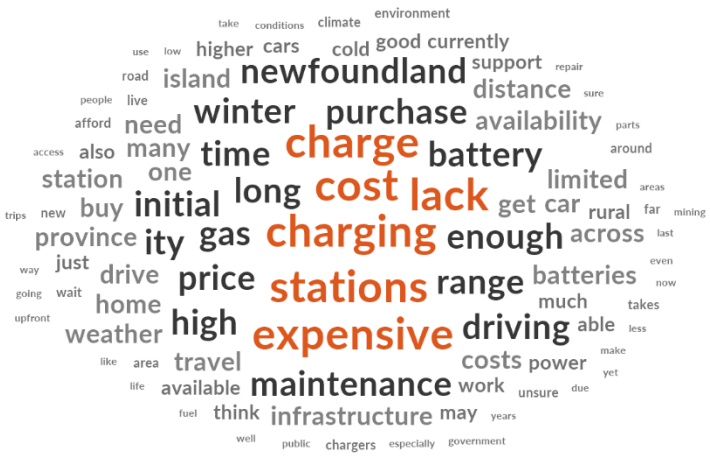


Figure 29: Word Cloud of Reasons for Not Choosing EVs (Answers of ICEV Drivers)

The hierarchy chart in Figure 30 displays the emerged codes/themes and respective frequencies on the topic of reasons for not choosing an EV. As anticipated, the primary reasons cited prominently relate to the unaffordability of purchasing prices and the inadequate charging network. Additionally, the technological concerns, such as range limitations, performance in winter conditions, and the inconvenience associated with charging, are also prominently highlighted among the reasons. Grouped by color, the chart indicates that financial issues, infrastructure challenges, and technological features respectively are frequently mentioned within the discussions on charging.

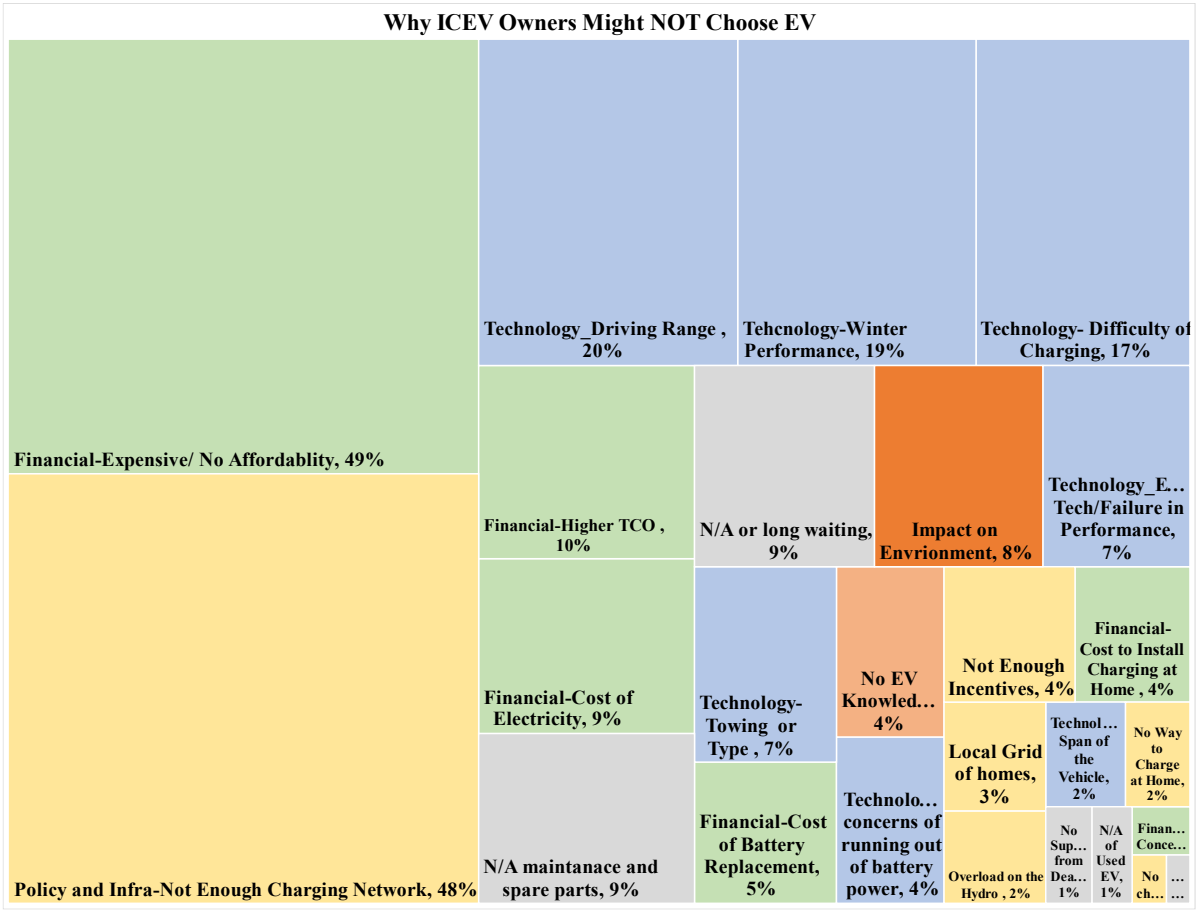


Figure 30: Hierarchy Chart of Codes Extracted from Reasons for Possibly Not Choosing EVs (By ICEV Drivers)

B) Themes

The themes are ordered based on how frequently they were mentioned in the answers. The categorization of themes in this section, such as situational factors and contextual factors,

has been conducted based on the classifications extracted from the literature review presented in Chapter 2.

Theme 1 - Situational Factors (Environmental Reasons): ICEV drivers who might not choose an EV cited various environmental concerns as their reason. This theme includes the idea that EVs are not environmentally friendly and have a negative impact on the environment. Some participants indicated that the manufacturing and disposal of batteries contribute to environmental damage. For example, one participant stated, "From what I know they are no more environmentally friendly than a gas vehicle. The mining needed to produce the batteries plus the use of electricity to power[15] them causes just as much if not more environmental damage than a gas vehicle does." Others expressed concerns about the source of electricity used to charge EVs, as it may be generated from fossil fuels. Participants also raised issues related to the production and disposal of EV batteries, citing concerns about toxic metals and components, mining requirements for lithium, and the carbon footprint associated with their manufacturing. One participant commented, "Newfoundland doesn't have a reliable renewable energy source with which to charge electric vehicles. Plugging in at home just burns diesel at the Holyrood station, it's not any greener."

Theme 2 - Situational Factors (Technology-Related Reasons): The qualitative analysis identified several technology-related sub-themes, including concerns about the evolving technology, charging inconvenience, poor performance in harsh weather, and range anxiety.

Some of the ICEV drivers expressed concerns about the evolving technology and the potential for technology malfunction, including recalls on EV vehicles that may catch fire.

[15] See Chapter 5 for responses to potentially inaccurate perceptions, as numerous instances of inaccurate perception or misperceptions have been observed among the answers.

Many respondents also preferred proven technologies that have been tried and tested. They cited better ranged vehicles coming out in the future and battery technology that lags behind where it should be. Respondents expressed concerns about the unpredictability of future value due to rapid advances in battery and motor technologies, and the inability to perform maintenance themselves. Additionally, some felt that the new technology was too new and untested, which resulted in a lack of confidence in the technology.

Another factor under this theme was charging inconvenience. Respondents noted that charging times were a problem and that multiple stops were required to recharge compared to fewer stops to fuel gas tanks. They mentioned the need for a longer distance between charges and expressed concern about the slow charging rate. Respondents noted that long-distance travel would take an excessive amount of time to complete and expressed reluctance to stop for more than an hour, affecting their schedules. Many felt that once electric cars can be charged and ready to be back on the road as quickly as they can fill up their car full of gas, they would consider leaving gas.

The ICEV drivers also expressed concern about EVs' performance in harsh weather. Some participants expressed concerns about colder weather being harder on battery life and getting stranded with limited heat if caught in a storm. Others were unsure how EVs will handle Newfoundland weather, rugged terrain, and overall, poorly kept roads. Concerns also exist about the lack of studies that examine the performance of EVs in winter, with some participants feeling that EVs would not be reliable in northern Labrador. Other concerns include how EVs will hold up against salt air, handle in the snow, and the corrosion of vehicle components, battery electrodes, and wires. For example, one participant said, "With the temperatures here in Newfoundland, an electric vehicle wouldn't even start in the cold winter months." They noted that colder weather was harder on battery life and expressed concern about getting stranded with limited heat if caught in a storm.

The ICEV Respondents expressed worries about the limited range of EVs, especially in winter and in extreme weather conditions. Some ICEV drivers mentioned the fear of getting stranded in a snowstorm or on a remote road without access to assistance, heat, or a charged cell phone battery. Some of ICEV drivers were concerned concerns about the limitations of long road trips in EVs, citing the low range of EVs and the scarcity of charging stations, particularly in rural areas. Respondents argued that making a quick trip across the island would require adding hours or days for recharging, making EVs less feasible for long journeys. Some ICEV drivers suggested that hybrid models may be a more viable option for long-distance travel. They noted that the driving range limits EVs' usability, especially in winter, and perceived that the vehicle's battery range would be reduced about 50% in Newfoundland's cold winters.

Another factor that emerged from the responses is towing capacity or vehicle type. Many ICEV drivers expressed concerns about the inability of EVs to tow heavy loads, such as travel trailers or firewood [in utility trailers]. Some mentioned the lack of 4WD options, especially for snowy and hilly terrains, and the limited availability of mid-size trucks or SUVs that can match the capabilities of ICEVs. Some respondents also criticized the design of EVs, stating that most models are unattractive and do not appeal to their tastes.

Theme 3 - Situational Factors (Financial Reasons): Many ICEV drivers expressed financial concerns as a barrier to choosing an EV. This theme is characterized by sub-themes such as price and affordability, cost of electricity, concerns of resale value, higher total cost of ownership, cost of battery replacement and longevity, and cost to install charging at home.

Sub-theme 1 - Price and Affordability: The high initial cost of EVs is a significant barrier for potential buyers, especially those from middle- to lower-income families. Cost of living increases are a serious challenge in NL, making it more difficult for people to purchase

EVs, even with government rebates. The initial purchase cost is higher for EVs than ICEVs, which requires the consumer to have access to savings or loans, especially as car companies do not offer the same low financing rates for their EV offerings.

Sub-theme 2 - Cost of Electricity: Some ICEV drivers are concerned about the cost of electricity to power EVs, in case they buy an EV. The current high cost of electricity in some regions reflects the uncertainty of future electricity prices. A respondent said, "What happens with the cost of our electricity rising and then having to charge vehicles? Do we sacrifice our heat then for the vehicle charging?" Additionally, they fear that the government will increase taxes on electricity to replace taxes on gasoline and diesel, making the charging cost even more expensive.

Sub-theme 3 - Concerns of Resale Value: Some respondents are concerned about the future value of their EVs due to rapid advances in battery and motor technologies. Some others are unsure of the value of their EVs after five to seven years or believe that the batteries would not be any good after 15+ years of use.

Sub-theme 4 - Higher TCO: ICEV drivers are unsure of the costs associated with buying and operating an EV, including maintenance costs. Some are familiar with hybrids and know that maintenance costs are higher than those of traditional gasoline-run vehicles. Others are unsure if the benefits of owning an EV outweigh the costs. Additionally, potential buyers are concerned that the electronics in EVs break down more easily in a salty environment, leading to costly repairs. ICEV drivers are concerned about the cost of replacing EV batteries, which they typically saw as needing replacement within ten years. Insurance costs are also a concern, as individuals are unsure of how much their payments will increase with an EV.

Sub-theme 5 - Cost to Install Charging at Home: ICEV drivers are concerned about the cost of installing EV charging stations in their homes. Upgrading homes to support EV

charging is another concern, with some potential buyers worried that their homes are not wired to take the extra electricity needed, or that adding 75 amps of power would be an unreasonable additional cost. Some ICEV drivers believe that the power grid is old and cannot sustain everyone owning/charging EVs at once.

Theme 4 - Situational Factors (Market Effectiveness): ICEV drivers identified various market challenges that make it difficult for them to choose an EV, including limited availability of vehicles, lack of maintenance and spare parts, unavailability of used EVs, lack of support from dealers, and absence of test drives.

One of the major concerns expressed by ICEV drivers is the lack of availability of EVs in their area. Some mentioned long wait lists of up to two years, while others reported that high-quality EVs are not readily available in their living area. Availability of specific types of vehicles, particularly vans, was also mentioned as a barrier.

Another concern raised by ICEV drivers is the lack of maintenance and spare parts for EVs. Participants expressed apprehension about finding mechanics and technicians qualified to service EVs in their locality. They also expressed concerns about the availability of parts in case of accidents or damages, and the absence of authorized service garages in their area.

Another issue raised by ICEV drivers is the lack of support from dealerships. Many mainstream dealerships were reported not to support EVs locally. Participants also expressed dissatisfaction with the customer service provided by Tesla dealerships in NL, indicating that it was a significant factor in their decision-making process. Lastly, the lack of used EVs available for purchase, limited access to vehicles to try before buying, and the absence of demos available to test drive were significant concerns for some. ICEVs also mentioned the absence of rental options for EVs as a limiting factor in their decision-making process.

Theme 5 - Contextual Factors (Infrastructure): One of the most prominent factors that deter ICEV drivers in NL from choosing an EV is the lack of charging infrastructure in the province. Many participants expressed concerns about the inadequate number of charging stations in NL, especially in rural areas and small towns. For instance, some ICEV drivers' participants perceived that there are no charging stations in outport communities, Labrador, or places west of the Avalon peninsula. Additionally, some ICEV drivers living in rural areas stated that they would not consider EVs as they could be stranded on a rural highway with no cell service due to a lack of charging stations.

Some ICEV drivers also expressed concerns about the consistency and reliability of charging stations, especially in rural areas. Even in urban areas, some ICEV derivers perceived that charging stations are not conveniently located or are unreliable. Furthermore, many participants highlighted that the existing stations are primarily located along the Trans-Canada Highway. This lack of infrastructure makes it challenging to travel to remote areas such as the Northern Peninsula and Labrador. As one respondent said:

> "Yes, there are many "fast charge" stations being placed within the province, but most of these are along the TCH. What does somebody with a fully electric vehicle do once they leave the TCH? What if somebody is heading up the Northern Peninsula and continuing on to Labrador, for example? There are no charging stations beyond Rocky Harbour that I am aware of. I think we have a long way to go before many people would even be able to consider this option."

Apart from the lack of charging stations, some participants expressed concerns about the absence of charging facilities in public places, workplaces, and schools. Additionally, participants living in apartments or condos stated that they do not have access to charging facilities due to parking restrictions and rental agreements.

Lastly, some participants expressed concerns about the potential overload on the hydro lines due to the increased demand for electricity from EVs. They fear that NL's power system

may not be able to support the extra amount of power needed, leading to power outages and hindering mobility.

Theme 6 - Contextual Factors (Insufficient Government Incentives): One common theme that emerged from the qualitative analysis of reasons given by ICEV drivers in NL for not choosing an EV is the perception that there are not enough government incentives. Many respondents expressed frustration with the current incentives, which they feel do not make up for the extra cost of purchasing an EV.

For instance, one respondent noted, “The incentives don’t make up for the extra cost.” Another suggested that the government should initiate a program similar to when the internet first became a necessary tool, providing public access points for EV charging stations in every community. This would help to drive a shift in the use of EVs.

However, some respondents expressed skepticism about the government’s motives for offering incentives. One respondent suggested that the government was pushing EVs to get more taxes on the high cost, calling it “just another tax grab.”

Other concerns related to the limited applicability of government incentives. For instance, one respondent noted that the federal subsidy did not apply to most of the AWD SUVs they were looking at. Others suggested that not all rebates were applicable to used vehicles.

Finally, some respondents expressed concern about the potential for increased taxes on electricity to replace taxes on gasoline and diesel. They pointed out that without gas vehicles, there would be less road tax revenue, and argued that electricity rates would inevitably go up to make up the difference. As one respondent put it, “People need to look at the bigger overall picture, which never happens.”

Theme 7 - Contextual Factors (NL Specific Challenges): Several ICEV drivers in NL identified specific challenges unique to their province that make choosing an EV less appealing. These challenges include NL weather conditions, the condition of highways, and the average distance between towns/cities. One respondent noted that "with the terrain in Newfoundland, I don't think they would last long" and added that weight and bad roads would further exacerbate the issue. Another noted that "road conditions prevent me from choosing electric" due to durability concerns on the province's bumpy roads.

Moreover, several respondents highlighted the effect of extreme coastal weather and the added challenge of living in Labrador, where urban centres are few and towns are far away from each other. They noted that charging infrastructure is inadequate, and traveling long distances would require too much time spent charging. One respondent mentioned that they travel 1,096kms in one day when going to their hometown for a visit, and it is much faster to gas up a vehicle and go instead of charging. Another noted that "electric vehicles are okay for cities but not for rural communities."

Furthermore, some ICVE drivers pointed out that the province's distance and connectivity issues make owning an EV less appealing. One respondent noted that "our province is so widespread, and towns are far apart," and another mentioned that they would not choose an EV due their perception that a "constant connection [is] required to the internet (which NL does not have).". One respondent summarized the issue, stating that "you can't make it across the island on one charge."

Theme 8 - Psychological Factors (Lack of Familiarity and Knowledge about EVs): One of the themes that emerged from the analysis is the lack of familiarity and knowledge about EVs. Some respondents expressed that they are unfamiliar with electric cars, their pros, and cons, and how they work. For example, consider the latter part of this comment: "As a

debt free family, electric vehicles are major expensive. And we will not take on debt to get one, and not enough knowledge about them to buy a used one". Some respondents expressed a reluctance to be the first to adopt this technology and would rather wait and observe how it works out for others. Others were unsure if they would have to install a special outlet for home charging or how often batteries need to be replaced.

Furthermore, respondents highlighted the need for more information about EVs, their performance, cost, and maintenance/parts/repair costs. Many were not aware of the locations of charging stations, which is a crucial factor in the decision-making process. Some ICEV drivers also expressed concerns about the time it takes to fully charge an EV. Other concerns regarding unfamiliarity about EV performance in winters expressed "I have no idea How well would they really hold up in our windy wet freezing rain weather?" Some demonstrated lack of knowledge about charging costs, as in this comment: "I'm fairly unfamiliar with their performance as well as cost. NL has high electricity rates, so can it compared [sic] to the price of gas? Both are expensive but I feel like charging an electric car would be way more". This lack of knowledge was seen also for the topics of home charging and EV disposal: "I have no idea if its practical to charge an electric vehicle at home. Will government allow this? The disposal of the batteries in electric vehicles, will there be places to dispose of them like garages or the dump. There are too many unknowns".

Overall, the lack of familiarity and knowledge about electric cars might be a barrier for ICEV drivers in NL, and they need more information and education about this technology to make "an educated decision".

4.3.4. Qualitative Analysis Part 4: Reasons for Not Choosing EV (Responses from EV Drivers)

Theme 1 - Price: One dominant theme that emerged was concerns about price. EV drivers consistently cited the high up-front cost of EVs as a major barrier to adoption. As one participant stated, “Price of EV’s and PHEV’s is higher when compared to ICE models. everyone can’t get approved for a high purchase price upfront.” Others echoed this sentiment, with comments such as “Many people simply cannot afford the extra cost of EVs,” and “Biggest reason seems to be cost of cars.” The perceived unaffordability of EVs was a recurring concern, with some respondents even noting a stigma attached to them. One participant observed, “There is a stigma towards them that they are unaffordable.” Overall, the consensus among EV drivers was that the high purchase price of EVs is one of the main obstacles preventing wider adoption.

