An Examination of Electric Vehicle Technology, Infrastructure Requirements and Market Developments

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Newfoundland Labrador

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Executive Summary

In 2011, the Government of Newfoundland and Labrador released *Charting our Course: Climate Change Action Plan*. This plan establishes the Provincial Government's strategic approach to climate change and sets out its vision and goals for the next five years alongside 75 commitments to action. As part of its goal to reduce greenhouse gas (GHG) emission levels within the transportation sector in the province, government committed to "examine the state of technology, infrastructure requirements and market developments for electric vehicles (EVs)."

This report, developed by the Office of Climate Change and Energy Efficiency, provides an overview of these issues in light of the current global and domestic EV landscape. It outlines some of the key considerations surrounding EVs that are of interest to consumers, policymakers and electrical utilities, such as:

- What is an electric vehicle?
- How do EVs differ from conventional automobiles?
- Why is there growing interest in EVs?
- How has EV technology advanced?
- What infrastructure is necessary to support EVs?
- How EVs could impact electricity grids?
- What has been done in other jurisdictions to support EV deployment?

These considerations were also analyzed, where possible, from a Newfoundland and Labrador perspective to identify any climatic, geographical, and logistical challenges to EV deployment, and to consider any potential opportunities and benefits that can be realized through large-scale EV adoption.

The following is a summary of the report's key findings:

- When powered by renewable electricity, EVs do not produce any greenhouse gas emissions or local air contaminants during their operation. This helps to tackle climate change and improve local air quality.

- Although still a small percentage of total vehicles purchases, EV sales have grown significantly in Canada, the United States and abroad in recent years. Globally, the International Energy Agency reports that there were 665,000 EVs on the road at the end of 2014, up from 180,000 in 2012. The most recent available figures show EVs currently account for 0.28 per cent of the light-duty automobile market in Canada.

- Although EV technology has existed for a number of years, those in the automobile industry believe that consumers do not have an accurate understanding of the capabilities of EVs relative to conventional automobiles powered by an internal combustion engine (ICE). As such, more education and awareness raising activities is expected to be needed for EVs to become a more attractive option for many consumers.

- While EV battery capacity has increased in recent years, providing for extended EV range, some consumers may be reluctant to purchase an EV without necessary EV infrastructure in place.

This is of particular concern to those who may be required to drive extended distances daily or who may not have access to recharging infrastructure on an as-needed basis. Evidence from other jurisdictions has shown that publicly available charging stations of various capacities may help support EV growth and potentially reduce these concerns.

- Although market forces are likely to play a significant role in determining the direction of EVs moving forward, evidence from jurisdictions across Canada, the United States and Europe suggests governments can play a role in raising awareness of EVs through various policies and measures.

- A number of jurisdictions across Canada, the United States and Europe have utilized a mix of financial and non-financial incentives to help overcome barriers to EV adoption by consumers. Newfoundland and Labrador does not currently offer any financial or non-financial incentives towards the purchase of EVs or EV infrastructure.

- While there are some electric vehicles in Newfoundland and Labrador, penetration is still very limited. However, EVs can be purchased in-province and a growing number of automobile dealers are training their staff and building servicing capacity to support EV purchases in the event that demand for EVs increases. There are currently about 47 EV charging stations in Newfoundland and Labrador.

- In a Newfoundland and Labrador context, the effects of EVs on the local electricity grid and their impacts on generation, transmission and distribution infrastructure appear to be manageable at lower levels of EV penetration. A more detailed review of electricity distribution infrastructure may be required by the utilities at higher levels of penetration.

1.0 Introduction

In 2011, the Government of Newfoundland and Labrador released *Charting our Course: Climate Change Action Plan*. This plan establishes the Provincial Government's strategic approach to climate change and contains 75 commitments to action. One of the commitments is to "examine the state of technology, infrastructure requirements and market developments for electric vehicles (EVs)." This report delivers on this commitment by providing a comprehensive assessment that can inform future discussions on this issue.