Theme 2 - Lack of Knowledge: The qualitative analysis of responses from EV drivers in the survey revealed that a common reason for why others are not choosing EVs is misinformation and lack of knowledge. Many respondents mentioned that people were not aware of the range and capabilities of EVs and held misconceptions about the technology. One respondent stated, “I also think people are skeptical because of their lack of knowledge or fear of change. Once people have more personal experience with EVs, I suspect the transition will happen quickly.” Lack of education about range, charging times, and infrastructure was also mentioned as a factor, with one respondent saying, “lack of education of range, charging times also is a factor.” Or the other one mentioned “People are still worried about charging, how, where, when...they think cars are like your Apple Phone, and they die after 4hrs of use, and you have to plug them back in.” Other listed misconceptions included the belief that there are not enough charging stations or that the batteries will need to be replaced during the car’s lifetime. One respondent mentioned, “Ignorance due to fossil fuel

funded mis info" and another mentioned, "People are afraid of a lack of infrastructure to charge, while they are unaware that the vast majority of EV charging is done at home." Lack of familiarity with the technology and skepticism about its capabilities were also mentioned, with one respondent stating, "People are skeptical because they're generally unfamiliar with them and see it as unproven technology."

Theme 3 - Psychological or Cultural Barriers: The theme of psychological or cultural barriers emerged as a reason why others are not choosing EVs. Many respondents noted a resistance to change and an unwillingness to trade some inconveniences for the benefits of driving an EV. One respondent commented, "People are a little back on the times and don't handle change well," while another noted, "Unwillingness to change/concern about the unknown." This unwillingness to embrace new technology was seen as particularly prevalent among the older generation, with one respondent saying, "Electric vehicle adoption will hinder until the older generations are full stop proven wrong on said misinformation and or they cease to exist."

In addition to a resistance to change, there was also a sense that the culture of Newfoundland itself was a barrier to EV adoption. Respondents noted that the population as a whole was "stubborn" and "stuck in old world thought," with one saying, "People in Newfoundland are frankly not forward thinkers." This cultural resistance to new ideas and technologies was seen as a major obstacle to widespread EV adoption in the province among the respondents.

Theme 4 - Charging Infrastructure: Based on the responses provided by EV drivers, some of the most frequently mentioned perceived concerns were those about charging infrastructure. The EV drivers mentioned the lack of charging stations as a reason why others are not choosing EVs. According to them, some people are not aware that they can charge

their EVs at home, while others expressed concerns about the availability of charging infrastructure outside major urban centers, with one respondent agreeing that “there is a lack of chargers, especially off the TCH.” Additionally, some people are hesitant to make the switch to EVs because they believe that the current charging infrastructure will be inadequate as EV adoption increases, leading to lengthy queues for charging and increased travel time. As one respondent noted, “as EV adaption [sic] increases the current charging infrastructure will be inadequate.”

Another factor that contributes to concerns about charging infrastructure is the inability to manage the transition to EVs, particularly for those who live in condominiums or city center townhouses. As one respondent noted, “charging availability (no option to install home charger-i.e., live in condo or city center townhouse)” is a major barrier to EV adoption.

Theme 5 - Market Effectiveness: Another theme that emerged was the market effectiveness. This theme included subthemes of availability and concerns about maintenance. On the availability front, respondents cited several issues, including “inability to find second-hand vehicles,” “long wait lists for new vehicles,” and “inability to find an electric version of a familiar brand.” Additionally, the lack of larger EV models was also noted, with one participant stating, “People want larger vehicles and there are few large EVs available. Those that are available are priced too high for most people.”

In terms of concerns about maintenance, respondents raised issues related to a lack of hands-on experience and concerns about EV/hybrid maintenance in their area. As one participant stated, “lack of hands-on experience is a major issue when considering EVs,” while another noted that “concerns about EV/hybrid maintenance in their area” were a potential barrier to adoption.

Theme 6 - Risk of Evolving Technology: Another theme that emerged was the risk of evolving technology. Respondents expressed concerns about the uncertainty surrounding EVs and the perceived risks of investing in new technology. As one participant stated, “A big risk on ‘new’ technology,” while another noted, “People distrust the technology; they are unsure if the vehicles are actually better for the environment and for their monthly expenses.” These sentiments were echoed by others who expressed uncertainty about the long-term reliability and performance of EVs.

Theme 7 - Specific Challenges in NL: Respondents highlighted NL-specific challenges that make it difficult for people to switch to EVs. One such challenge is weather, with several participants noting the need for all-wheel drive vehicles for snow and off-roading This perspective may come from the perception that there is no such thing as all-wheel EVs or EVs designed for off-road use – or that such vehicles are far more expensive (see Chapter 5 for the discussion of misperceptions regarding owning and driving an EV). Another challenge is utility, with respondents citing the need to tow boats, tools for work, and materials and supplies for construction. There possibly exists a misperception that EVs are unable to fulfill these tasks effectively. Additionally, some respondents pointed to the distances they need to travel and the areas they need to cover for work as a major influencing factor. As one participant noted, “Job requires huge site-to-site mileage (pipe surveying and whatnot).”

Furthermore, the lack of infrastructure and public transportation in NL was also cited as a challenge. Respondents noted that owning an EV requires planning and that NL residents rely heavily on their vehicles for daily living. As one participant noted, “There is some planning to owning an electric vehicle. We as Newfoundlanders depend on our vehicles for daily living as there is no great public transportation to avail of.” Finally, the commitment to oil and gas was also cited as a challenge for EV adoption in NL, with some respondents

expressing a belief that NL residents are reluctant to switch to EVs due to their ties to the oil and gas industry.

4.3.5. Qualitative Analysis Part 5: Suggestions for How Government Can Better Manage the Issue of Electric Vehicles (Responses from ICEV Drivers)

A) Content Analysis

The most frequent words in the word cloud (Figure 31) include “rebates,” “stations,” “charging,” “incentives,” and “purchase.” These words suggest that respondents are concerned about government incentives for EV ownership, such as rebates and charging stations. The next level of frequently used words includes “home,” “install,” “tax,” and “education,” indicating that respondents may also be interested in government support for home EV charging installation, tax incentives, and educational initiatives to raise awareness about EV ownership.

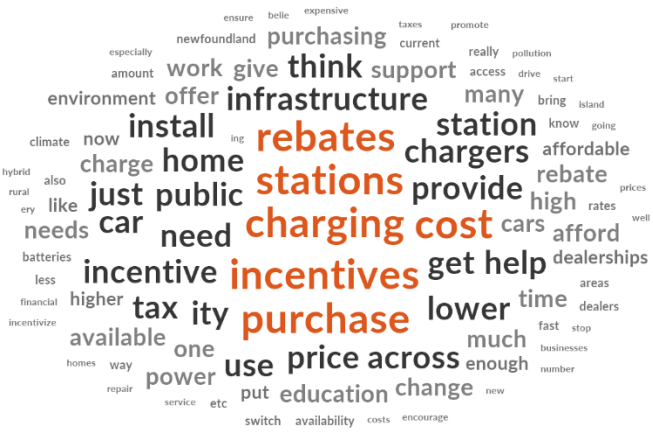


Figure 31:Word Cloud of How Government Can Better Manage EV Issues (Answers of ICEV Drivers)

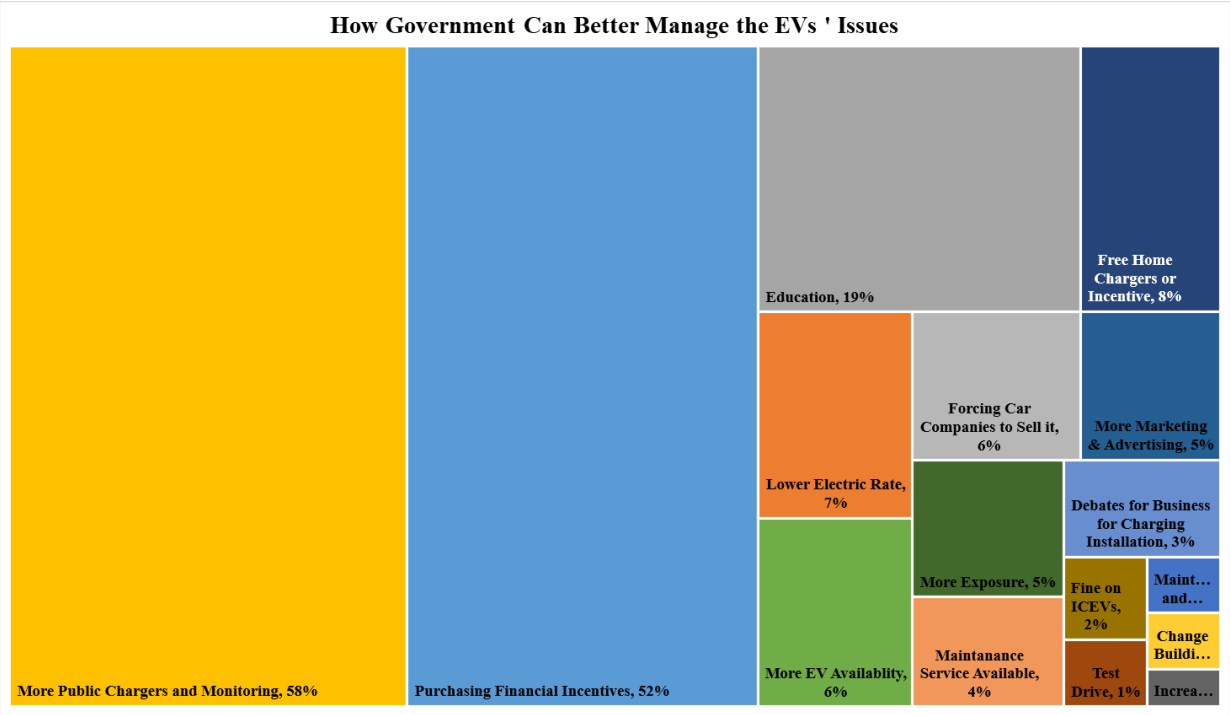


Figure 32: Hierarchy Chart of Codes Extracted from Ways the Government Can Better Manage EV Issues (Answers of ICEV Drivers)

Figure 32 presents the emerged codes and their frequency for suggestions from ICEV drivers on how the government can better manage EV issues. The chart displays the different codes that have been identified across 325 answers, with the most frequent ones listed on the left and at the top. The most significant factor is more public chargers and monitoring, identified in 58% of responses to this question. Purchasing financial incentives follow closely at 52%. Education is at 19%, and free home chargers or incentives make up 8%. Other suggested ways to manage EV issues include lower electric rates, maintenance service availability, and more exposure, all of which fall within the range of 3-7%.

B) Themes

In response to the question of how the government can better manage the issue of EVs, 325 valid answers were received and analyzed for common themes. These themes are presented in two main categories: supply-side issues and demand-side issues.

Demand-Side Themes 1 - Financial Incentives

Subtheme 1 - Purchasing Incentives: Many respondents suggested that the government could help finance the purchase of EVs by offering lower interest rates, longer payment terms, tax breaks, and rebates. For instance, one respondent noted that "an 8-year payment for a new PHEV SUV with a reduced interest rate (or interest rate of 0%) would allow users to recoup gas costs for a net savings in year one."

Several other respondents suggested enhancing incentives, increasing tax credits, and providing better rebates to make EVs more affordable. One respondent argued that "larger incentives, lower insurance, etc., would make the appeal of EVs better." Another respondent suggested offering a tax rebate for every year someone drives an EV. However, some respondents expressed concerns about the effectiveness of such incentives, with one respondent arguing that "wealthy people who can afford to buy EVs do not need rebates.". Several respondents suggested that the government should provide better incentives, such as buyback incentives to encourage people to turn in their old vehicles. Some even suggested providing incentives for early adopters to take the risk and purchase EVs. One respondent stated, "There is ZERO incentive from the Government to help with the purchase price. For a small business, this makes it extremely hard to do the right thing."

Furthermore, several respondents argued that EVs should be priced similarly to ICEVs of the same type. One respondent pointed out that "they have to be priced similarly to ICE vehicles of the same type," while another suggested that "…they [EVs] must be less expensive than gas vehicles." Respondents also suggested that the government could remove taxes on EVs, lower the price for the registration of an EV, offering buy-back incentives to have people turn in their old, unwanted vehicles, make car insurance the lowest in the market,

and matching provincial rebates to the federal rebate to encourage more people to switch to EVs.

Subtheme 2 - The High Cost of Living and Poverty Reduction in NL: The analysis reveals a concern about the high cost of living and poverty reduction. A considerable number of respondents believe that the government needs to do more to address these issues before promoting the adoption of EVs. One respondent stated that "Cutting the cost of living, increasing the minimum wage, and reducing taxes should be the starting point."

Several respondents also pointed out that pushing for EV adoption without addressing poverty reduction would be unrealistic. One respondent stated, "The people of NL are in economic crisis. Now is not the time for the Government of NL to push this issue unless they will provide the home port installation/upgrade for free, upgrade electrical grids, slash electric utility rates, and offer healthy rebates for their purchase." Another respondent expressed concern about the impact of high gas prices on people's ability to afford electric vehicles, saying, "You can't just drive gas prices so high that people can't afford to operate their cars or buy groceries and expect them to just start buying electric vehicles." Respondents stressed that the government needs to provide more incentives such as realistic poverty reduction measures, higher minimum wage, and fewer taxes. Without these measures, it will be difficult for many people to afford EVs.

Subtheme 3 - Electric Power Rate: a common theme that emerged was the need for lower electric rates. Many respondents expressed concern over the cost of electricity and how it could impact their ability to switch to an EV. As one respondent stated, "As long as power rates continue to climb, people will resist making the change."

To address this issue, respondents suggested various solutions, including lowering the electrical rate for those who own EVs and providing rebates on bills. One respondent noted, "Lower the electrical rate if you own an electric car and subsidize the cost."

Participants also suggested implementing the policy of time-of-use electricity rates. This would incentivize EV drivers to charge their vehicles during off-peak hours when electricity is cheaper, thus saving money on their electric bills.

Overall, respondents believed that the cost of electricity would be a significant factor in their decision to switch to an EV, and the government should take steps to make it more affordable. As one respondent put it, "They will have to keep electricity rates lower."

Subtheme 4 - Incentives for Home Chargers: One of the primary concerns of ICEV drivers in NL is the need for the government to provide free home chargers or incentives for installing charging infrastructure. Some even suggest that the government should cover the entire cost of installing a charging station for those who lack access to one. As one participant stated, "Everyone that buys one should automatically get a charging station [i.e., a charger] installed at their home by the government." Many others echoed this sentiment and suggested that the government should provide financial assistance, rebates, or cover the cost of installing a charging outlet at home. Participants emphasized that "Not everyone can afford to modify their home's electricity to even get off oil/propane alone to add a charging station for their car." Some also highlighted the need for support in installing chargers in multi-unit residential buildings. As one participant pointed out, "There are no programs, assistance, or knowledge with regard to charger installations in Multi Unit Residential Buildings."

The participants also suggested that the government should remove permit requirements for homeowners to install charging stations and offer rebates for the labor cost of installing a charging station in people's homes. Another respondent stated, "The government incentive

rebates only ever affect a certain population. I have tried for years to use their rebates to upgrade my home and make it more efficient, but the rebates are so specific that they only help a few instead of the general public at large."

Subtheme 5 – Increase Gas Price and More Taxes for ICEVs: After analyzing the responses of ICEV drivers, a theme emerged that suggested increasing gas prices and imposing fines on ICEVs. Increasing gas price, could be achieved through a variety of means, including imposing a carbon tax or raising existing taxes on gasoline. Additionally, some of the suggestions put forth by the respondents included "tax surcharge on large engines for personal use" and "fine on ICEVs in terms of maintenance tax, insurance, road tax, etc." The idea behind these suggestions possibly is to encourage the adoption of EVs by making it more expensive to drive ICEVs.

Demand-Side Theme 2 – Infrastructure

Subtheme 1 - Expanding Public Charging Network: Another major theme that emerged from the qualitative analysis of ICEV drivers' opinions is the need for the government to improve EV charging infrastructure across the province. This includes not only increasing the number of charging stations but also ensuring their reliability and consistent availability. Respondents emphasized the need for more public charging stations in easily accessible locations such as grocery stores, recreational complexes, and provincially owned buildings. As one respondent put it, "Provide more charging stations and advertise where they are located." Another suggested "charging stations in rural areas." There was also a call for more information on the location of charging stations, with one respondent suggesting "seminars to discuss new technology and how they work. More info on where to find charging stations."

The need for consistent charging station standards across the province was also highlighted. Respondents recommended that the government ensure "consistent charging

stations across the province" and "enforce time limits on parking at existing charging stations." The term "consistent charging stations across the province" likely refers to the need for standardized infrastructure for EV charging. Currently, there might be inconsistencies in the types of charging stations available, their compatibility with different EV models, charging speeds, and even their geographical distribution.

Some respondents suggested that gas stations be retrofitted with facilities for EVs. One respondent suggested that the government "retrofit all gas stations with facilities required for electric vehicles" and another recommended "make super charge stations at various locations across the TCH." Finally, there were suggestions for incentivizing businesses to install charging stations. Respondents recommended "incentivizing charging stations at businesses like restaurants grocery stores and shopping centers so charging is not a problem" and "give a specific gas station an incentive to put stations at every Irving." Respondents believed that such measures would help to ensure that EV drivers had access to reliable charging infrastructure across the province.

Subtheme 2 - Improving Road Conditions: Another theme emerging in the qualitative analysis was the need for the government to improve the maintenance and repair of roads across the province. Respondents pointed out that poorly maintained roads not only pose a safety hazard but can also lead to increased wear and tear on EVs. Respondents recommended that the government should "maintain and repair the highways and streets in towns, cities, and rural areas better." There were also concerns about the state of roads in more remote areas, with one respondent stating that "GNP roads are hazardous." By improving the quality of roads across the province, respondents believed that the government could help to ensure that EV drivers had safe and reliable routes for travel. Improved road maintenance could also help to increase the lifespan of EVs. As one respondent noted, "potholes and rough roads can

cause damage to the undercarriage of electric vehicles." By addressing these issues, the government could help to reduce the maintenance and repair costs for EV drivers.

Demand-Side Theme 3 - Education and Outreach

Subtheme 1 - Education: One recurring theme was the need for greater education and awareness about EVs. ICEV drivers suggested that many people in the province were not fully aware of the benefits of EVs or did not have a clear understanding of how they worked. Some respondents suggested that the government could "begin a provincial education program in the province through ads, brochures, and interviews with experts" to help educate the public. Others suggested incorporating EV education into high school science programs or incentivizing salespeople to help educate customers. Respondents also emphasized the need for more information on topics such as the durability of EVs in harsh weather conditions, how to find charging stations, and the maintenance and recycling of EVs.

By improving education and awareness about EVs, respondents believed that the government could help to increase the adoption of EVs in the province. One respondent noted that the government would "have to prove it is cheaper to operate an electric vehicle," suggesting that education could help dispel misconceptions about the cost of EVs and highlight their long-term cost savings. In conclusion, respondents emphasized the importance of educating the public about the benefits of EVs, how they work, and their long-term cost savings.

Subtheme 2 - More Aggressive Marketing Affairs: Based on the responses of ICEV drivers in NL, it appears that marketing is a key issue on the demand side of the EV industry. Some respondents feel that there is a lack of awareness and education about EVs in the general public, and that more needs to be done to promote their benefits. As one respondent noted, "there needs to be more commercials or ads on TV, radio, FB, etc."

This sentiment was echoed by other drivers, who emphasized the importance of spreading information about EVs through various channels. For example, one respondent suggested that "the government should put up posters in public places, on buses, etc. to increase awareness about electric vehicles." Overall, it is clear that marketing and education play a critical role in increasing demand for EVs and promoting their adoption on a larger scale.

Subtheme 3 - Conduct Special Research about Running EVs in NL: the need for special research to be conducted to assess the feasibility of running EVs in the province. Specifically, participants called for more information and studies on how EVs perform in Newfoundland's winter weather conditions and a comprehensive analysis of the province's electrical grids to ensure that they can supply the electric power to meet the demands of a switch to EVs.

One respondent suggested, "We need more information and studies on how they [EVs] perform in our climate, especially during our harsh winters." Another participant called for a study to "assess the actual reliability of EVs in our climate." These responses suggest that there is a lack of information and research on the suitability of EVs for the province's weather conditions, which may be hindering their adoption. Moreover, participants expressed the need for research to be conducted to ensure that the province's electrical grids can handle the increased demand that would come with a widespread shift to EVs. As one participant noted, "We need a study in our province to assess our electrical grids and prove that we can supply electric power to meet the demands of a change to electric vehicles." These responses highlight the need for the government to take a proactive role in conducting special research to assess the feasibility of EVs in Newfoundland and Labrador, particularly in terms of weather and infrastructure. Benchmarking with countries such as Norway, which has a high rate of EV adoption, could also provide valuable insights for the province, as suggested among the answers.

Demand-Side Theme 4 - More Exposure: One of the frequent themes that emerged is the need for more exposure to EVs. Respondents believe that the government should take the lead in promoting the use of EVs and raising awareness about their benefits. Several respondents suggested that the government should introduce EVs into their fleets, with one stating, “Government vehicles should be EVs to show the public that these are viable alternatives.” The respondents also suggested incentives for municipalities to procure EVs.

As one respondent said, “Maybe the government can start the initiative with the purchase of their own vehicles. Maybe our buses and taxis should go electric first as well.”

Some suggested that the government should purchase EVs themselves to support the industry, show their effectiveness and lead by example. As one respondent stated, “Maybe government officials should be driving electric vehicles themselves.”

Demand-Side Theme 5 - Changing Building Codes: One important theme that emerged from the analysis of responses is the need to change building codes. Respondents suggested that the government should ensure that new homes and multi-unit residential buildings are built with EV charging stations available. As one respondent stated, “Ensure new homes are built with EV charging available. There are no programs, assistance or knowledge with regard to charger installations in multi unit residential buildings.”

Respondents also expressed concern about the accessibility of charging stations for seniors and people with disabilities. They emphasized that ease of use is critical, and that the government needs to ensure that charging stations are installed in locations that are accessible to everyone. As one respondent noted, “Ease of use is also important for seniors and people with disabilities.”

Supply-Side Themes

Supply-Side Theme 1 – Forcing Car Companies to Sell EVs: One of the major concerns raised by ICEV drivers in NL is the lack of supply of EVs. Many participants suggested that the government should work with car companies and dealers to increase the supply of EVs and encourage them to sell them. One participant said, “Try to incentivize dealers to bring in a larger supply of electric vehicles.” Another participant suggested that the government should mandate dealerships to carry a minimum number of EVs or increase sales numbers. Participants also highlighted the need for more local suppliers of EVs. They suggested that the government should influence dealerships to get certified to sell EVs and mandate a certain percentage of overall sales to be EVs and “help dealers bring in demos to promote purchase”. Some ICEV drivers expressed their frustration with having to travel long distances to bring an EV to NL, saying “Government should be involved to make available electrical vehicles here and no people should drive 1500-3000km to bring them here.”

Supply-Side Theme 2 – Make EV Maintenance Services More Available: One of the challenges stressed by ICEV drivers is the lack of maintenance service availability in NL. Several participants suggested that the government could incentivize smaller repair shops to have EV training and equipment on-site. One participant stated, “Right now, you’re stuck with the dealer for maintenance and repair on an EV.”

Another suggestion was to provide incentives to train mechanics in EV maintenance. With the shift towards EVs, there will be a growing demand for skilled workers who are knowledgeable about EVs’ unique maintenance needs. As one participant suggested, “incentives to train mechanics” would help increase the number of qualified mechanics who can provide reliable service for EV drivers.

Overall, the supply-side issues seem to be a significant barrier to the adoption of EVs in NL. Participants stressed the importance of the government's role in increasing the supply and availability of EVs to meet the demand.

4.3.6. Qualitative Analysis Part 6: Suggestions for How Government Can Better Manage the Issue of Electric Vehicles (Responses from EV Drivers)

Demand-Side Theme 1 - Financial Issues

Subtheme 1 - Purchasing Incentives: Comparing the responses from EV drivers to the theme of financial incentives that emerged from ICEV drivers, the following specific and important answers from EV drivers can be added:

- More incentives, such as tax breaks: EV drivers suggested that the government should provide additional incentives, such as "tax breaks".
- "Offer vehicle trade-up to an EV": Some EV drivers proposed that the government could implement programs or initiatives that facilitate the trade-in of conventional vehicles for EVs, encouraging a smoother transition for individuals who wish to switch to EVs.
- Critique of provincial government's commitment to EVs: one EV driver expressed dissatisfaction with the provincial government, stating that they believe "the government is not fully committed to advancing the use of electric vehicles" and that they need to develop stronger incentives and embrace future needs. They specifically mentioned a rebate program that excluded hybrids, highlighting the need for inclusive support.

- Additional tax on non-diesel vehicles: An EV driver suggested the implementation of "a large extra tax on non-diesel vehicles above a certain L/100km rating, which would directly subsidize towing-capable electric vehicles". This proposal aims to encourage the adoption of EVs by providing financial incentives linked to the fuel efficiency of vehicles.

Subtheme 2 - Purchasing Incentives: EV drivers emphasized the importance of "introducing time-of-day electricity pricing to promote overnight charging". By taking advantage of off-peak hours when electricity rates are lower, EV drivers could save money on their electric bills, ultimately making the overall cost of owning an EV more affordable.

Subtheme 3 - Incentives For Home Chargers: The important answers from EV drivers related to the subtheme of Incentives for Home Chargers revolve around subsidizing and guiding individuals regarding EV chargers at home. EV drivers suggested offering free home chargers and installation, providing rebates for installing home chargers, offering assistance and recommendations for charger installation, and implementing programs to subsidize home charger implementation while providing guidance.

Subtheme 4 - Increase Gas Price and More Taxes for ICEVs: EV drivers echoed the suggestions of ICEV drivers to increase gas prices and impose more taxes on ICEVs. They recommended raising fuel taxes, imposing additional taxes on repairs and maintenance of gas-operated vehicles, prohibiting the use of gasoline, and increasing insurance premiums and road taxes for households owning gas-operated vehicles. This shared perspective highlights the importance of raising the cost of driving ICEVs.

Demand-Side Theme 2 - Expanding Public Charging Network: The theme of infrastructure is consistent between EV drivers and ICEV drivers. EV drivers mentioned the need for an expansion of charging infrastructure, including an "increase in charging stations

across the island with more Level 3 chargers". They emphasized the importance of addressing "gaps" in the charging network, particularly in "rural areas" and "along secondary roads". EV drivers also suggested "better monitoring of chargers", "reliable charging networks", and the presence of public chargers at strategic locations such as restaurants, theaters, shopping areas, and parking lots. Additionally, they recommended providing assistance to municipalities for the installation of Level 2 charging for renters and on-street parkers. To encourage private sector involvement, some of EV drivers proposed planning ahead to facilitate high-speed charger installations. They also emphasised improving the "signage" of where the EV chargers are located specially those along the TCH: "Make the presence of public chargers obvious and most people assume there are none there".

Demand-Side Theme 3 - Education and Outreach: The theme of more education and outreach is consistent between EV drivers and ICEV drivers. Specific suggestions from EV drivers include promoting the benefits of EVs, such as significant fuel savings, low maintenance, and convenience and "demonstrate that the majority of travel is easily done on the range". They also emphasized the importance of providing accurate information and opportunities for test drives and discussions with actual EV drivers like "EV Resource Centers". EV drivers recommended looking at successful examples, such as Norway, and adapting their strategies to fit the local jurisdiction.

Demand-Side Theme 4 - More Exposure: Both EV drivers presented a similar perspective on the theme of more exposure, specifically regarding the use of EVs in governmental fleets at the provincial and municipal levels, as a visible demonstration of the technology's viability and benefits.

Demand-Side Theme 5 - Changing Building Codes: EV drivers and ICEV drivers were in agreement regarding the need for changing building codes. EV Drivers recognized the

importance of incorporating provisions in building codes to “mandate wiring for home chargers” and ensure the availability of Level 2 charging infrastructure in new rental properties, new commercial buildings, restaurants, and hotel parking lots.

Supply-Side Theme - Forcing Car Companies to Sell EVs: Both EV drivers and ICEV drivers share the perspective that car companies should be compelled to sell EVs. The EV drivers emphasized the need for increased availability of EVs locally, with more stock readily accessible and a greater variety of models available for “test drives”. They highlighted the importance of “making EVs more visible in car lots” and ensuring their availability for purchase. EV drivers also stressed the significance of “creating market viability for electric vehicles that can tow”, addressing a common concern among potential buyers. Suggestions were made to “mandate a minimum percentage of EV sales by new car dealers, similar to the regulations in Quebec and British Columbia”, and to enhance education for mechanics regarding EV maintenance. Furthermore, EV drivers expressed the need for improved access to EVs through “faster ordering processes”, and “increased information and car meet-ups”. Overall, the approach to distribution, sales, and market management has evidently been a significant and crucial subject from the perspective of EV drivers, as well as ICEV drivers. It seems apparent that this aspect has not gone unnoticed from the viewpoint of both groups, proving to be a critical and contentious issue in the EV market.

4.3.7. Qualitative Analysis Part 7: Planning Longer Trips (Responses from EV Drivers)

Theme 1 - Planning Ahead and Using Charging Network Apps

Several respondents mentioned the importance of planning ahead and utilizing charging network apps to ensure a smooth journey. They rely on software applications such as PlugShare, ChargePoint, and A Better Route Planner (ABRP) to identify charging stations along their planned routes. By checking for available spots and the type of chargers at each

location, they can estimate charging times and make necessary adjustments to their itinerary. For example, one respondent stated, “I use the PlugShare and ChargePoint apps. Typically, I charge every 200 km on a road trip for 15-20 minutes each time. I check ahead so I can wait or lose myself for the charger if needed.” This theme highlights the proactive approach of EV drivers who rely on technology to ensure they have access to charging infrastructure throughout their journeys.

Theme 2 - Using Gas or Owning PHEVs

A significant number of respondents mentioned using gasoline or owning plug-in hybrid electric vehicles (PHEVs) as a strategy for longer trips. They considered PHEVs advantageous because they could switch to gas when the electric range was insufficient. Some respondents pointed out the limitations of current charging infrastructure, leading them to rely on gasoline for longer journeys. For example, one respondent mentioned, “Due to the lack of chargers available in the province, I bought a plug-in hybrid so that I could switch to gas for longer trips.” This theme highlights the flexibility offered by PHEVs, allowing drivers to rely on both electricity and gasoline, depending on their travel requirements and the availability of charging infrastructure.

Theme 3 - Using Public Fast Chargers

The use of public fast chargers (i.e. Level 3) emerged as another important theme. EV drivers plan their trips around the availability of public fast chargers, often choosing locations where these chargers are installed. They may even plan their breaks, meals, and restroom stops around Level 3 charging stations. This approach ensures they can make efficient use of their charging time while on the road. One respondent mentioned, “When planning a long drive, we may decide to stop for a meal where a rapid charger is available.” This theme

highlights the reliance on fast charging infrastructure to minimize the charging time required during longer trips.

In conclusion, EV drivers employ various strategies when planning longer trips. They rely on charging network apps to identify charging stations, consider using gasoline or owning PHEVs for greater flexibility, and prioritize the use of public fast chargers to minimize charging time.

4.3.8. Summary of Qualitative Analysis

In Tables 8, 9 and 10 below, a concise overview of the identified themes, their explanations, and the frequency of responses from participants is provided. These tables offer a quick reference to understand the significance of each theme.

Table 8: Themes Derived for the Reasons Why People May Choose EVs

Theme	**Description**	**Based on responses by ICEV Drivers**	**Based on responses by EV Drivers**
Theme 1 - Financial Reasons: Gas Price and Cost Savings	Highlighting the financial advantages of owning an EV over a traditional gas-powered vehicle, focusing on savings in gas expenses, overall ownership cost savings, and also predictability in expenses, particularly for longer commutes	429 out of 576 answers (75%)	32 out of 71 (45%)
Theme 2 - Environmental Responsibility	Embracing various reasons centered on a conscious sense of responsibility towards the environment including reducing carbon footprint, curbing greenhouse gases, supporting sustainable transport, and contributing to provincial electrification.	375 out of 576 (65%)	23 out of 71 (32%)
Theme 3 - Technological Attractions and Better Performance	attraction towards EVs for technological advancements, including overnight charging convenience, high-torque driving, perceived longevity, quieter rides, better acceleration, stylish designs, safety features, easier maintenance, spacious interiors, plug-in hybrid flexibility, perceived safety, continuous improvement, and superior driving experiences	96 out of 576 (17%)	18 out of 71 (25%)

Theme	Description	Based on responses by ICEV Drivers	Based on responses by EV Drivers
Theme 4 - Governmental Incentives and Charging Infrastructure	Valuing governmental incentives (tax exemptions, rebates, carbon credits) and expanding charging stations.	28 out of 576 (5%)	3 out of 71; only 2 mentioned subsidies and 1 about charging stations (4%)
Theme 5 - Driving Habits and Range Suitability	recognizing their driving habits as compatible for short city commutes or as a secondary/in-town vehicle and acknowledging EV suitability for most of their range needs, yet some note limitations for longer trips.	10 out of 576 (2%)	4 out of 71 (6%)
Theme 6 - Future Proofing	viewing EV ownership as a way to future-proof their investment in transportation due to the evolving nature of the industry.	18 out of 576 (3%)	0 out of 71 (0%)
Theme 7 - "I will buy if"	expressing interest in EVs but citing concerns about price, technology maturity, and charging infrastructure as barriers. awaiting for the EV cost parity, improving technology for harsh climates like NL, more accessible charging infrastructure, and desired features like 4x4 or high hauling power before considering an EV purchase, hoping for future advancements to align with their needs.	24 out 576 (4%)	0 out of 71

Table 9: Themes Derived for the Reasons Why People May NOT Choose EVs

Theme	Description	Based on responses by ICEV Drivers	Based on responses by EV Drivers
Theme 1 - Situational Factors (Environmental Reasons)	Environmental concerns about battery manufacturing, disposal, mining impact, and concerns about reliance on fossil fuels in the local power production	61 out of 752 (8%)	0 out of 63 (0%)
Theme 2 - Situational Factors (Technology-Related Reasons)	various technology-related worries about EVs, including concerns about evolving technology's reliability, potential malfunctions, recalls, and the preference for proven, tested technologies; also concerns inability to self-maintain EVs, charging inconveniences, performance issues in harsh weather and limited range, especially in extreme conditions like Newfoundland winters; and a lack of suitable vehicle types, particularly for rugged terrain, snowy conditions, and towing heavy loads	405 out of 752 (%54)	3 out 63 (5%)
Theme 3 - Situational Factors (Financial Reasons)	various financial barriers: initial cost and affordability, rising electricity expenses, uncertainty about EV resale value due to technology advancements, higher total ownership expenses (maintenance, repairs, insurance), and concerns about home charging costs and grid capacity for widespread EV usage	465 out of 752 (62%)	4 out 63; only on upfront price (6%)
Theme 4 - Situational Factors (Market Effectiveness)	limited vehicle availability, maintenance and spare parts scarcity, absence of used EVs, lack of dealer support, and inadequate test drive opportunities and absence of EV rentals	133 out of 752 (18%)	19 out of 63 (30%)

Theme	Description	Based on responses by ICEV Drivers	Based on responses by EV Drivers
Theme 5 - Contextual Factors (Infrastructure)	inadequate charging stations, especially in rural and remote areas, concerns about station consistency and reliability, limited placement primarily along the Trans-Canada Highway, absence of charging options in public areas, and restrictions for apartment/condo residents and lastly potential power grid overload	388 out of 752 (52%)	4 out of 63 (6%)
Theme 6 - Contextual Factors (Insufficient Government Incentives)	perceived inadequacy of incentives to offset EVs' extra cost, frustration with incentive applicability, skepticism about government motives (viewed as a tax grab), concerns about limited federal subsidy application to certain vehicle types (e.g., AWD SUVs), and doubts about rebates' applicability to used vehicles. Concerns also extend to potential future tax shifts from gasoline/diesel to electricity	32 out of 752 (4%)	1 out of 63 (1.5%)
Theme 7 - Contextual Factors (NL Specific Challenges)	concerns about NL's harsh weather conditions impacting EV durability, road conditions, challenges related to extreme coastal weather, living in Labrador with inadequate charging infrastructure for long distances, connectivity issues and distance between towns	373 out of 752 (50%)	24 out of 63 (38%)
Theme 8 - Psychological Factors (Lack of Familiarity and Knowledge about EVs)	lack of knowledge about EV functionalities, pros, cons, used EVs, battery life, home charging, charging station locations, charging duration, and comparative costs with gas; EV drivers also focused on misinformation about EVs and also and a NL specific cultural mindset like resistance to change and unwillingness to embrace inconveniences	33 out of 752 (4%)	34 out 63 (54%)

Table 10: Summary of Suggestions for Government to Improve current EV Adoption Situation

Theme	Description	Comes from ICEV Drivers	Comes From EV Drivers
Demand-Side Theme 1 - Financial Incentives	Providing various financial incentives like reduced interest rates, extended payment terms, tax breaks, and rebates. Addressing poverty, reducing living expenses, implementing time-of-use electricity rates, providing home chargers or financial aid for installation, and increasing gas prices or taxes on ICEVs.	x	x
Demand-Side Theme 2 - Infrastructure	Providing enhanced infrastructure to facilitate EV adoption. This includes expanding the public charging network, ensuring consistent standards, retrofitting gas stations, incentivizing businesses to install charging stations, and improving road conditions to ensure safe and durable routes for EV travel, particularly in rural and remote areas.	x	x
Demand-Side Theme 3 - Education and Outreach	Widespread EV education, advocating for ad campaigns, school programs, and informed sales approaches. Emphasizing aggressive marketing via ads and posters, widespread education	x	x
Demand-Side Theme 4 - More Exposure	Increased visibility of EVs, proposing government fleet integration, incentives for municipal EV adoption, and government officials leading by example. Emphasizing the role of government vehicles, buses, and taxis as electric pioneers.	x	x

Demand-Side Theme 5 - Changing Building Codes	Altering building codes to mandate EV charging provisions in new homes and multi-unit residential buildings. Accessibility concerns for seniors and people with disabilities are highlighted.	x	x
Supply-Side Theme 1 - Forcing Car Companies to Sell EVs	The need for the government to collaborate with car companies and dealerships to enhance the availability of EVs, through incentivizing dealerships to bring in more EVs, mandating a minimum number of EVs at dealerships, fostering local suppliers for EVs, and assisting dealerships to promote EV sales.	x	x
Supply-Side Theme 2 - Make EV Maintenance Services More Available	In response of the challenge of limited maintenance services for EVs in NL, recommendations include incentivizing smaller garages to offer EV services, promoting on-site EV training and equipment, and providing incentives to train mechanics in EV maintenance also to address the current dependence on dealerships for EV maintenance and ensure a broader network of qualified mechanics.	x	x

4.4. Summary of the Results

This Chapter examined various aspects of ICEV drivers in the sample, including their urbanization level, vehicle types, driving habits, environmental attitudes, perceptions of EVs versus ICEVs, familiarity with EVs and EV initiatives, and interest in adopting EVs. Notably, the majority reside in small cities or large towns, and SUVs are the most commonly owned vehicle type. Most ICEV drivers in the sample do not typically drive long distances weekly, and there is a prevalent environmental consciousness among them, though there are misconceptions regarding certain environmental issues. While there is a growing interest in EVs, barriers such as cost, infrastructure limitations, and practical concerns hinder their adoption.