Much has changed in the road transportation sector in recent years. While conventional automobiles powered by internal combustion engines (ICE) continue to dominate the automobile market, the electrification of transportation, including passenger vehicles as well as public transit, is occurring at an increasing pace. Given that EVs that are powered by clean energy produce no tailpipe emissions, the electrification of transportation offers an opportunity to reduce greenhouse gas (GHG) emissions from the transportation sector, as well as local air contaminants.

This is of relevance to Newfoundland and Labrador given both that light-duty on-road transportation accounts for 7.5 per cent of provincial greenhouse gas emissions[1] and the province has extensive clean energy resources. Currently, the province has over 6,700 mega-watts of developed hydroelectric capacity, over 6,000 mega-watts of undeveloped capacity (including Muskrat Falls) and over 5,000 mega-watts of undeveloped wind energy resources. Upon completion of Muskrat Falls, 98 per cent of the electricity consumed in the province will be renewable and therefore free of GHG emissions.

As the presence of EVs in the marketplace has advanced, so too has EV technology and related infrastructure. An increasing number of models of EVs are now available, ranging from compact cars to luxury vehicles. There is also increasing availability of charging stations throughout Canada, especially in jurisdictions that have incentivized their installation.

This report examines the state of EV technology and infrastructure, and the latest market developments. It begins by defining what an EV is and why there is growing interest in these vehicles. It describes the key components and features of an EV and outlines the types of EVs available in the market today. The report goes on to examine infrastructure considerations, including the cost of charging stations and implications for increased demand on electricity grids. Following a review of the policies and measures in place in jurisdictions that have actively supported increased penetration of EVs, the report considers the current state of the market in Newfoundland and Labrador. It examines the climatic, geographical, and logistical challenges to EV deployment, in order to identify the potential opportunities and benefits that can be realized through large-scale EV adoption.

[1] This figure excludes light duty trucks.

2.0 What is an Electric Vehicle?

Broadly defined, an EV is an automobile which is fully or primarily propelled by electricity. This class of light-duty automobile uses electric motors, powered by electrical energy stored in a rechargeable battery as opposed to gasoline or diesel, to turn the vehicle's wheels. EVs receive the electricity needed to power them via special charging stations or at home, which vary in performance capability (for more details, see Section **4.0**).

While consumer awareness of EVs is increasing, many consumers are less aware of the types of EVs currently in the marketplace, and the technological differences that separate them from ICE vehicles.[2] This section highlights these differences, as well as the basic components of EVs, the current state of EV technology, and strategic considerations associated with owning and operating one of these vehicles.

2.1 Types of EVs

In general, there are three types of EVs. The primary difference in these vehicles is related to their propulsion systems.

- **Conventional hybrid electric vehicles (HEVs) –** HEVs are a form of conventional automobile that is propelled by an ICE, as well as an electric motor and battery, which can provide additional power to the drive wheels during acceleration and to maintain speed. In HEVs, the ICE sends power to the electric motor and also recharges the battery. As a result, ICEs do not need to work as hard to propel the vehicle, and can also be smaller than their traditional, non-hybrid counterparts, which increases fuel efficiency. HEVs operate entirely on fuel and their batteries cannot be charged by plugging in to the electricity grid through a power outlet.

- **Plug-in hybrid vehicles (PHEVs) –** PHEVs contain similar features as battery electric vehicles, but are also supplemented by an ICE. Therefore, they provide for both the benefits of an EV and the capacity of a traditional automobile. PHEVs can run solely on electricity, generally for a distance of around 60 kilometres on a full charge, but also employ an ICE as a backup. When the electric battery is drained of its energy, the ICE- powered by gasoline or diesel- takes over and can either propel the vehicle or recharge its drained battery. This type of EV produces tailpipe emissions when the ICE is operating, but has significantly improved fuel economy over traditional ICE automobiles and is not limited from a range standpoint.

- **Battery electric vehicles (BEVs) –** BEVs are a form of plug-in EV propelled entirely by electric motors, which receive power through specialized lithium batteries. These batteries are primarily charged when the vehicle is not being driven, and must be recharged once they are drained. The power train of a BEV consists of a battery, a power convertor and electric motor instead of an engine, transmission, belts and pulleys. BEVs fully displace ICEs in favor of electric motors, and thus they do not consume petroleum, nor emit tailpipe emissions in their everyday operation.

[2] Natural Resources Canada. 2010. "Electric Vehicle Technology Roadmap for Canada: A Strategic Vision for Highway-capable Battery-electric, Plug-in and Other Hybrid-Electric Vehicles," Ottawa: Government of Canada, pg. 45.

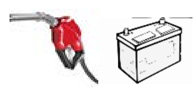
Without recharging, most BEVs operate within a range capacity of between 100-200 kilometres depending on the vehicle; however some higher-end models have a range in excess of 300 kilometres

While conventional hybrids are often considered EVs, they do not require additional infrastructure, such as charging stations, to operate. As such, given this report explores the state of EVs and their related infrastructure, it will focus on BEVs and PHEVs.

Comparing EVs and Conventional ICE Vehicles

The following table provides a detailed overview of how EVs compare to a conventional automobile.

Table 1: Comparison of Vehicle Types[3]

Vehicle Type	Conventional ICE Automobile 	Conventional Hybrid (HEV) 	Plug-In Electric Vehicle (PHEV) 	Battery Electric Vehicle (BEV) 
Method of Propulsion	ICE	ICE, supplemented by an electric motor and battery for additional power	Electric motor, supplemented by an ICE for increased range	Electric motor
Range (km)	700-800	700-800	700-800 (60km when operating solely on electricity)	100-335
Battery Charging	N/A	Generated on-board	From electricity	From electricty
CO_2 Emissions (g/km)	100-400	100-250	100-250 (when operating solely on gasoline)	0
Examples of Models	Honda Civic Toyota Camry	Ford Fusion Hybrid Toyota Camry Hybrid	Chevrolet Volt Toyota Prius Plug-In	Nissan Leaf Ford Focus EV
Regenerative Braking	N/A	Yes	Yes	Yes

[3] The figures outlining range and CO_2 emissions have been adopted from: http://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/oee/pdf/transportation/tools/fuelratings/Model%20Year%202015%20Vehicle%20Tables.pdf. The average range for BEVs sold in Canada is approximately 150 km. **The Tesla Model S (85 kWh battery) has a range of 425km.

2.2 Key Components and Features of an EV

While, in principal, EVs contain many features similar to ICE automobiles powered by gasoline or diesel, there are several key technological and operational differences that serve to separate them. The following section provides an overview of these differences.

Electric Motors

EVs utilize powerful electric motors that either replace and/or supplement traditional ICEs. BEVs and PHEVs typically employ alternating current (AC) motors to propel the vehicle, which vary significantly in size and power output. Measured in kilowatts, electric motor size and output in passenger BEVs can typically range from approximately 50 kilowatts (which equates to approximately 65 horsepower and is roughly equivalent to the amount of power produced in sub-compact cars such as the SmartCar, Mitsubishi Mirage and Chevy Spark), to upwards of 350 kilowatts in high-end, performance EVs (producing the equivalent of more than 450 horsepower).

With an electric motor, the energy transfer is more direct and efficient, as there are fewer steps to go through to get energy to the wheels.[4] As a result, electric motors convert up to 90 per cent of applied energy to traction, compared to ICEs which normally convert approximately 30 per cent of applied energy to traction (diesel engines convert up to 40 per cent).[5] Therefore, electric motors provide significant torque when accelerating from a standing start and at low speeds, which contributes to their superior performance in stop-start conditions and during acceleration from low speeds.

In addition, some EVs can have multiple (two to four) electric motors. In a typical two-motor configuration, an electric motor is positioned on both the front and rear drive axles, which simplifies power delivery and increases efficiency. In the four-motor configuration, a smaller electric motor can be positioned at each wheel, which allows for even greater variation in the amount of power transferred to each wheel for improved traction and handling.

Electric motors typically have few moving parts, compared to ICEs that usually have hundreds of moving parts.[6] As a result, electric motors require less frequent maintenance than ICEs.

Battery Packs

Electric motors need electricity to function, and that electricity, which replaces the gasoline or diesel fuel in a traditional ICE, is stored in large lithium battery packs. EV battery packs are primarily charged through standard electrical outlets, specialized higher-voltage charging stations, and through regenerative braking. Additionally, PHEVs can utilize their ICEs to charge a battery pack when it becomes depleted. EV battery charging will be discussed in greater detail in the next section.