To test hypotheses related to EV interest among ICEV drivers, we used a multivariate ordinal logistic regression to examine the correlations between EV interest and seven independent variables on the sample of this study. The results indicate that EV perception, EV familiarity, income level, driving frequency, and environmental concern positively correlate with EV interest. Living in rural areas, however, shows a negative correlation with EV interest. Interestingly, the type of ICEV vehicle driven does not significantly influence EV interest. These findings might generate some insights for EV promotion and policy.

Results of the qualitative analysis reveal that reasons to choose EVs (across both ICEV and EV owners) may include: financial considerations, environmental responsibility, technological appeal, government incentives, driving habits, range suitability, future-proofing, and conditional interest make purchases once the necessary adjustments in market conditions, policies, and infrastructure are implemented according to their preferences).On the contrary, reasons for avoiding EVs include concerns about situational factors, such as: environmental impacts, technological reliability, financial barriers, market effectiveness, infrastructure limitations, lack of government incentives, NL-specific challenges, and lack of familiarity with EVs. Lastly, suggestions for government action encompass: financial incentives, infrastructure development, education and outreach initiatives, increased EV visibility, changes in building codes to promote EV charging provisions, collaboration with car companies to enhance EV availability, and efforts to expand EV maintenance services, catering to both demand-side and supply-side needs.

The above results show the multifaceted and unique dynamics underlying the adoption of EVs in different jurisdictions and the challenges hindering their widespread acceptance. From financial incentives to environmental awareness, technological attraction to infrastructure concerns, the reasons for choosing or avoiding EVs reflect a complex interplay of factors influenced by individual preferences, contextual circumstances, and regional considerations. Moreover, the suggestions put forth for government intervention underscore the need for a comprehensive approach, encompassing financial incentives, infrastructure development, educational outreach, and collaboration with stakeholders to overcome barriers and accelerate the transition to sustainable transportation. In the next Chapter, the results will be discussed in detail.

Chapter 5: Discussion and Conclusion

The transportation sector in NL still heavily depends on petroleum-based products. This reliance poses challenges for reducing GHG emissions and finding cleaner alternatives. Among modes of transportation, private passenger vehicles on roads are the most polluting component. The main goal of this study is to identify the barriers that hinder the adoption of EVs by the public in NL. By understanding these barriers, policymakers can develop strategies to address perceptions and encourage more people to choose EVs as their preferred mode of transport. Additionally, this study explores the influence of factors that may influence individuals' interest in purchasing EVs, such as knowledge/awareness about EVs, urbanization levels, income levels, driving habits, environmental concerns and the type of ICEV people predominantly drive. This study focused on NL, employing an exploratory approach, which combined qualitative and quantitative methods to analyse the data collected via a cross-sectional survey.

This chapter presents and analyzes the findings related to the research problem, objectives, and hypotheses. It starts by discussing the results of the survey to shed light on respondents' perceptions and identify barriers they have encountered. Then, insights will be provided, derived from the survey data, regarding the ways to improve the current situation and explore policy options that provincial policymakers and authorities could implement to overcome negative perceptions and promote greater acceptance of EVs. Essentially, this chapter synthesises and integrates the literature, individual statistical results, emerging qualitative themes from ICEV respondents and emerging qualitative themes from EV respondents into broader findings with only two major categories: barriers and solutions (i.e. corresponding to the two research questions).

5.1. Overview of Findings on General Perceptions of EVs

The study's findings provide insights into important aspects of EV adoption among the sample, which has been taken from the general public in NL.

The ICEV drivers in the sample show a considerable environmental consciousness, acknowledging the significance of individual efforts in fighting against climate change. This awareness could be leveraged to motivate drivers to adopt EVs as a greener choice. However, some respondents have inaccurate knowledge regarding GHG emissions and the extent of EV adoption in the province. Additionally, in terms of perspectives on EVs compared to ICEVs, while ICEVs are seen as having advantages in terms of the purchase cost and driving range, EVs are recognized as being better for the environment and reducing air pollution. This indicates an increasing recognition of EVs' benefits, which could be enhanced in promotional initiatives in future.

Another significant finding highlights the level of familiarity that ICEV drivers in the sample have with EVs. Although most had some degree of familiarity with EVs, one-fourth reported having no knowledge about them all. This reflects a need for enhanced education and awareness programs to familiarize the public with EVs and encourage their adoption. Moreover, respondents also demonstrated limited awareness about initiatives promoting EV adoption, indicating a requirement for increased outreach and educational campaigns on this issue.

In the end, even though most current ICEV drivers still prefer gasoline-powered cars, many respondents show increased interest in EVs. This finding highlights a change in opinion towards EVs and implies that by spreading awareness and correcting misconceptions, the province can generate even greater interest in adopting EVs. Specifically, the statistical analysis of Hypothesis 1 (revealed EV knowledge/awareness correlates positively with EV

interest), revealed a significant positive correlation between positive perceptions of EVs compared to ICEVs and interest in EV adoption (EXP (β) = 1.34, $p < 0.001$), as well as a positive correlation between familiarity with EVs and government incentives and interest in EV adoption (EXP (β) = 1.27, $p < 0.001$). These findings underscore the importance of fostering positive perceptions and increasing familiarity with EVs to drive their adoption.

5.2. Barriers to Public EV Adoption Identified in the Sample

5.2.1. Financial Concerns: Financial concerns are a prominent multifaceted barrier cited by many of the study participants. These concerns include the high purchasing cost of EVs, the cost of electricity to power them, future resale value, maintenance costs and the installation expenses for charging stations at home.

Even with government rebates, the upfront cost of EVs is often seen as a hurdle for potential buyers in the sample, particularly those from middle-to-lower-income families that seriously struggling to meet their basic living expenses, especially in the current socioeconomic climate. This financial barrier restricts the accessibility of EVs for segments of the population like low-income families and retirees, who find it difficult to prioritize owning an EV over needs like heating and food. This observation aligns with the statistical analysis results for Hypothesis 3; there is a significant and strong positive correlation between income levels and interest in EVs ((EXP (β) = 1.55, $p < 0.001$). The positive coefficient signifies that, in the sample, as income rises, the likelihood of interest in EVs also increases, therefore it can be suggested that income level is a crucial factor influencing EV interest. This finding also raises equity concerns, as the benefits of cleaner transportation could be disproportionately enjoyed by more affluent segments of the population. Addressing this financial barrier requires targeted interventions and tailored government approaches. For instance, implementing financial support programs for low-income residents could significantly

alleviate the burden. Drawing inspiration from successful policies can guide the development of effective strategies, such as the one in British Columbia in 2022, where the government introduced income requirements for their EV rebate program (see section 2.5.3.1). This tailored approach holds great potential for making EVs more accessible to a diverse range of consumers, including rural residents, low-income individuals and retirees.

Out of the insights gathered from existing EV drivers, a dominant belief of "EVs being too expensive" persists in NL, contributing to a significant negative perception associated with their purchase. This underscores the necessity for additional government interventions aimed at reshaping this perception. Altering the perception of unaffordability requires disseminating accurate information about EV pricing dynamics and promoting a broader understanding of total cost of ownership. It is crucial for individuals to grasp the dynamics behind EV pricing, moving beyond just the initial purchase cost. When planning an EV purchase, considering the total cost of ownership becomes essential, not solely the initial expense. Of course, even if the total cost of ownership over time is competitive with ICEVs, the weight towards up-front cost is still a barrier to potential lower-income purchasers.

Furthermore, worries about the cost of electricity required to charge EVs also contribute to people's hesitation in adopting these vehicles. There is a strong fear that the NL government might increase taxes on electricity as a replacement for gasoline and diesel taxes. Such a move could lead to increased charging costs and consequently discourage potential buyers from considering an EV. This highlights the importance of clear and consistent policies that support the transition to EVs while minimizing unexpected financial burdens on consumers.

Further major financial concern relates to the resale value of EVs due to the fast advancements in battery and motor technologies. Potential buyers are uncertain about how

these advancements will affect the long-term value of their EVs. In addition, maintenance costs are a worry as some people fear that EVs may be more susceptible to breakdowns when exposed to salty environments. The cost of replacing EV batteries, which usually need replacement within ten years, also adds to the perceived burden of owning a vehicle. However, what is often misunderstood is that all EVs in these days come with at least an eight-year battery warranty or 100,000 miles (Mc Aleer, 2022). Additionally, the U.S. Department of Energy (n.d. d) suggests that modern EV batteries often outlast their warranties, lasting between 12 to 15 years in moderate climates. However, in harsher conditions, this lifespan might range between 8 to 12 years. Notably, some sources collectively indicate that the average lifespan of a vehicle in Canada is around ten to twelve years (BrokerLink Communications, 2023; Car Nation Canada, 2023), therefore this lifespan of EV batteries is compatible with current customer trends in Canada. As a result, participants in this study may mistakenly believe they must replace the batteries of their electric vehicles during the vehicle's lifespan. However, should such replacement be necessary, manufacturers' warranties are in effect, alleviating concerns about the cost of battery replacement. In terms of corrosion, it is evident that salt accelerates metal corrosion, particularly affecting vehicle undercarriages exposed to winter road salt (CRS Authomotive, 2022), impacting both EVs and ICEVs. To mitigate corrosion in electrical systems, EV manufacturers implement design strategies (Stevens, n.d.; CORTEC Corporation, 2023). Additionally, regular maintenance by vehicle owners such as inspections and washing, is crucial for ensuring EV longevity and safety (Stevens, n.d.). Disseminating precise information and offering proper education to the public is crucial in correcting these misunderstandings.

Moreover, potential buyers and existing EV drivers anticipate a challenge when it comes to installing EV charging stations at home. Concerns about home infrastructure, such as inadequate wiring or capacity to handle the increased power demands, act as deterrents for

adopting EVs. For home charging, EV owners can satisfy their daily driving requirements by charging overnight with Level 1 equipment, utilizing existing power outlets at no additional expense, given a dedicated branch circuit is available at their parking location (U.S. Department of Energy, n.d. e). Additionally, Level 2 chargers, which are faster and more commonly used at home, require a 240V outlet such as those used for ovens or dryers (City of St. Jose, n.d.). Electricians can assess if a home has sufficient electrical capacity for Level 2 charging, though there may be additional requirements, such as extra circuits (U.S. Department of Energy, n.d. e), local government permits as it is stated in electrical bulletin of government of NL (2022), and expenses to accommodate this need. Addressing these concerns through incentives for home chargers' infrastructure improvements could add more confidence in adopting EVs.

Overall, financial obstacles such as high EV prices, worries about electricity costs, and concerns regarding resale value and home charging impact middle-to-lower-income families more. Government interventions targeting these issues, informed by successful policies, can enhance EV accessibility and equity in transportation. Additionally, changing negative views on EV affordability necessitates spreading accurate information and understanding total ownership costs, going beyond just the initial purchase.

5.2.2. Limited and Uneven Charging Infrastructure: This study highlights a critical barrier hindering the widespread adoption of EVs: the limited and uneven distribution of charging infrastructure. Participants noted concerns about the scarcity and uneven placement of chargers, especially in rural areas, small towns, outport communities, Labrador, and regions west of the Avalon Peninsula. Most charging stations are concentrated along major highways, leaving remote areas underserved. This lack of infrastructure raises fears of being stranded without power in remote locations, worsened by the absence of cellular service in some areas. EV drivers also highlighted the issue, emphasizing that, as more people switch to

EVs, there could be longer waiting times at charging stations and increased travel durations. This situation may discourage individuals from transitioning to EVs unless the government prioritizes the expansion of the EV charging network. Charging infrastructure not only provides utility but also shapes people's perceptions of EV viability by enhancing exposure to EVs. Numerous EV drivers emphasized the significance of charging stations in inspiring greater EV adoption among the public.

To address this, strategic planning through reassessing of the current situation and current standards and best practices is imperative (See Section 2.5.3.1 about charging network standards and NL situation). Resolving this issue extends beyond adding public charging stations; it necessitates charger installations in diverse settings like workplaces, schools, universities, and bustling public spaces. Additionally, residents in existing apartment complexes and condos encounter obstacles due to owners' reluctance to install chargers, citing reasons like budget constraints and limited parking space. Establishing an accessible charger network becomes critical, particularly in light of outdated infrastructure in residential complexes. Addressing this concern requires collaboration between businesses, property managers, and local governments to incentivize and facilitate the installation of charging stations in these settings. Moreover, fostering knowledge about the usage, charge cost, and practicality of electric chargers is imperative. Awareness about the differences among charger types and their functionalities needs enhancement to facilitate wider acceptance.

The current uneven distribution may reinforce the belief that EVs are only suitable for urban settings, potentially discouraging adoption in rural and remote areas. Conversely, a well-distributed network could boost confidence in EVs. This finding is related to the statistical analysis results of Hypothesis 2. The observed negative correlation between residing in rural areas and EV interest (EXP (β) = 0.84, p = 0.040) in Hypothesis 2 potentially coincides with the context of uneven EV infrastructure. Although the effect size of this

relationship is relatively small, this finding echoes the discourse on the uneven distribution of EV infrastructure, suggesting a potential link between infrastructure availability and EV interest across different regions. Addressing the disparity in charging infrastructure between urban and rural areas in NL could potentially mitigate this negative impact, fostering increased interest in EV adoption across diverse geographical settings.

Another infrastructural concern among the participants of this study was that as EVs are becoming more and more popular, the electric grid will need to be able to handle the increased demand for electricity. This could put a strain on the grid and lead to potential outages and make it difficult for people to get around. This challenge highlights the necessity of comprehensive energy planning. To ensure a smooth transition, as it is also recommended by the United States Environental Protection Agency (2023) that efforts must be made to upgrade the grid, integrate renewable energy sources, and balance the growing demand for electricity with grid stability with some new solutions such as Vehicle-to-Grid (V2G) charging.

The study underscores the critical barrier of limited and uneven EV charging infrastructure in NL, particularly affecting in less urbanized areas. To address this issue, strategic planning and broader charger installations in various settings are needed. Collaborative efforts to incentivize installations, raise awareness, and ensure grid stability are crucial for equitable EV adoption.

5.2.3. Technology-Related Concerns: Technology-related obstacles seem to prevent many participants from adopting EVs.

A big worry is how quickly EV technology changes. The fast improvements in battery and motor technology can make it difficult for people to keep up with the latest technology. This makes them hesitant to invest in a vehicle that may become outdated within a few years.

Nonetheless, while EVs experience depreciation like any other vehicles, their rate is not notably faster than ICEVs (Cardino, n.d.). The early EV models suffered quicker depreciation due to limited demand and quality concerns. However, technology advancements have significantly altered this landscape (ibid). Low resale value of EVs (or rapid depreciation of EVs) is among several myths and misconceptions around EVs that could be addressed through educational and promotional programs by government, including emphasis on lower running costs, reduced maintenance and long-term value.

Harsh weather conditions pose additional challenges for EV adoption. Concerns are expressed about the performance of EVs in colder weather, battery life reduction, and the risk of getting stranded without sufficient heat during storms. The corrosion of vehicle components, battery electrodes, and wires due to salt air exposure is also cited as a potential issue. While the influence of cold weather on EVs' batteries is acknowledged, it is also crucial to clear up some misunderstandings about this issue (Rooks, 2023). As cited by Prat (2021), the Norwegian Automobile Federation revealed, through a test, that cold temperatures can reduce the range of an unplugged EV by approximately 20 percent, and also make the charging speed slower. However, these effects are temporary and do not result in long-term damages to EVs' batteries (Liu, 2023). Nevertheless, extremely cold temperatures may have a gradual impact on the battery's long-term health (Rooks, 2023). To mitigate such potential effects, it is advised to store an EV in a garage whenever feasible, and to avoid lengthy exposure to extreme cold conditions (Liu, 2023; Rooks, 2023).

Limited driving range is also a notable barrier, particularly in winter and extreme weather conditions. Some ICEV drivers are worried about the practicality of long road trips in EVs due to their low range and the scarcity of charging stations, particularly in rural areas. Towing capacity is another concern, with potential buyers expressing doubts about the ability of EVs to tow heavy loads like travel trailers or firewood. The lack of 4WD options for snowy

and hilly terrains and limited availability of mid-size trucks or SUVs impact the decision-making process, because these vehicle types are widely available for ICEVs. EVs have made significant progress in addressing concerns about range, towing capacity, and 4WD options, however. Many newer models offer competitive ranges, towing capabilities, and 4WD options, making them more practical for a wider range of consumers. Additionally, based on the claims of 931 ICEV drivers in this study, approximately 70% of participants cover a weekly distance of less than 300 km. The existing range of BEVs, typically falling between 300 km and 450 km (Goodwin, 2023), comfortably accommodates their usual weekly driving distances. Interestingly, while range is identified as one of the barriers in the sample, the results of the statistical test show that driving frequency has a positive correlation with interest in EVs, showcasing that range concerns can be considered as a misperception. The statistical analysis conducted for Hypothesis 4 reveals that driving frequency correlates positively with EV interest (EXP (β) = 1.15, $p = 0.032$). This implies that individuals who drive more frequently or cover longer distances per week are more likely to have a higher level of interest in EVs. Education efforts focused on addressing range limitations could be particularly effective in addressing related misperceptions.

5.2.4. NL-Specific Challenges: Challenges specific to NL were also cited as a barrier in this study. Such concerns include harsh weather conditions, geographical remoteness, poorly maintained highways, and some cultural characteristics.

NL's harsh weather conditions and varying road quality create hurdles for EV adoption. Concerns about EV durability in Newfoundland's rugged terrain and extreme coastal weather were voiced by participants. While it is true that cold weather can impact EV battery performance, resulting in reduced range and slower charging speeds, as mentioned above, there are various measures and maintenance techniques to boost vehicle efficiency in these conditions. Some EV energy-saving practices include: preheating the vehicle while plugged

in, utilizing seat warmers instead of heating the entire cabin, maintaining optimal tire pressure for energy efficiency, and parking in a garage whenever possible (EV Solutions, 2020). Expanding awareness and outreach about these measures is crucial. Even though various regions with harsh and cold winters, including numerous Canadian provinces, Norway, Iceland, and Sweden, have successfully integrated EVs into their private transportation systems, it is clear that NL requires tailored infrastructure developments to address specific weather-related barriers to adoption (e.g. storm force winds, freezing rain, heavy windblown snow, according to Newfoundland and Labrador Heritage (n.d.)) or at least some research about durability of EVs in sever harsh winter locations. Additionally, PHEVs could be promoted as a better match for NL's harsh winters. The flexibility of using gasoline mode in emergencies when electric drive is not feasible could be advantageous.

In addressing NL-specific challenges, the study also delved into the implications of living in rural areas on EV interest, as indicated by the results of Hypothesis 2. The hypothesis posited that living in urban areas correlates positively with EV interest. Indeed, findings revealed a statistically significant negative correlation between living in rural areas and EV interest (EXP (β) = 0.84, $p = 0.040$). This suggests that rural living is associated with a decrease in EV interest, highlighting a challenge specific to NL. The significance of this relationship underscores the importance of tailored strategies to address the needs and preferences of rural communities.