[4] http://www.plugincars.com/electric-vehicle-motors-101-124921.html, (accessed July 15, 2015).
[5] Natural Resources Canada. 2010. “Electric Vehicle Technology Roadmap for Canada: A Strategic Vision for Highway-capable Battery-electric, Plug-in and Other Hybrid-Electric Vehicles,” Ottawa: Government of Canada, pg. 8.
[6] Ibid. pg.9.

Battery packs are the heaviest and most expensive component of an EV. Lithium battery packs are increasingly used in BEVs and PHEVs due to their improved power-to-weight ratios and increased lifespans over older battery types. However, while battery technology is improving, the main issues concerning EV batteries remain lifespan, cost, and range. These issues are explored later in the report.

Additional Uses for EV Battery Packs

There are increasing options for EV battery packs when they reach the end of their use in a vehicle. For example, there are options to recycle used EV batteries, as the materials in batteries can be quite valuable. In addition, there are also options for second-life uses for EV battery packs that are no longer being used in vehicles, such as potential energy storage for solar panels and residential back-up power for emergencies. Lastly, in some instances, an EV parked in the driveway can be source of electricity to a household in emergencies as it can feed electricity back to the home; a process known as "vehicle-to-grid." This process, however, requires advanced and specialized electrical connections.

Regenerative Braking

While driving, BEVs and PHEVs can recover a portion of the energy produced during braking to recharge batteries through a process known as regenerative braking. In these systems, braking forces turn small electric motors that:

1.) assists in decelerating the vehicle through resistance; and
2.) sends electricity to the vehicle's battery, which effectively increases driving range each time the brakes are applied.

By converting kinetic energy into usable electricity in this manner, energy that would otherwise be wasted can either be used immediately or rerouted to a battery, thereby enhancing the vehicle's overall efficiency and range.

2.3 Overview of Currently Available Light-Duty EVs

At present, the majority of EVs available in the marketplace are compact and midsize passenger vehicles. However, manufacturers are working on expanding the lineup of EV offerings to include small passenger and cargo vans and pickups. Over time, as EV technology advances, a greater range of vehicle types will become available. Table 2 lists some of the EVs available in the Canadian marketplace in 2015 and includes information on some of their key specifications.

Table 2: Overview of EVs in Canada[7]

Model	Type	Approximate Purchase Price (CAN $)[8]	kWh Per 100/km	$ Per Year Operations[9]	Tailpipe CO2 Emissions (g/km)	Range (km)	Recharge Time (hrs)[10]
Chevrolet Spark EV	BEV	$30,800	17.8	$427	0	131	7
Chevrolet Volt	PHEV	$41,200	21.4 + 0.1L	$937	147	547	4
Ford Focus EV	BEV	$35,700	20.0	$480	0	122	4
Kia Soul EV	BEV	$36,000	19.9	$478	0	149	4
Mitsubishi i-MiEV	BEV	$28,700	18.7	$449	0	100	7
Nissan Leaf	BEV	$32,700	18.4	$442	0	135	5
Smart ForTwo Electric	BEV	$27,600	19.6	$470	0	109	8
Tesla Model S (60kW)	BEV	$84,600	21.9	$526	0	335	10
Toyota Prius Plug-In	PHEV	$36,800	18.0 + 0.4L	$1037	108	845	1.5

[7] Figures adopted from: NR Can Fuel Consumption Guide 2015, Available: http://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/oee/pdf/transportation/tools/fuelratings/Model%20Year%202015%20Vehicle%20Tables.pdf.

[8] Figures adopted from: International Energy Agency. 2015. "Hybrid and Electric Vehicle Implementation Agreement, Hybrid and Electric Vehicles: The Electric Drive Delivers," pg. 149, Available: http://www.ieahev.org/assets/1/7/Report2015_WEB.pdf. Prices have been converted to Canadian dollars based on the exchange rate as of August 13, 2015 and do not reflect taxes or subsidization.

[9] Estimated annual fuel cost is based on a combined rating on 55 per cent city and 45 per cent highway driving, a driving distance of 20,000 km, and forecast prices of $1.27/L for gasoline, $1.40/L for premium gasoline and $0.12/kWh for electricity. For PHEVs, annual fuel costs reflect a mixture of electricity and gasoline consumption.

[10] Charge times are based on the use of a level two charger.

3.0 Why is There Growing Interest in EVs?

EVs have become more prominent within road transportation sectors around the world in recent years and have attracted growing interest from consumers, governments, electrical utilities and automobile manufacturers.

On a global scale, EV sales have grown significantly in the last number of years. According to the International Energy Agency, there were approximately 180,000 such vehicles on the road at the end of 2012. By the end of 2014, this number increased to over 665,000.[11] There are a number of potential factors to which this increase could be attributed including operational features unique to EVs such as ease of maintenance, as well as performance and reduced operating costs. From a broad societal perspective, there are also benefits in terms of reduced dependency on fossil fuel use in the transportation sector and the associated reduction in GHG emissions.

Societal Benefits

- **Improve energy security:** EV deployment provides an opportunity to reduce reliance on gasoline, of which over 40 billion litres was sold in Canada in 2014,[12] towards electricity.
- **Tackle climate change:** When EVs are fueled by electricity that is generated from clean sources of energy such as hydro, solar, or wind, no GHG emissions are released in powering the vehicle.
- **Improve local air quality:** The exhaust gas from ICE vehicles contains local air contaminants that can be harmful to human health. However, unlike ICE automobiles, when operating on electricity, EVs produce no tailpipe emissions

User Benefits

- **Simplicity to Maintain:** Unlike conventional automobiles, battery electric vehicles (BEVs) contain few moving parts that may need replacing; there are no coolants, oils, belts, pulleys or exhaust systems.
- **Performance:** In comparison to ICE automobiles, electric motors emit very little sound during operation and provide for instant torque, allowing for a more comfortable drive.
- **Reduced Operating Cost:** EVs provide significantly improved fuel economy over ICE automobiles. On average, its costs as little as $2.38 to drive 100 kilometres in an EV in Canada.[13] In comparison, to drive the same distance in a comparable ICE, such as a Toyota Camry, it can cost as much as $10.[14]

[11] International Energy Agency. 2015. "Global EV Outlook 2015," Available: http://www.iea.org/evi/Global-EV-Outlook-2015-Update_1page.pdf.
[12] Statistics Canada. 2015. "Sales of fuel used for road motor vehicles, by province and territory," Available: http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/trade37a-eng.htm.
[13] This figure is based on the average electricity price per kilowatt hour as well as the average kilowatt hour consumption per 100 kilometres for EVs in Canada.
[14] This figure was determined using numbers from Natural Resources Canada's Fuel Consumption Guide, which assumes and annual driving distance of 20,000 KM and a fuel price of $1.27/L for regular gasoline.

EVs and Climate Change

Growing environmental awareness has contributed to increased interest in EVs.[15] Scientific evidence about the dangers of rising global GHG emissions has prompted governments to put in place policies and measures to tackle climate change. In some cases, these have included initiatives to increase the penetration of EVs.

The light-duty passenger vehicle on-road transportation sector (excluding light duty trucks), accounts for 5.4 per cent of GHG emissions in Canada and 7.5 per cent in Newfoundland and Labrador.[16] The GHG emissions profile from operating an EV depends on how the electricity used to power the vehicle was generated. For example, generating electricity from fossil fuels (such as coal, natural gas and heavy oil) emits GHGs. Therefore, an EV powered by such electricity will displace rather than eliminate GHGs emissions because although no GHGs are emitted when the EV is being driven, GHGs will have been emitted upstream to produce the electricity needed to power the EV.

However, EVs that obtain their electricity from clean, renewable sources of energy, such as hydro, wind and solar, produce zero GHG emissions during charging. Currently, 63 per cent of electricity generated in Canada is from hydroelectricity[17] and, by 2018, 98 per cent of electricity consumed in Newfoundland and Labrador will be from hydroelectricity and wind. As such, the large-scale deployment of EVs, coupled with clean electricity generation, could provide an opportunity to reduce GHG emissions from this sector and in turn tackle climate change.