A lack of charging infrastructure and the need to travel long distances pose challenges for residents of remote areas such as Labrador. This, in turn, shapes the perception that EV ownership might be less practical in these circumstances. Furthermore, the vast geography of the province affects the suitability of EVs for local transportation.

Another perceived constraint in NL is the lack of consistent internet connectivity, which might make it difficult for EV drivers to use mobile applications to access charging stations. To correct this misperception, it is important to promote the fact that EVs do not necessarily need an internet connection to operate while driving. However, some EVs utilize internet connectivity for certain features such as remote monitoring when they are connected to a charger (ENERGY5, 2023), over-the-air software updates (Punde, 2023), GPS navigation, live traffic information, and accessing additional smart features through a mobile applications (none of which are essential for actual driving). Additionally, it is recommended that for having a smooth and efficient long-distance journey with an EV, charging stops should be planned in advance. This approach enables drivers to identify charging stations, optimize for faster charging, and extend their vehicle's range, even if they cannot access online services for the whole trip. By doing so, drivers can travel with peace of mind, avoiding the stress of potential battery running out during the trip (Ferreira, 2023).

From the viewpoint of current EV drivers, challenges related to weather and utility demands stand out. They cited the necessity for all-wheel drive vehicles in snowy conditions and the requirement to tow equipment such as boats and tools is always a major consideration for NL residents. Towing with EVs reduces their range by about 23-31% (Arval UK, 2023), a factor crucial for Newfoundlanders and Labradorians. There is a similar effect when EVs (for those models that are capable of it) operate in AWD mode, which necessitates specific, heavy mechanical equipment to power all four wheels, inevitably draining battery range (MotorBuiscuit, 2022). For instance, consider the Volkswagen ID.4: its range decreases from 280 miles with Rear-Wheel Drive (RWD) to 251 miles with AWD (ibid). Furthermore, the need to cover extensive travel distances for work and daily life choices adds complexity to the decision-making process. This is particularly challenging as the people of NL depend heavily on vehicles for daily routines, given the dispersed population. However, it is important to note

that, based on the study participants, the weekly driving demands of individuals comfortably fall within the capabilities of current EVs, even when utilizing features like AWD or towing. While the technology is continually advancing, EVs currently can meet most people's weekly driving needs. Therefore, there is a pressing need to expand public knowledge about EVs to address concerns that are potentially unfounded. By educating the public, governments can address misconceptions and ensure accurate understanding of EV capabilities, encouraging wider adoption and confidence in these vehicles.

NL-specific cultural factors also contribute to barriers. Some participants noted a cultural resistance to change, labelling the population as "stubborn" and slow to welcome new ideas. The study does not offer any evidence to validate this claim (from some survey participants), but, if true, this sentiment indicates that the traditional mindset prevalent in NL restrains the acceptance of cutting-edge technologies such as EVs.

In numerous instances within this study sample, it became evident that individuals hold numerous misperceptions around EVs, spanning various aspects including their functionalities and associated costs. As well as these prevalent misperceptions, the statistical analysis of Hypothesis 1 underscores the importance of individuals' perceptions toward EVs.

Moreover, these results emphasize that addressing and rectifying misperceptions, be they related to functionalities, costs, or other facets of EVs, is integral to promoting these vehicles successfully. The statistical evidence supports the notion that actively working on improving people's perceptions can be a strategic approach to advancing EV promotion efforts. By reshaping perceptions, there exists a substantial opportunity to not only enhance interest levels but also contribute to the broader acceptance of EVs.

5.2.5. Market Effectiveness: Concerns about lack of market effectiveness stand out as a noteworthy barrier to EV adoption, with participants highlighting several challenges that

deter them from choosing an EV as their preferred mode of transportation. These challenges encompass a range of factors, including the limited availability of EV models, scarcity of maintenance and spare parts, absence of used EV options, inadequate dealer support, and the lack of opportunities for test drives.

Some participants noted instances of long waitlists for EVs, sometimes extending up to two years, while others pointed to the constrained accessibility of high-quality EVs in their localities. Worries were expressed about the scarcity of skilled mechanics and technicians capable of servicing EVs in their communities. This lack of options can make it difficult for drivers to get the service they need, and it can also increase costs. Therefore, incentivizing and providing training for smaller repair shops would not only benefit EV drivers but also promote entrepreneurship and job creation in the area. Additionally, it could be beneficial for the government to work with manufacturers to ensure that maintenance training is widely available and accessible, especially in areas where EV adoption is still relatively low. Ultimately, increasing the availability of maintenance service options for EV drivers will be crucial for the continued growth and success of the EV industry in NL.

Furthermore, participants indicated that many conventional dealerships do not offer substantial support for EVs, and dissatisfaction by a few ICEV drivers in the sample was voiced regarding the customer service standards provided by Tesla dealerships. The absence of used EVs and unavailability of EV rentals in the market emerged as distinct obstacles, further influencing potential buyers' hesitation.

EV drivers shared similar concerns, highlighting their struggles to find second-hand EVs and the extended wait times for new vehicles. Moreover, participants expressed difficulty in locating electric versions of familiar automobile brands, indicating a lack of diversity in the market. Furthermore, participants noted that there were fewer larger EV models available,

while observing their limited availability and high prices. The absence of practical hands-on experience with EVs and worries surrounding the maintenance of EVs or hybrids within their local area also echoed as a severe concern. These responses indicate that there is a desire among ICEV drivers to see more options for EVs and a willingness to shift towards EVs, but that the availability and accessibility of these vehicles is a significant barrier. Therefore, the government has a role to play in ensuring that EVs are more widely available and accessible to consumers as demonstrated by successful ZEV mandates in some Canadian jurisdictions (See section 2.5.3.1).

5.2.6. Insufficiently Planned Government Incentives and Signs of Government Distrust: One of the other obstacles identified is the perceived inadequacy or poor planning of current government incentives. Even the existing government incentives are, however, viewed with some distrust by participants. It is believed by some participants that the government is promoting EVs in order to generate additional taxes, labelling it a "tax grab." There were also concerns about the potential for increased taxes on electricity as a replacement for gasoline and diesel taxes. Furthermore, there was a prevalent sense of distrust toward the government, which serves as a significant indicator for governmental considerations.

On the other side, respondents believe that these incentives do not sufficiently offset the additional expenses associated with purchasing an EV. Furthermore, limitations in the scope of government incentives were noted. For example, the federal subsidy did not apply to most AWD SUV EVs. Others pointed out that not all rebates were applicable to used vehicles. Participants' concerns about government incentives not being inclusive enough or having limitations, such as the exclusion of certain vehicle types from subsidies or restrictions on rebates for used vehicles, likely contributed to this feeling of mistrust. Moreover, apprehensions regarding potential future tax implications on electricity potentially replacing

traditional fuel taxes could have added to this sentiment. Understanding and addressing these concerns and possibly the distrust is pivotal for policymakers and government bodies aiming to encourage EV adoption.

5.2.7. Knowledge and Familiarity Gaps: The lack of familiarity and knowledge about EVs among the public emerged as one of the barriers identified in this study. A substantial number of respondents indicated that they were uncertain regarding the fundamental aspects of EVs, including their advantages, disadvantages, operational mechanisms and practical matters (e.g., charging infrastructure at home or battery replacement frequency). Some individuals were reluctant to be early adopters, preferring to observe EVs' performance among others before adopting them. The statistical analysis of Hypothesis 1 confirms the importance of raising awareness and dispelling misconceptions which can lead to increased interest in EV adoption. The analysis of Hypothesis 1 demonstrates a significant positive correlation between favorable perceptions of EVs over ICEVs and interest in EV adoption ($EXP(\beta) = 1.34$, $p < 0.001$). Additionally, familiarity with EVs and government incentives also positively correlate with interest in EV adoption ($EXP(\beta) = 1.27$, $p < 0.001$).

Misinformation and inadequate education surrounding EVs emerged as another aspect of this barrier to adoption. According to this study, respondents have a misconception about the capabilities and limitations of EVs. Despite these vehicles' extensive ranges and capabilities, many individuals were unaware of their capabilities and held preconceived notions that were not accurate in reality. Essential factors such as charging times, driving range, and the current state of charging infrastructure were often misunderstood. Moreover, some respondents expressed unfounded fears of insufficient charging stations and misconceptions about battery longevity. This study also found that home-based charging, the backbone of EV charging infrastructure, is not as well known as it could be. Another knowledge gap identified in this study was about uncertainty around how environmentally

friendly EVs. It notable that in this realm there are different and evolving debates. What can be generally said, according to Hausfather (2020), is that numerous studies have shown that EVs have a higher environmental impact during the manufacturing phase, particularly because of battery production. However, their lifetime emissions (which include producing, operating and disposing) are usually lesser than those from ICEVS. This is because EVs can avoid emitting greenhouse gases during operation (ibid). It is evident from these findings that a concerted effort must be undertaken to address these knowledge gaps and eliminate misconceptions to promote greater acceptance and adoption of EVs in the region.

Overall, the outcomes from this study highlight the need for education and information about EVs to address misconceptions and increase familiarity with the technology. Clear communication about the range, capabilities, and charging options for EVs may help to address skepticism and encourage adoption of cleaner transportation in the region.

5.2.8. Summary of Significant Barriers

This section shows multifaceted barriers hindering EV adoption (as illustrated in Figure 33) for the sample of participants in this NL-based study. Financial concerns were cited by many participants, but it is evident that the effect is disproportionately on middle-to-lower-income families, emphasizing the necessity of targeted government interventions. The limited and uneven charging infrastructure, especially in less urbanized areas, requires strategic planning and collaborative efforts for broader installations. Technology-related obstacles, NL-specific challenges, and market effectiveness concerns further contribute to the complexity of the issue. Additionally, insufficiently planned government incentives, coupled with signs of distrust, pose challenges that need careful consideration. Lastly, addressing knowledge and familiarity gaps through education and clear communication emerges as a pivotal strategy for dispelling vast misconceptions.

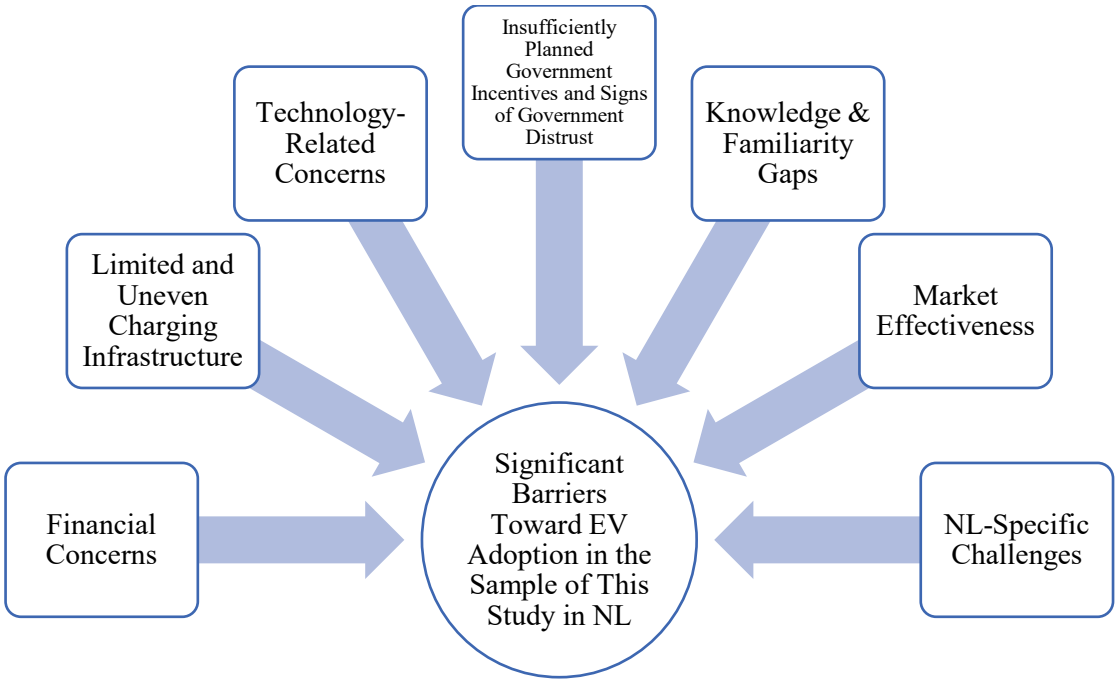


Figure 33: Potential Barriers to EV Adoption Found in This Case Study in NL

5.3. Possible Policy Options

The potential policy options outlined below are categorized into two main groups: demand-side policies and supply-side policies. The division into demand-side and supply-side policies is based on established classifications found beneficial through the literature review, as identified by Axsen et al. (2016). This approach organizes potential EV uptake policy options by providing a clear framework for analysis and discussion in the subsequent sections. Note that survey responses of the general public are a valid starting point for identifying possible policy options, especially given the relatively large sample size; however, members of the general public are not policy experts and there may be other promising policy options outside of what is covered by the survey analysis and literature review in this thesis.

5.3.1. Demand Side: Policy Area 1 - Financial Incentives

1. Purchasing Incentives and Making EVs Affordable: Respondents consistently emphasized the necessity of making EVs financially viable compared to traditional gas-

powered vehicles. To address this, policymakers could employ a range of strategies to reduce the upfront cost burden on potential EV buyers. These strategies encompass multiple facets, including offering lower interest rates on EV loans and extending payment terms, which would alleviate the immediate financial strain associated with EV purchases. Tax breaks and rebates, designed to directly offset the higher initial cost of EVs, were highlighted as pivotal tools in making the transition to EVs financially feasible for a broader segment of the population.

Furthermore, the concept of more substantial incentives gained importance in respondents' suggestions. The idea of offering lower insurance premiums for EVs could tip the scales toward electric mobility. Additionally, an ongoing tax rebate for each year an individual drives an EV could reinforce the financial attractiveness of such vehicles. To encourage individuals to trade in their older, emissions-intensive cars, buyback incentives were proposed. However, an equitable distribution of incentives was stressed. While providing incentives for affluent buyers might further drive EV adoption, it is essential to consider the needs of lower-income individuals and households. Some participants expressed concern that wealthy individuals who can already afford EVs might not require the same level of rebates, suggesting a focus on creating policies that benefit a broader range of socio-economic groups.

2. Addressing High Cost of Living and Poverty Reduction: The survey data shed light on an often-overlooked aspect—the intersection of the high cost of living and EV adoption. Many respondents stressed that promoting EVs without simultaneously addressing overarching economic challenges such as the high cost of living and poverty reduction could undermine the effectiveness of EV policies. Suggestions revolved a recurring sentiment that enhancing the affordability of EVs should be complemented by broader poverty reduction measures. Respondents argued that raising the minimum wage, reducing taxes, and creating

mechanisms to cut living expenses would lay a solid foundation for encouraging EV adoption. These measures, in combination with EV incentives, could create a positive feedback loop where not only environmental sustainability but also social equity is promoted.

3. Electric Power Rates and Time-of-Use Pricing: To alleviate concerns about the cost of electricity associated with EV ownership and promote EV adoption, policymakers could contemplate strategies aimed at reducing electricity expenses for EV drivers. This could entail a lower electrical rate specifically for those who own EVs. Additionally, introducing rebates on energy bills could incentivize EV ownership by partially offsetting the additional electricity consumption.

Time-of-use pricing emerged as a noteworthy avenue to address both consumer concerns and grid management. By implementing policies that encourage EV charging during off-peak hours when electricity demand is lower, consumers could save money while contributing to grid stability. Such a dual-benefit policy could not only mitigate financial apprehensions among potential EV buyers but also contribute to the overall sustainability of the electricity grid. Smart metering facilitates precise billing and real-time monitoring, empowering utility companies to incentivize charging during low-demand periods when electricity rates are cheaper (Rameez, 2023). As of March 2024, Newfoundland Power currently does not employ smart meters (Newfoundland Power, n.d.). Despite this, in absence of smart metering, encouraging EV charging during off-peak hours is still feasible, yet it is less optimal. Without smart meters, according to Kula (2023), alternatives like time-of-use pricing, incentives, or peak-demand alerts can promote off-peak charging. Nevertheless, their precision and efficacy may be constrained compared to the comprehensive data and control provided by smart metering.

4. Incentives for Home Charging Infrastructure: The lack of convenient and accessible charging infrastructure remains a key barrier to EV adoption. Recognizing this, policymakers might consider comprehensive measures to stimulate the installation of home charging solutions. A particularly impactful strategy could involve providing free home chargers or offering financial incentives to individuals who install charging stations.

The positive development is that NL Hydro (n.d. b) has launched a "commercial EV charger rebate" program, wherein commercial settings and workplaces can receive up to 50% reimbursement of costs incurred in installing an EV charger on their premises. While this approach can address the challenge of charging access for individuals without suitable charging options at home, it seems not many workplaces in NL are aware of this rebate. One possible way to promote this rebate could be through targeted marketing campaigns aimed at businesses and workplaces in NL. Additionally, they could leverage their existing communication channels, such as newsletters, social media platforms, and website announcements, to raise awareness and visibility of this rebate program among potential applicants.

By covering the installation cost, the government would effectively eliminate a significant financial hurdle. Moreover, extending this policy to multi-unit residential buildings could tap into a significant segment of the population that might otherwise face charging difficulties. Respondents' concerns about the lack of support for charger installations in such settings highlight the need for inclusive policies that cater to a diverse range of housing situations.

5. Increasing Gas Prices and Imposing Fees on ICEVs: Respondents put forward suggestions that focus on creating a financial disincentive for driving ICEVs. Raising gas prices and imposing fees on ICEVs were proposed as mechanisms to encourage EV adoption.

The idea behind these suggestions is that by making the cost of driving ICEVs more expensive, individuals would be motivated to switch to more environmentally friendly alternatives like EVs. Imposing additional fees and surcharges, such as maintenance taxes and insurance premiums, could effectively tip the balance in favor of EV ownership. The revenue generated from these measures could then be reinvested into developing EV infrastructure, including the expansion of public charging stations. Such a strategy offers a dual advantage: reducing reliance on fossil fuels while creating a self-sustaining funding stream for EV adoption and infrastructure development.

While these measures can incentivize EV adoption, they may encounter resistance. Increased costs for driving ICEVs could disproportionately affect low-income individuals or those with limited transportation options. Additionally, introducing fees and surcharges might face opposition, potentially leading to public backlash or political challenges. Addressing these concerns and ensuring equitable implementation would be crucial in promoting EV adoption while mitigating negative impacts. These considerations may be explored further in viability and prioritization of governmental holistic planning.

5.3.2. Demand Side: Policy Area 2 - Infrastructure

1. Expanding Public Charging Network and Grid Readiness: A key takeaway from the survey is the pressing need for the government to enhance the EV charging infrastructure throughout the province. Respondents emphasized that this involves not only increasing the sheer number of charging stations but also ensuring their reliability and accessibility. Respondents urged the placement of more public charging stations in easily reachable locations, such as grocery stores, recreational centers, and government-owned buildings. The importance of advertising the locations of these stations was also highlighted to make them more visible and accessible to potential EV users.

The proposal to retrofit existing gas stations with EV charging facilities showcases a viable approach, as it repurposes existing infrastructure to accommodate EV needs. The survey participants emphasized the significance of addressing charging gaps, particularly in rural and less-traveled areas. This recognizes the importance of inclusivity in EV adoption, ensuring that everyone, regardless of location, has convenient access to charging facilities.

Respondents also pointed out the importance of a reliable charging network and better monitoring of charging stations. This addresses concerns about technical issues and maintenance, which could otherwise hinder the widespread use of EVs. Additionally, the idea of having charging stations strategically placed in common areas like restaurants, theaters, shopping centers, and parking lots aligns with the concept of integrating EV charging seamlessly into people's daily lives.

The role of municipalities also emerged in the discussion, with suggestions to provide assistance for the installation of Level 2 charging stations for renters and on-street parking users. This recognizes the need for a diverse range of charging solutions to cater to different living situations and travel patterns.

2. Improving Road Conditions: The importance of improving the state of roads across the province was cited through this study. Beyond the safety concerns associated with poorly maintained roads, participants pointed out that these roads can lead to increased wear and tear on EVs. Addressing road maintenance not only benefits all drivers in terms of safety but also reduces the maintenance and repair costs that EV drivers might face due to road conditions. It is also important to recognize that EVs, like any other vehicles, rely on well-maintained roads to operate optimally. Roads that are in good condition can extend the lifespan of EVs, minimizing maintenance needs and associated costs. By focusing on road improvement initiatives, the government can support both the overall driving experience and the long-term

affordability of EV ownership. This aligns with the broader goal of creating an environment that encourages the adoption of sustainable transportation options like EVs.

3. Changing Building Codes: Respondents highlight the necessity of adapting building codes to accommodate the growing trend towards EVs. They suggest that the government should mandate the inclusion of EV charging stations in new homes and multi-unit residential buildings. This proactive step ensures that the necessary infrastructure is integrated right from the start, making it more convenient for residents to transition to EV ownership. Inclusive accessibility is also a key concern, with respondents pointing out that charging stations should be designed to accommodate seniors and people with disabilities. This includes considerations such as location and spacing, user-friendly interfaces, clear signage and wayfinding, and features like height adjustability (Zamanov, 2023). Addressing these considerations helps ensure that EV adoption is accessible and practical for everyone in the community. By adjusting building codes to account for EV charging infrastructure, the government can create an environment that supports and encourages the adoption of sustainable transportation options.

5.3.3. Demand Side: Policy Area 3 - Education and Outreach

The survey results strongly advocate for a comprehensive education and outreach program to address the gaps in public knowledge about EVs. Respondents highlighted the importance of informed decision-making, which requires accurate and accessible information. As it was derived through the statistical analysis of this study, higher level of perception toward EVs (a greater understanding and positive view of EVs compared to ICEVs), higher level of EV familiarity (Hypothesis 1) and higher level of environmentalism (Hypothesis 5) could be considered as potential elements that can shape EV interest. These elements can be effectively shaped through educational initiatives and outreach efforts. Given the prevalent

misconceptions identified across various aspects of EV ownership in this study, it becomes evident that elevating awareness about EVs and fostering environmental consciousness plays a pivotal role in promoting clear and sustainable private transportation.

A central proposal is the establishment of a provincial education initiative. This program could be promoted through diverse channels such as advertisements, brochures, and interviews with experts. Such an approach aims to raise awareness and build a solid understanding of EVs among the public. By providing clear and reliable information, potential buyers can make informed choices about transitioning to EVs.

Participants also emphasized the value of integrating EV education into high school science programs. This proactive approach not only imparts knowledge to the current generation but also prepares future consumers to embrace sustainable transportation solutions. One particularly engaging suggestion involves using public spaces, buses, and other visible platforms to spread awareness about EVs. This could involve displaying informative posters to capture the attention of a wide audience, further promoting understanding and interest in EVs.

Incentivizing salespeople to educate customers about EVs is a practical way to bridge the information gap. Educated salespeople can guide potential buyers through the unique features and benefits of EVs, alleviating any concerns or misconceptions they might have.

The need for further research about EVs' suitability for the province's weather conditions and the capacity of electrical grids was also highlighted by respondents. These concerns may be contributing to the hesitancy in adopting EVs. Addressing these uncertainties through dedicated research can provide reassurance to potential buyers and demonstrate the viability of EVs in the local context.

By addressing the misconceptions and lack of information, the government's efforts to educate the public can have a twofold effect: dispelling doubts about EVs' costs and highlighting the long-term financial benefits of adopting them. Ultimately, a well-informed public is more likely to consider EVs as a practical and environmentally responsible transportation option. The recognition of the potential strain on electrical grids underscores the importance of preparing infrastructure for the future. Research into the capacity of these grids can guide planning and investment to accommodate the increased demand that will accompany the widespread adoption of EVs. This anticipatory approach ensures that the necessary infrastructure is in place to support a sustainable transportation transition.

5.3.4. Demand Side: Policy Area 4 - More Exposure

Survey participants strongly advocate for the government to play a leading role in promoting the adoption of EVs and raising awareness about their benefits. Respondents recognize the significant influence of EV adoption within the government fleet and believe that its active involvement could catalyze a wider shift towards EVs.

A noteworthy proposal is for the government to set an example by integrating EVs into its own operations. This includes purchasing EVs for government use, thereby supporting the industry and showcasing the practicality of these vehicles. By incorporating EVs into the government fleet, the administration can demonstrate its commitment to sustainability and provide tangible evidence of EV effectiveness. This not only strengthens the government's credibility but also encourages public trust in EV technology.

Furthermore, participants recommend that the province provide incentives to municipalities to procure EVs. This multi-tiered approach encourages local governments to take part in the adoption of EVs. Incentives can range from financial support to streamlined

procurement processes, making it easier for municipalities to introduce EVs into their operations.

In summary, the discussed demand-side policies are essential for driving EV adoption and addressing transportation challenges. Financial incentives, economic support, education programs, and infrastructure development are all crucial components. By integrating EVs into government fleets, incentivizing municipalities, and promoting sustainable transportation, the government can pave the way for widespread EV adoption, environmental sustainability, and infrastructure readiness.

5.3.5. Supply Side: Policy Area 1 - Helping Car Companies to Sell EVs and Diversify the Market

The importance of government intervention to stimulate the supply of EVs in the market was expressed in the survey results. Respondents emphasized the need for collaboration between the government and car companies, as well as dealerships, to increase the availability and accessibility of EVs.

Many participants suggested that the government should incentivize dealerships to bring in a larger variety of EV models. This could be achieved by offering financial incentives or other benefits to dealers who expand their EV offerings. Some even proposed mandating dealerships to maintain a minimum inventory of EVs or to achieve specific sales targets for these vehicles. This approach ensures that EVs become a more prominent and accessible option for potential buyers when they visit dealerships.

Moreover, respondents stressed the importance of certifying dealerships to sell EVs. This certification process would ensure that dealerships are knowledgeable about EV technology and can provide accurate information to customers. Additionally, mandating a certain percentage of overall vehicle sales to be EVs could further drive the adoption of these

vehicles. Participants also emphasized the role of dealerships in promoting EV adoption through demonstrations. Encouraging dealerships to offer test drives and informative sessions could familiarize potential buyers with EV features and benefits.

5.3.6. Supply Side: Policy Area 2 - Making EV Maintenance Services More Available

The survey responses shed light on a significant challenge: the limited availability of maintenance services for EVs in the province. Respondents pointed out that many ICEV drivers feel constrained to rely solely on dealerships for maintenance and repairs, which can be inconvenient and costly.

To address this issue, participants suggested that the government could incentivize smaller repair shops to offer EV maintenance services. Providing these shops with training and necessary equipment to handle EVs would create a more decentralized network of service providers. This approach not only increases accessibility for EV drivers but also stimulates the growth of a specialized workforce trained in EV maintenance. The suggestion to incentivize mechanics to undergo training in EV maintenance aligns with the anticipated demand for skilled workers in this field. As EV adoption grows, the need for mechanics who are well-versed in EV-specific technologies and repairs will become paramount. Offering incentives for training would motivate mechanics to acquire the necessary skills, ensuring that enough qualified professionals can meet the rising demand for EV maintenance.

In summary, these suggested supply-side policies demonstrate the significance of government intervention in shaping a conducive environment for EV adoption. By working closely with car companies, dealerships, and maintenance providers, the government can effectively increase the availability, accessibility, and support for EVs throughout the province.

5.3.7. What Can Shape EV Interests

The statistical analysis in the study yields insightful findings regarding the factors influencing EV interest among respondents. Firstly, there are statistically significant positive correlations between EV interest and: perceptions favoring EVs (Hypothesis 1), familiarity with EVs (Hypothesis 1), living in urban areas (Hypothesis 2), environmental concerns (Hypothesis 5), income levels (Hypothesis 3), and driving frequency (Hypothesis 4). This indicates that individuals with more positive perceptions, higher familiarity, stronger environmental concerns, greater income, and higher driving frequency tend to demonstrate increased interest in EVs.

Moreover, the analysis also identifies factors that lacked significant correlations with EV interest. For instance, what was found in this study was that the type of ICEVs driven (Hypothesis 6) did not significantly impact EV interest, according to the analysis.

These findings collectively suggest that perceptions, familiarity, environmental concerns, income levels, and driving frequency play pivotal roles in influencing interest in EVs, potentially. Addressing and enhancing these aspects through education, outreach, and policy initiatives could significantly impact and encourage greater adoption of EVs, especially among populations with lower familiarity, income, or residing in rural areas.

5.4. Comparison of Key Findings with Existing Literature

This section will compare the research findings with existing literature, structured around demographic, situational, contextual, and psychological factors.

In terms of demographic factors, the literature highlights the multifaceted nature of demographic characteristics impacting EV adoption intentions, spanning individual and household attributes. This study notably corroborates the positive correlation between higher

income and greater EV interest (Hypothesis 3), aligning with perspectives emphasizing income's influence on EV adoption intentions, as seen in studies by Vassileva & Campillo (2017) and Xue et al. (2021). This study results also mirror the literature's recognition of urbanization's role, showcasing a negative correlation between rural living and EV interest (Hypothesis 2), aligning with Javid and Nejat (2017) and Christidis & Focas (2019). This study faced a limitation in assessing the relationship of all demographic factors, indicating a potential avenue for further exploration in future studies.

When comparing the literature's insights on environmental factors as one of situational factors influencing EV adoption with this study's findings, a clear alignment emerges regarding the influence of environmental concerns. Both the literature, as suggested by Singh et al. (2020), and this research (Hypothesis 5), underscore a positive correlation between stronger environmental concerns and increased interest in EVs. This alignment validates the notion that individuals with heightened environmental awareness tend to exhibit a more significant interest in adopting EVs, offering a consistent perspective across the literature and this study's finding. However, discrepancies exist concerning the magnitude of environmental factors' influence on EV adoption. While this study strongly supports the positive correlation between environmental concern and EV interest, the literature suggests that environmental benefits, although recognized, might not be the primary motivators for purchasing EVs, as highlighted in findings by Hidruea et al. (2011), Muslim et al. (2018), Rowe et al. (2012), and Delang & Cheng (2013).

However, when it comes to technological factors influencing EV adoption, several areas of alignment and contrast emerge. The literature extensively discusses concerns such as limited driving range, charging time, and vehicle performance in harsh weather conditions as key impediments to EV adoption, a sentiment echoed in the findings of this study. The study conducted by Castrol (2020) aligns with this thesis in emphasizing that an extended driving

range significantly impacts consumers' decisions when considering EVs. Similarly, the concern over charging time emerges as a key obstacle in both the literature and this research.

Financial factors play a pivotal role in the adoption of EVs, as extensively explored in existing literature. The literature identifies several key impediments, notably the high upfront costs, concerns regarding ongoing expenses like electricity charges, uncertainties about resale value, maintenance costs, and apprehensions about home charging infrastructure. A parallel is found in this study, reinforcing the importance of addressing these financial barriers to democratize access to EVs, particularly among middle- to lower-income groups. Existing literature, exemplified by Parker et al. (2021), highlights the challenge of upfront costs. This study echoes the concern about cost, showcasing a strong correlation between income levels and EV interest, emphasizing the necessity of tailored government support programs to bridge this affordability gap. While this study aligns with existing literature in highlighting financial barriers, there are potential gaps that warrant further exploration. For instance, the specific impact of government policies or interventions on altering public perceptions about EV affordability might require deeper investigation. Additionally, understanding the effectiveness of tailored support programs for different income brackets could be a focus of further studies.

The literature emphasizes the pivotal role of market dynamics in facilitating widespread acceptance. It underscores the importance of factors like model diversity, after-sales services, dealer support, advertising, and available inventory in influencing consumer decisions. Notably, Slowik & Lutsey (2018) and Dunsky Energy+Climate Advisors (2021) emphasize the need for a broader range of EV models, especially those with longer ranges and lower costs, to drive market growth. Loveday (2021) and Castrol (2020) highlight the positive correlation between model diversity and EV adoption, demonstrating that consumers are more likely to switch to EVs if comparable options to their favorite ICEVs are available. Similarly, this study supports existing literature by pointing out critical barriers hindering EV adoption,

particularly related to market effectiveness. Participants highlighted several challenges, including limited model availability, scarcity of maintenance services and spare parts, insufficient dealer support, absence of used EV options, and inadequate opportunities for test drives. This is compatible with findings by Plug in America (2021) and Dunskey Energy Consulting (2020), emphasizing the scarcity of EV options at local dealerships and insufficient dealer knowledge. However, this study also shows situations in the market dynamics not extensively covered in existing literature. It brings to light concerns about the lack of skilled mechanics for EV servicing, the unavailability of rental options for EVs, and challenges in accessing second-hand EVs. Additionally, the study reveals dissatisfaction with dealer support and customer service standards, indicating a need for improvement in customer experience at both traditional and specialized dealerships that the literature did not focus on these aspects.

The availability and accessibility of charging infrastructure emerge in the thesis findings as pivotal factors influencing the widespread adoption of EVs, a sentiment supported by various scholars (Singh et al., 2020; Axsen et al., 2016). Both this study and existing literature highlight the critical role of charging infrastructure in facilitating widespread EV adoption.

Singh et al. (2020) and other studies indeed emphasize the critical role of policies in driving EV adoption, distinguishing between demand-focused and supply-focused policies. This study aligns with this distinction between policy types. While the literature primarily emphasizes the significance of these policy categories in promoting EV adoption, it might not explicitly discuss the sense of distrust toward government initiatives in the context of EV incentives and policies. The absence of this aspect in literature does not invalidate its importance. Instead, it might indicate a gap in some studies that have not explicitly addressed or examined public trust or skepticism toward government-led EV initiatives.

5.5. Implications for Policy Makers

In light of the analysis of barriers to EV adoption presented in this study, a set of possible policy implications emerges to foster the transition to sustainable transportation in our region. The identified barriers, ranging from financial concerns and infrastructure limitations to knowledge gaps and inadequate incentives, necessitate a multifaceted approach that addresses these challenges. By leveraging the insights gained from this study, policymakers can tailor various interventions (i.e. a policy toolkit) to alleviate barriers and promote EV adoption. Table 11 provided below presents all the specific barriers highlighted in the survey and a range of possible solutions, their underlying aspects, and recommended approaches.

Table 11: Summary of Barriers, Essential Approach, and A Range of Possible Policies

Main Barrier	Different Aspects of the Barrier	Essential/Recommended Approach	Policy Options Generated from the Survey Responses					
			Demand Side				Supply Side	
Financial Concerns	High purchasing cost of EVs, especially for middle to lower income families.	• Equity and accessibility of cleaner transportation to all segments of the population • Make EVs more affordable through incentives, rebates, and financial support.	1-1 1-2					
	Electricity cost and fear of potential tax increase on electricity	• Comprehensive strategy that ensures affordable and predictable charging costs • Collaborating with utility providers to ensure competitive and transparent charging costs • Clear and consistent policies that support the transition to EVs while minimizing unexpected financial burdens on consumers	1-3 1-4	2-1	3			
	Resale Value	• Effective communication about the positive impact of technology improvements on long-term value			3			
	Maintenance Costs	• Targeted educational campaigns • Incentives for maintenance and infrastructure improvements could instill more confidence in adopting EVs		2-1 2-2 2-3	3			2
	Expenses Associated with Home Chargers Installation	• Targeted educational campaigns and incentives for infrastructure improvements such as providing support to homeowners to upgrade their electrical systems.	1-4	2-1 2-3	3			

Main Barrier	Different Aspects of the Barrier	Essential/Recommended Approach	Policy Options Generated from the Survey Responses					
			Demand Side				Supply Side	
Infrastructure	Limited and Uneven Distribution of Charging Infrastructure	• Need for equitable access to charging facilities • Targeted investments in charging networks • Prioritize investment in a comprehensive charging network, strategically placing stations in underserved areas, workplaces, and residential complexes		2-1				
	Concentration of Charging Stations; Lack of Charging Stations in Rural, Remote, and Less Densely Populated Areas	• Need to expand infrastructure beyond major highways • Ensuring equitable access to charging facilities across urban and rural landscapes		2-1				
	Lack of Charging Facilities in Public Spaces	• Regulatory support to encourage installation in public and private spaces • Collaboration between governmental bodies, property owners, and private enterprises to promote the installation of charging stations in various settings		2-1 2-3				
	Parking Restrictions and Rental Agreements	• Prioritize investment in a comprehensive charging network, strategically placing stations in underserved areas, workplaces, and residential complexes • Update building construction or retrofit codes		2-1 2-3				
	Electricity Grid Capacity and Demand; Could Lead to Outages	• Collaboration with utility companies to ensure grid readiness for increased EV usage • Ensuring that the grid can accommodate the additional load is crucial for maintaining reliable electricity supply and preventing potential outages		2-1				

Main Barrier	Different Aspects of the Barrier	Essential/Recommended Approach	Policy Options Generated from the Survey Responses					
			Demand Side				Supply Side	
Technology Related	Rapidly Changing Technology	• Broadcasting and promote transparent communication from manufacturers about their technology roadmaps and the potential longevity of their products		2-1	3	4	1	2
	Technology-Related Problems and Recalls	• Timely responses to potential issues to build consumer confidence by manufacturers and dealers					1	
	Limited Access to Repair Services	• Establishing robust support systems for EV maintenance and repair			3			2
	Charging Inconvenience	• Improving charging infrastructure and developing faster-charging technologies		2-1	3			
	Performance in Harsh Weather Conditions	• Targeted informative campaigns regarding how to use EVs in winters		2-1	3	4		
	Corrosion through Salt Exposure	• durable materials and protective measures in EV design, particularly important in regions with coastal environments.			3	4	1	
	Limited Driving Range, Towing Capacity and Utility	• Expanding the diversity of EV models in the local market		2-1	3		1	
Specific To NL Geography and Culture	Harsh Weather Conditions and Terrain	• Targeted informative campaigns regarding how to use EVs in winters and their reliability		2-1	3			
	Geographical Remoteness and Lack of Charging Infrastructure in Remote Areas	• Charging stations in remote areas	1-4	2-1 2-2				

Main Barrier	Different Aspects of the Barrier	Essential/Recommended Approach	Policy Options Generated from the Survey Responses					
			Demand Side				Supply Side	
Specific to NL geography and culture	Poorly Maintained Highways	• Improving road infrastructure		2-2	3			
	Internet Connectivity Constraints	• Improving internet infrastructure can enhance the overall EV ownership experience by enabling convenient access to charging services • Developing offline-capable charging station databases and mobile applications		2-1	3			
	Utility Demands and Long Distances	• Provide some incentives to encourage the availability of EV models that can accommodate towing and all-wheel drive capabilities in snowy conditions				4	1	
	Cultural Resistance to Change	• Promoting the benefits of EVs and addressing common misconceptions can help shift the mindset and encourage greater acceptance of electric mobility			3	4		
Market Effectiveness	Limited Availability of EV Models	• Provide some incentives to encourage a diverse lineup of EVs					1	
	Scarcity of Maintenance and Spare Parts	• Providing training and incentives to local repair shops and technicians						2
	Long Waitlists and Accessibility Issues	• Steady supply of EVs to the market and expand the availability of high-quality models					1	
	Lack of Used EV Options	• Adding EV used vehicles to the market					1	
	Dealer Support and Customer Service	• Ensuring that dealerships are adequately trained to handle EV-related queries and concerns is essential for building consumer trust. • Collaborative efforts between manufacturers, dealerships, and the government			3	4	1	

Main Barrier	Different Aspects of the Barrier	Essential/Recommended Approach	Policy Options Generated from the Survey Responses					
			Demand Side				Supply Side	
Market Effectiveness	Unavailability of Rental Options	• Expanding the availability of used EVs and introducing rental options • Encouraging the availability of used EVs in the market through incentives and awareness campaign			3	4	1	
	Limited Availability of Larger EV Models		1-1		3	4	1	
Insufficient incentives	Inadequacy of Current Government Incentives	• Harmonizing provincial subsidies with federal government subsidies	1-1					
	Distrust of Government Incentives	• transparent communication and clear explanations about the purpose and benefits of incentives • Governments should work on building trust	1-1 1-2	2	3	4		
	Limited Coverage across Vehicle Classes	• Expanding the scope of incentives to cover a wider range of EV models	1-1		3	4	1	
	Inapplicability to Used Vehicles	• Extending incentives to include the used EV market	1-1					
	Potential for Increased Taxes on Electricity	• governments should communicate their long-term plans for energy taxation clearly and provide assurances that the cost savings associated with EV ownership won't be negated by rising electricity prices			3			
Lack of knowledge and familiarity	Lack of Familiarity and Knowledge About EVs	• Comprehensive Educational initiatives should focus on explaining EV technology, its advantages (such as lower operating costs and reduced emissions) and addressing common misconceptions • Fact-Based Communication • Engagement of current EV Drivers			3	4		

Main Barrier	Different Aspects of the Barrier	Essential/Recommended Approach	Policy Options Generated from the Survey Responses					
			Demand Side				Supply Side	
	Misinformation and Inadequate Education fueled by fossil fuel interests	• Counteract misinformation by providing accurate and unbiased information through official channels, educational workshops, and collaborations with trustworthy sources			3	4		
	Unfounded Fears and Misconceptions about charging stations and misconceptions about battery longevity	• Accurate data about the growing network of charging stations and improvements in battery life, along with real-world examples from current EV drivers			3	4		
	Lack of Awareness About Home-Based Charging	• Promoting the benefits of home charging and providing information about the necessary charging equipment	1-4		3	4		

5.6. Conclusion

This thesis examined the pressing issue of low EV adoption in NL. This province encounters continuing challenges in reducing GHG emissions, especially in the private road transportation sector. Currently, transportation stands as NL's main contributor to GHG emissions in NL, comprising 41%, with private cars being a major factor. Even though NL is Canada's fifth-largest electricity producer and 96% of its generated power comes from renewable resources, the province greatly relies on petroleum-based products for fuel. The contrast between the province's abundant renewable energy capacity and its continued dependence on fossil fuels for transportation raises critical questions about why EV adoption is not progressing more quickly. The present study aimed to explore the reasons behind low EV uptake rates in NL and suggest potential policy solutions to tackle this problem.