Financial and Non-Financial Incentives

Financial and non-financial incentives may play a role in increasing consumer interest in EVs. For example, a number of governments offer point-of-purchase rebates and some lenders offer loan reductions for EVs and EV charging stations, which make EVs more cost competitive in the marketplace. In addition, EV owners in some jurisdictions receive a green license plate that allows them access to preferential parking locations and carpool lanes.

Financial Considerations

Prior to purchasing, it is likely a consumer will consider the total cost of purchasing, owning and operating an EV.[18] While it is generally understood that the upfront capital costs are higher than a comparable ICE automobile,[19] there is also an understanding among some consumers that EVs are

[15] Deloitte. 2011. "Unplugged: Electric vehicle realities versus consumer expectations," Available: http://www2.deloitte.com/content/dam/Deloitte/global/Documents/Manufacturing/gx_us_auto_DTTGlobalAutoSurvey_ElectricVehicles_100411.pdf.

[16] Environment Canada. 2015. National Inventory Report, April 2015.

[17] The Council of the Federation. 2015." Canadian Energy Strategy," pg. 5, Available: http://www.canadaspremiers.ca/phocadownload/publications/canadian_energy_strategy_eng_fnl.pdf.

[9] Angelica Argyropoulos, Kevin Harris and Jessica Barnett. 2014. "Recharging Public Perceptions: Assessing the Effect of the EV Experience on Prospective EV Consumers." Available: http://emc-mec.ca/wp-content/uploads/Final-Project-Report_PlugnDrive.pdf

[10] Electric Power Research Institute. 2013. "Total Cost of Ownership Model for Current Plug-in Electric Vehicles," Available: http://tdworld.com/site-files/tdworld.com/files/uploads/2013/11/tcopev.pdf.

cheaper to own and operate over the longer term. In a 2013 survey of consumer perceptions of EVs, Navigant Research determined that 60 per cent of surveyed consumers either completely or somewhat agreed that EVs are less expensive to own in the long run than ICE automobiles.[20]

[11] Navigant Research. 2013. "Electric Vehicle Consumer Survey: Consumer Attitudes, Opinions, and Preferences for Electric Vehicles and EV Charging Stations," pg. 12.

4.0 Electric Vehicle Technology

4.1 Key Technological Considerations

There are a number of technological considerations that are often taken into account by consumers prior to purchasing an EV. Individuals may consider such as how and where they intend to use the vehicle (e.g. is it the only household vehicle or a second one, will it be used primarily for highway or city driving, how far is the regular commute, where will the vehicle be charged, what is the climate like) and the proximity of maintenance facilities. This section examines EV range, battery lifespan, performance in cold weather, city versus highway driving, and maintenance. The total cost of vehicle ownership and maintenance is examined separately in the context of provincial market conditions in section 7.0 on Newfoundland and Labrador.

EV Range

Although battery technology is constantly improving to achieve greater capacity at lower weight, a BEV's range remains limited relative to conventional ICE automobiles. While higher-end BEVs with advanced battery packs, such as the Tesla Model S (65kWh), can achieve approximately 335 kilometres on a full charge, many compact ICE vehicles can travel upwards of 800 kilometres on a tank of gasoline.

The current range limitation for BEVs may be a barrier to the more widespread adoption of BEVs by some consumers. A 2011 survey conducted by Deloitte showed that 53 per cent of Canadian respondents would only purchase an EV if its range could exceed 320 kilometres, which is higher than almost all EVs available in the Canadian market.[21] This "range anxiety", however, is not a factor in PHEVs, as these vehicles have ICEs that can provide power to the wheels in instances when battery packs are depleted and/or additional power is required for quick acceleration. Greater access to charging stations may help alleviate concerns about range.

Battery Cost and Lifespan

Historically, as EVs began to emerge in the marketplace, two of the most prominent issues raised by consumers were the potential replacement cost and lifespan of an EV's battery. Previously, replacement battery packs for a Nissan Leaf and Ford Focus EV cost between $12,000 and $15,000 respectively.[22] At present, however, EV battery pack costs are decreasing. Since 2011, through advances in research and development, the cost of EV batteries has decreased by nearly 50 per cent.[23] Despite these advancements, there is still anxiety among some consumers concerning the cost and lifespan of EV batteries.[24]

[21] Deloitte. 2011. "Unplugged: Electric vehicle realities versus consumer expectations," pg. 6, Available: http://www2.deloitte.com/content/dam/Deloitte/global/Documents/Manufacturing/gx_us_auto_DTTGlobalAutoSurvey_ElectricVehicles_100411.pdf.