The research objectives, with a clear focus on the NL context, mainly used a cross-sectional survey methodology. This method had three main functions: at first, it was used to measure public opinions and viewpoints about the decarbonization of transportation; secondly, it helped to investigate the experiences of current EV drivers within the province of NL; and lastly, this method was used to carry out an extensive review of influential factors and critical insights obtained through survey results. This study applied an exploratory research design that employs methods for thoroughly exploring the obstacles in adopting EVs in NL. The study planned to use a survey method with open-ended and close-ended questions, sent through social media. The aim was to identify possible barriers that may be hindering the widespread EV adoption in NL. The research design included hypothesis testing and descriptive analyses to examine influential factors and gather some insights for policymakers and industry stakeholders, ultimately aiming to contribute strategic approaches for enhancing EV uptake in the province.

The possible barriers identified by this study are a combination of seven groups of barriers: financial concerns, limited and uneven charging infrastructure, technology-related concerns, insufficiently planned government incentives with limited coverage across vehicle classes and distrust, knowledge and familiarity gaps, market effectiveness and finally, NL-specific challenges. Overcoming the multifaceted barriers requires collaborative efforts among various stakeholders, including government bodies, manufacturers, and local communities. Financial concerns and infrastructure limitations emerge as critical barriers that obstruct accessibility and equity in cleaner transportation.

Tailored policy involvements are likely necessary to address these barriers. This study proposes broad policy options to address barriers and promote EV adoption in NL. A range of supply-side policies could consist of financial incentives such as tax breaks and lower interest rates to make EVs more affordable, along with broader poverty reduction measures. Policies that concentrate on infrastructure might involve expanding the public charging network, improving road conditions, and adapting building codes to include EV charging stations. However, it is important to recognize that some policies may require more time to implement but are easier to execute. In contrast others may be more cost-effective but need careful tailoring to local circumstances. For example, plans for developing infrastructure must take into account the NL's unique geographical and weather-related challenges. NL poses unique challenges and circumstances that may not be exactly compared with other regions in the country. Factors such as extreme weather conditions, separated population centers, and diverse geographical landscapes can greatly affect the possibility and ease of use of EVs in NL.

Similarly, educational initiatives must be culturally sensitive and address specific misconceptions prevalent in NL communities. Tailoring policies to local needs can ensure that interventions are relevant, impactful, and sustainable in promoting widespread EV adoption. Combining educational initiatives with transparent communication emerges as a powerful strategy to overcome knowledge gaps and dispel misconceptions about EVs. By providing accurate and unbiased information through workshops, public campaigns, and collaborations with trustworthy sources, public trust and confidence in EV technology and government policies could be built. The government's active involvement in promoting EV adoption, setting an example through EV integration in its operations, and incentivizing municipalities to procure EVs, are seen as crucial strategies to catalyze a wider shift towards EVs.

Several proposed policies such as those in the realm of infrastructure, residential bylaws, and spreading awareness intersect with municipal authorities. It is worth noting that municipalities can collaborate with provincial government bodies and private enterprises to facilitate infrastructure development and incentivize EV procurement. Furthermore, municipalities can play a crucial role in educating local communities about EVs and dispelling myths through targeted outreach programs.

Certainly, governments have limited budgets and many things to invest in, such as solving current housing and healthcare problems. Although promoting the use of EVs is essential for sustainable transportation, it is crucial that these efforts are balanced with other social needs.

In light of this, here are a few options for policies that can be seen as a reasonable start, due to their low-risk approaches, low cost, or high ratio of likely benefits to likely costs:

1 - Conduct Studies or Pilots for Targeted EV Purchase Incentives: Perform studies or pilots to evaluate the usefulness of EV purchase incentives with income qualification standards. This approach makes sure that financial help goes to people who are truly in need, enhancing the effectiveness of these encouraging factors and using resources efficiently.

2 - Distribute Budget for Targeted Home Chargers Incentives: Dedicate a portion of the budget to cover costs related to installing home chargers, with a focus on income-based eligibility criteria. This could help in overcoming the obstacle of infrastructure for EV adoption. If government can support home charging infrastructure, it will make owning an EV more convenient and inspire people to use this type of transport.

3 - Encourage Businesses to Implement Workplace and Public Charging: Introducing and promoting incentives for businesses to set up charging stations at workplaces and public areas could greatly widen the network of charging infrastructure. This is a win-win situation for both employees or customers, as it makes EVs more accessible and visible in society.

4 - Use Federal Incentives for Electric Public Transportation: Make use of existing federal benefits for municipalities and school buses to transition to EVs (Federal Zero Emission Transit Fund or Green Municipal Fund from Federation of Canadian Municipalities). This can encourage the use of electric public transportation, decreasing emissions and displaying good sustainability habits within the government's vehicle fleet.

5 - Work with Academia for EV Research: Joining forces with academic organizations to investigate how NL can become more compatible with EVs may offer critical wisdom and advice for policy creation as well as infrastructure design. This partnership assures that choices are rooted in evidence and resources are used effectively.

6 - Targeted Informative Campaigns: running informative campaigns on EV use in winter, reliability, and selection criteria for EVs can tackle misconceptions and improve

public knowledge. Such education about real-life aspects of owning an EV will help people make better decisions while also boosting their trust in using these vehicles.

7 - Provide Incentives or Expand the Scope of Current Incentives for Residential Charging Infrastructure: For rental houses, apartments, and condominiums, rebates or incentives for installing EV chargers promotes private investment in the charging infrastructure. This method broadens access to charging for residents, not depending just on public chargers.

8 - Scholarships and Funding for EV Mechanic Training: providing scholarships and funding to train more EV mechanics guarantees that there will be enough skilled professionals available to handle the increasing need for maintaining and fixing EVs. This investment in workforce development supports the EV ecosystem while aiding sustainable transportation efforts.

Overall, a coordinated approach that integrates tailored policies, transparent communication, and local community engagement is recommended for promoting widespread EV adoption and fostering a sustainable transportation ecosystem in NL. Putting these policy options first, the government can perhaps make gradual progress in encouraging EV use while handling other important social requirements in a fair and low-cost way.

Future research opportunities could be as follows:

1 - Tailored Financial Incentives for NL and Promoting EVs in Terms of Equity and Affordability of EVs in NL: for future research, it might be beneficial to research how financial incentives can be designed to fit specifically for NL. The goal is to enhance the affordability of EVs and promoting equity in adoption. To achieve this, it will be necessary to study the economic changes happening within NL along with income distribution to formulate effective financial support mechanisms that reach diverse socio-economic groups.

2 - Effects of Loss in Government Tax Revenue due to Widespread EV Adoption: a key area for future research is looking into the possible effects on government revenue, specifically the decrease in fuel tax revenue on gasoline that could occur with wide usage of EVs. It will be important to comprehend the fiscal implications and create other revenue sources or tax systems as it helps policymakers to sustainably transit to a transport environment mostly dominated by EVs.

3 - Tailored Infrastructure Developments Considering Weather-Related Barriers in NL: Because of NL's special weather challenges, future research can focus on infrastructure developments that are tailored to overcome weather-related barriers for EV adoption. Investigating the impact of extreme weather conditions on charging infrastructure and EV performance in NL, and suggesting solutions to handle these challenges, would help to smoothly incorporating EVs into NL's transportation system.

4 - Managing Distrust in Government Policies: In order to deal with the current distrust that has been identified in the study, future research could explore effective strategies for restoring trust in government policies linked to EV adoption. Digging into the root causes of the distrust, evaluating communication strategies, and analyzing successful cases from other regions can inform the development of policies that foster public confidence and support.

The present study, while offering studied insights into the barriers of EV adoption in a sample from NL drivers of ICEVs and EVs, possesses several limitations that should be acknowledged.

The findings may lack broad generalizability beyond the specific geographical and contextual confines of NL. Also, the sampling bias is an inherent concern in the survey methodology employed, particularly when utilizing social media for data collection. The potential for sampling bias introduces a risk that survey responses may not be fully

representative of the diverse population, excluding specific demographic groups. Reflecting on these limitations is crucial to understanding the general validity of the study. Self-selection bias is another pertinent limitation, as individuals opting to participate in the survey might exhibit different attitudes towards EVs compared to those who choose not to participate. This inherent bias has the potential to impact the generalizability of the findings and may restrict the study's ability to draw comprehensive conclusions about the broader population.

The reliance on survey responses for understanding public opinions and experiences introduces the possibility of social desirability bias (Nikolopoulou, 2022). Participants may provide responses they deem socially acceptable rather than expressing their genuine opinions, potentially influencing the accuracy of the findings (ibid). Furthermore, it is imperative to acknowledge the incomplete coverage of factors influencing EV adoption in NL. The study may not have addressed all potential variables or aspects contributing to low EV uptake, leaving certain dimensions unexplored.

Temporal limitations are also noteworthy, as the study provides a snapshot of opinions and factors at a specific moment. Recognizing the dynamic nature of EV adoption and public perceptions is essential, as these dynamics are subject to change over time.

Suggestions for future research include exploring diverse geographic contexts to enhance generalizability. To mitigate sampling bias, future studies could employ varied sampling strategies. Combining random sampling techniques with social media distribution and collaboration with local organizations or municipalities can ensure a more diverse and representative sample. Incorporating a mixed-methods approach in future research, including qualitative methods such as interviews or focus groups, is recommended. This would enable a deeper understanding of participants' attitudes, motivations, and barriers that quantitative surveys alone may not fully capture.

At the end, it is noteworthy that collaborative research endeavors involving academic institutions, government bodies, industry stakeholders, and local communities can contribute to evidence-based policymaking and innovative solutions tailored to NL's specific needs. Academic research can provide valuable insights into consumer behavior, technological advancements, and policy effectiveness, ultimately informing strategies to overcome barriers and accelerate EV adoption. By fostering interdisciplinary collaboration and knowledge exchange, academia can play a pivotal role in driving sustainable transportation transitions in NL as well.

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Appendices

Appendix A: Full Version of Questionnaire (implemented in Qualtrics)

Barriers to Electric Vehicle Uptake in Newfoundland

Start of Block: Informed Consent

Q1

My name is Samira Hatami and I am a graduate student at Grenfell Campus, Memorial University of Newfoundland and Labrador. I am conducting a survey called "Barriers to Electric Vehicle Uptake in Newfoundland" as part of my master's thesis.

If you are at least 19 years old, live in the province of Newfoundland and Labrador, and regularly drive a vehicle belonging to your household, then you are invited to take part in this survey. It will ask you about your driving habits, environmental awareness, and perceptions about electric vehicles. The survey ends with a few demographic questions as well (e.g. income, age, gender, education, and general location). Your input will help me understand the opportunities and challenges for electric vehicles in Newfoundland.

The survey is anonymous and voluntary. It does not collect any contact or other identifying information. It is available in English, contains about 20 questions, and should take no more than 10 minutes to complete. At the end of the main survey, you will be redirected to a separate survey giving you the opportunity to enter your email address into a draw to win one of three visa gift cards of $50. This information will not be linked to your answers in the main survey.

You can skip any questions you don't want to answer (except for some brief eligibility questions at the beginning) and you may withdraw from the study at any time. If you choose to withdraw mid-way through the survey, any data collected from you up to that point will be destroyed.

The survey platform is called Qualtrics. Data collected from you as part of your participation in this project will be hosted and/or stored electronically by Qualtrics and is subject to their privacy policy and to any relevant laws of the country in which their servers are located. Qualtrics' privacy and security policy can be found at: https://www.qualtrics.com/support/survey-platform/getting-started/data-protection-privacy/.

If you would like more information about this study, please email me at shatami@grenfell.mun.ca or my supervisor at grichards@grenfell.mun.ca. My thesis will be publicly available through the Memorial University thesis collection and accessible online at https://research.library.mun.ca/view/theses_dept/.

The proposal for this research has been reviewed by the Grenfell Campus Research Ethics Board (GC-REB) in Human Research and found to be in compliance with Memorial University's ethics policy. If you have ethical concerns about the research, such as the way you have been treated or your rights as a participant, you may contact the chairperson of the GC-REB at gcethics@grenfell.mun.ca.

By completing and submitting the survey, you indicate that you are at least 19 years old, you understand the above conditions of participation in this study, and your free and informed consent is implied. You may print this page for your records.

End of Block: Informed Consent

Start of Block: Introduction

Q41 This survey does not have a "back" button. Please be sure you have responded to questions accurately before clicking the "next" arrow on each page. Thank you!

End of Block: Introduction

Start of Block: Mandatory Eligibility Questions

Q2 Is your main place of residence (household) located in Newfoundland and Labrador?

- Yes (1)
- No (2)

Q3 Does your household have a motor vehicle that you drive regularly?

- Yes (1)
- No (2)

Q4 For the purposes of this survey, an electric vehicle is either a battery electric vehicle (also known as an all-electric vehicle) or a plug-in hybrid electric vehicle. Does your household have an electric motor vehicle that you drive regularly?

- Yes (1)
- No (2)

End of Block: Mandatory Eligibility Questions

Start of Block: ICE Owners

Q5 How would you describe the area where you live?

- City centre of a large city (1)
- Suburb of a large city (2)
- Small city or large town (3)
- Small town (4)
- Rural (5)
- Unsure or prefer not to say (6)

Page Break

Q6 Of the vehicles your household has, what is the main type of motor vehicle that you drive?

- ○ Motorcycle (1)
- ○ Two-door car (2)
- ○ Four-door car (3)
- ○ Sport utility vehicle (SUV) or crossover (4)
- ○ Minivan or van (5)
- ○ Two-door truck (6)
- ○ Four-door truck (7)
- ○ Unsure or prefer not to say (8)

Q7 On average, how much do you drive this vehicle each week?

- ○ 0 to 99 kilometers (1)
- ○ 100 to 199 kilometers (2)
- ○ 200 to 299 kilometers (3)
- ○ 300 to 399 kilometers (4)
- ○ 400 to 499 kilometers (5)
- ○ 500 kilometers or more (6)
- ○ Unsure or prefer not to say (7)

Page Break

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)	Unsure or prefer not to say (6)
climate change is affecting the province of Newfoundland and Labrador (1)						
the burning of fossil fuels like gasoline is						

contributing to a changing climate (2)

more electric vehicles in NL would be a good thing for the environment (3)

each person should do their part to address climate change (4)

compared to other provinces, the province of Newfoundland and Labrador has a high rate of greenhouse gas emissions per person (5)

Compared to other provinces, the province of Newfoundland and Labrador has a low rate of electric vehicle ownership (6)

Q9 Please indicate your perception of how standard gas vehicles and electric vehicles (EVs) compare:

	Gas vehicles much better than EVs (1)	Gas vehicles slightly better than EVs (2)	Both types about the same (3)	EVs slightly better than gas vehicles (4)	EVs much better than gas vehicles (5)	Unsure or prefer not to say (6)
Affordability of initial purchase (1)	○	○	○	○	○	○
Affordability of running and maintenance costs (2)	○	○	○	○	○	○
Driving range (3)	○	○	○	○	○	○
Function in winter weather (4)	○	○	○	○	○	○
Limiting air pollution (5)	○	○	○	○	○	○
Environmentally responsible construction and disposal (6)	○	○	○	○	○	○

Q10
Please indicate your level of familiarity with the following:

	Not familiar at all (1)	Slightly familiar (2)	Moderately familiar (3)	Very familiar (4)	Extremely familiar (5)	Unsure or prefer not to say (6)
The differences between battery electric vehicles, plug-in hybrid electric vehicles, and regular hybrid electric vehicles (1)	○	○	○	○	○	○
Rebates from the provincial and federal governments for purchasing electric vehicles (2)	○	○	○	○	○	○
The takeCHARGE energy efficiency initiative and website from NL Hydro and Newfoundland Power (3)	○	○	○	○	○	○

Q11 When your household gets its next vehicle, how likely is it that you would choose an electric vehicle?

- ○ Much more likely to choose a standard gas vehicle than an electric vehicle (1)
- ○ Slightly more likely to choose a standard gas vehicle than an electric vehicle (2)
- ○ Equally likely to choose each type (3)
- ○ Slightly more likely to buy an electric vehicle than a standard gas vehicle (4)
- ○ Much more likely to buy an electric vehicle than a standard gas vehicle (5)
- ○ Unsure or prefer not to say (6)

Q12 Off the top of your head, what are some of the main reasons you might choose an electric vehicle? List as many as you like.

- ○ I will list my reasons in the below text box (1)

_____

- ○ I don't think there are any reasons to choose an electric vehicle (2)
- ○ Not sure or prefer not to say (3)

Q13 The following is a list of possible reasons to choose an electric vehicle. Which of these would you agree with? Check as many as you like.

- ☐ They pollute less, which helps to protect the environment (1)
- ☐ They save money on fuel and maintenance (2)
- ☐ They are a cutting-edge technological innovation (3)
- ☐ They are convenient and stylish (4)
- ☐ They are fun to drive (5)
- ☐ There are public charging stations to support them (6)
- ☐ There are government purchasing incentives to support them (7)
- ☐ ⊗ OR I don't think there are any reasons to choose an electric vehicle (8)

☐ ⊗OR Not sure or prefer not to say (9)

Q14 Off the top of your head, what are some of the main reasons you might *not* choose an electric vehicle? List as many as you like

- ○ I will list my reasons in the below text box (1)

_____

- ○ I don't think there are any reasons *not* to choose an electric vehicle (2)
- ○ Not sure or prefer not to say (3)

Q15 The following is a list of possible reasons to *not* choose an electric vehicle. Which of these would you agree with? Check as many as you like.

- ☐ They are expensive to purchase (1)
- ☐ They have a low resale value (2)
- ☐ They are not available at local dealerships (or the selection is limited) (3)
- ☐ They do not help protect the environment (4)
- ☐ There are not enough government purchasing incentives to support them (5)
- ☐ There are not enough public charging stations to support them (6)
- ☐ They are inconvenient because of charging time (7)
- ☐ They are difficult to charge at home (8)
- ☐ They have a limited driving range (9)
- ☐ The technology is immature or unproven (10)
- ☐ They are unsafe (11)
- ☐ They are unfamiliar to me (I don't know enough about them) (12)
- ☐ ⊗ OR I don't think there are any reasons *not* to choose an electric vehicle (14)
- ☐ ⊗ OR Not sure or prefer not to say (15)

Q16 If you have any suggestions for how government can better manage the issue of electric vehicles, please share them here:

- ○ I will write my suggestions in the below text box (1)

_____

- ○ I have no comments (2)

Q17 If you would like to provide any additional comments on your opinions about electric vehicles, please do so here:

- ○ I will write my comments in the below text box (1)

_____

- ○ I have no comments (2)

End of Block: ICE Owners

Start of Block: EV Owners

Q18 How would you describe the area where you live?

- ○ City centre of a large city (1)
- ○ Suburb of a large city (2)
- ○ Small city or large town (3)
- ○ Small town (4)
- ○ Rural (5)
- ○ Unsure or prefer not to say (6)

Q19 What type of electric vehicle does your household have?

- ○ Battery electric vehicle (1)
- ○ Plugin hybrid electric vehicle (2)
- ○ Regular hybrid electric vehicle (3)
- ○ Unsure or prefer not to say (4)

Q20 About how long has your household had an electric vehicle?

- 0 years (i.e., brand new) (1)
- 1 year (2)
- 2 years (3)
- 3 years (4)
- 4 years (5)
- 5 years or more (6)
- Unsure or prefer not to say (7)

Q21 On average, how much do you drive this vehicle each week?

- 0 to 99 kilometers (1)
- 100 to 199 kilometers (2)
- 200 to 299 kilometers (3)
- 300 to 399 kilometers (4)
- 400 to 499 kilometers (5)
- 500 kilometers or more (6)
- unsure or prefer not to say (7)

Q22 How satisfied have you been with this electric vehicle?

- Not at all satisfied (1)
- Slightly satisfied (2)
- Moderately satisfied (3)
- Very satisfied (4)
- Extremely satisfied (6)
- Unsure or prefer not to say (5)

Q45 In terms of charging habits for this electric vehicle...

Q23 a. What kinds of chargers do you have regular access to? Check all that apply.

- [ ] At-home level-1 charger (1)
- [ ] At-home level-2 charger (2)
- [ ] Workplace level-1 charger (9)
- [ ] Workplace level-2 charger (3)
- [ ] Workplace level-3 (fast) charger (4)
- [ ] Public level-2 charger (5)
- [ ] Public level-3 (fast) charger (6)
- [ ] ⊗ My electric vehicle is a regular hybrid that does not need to charge (7)
- [ ] ⊗ Unsure or prefer not to say (8)

Q24 b. How much of your EV charging is done at home?

- ○ 0 - 19% (1)
- ○ 20 - 39% (2)
- ○ 40 - 59% (3)
- ○ 60 - 79% (4)
- ○ 80 - 100% (5)
- ○ My electric vehicle is a regular hybrid that does not need to charge (6)
- ○ Unsure or prefer not to say (7)

Q25 c. For longer trips, how do you plan around charging range, charger availability, and charging time?

- ○ I will write my comments in the below text box (1)

_____

- ○ My electric vehicle is a regular hybrid that does not need to charge (2)
- ○ I have no comments (3)

Q26 Why did you choose an electric vehicle over a standard gas vehicle? Say as much or as little as you like.

- ○ I will list my reasons in the below text box (1)

_____

- ○ I have no comments (2)

Q27 What do you think are some of the main reasons that other drivers in this province might not choose an electric vehicle? Say as much or as little as you like.

- ○ I will list my reasons in the below text box (1)

_____

- ○ I have no comments (2)

Q28 In your opinion, what more should be done in this province to encourage other drivers to choose electric vehicles? Say as much or as little as you like.

- ○ I will write my comments in the below text box (1)

_____

- ○ I have no comments (2)

Q29 If you would like to provide any additional comments on your opinions about electric vehicles, please do so here:

- ○ I will write my comments in the below text box (1)

_____

- ○ I have no comments (2)

End of Block: EV Owners

Start of Block: Demographic Questions

Q30 What are the first three characters of the postal code for your main place of residence?

The first three digits of my postal code are as follows (1) _____

- Unsure or prefer not to say (2)

Q31 What is your age?

- 19 - 24 years (1)
- 25 - 34 years (2)
- 35 - 44 years (3)
- 45 - 54 years (4)
- 55 - 64 years (5)
- 65 - 74 years (6)
- 75 years or over (7)
- Prefer not to say (8)

- Q32 What is your gender?
- Female (1)
- Male (2)
- Transgender female (3)
- Transgender male (4)
- Gender variant/non-conforming (5)
- Not listed (6) _____
- Prefer not to say (7)

Q33 What is your highest-attained level of education?

- Less than secondary (high) school graduation (1)
- Secondary (high) school diploma or equivalent (2)
- Some postsecondary education (3)
- Postsecondary certificate, diploma, or degree (4)
- Graduate or professional degree (5)
- Prefer not to say (6)

Q34 What is your household's approximate annual total income (before tax)?

- Under $10,000 (1)
- $10,000 to $19,999 (2)
- $20,000 to $29,999 (3)
- $30,000 to $39,999 (4)
- $40,000 to $49,999 (5)
- $50,000 to $59,999 (6)
- $60,000 to $69,999 (7)
- $70,000 to $79,999 (8)
- $80,000 to $89,999 (9)
- $90,000 to $99,999 (10)
- $100,000 and over (11)
- Unsure or prefer not to say (12)

Q35 How many people live in your household?

- ○ Just me (1)
- ○ 2 (2)
- ○ 3 (3)
- ○ 4 (4)
- ○ 5 (5)
- ○ 6 (6)
- ○ More than 6 (7)
- ○ Prefer not to say (8)

End of Block: Demographic Questions

Start of Block: Ending Note

Q39 You have reached the end of the survey. Your responses will not be submitted until you click the "next" button one final time.

End of Block: Ending Note

Appendix B: Recruitment Text

[[text that will be sent to group owners]]
Dear [name of the group owner],
My name is Samira Hatami and I am a graduate student at Grenfell Campus, Memorial University. I am conducting a survey called "Barriers to Electric Vehicle Uptake in Newfoundland" as part of my master's thesis.
The survey needs to be distributed to the general public of Newfoundland (all regions). To that end, I would like to ask for permission to post a short comment containing the survey link to [group name]. [If that sounds all right, could you add me to the group?] Alternatively, I would greatly appreciate it if you could share the link as the group administrator and – if possible – pin it for a few days to increase visibility. Participants will have the opportunity to win one of three $50 gift cards upon completing the survey.
I am looking forward to receiving your kind confirmation. If you are willing to post the survey link yourself, I will forward the actual text for posting to the group. Thank you!

[[text that will be posted on groups]]
Dear members of this group,
My name is Samira Hatami and I am a graduate student at Grenfell Campus, Memorial University. I am conducting a survey called "Barriers to Electric Vehicle Uptake in Newfoundland" as part of my master's thesis.
If you are at least 19 years old, live in the province of NL, and regularly drive a vehicle belonging to your household, then you are invited to take part in this survey. It will ask you about your driving habits, environmental awareness, and perceptions about electric vehicles.
The survey should take no more than 10 minutes to complete. When you finish, you can enter a draw for one of three $50 gift cards. Your answers will be kept confidential and no contact details or identifying information will be collected. Participation is voluntary. More information will be provided on the first page of the survey.
If you are interested, click the link below or copy-paste the URL into your browser.
[link/URL]
Thank you very much!

Appendix C: Ethical Approval Letter from Grenfell Campus Research Ethics Board

GRENFELL CAMPUS | MEMORIAL UNIVERSITY
Research Ethics Board
University Drive, Corner Brook, NL Canada A2H 5G4
Tel: 709-639-2398 Fax: (709)637-2885 http://www.grenfell.mun.ca/research-ethicsboard

March 22, 2022

Reference number: **20222674**

Dear Samira Hatami,

Thank you for your application for ethical clearance for your proposal ***Barriers to Electric Vehicle Uptake in Newfoundland.*** The Grenfell Campus Research Ethics Board (GC-REB) has reviewed your application and finds this application in ethical compliance with the Tri-Council Guidelines. We have two minor questions which you can fix in your application or submit an update to the application:

1. The research says it is on electric vehicles but there is mention of hybrids as well. Clarify and edit where necessary.

2. You mention that there is a "separate survey" to enter the draw. This survey should be attached to the application.

Your approval for this project expires on March 22, 2023. To remain in compliance with Article 6.14 (Continuing Research Ethics Review) of the Tri-Council Policy Statement on Ethics in Human Research (TCPS2), should your project continue past that date, you are required to renew your ethics approval before that time. As well, please note that any changes to the proposed study will need to be cleared by the GC-REB first.

The Board wishes you success with your research.

Best wishes,

John Bodner, Ph.D., Chair

IMPORTANT REMINDERS – PLEASE READ:

Important Notice regarding COVID-19: As the situation changes and develops with COVD-19, it is up to the PI to ensure that the research team remains in compliance with Memorial's current status on in-person data collection. You can follow information on the current status of policy here: https://www.mun.ca/research/.

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Appendix D: Sample Demographics and Representativeness

The survey sample's demographic characteristics need to be compared to those of NL's population in order to assess its representativeness[16]. Data on the province's demographic distribution has been obtained from the Statistics Canada Census of 2016 and 2021. By comparing the survey results with these census data, any potential biases in the sample can be identified and conclusions can be drawn regarding the generalizability of the findings. This section assumes, throughout, that the distribution of demographic characteristics across the general adult population in NL is roughly equivalent to the distribution of demographic characteristics across ICEV drivers in NL but not to that of EV drivers in NL. Thus, the analysis below generally assumes that discrepancies below between the general NL population and participating ICEV drivers are due to survey bias, but discrepancies between the general NL population and participating EV drivers are due to the distinct nature of the latter.

Age: Table 12 shows the age distribution of survey respondents, divided into ICEV drivers and EV drivers, compared to the age distribution of the general population of NL. For ICEV drivers, the 25-44 age group is overrepresented in the survey, the 55+ age group is underrepresented, and the 19-24 and 45-54 age groups are roughly represented accurately. The trends are similar for EV drivers, but exaggerated (e.g., the 25-44 age group is even more overrepresented). Overall, these figures reflect a bias of the survey toward younger age groups, probably because those groups are more likely to engage social media and thus participate in Facebook surveys.

[16] For representativeness analysis, the vehicle type or vehicle size in the sample was not compared to the population because the available statistics have no population measure (e.g. https://www.stats.gov.nl.ca/Statistics/Topics/transportation/PDF/Vehicle_Regs_NL.pdf)

Table 12: Age Distribution of the NL Population Compared to the Sample

Age	Population by Age Group in NL (2021)	ICEV Drivers	EV Drivers
19 - 24 years	31,240 (7.41%)	69 (7.35%)	5 (5.62%)
25 - 34 years	52,575 (12.46%)	199 (21.19%)	22 (24.72%)
35 - 44 years	60,340 (14.31%)	267 (28.43%)	35 (39.33%)
45 - 54 years	72,370 (17.16%)	189 (20.13%)	15 (16.85%)
55 - 64 years	84,675 (20.07%)	138 (14.70%)	10 (11.24%)
65 - 74 years	74,860 (17.75%)	73 (7.77%)	2 (2.25%)
75 years or over	45,750 (10.85%)	4 (0.43%)	0 (0.00%)
Total	421,810 (100.00%)	939 (100.00%)	89 (100.00%)

Gender: As shown in Table 13, participating ICEV drivers were 66.95% female and 32.62% male. Other gender identities comprised less than 1% of the sample. In terms of representativeness, the sample appears biased toward female ICEV drivers. According to Becker (2022), this difference could be due to gendered differences in the use of social media and survey participation generally.

Table 13:Gender Distribution of the NL Population Compared to the Sample

Gender	Population by Gender Group in NL aged over 19 (2021)	ICEV Drivers	EV Drivers
Female	217,390 (51.54%)	626 (66.95%)	36 (40.91%)
Male	204,425 (48.46%)	305 (32.62%)	52 (59.09%)
Transgender female	-	0 (0.00%)	0 (0.00%)
Transgender male	-	1 (0.11%)	0 (0.00%)
Gender variant/non-conforming	-	2 (0.21%)	0 (0.00%)
Not listed	-	1 (0.11%)	0 (0.00%)
Total	421,810 (100.00%)	935 (100.00%)	88 (100.00%)

However, participating EV drivers were 59.09% male and 40.91% female. This discrepancy may reflect the fact that EV drivers are more likely to be male, as evidenced by S&P Global Mobility (2023).

Education Attainment: Table 14 presents the education distribution of survey respondents, both ICEV drivers and EV drivers, in comparison to the education distribution of

the general population in NL. By looking at the data, there are notable disparities in educational representation among the driver categories and the general population. For instance, ICEV drivers exhibit lower proportions in the "Less than secondary school graduation" and "Secondary school diploma or equivalent & some post-secondary education" categories compared to the overall population, while being overrepresented in the "Postsecondary certificate, diploma, or degree" category. On the other hand, EV drivers demonstrate a higher representation in the "Secondary school diploma or equivalent & some post-secondary education" category and a lower representation in the "Postsecondary certificate, diploma, or degree" category than the general population. These variations suggest that the survey sample may not fully mirror the educational diversity of the broader population in NL.

Table 14: Education Distribution of the NL Population Compared to the Sample

Education	**NL Population by the highest level of educational attainment 2016**[17]	**ICEV Drivers**	**EV Drivers**
Less than secondary (high) school graduation	102,670 (23%)	10 (1.08%)	1 (1.12%)
Secondary (high) school diploma or equivalent & some post secondary education	109,480 (25%)	147 (15.82%)	35 (39.33%)
Postsecondary certificate, diploma, or degree	203,935 (47%)	551 (59.31%)	32 (35.96%)
Graduate or professional degree	21,855 (5%)	221 (23.79%)	21 (23.60%)
Total	437,940 (100%)	929 (100.00%)	89 (100.00%)

Income: Based on the household total income distribution of the respondents in the survey, as demonstrated in Table 15, the sample appears biased toward higher-income groups. In particular, nearly half (48.34%) of the participating ICEV drivers reported an annual

[17](detailed) by selected age groups 15 years and over, both sexes, 2016 counts, Canada, Newfoundland and Labrador and census metropolitan areas and census agglomerations, 2016 Census – 25% Sample data.

income of $100,000 or more. The survey, which was designed to reflect the same income categories used by Statistics Canada, does not capture any detail or differences within the $100,000+ income group. This may have limited the accuracy of the income data collected and could impact the generalizability of the findings. The participating EV drivers had an even greater over-representation of the $100,000+ income group, which is likely due to trends in EV ownership rather than bias in the survey response.

Table 15: Income Distribution of the NL Population Compared to the Sample

Income	Total NL - Household Total Income Groups	ICEV Drivers	EV Drivers
Under $10,000	4,935 (2.26%)	9 (1.10%)	0 (0.00%)
$10,000 to $19,999	16,890 (7.72%)	27 (3.31%)	1 (1.22%)
$20,000 to $29,999	21,555 (9.86%)	34 (4.17%)	7 (8.54%)
$30,000 to $39,999	22,325 (10.21%)	40 (4.91%)	11 (13.41%)
$40,000 to $49,999	17,065 (7.80%)	41 (5.03%)	2 (2.44%)
$50,000 to $59,999	15,745 (7.20%)	46 (5.64%)	1 (1.22%)
$60,000 to $69,999	14,835 (6.78%)	60 (7.36%)	4 (4.88%)
$70,000 to $79,999	13,210 (6.04%)	49 (6.01%)	5 (6.10%)
$80,000 to $89,999	11,965 (5.47%)	49 (6.01%)	2 (2.44%)
$90,000 to $99,999	10,690 (4.89%)	66 (8.10%)	2 (2.44%)
$100,000 and over	69,465 (31.77%)	394 (48.34%)	47 (57.32%)
total	218,680 (100%)	815 (100.00%)	82 (100.00%)

Household Size: As summarized in Table 16, participating ICEV drivers in the sample was representative of the population in terms of household size, except that single-person households were underrepresented, and four-person households were overrepresented. Participating EV drivers in the sample tended to represent larger households than the general NL population, which may be related to income effects (i.e., household income naturally correlates with household size and more household income means EVs are more likely to be affordable.)

Table 16: Distribution of Number of People in Household of the NL Population Compared to the Sample

Number of People in Household	Household Size NL	ICEV Drivers	EV Owners
Just me	53,750 (24.58%)	96 (10.33%)	4 (4.49%)
2	88,715 (40.57%)	373 (40.15%)	26 (29.21%)
3	37,705 (17.24%)	201 (21.64%)	25 (28.09%)
4	28,270 (12.93%)	203 (21.85%)	28 (31.46%)
5, 6, more than 6	10,235 (4.68%)	46 (4.95%)	6 (6.74%)
total	218,675 (100%)	929 (100.00%)	89 (100.00%)

Health Region: Table 17 presents a comparison of the NL population (over 19 years of age) in each health region, as of 2015, with the number of ICEV drivers participating in the survey from each health region, based on the first three digits of the provided postal codes. The table suggests that the West region was overrepresented in the sample, compared to the general population, while the Central and Labrador regions were underrepresented. This bias is probably due the location of the researcher (i.e., communities in the West region are more likely to be familiar with Memorial University's Grenfell Campus and therefore more likely to respond). Participating EV owners, on the other hand, mostly come from the East region, which makes sense due to the relative availability of EVs and charging infrastructure in that more densely populated area.

Table 17: Distribution of the Sample in each Health Region and NL Population

	NL Population in each Region 2015 (over 19)	ICEV Drivers in each Health Region	EV Drivers in each Health Region
Central	78,000 (18.25%)	43 (4.83%)	9 (13.43%)
East	256,100 (59.91%)	447 (50.17%)	48 (71.64%)
Labrador	27,875 (6.52%)	23 (2.58%)	2 (2.99%)
West	65,495 (15.32%)	378 (42.42%)	8 (11.94%)
Total	427,470 (100%)	891 (100%)	67 (100%)

In conclusion, the above-mentioned results suggest that the sample may be biased towards certain demographic groups, such as younger individuals, women, more highly educated individuals, higher-income earners, and those residing in Western NL. While these

biases may limit the generalizability of the findings to the overall population, the sample size and geographical coverage provide a good starting point for exploring patterns and trends in the province. Future research could benefit from efforts to increase the diversity of the sample in order to obtain a more representative picture of the population of interest (e.g., through random as opposed to voluntary sampling).