[22] International Energy Agency. 2013. Global EV Outlook: Understanding the Electric Vehicle Landscape Until 2020, Available: https://www.iea.org/publications/globalevoutlook_2013.pdf. Pg. 25.

[23] http://www.cleanenergyministerial.org/News/evi-releases-the-global-ev-outlook-2015-27091 (accessed July 16, 2015).

[24] http://autos.jdpower.com/press-releases/2012-electric-vehicle-ownership-experience-study (accessed July 16, 2015).

EV battery pack lifespans are increasing, and are now expected to last more than 10 years and to lose only 20 to 30 per cent of their capacity over this period. Additionally, most manufacturers cover battery packs in new EVs against defect and significant capacity loss, and some offer warranties for periods of as long as nine years.

Performance in Cold Weather

Cold weather affects battery performance which in turn affects an EV's range. Cold weather presents two main challenges for EVs: (i) cold air limits battery performance and (ii) the higher draw on the battery to provide heat for the vehicle's occupants, run window and mirror defrosters and other components, reduces range. For example, studies have shown that the peak battery performance of a Nissan Leaf (one of the most common EVs on the road) can be reduced by nearly 40 per cent in temperatures of -6°C.[25] To compensate for this, automakers have attempted to use the heat generated by the electric motor to heat the vehicle's battery. While this approach is more efficient, since it uses waste heat rather than electricity, it takes some time to take effect as electric motors do not produce large amounts of excess heat.[26] Despite this, however, EV range in the cold is increasing with technological advances.

Maintenance

BEVs typically require less maintenance than conventional ICE vehicles because the motor, battery pack and associated electronics require little to no regular maintenance. In BEVs there are fewer fluids to change, and there are far fewer moving parts relative to an ICE automobile,[27] which may translate to lower maintenance costs. However, since PHEVs contain both an electric motor as well as an internal combustion engine, they require maintenance similar to an ICE automobile. However, due to regenerative braking, PHEVs may require less frequent brake maintenance than their ICE counterparts.

While BEVs may require less maintenance than traditional ICE vehicles, these vehicles require mechanics that are trained in how to maintain the technology associated with the electric features of the vehicle. As such, there are challenges associated with the availability of service options. While ICE vehicles and EVs have much in common in terms of parts and manufacturing processes, there are fundamental differences, which require new skills, training and safety certifications for technicians involved in vehicle repair and servicing, particularly in relation to the safe handling of high-voltage battery packs.

While the vast majority of automotive dealerships within North America that sell EVs have qualified technicians that can provide service and maintenance on their brands, there are fewer third-party, independent automotive service providers with technicians on hand to service a range of EVs from multiple manufacturers and to provide safety inspections.

[25] Matt Stevens. 2015. "EV Performance in Canada: Real Life Performance in the Cold," Presentation given at the 2015 EMC Conference in Halifax, NS. This figure was calculated by examining the per cent change between optimal range at 20°C and the range at -6°C for Nissan Leaf Model Years 2013-2015.
[26] http://www.technologyreview.com/news/522496/electric-vehicles-out-in-the-cold/, (accessed July 16, 2015).
[27] http://www.afdc.energy.gov/vehicles/electric_maintenance.html, (accessed July 16, 2015)

First Responder Safety

As outlined above, the technology in an EV differs from a conventional ICE vehicle. EVs contain high voltage electric batteries and motors, and as such, first responders must be aware of how to safely immobilize the vehicle when responding to an emergency, in order to protect themselves and the vehicle's occupants from any hazards. In 2013, the Standards Council of Canada, on behalf of Natural Resources Canada's Federal Interdepartmental Electric Vehicles Working Group engaged the United States National Fire Protection Association to adapt training modules, first used by first responders in the United States, to build capacity on these matters amongst Canadian first responders.[28]

[28] Standards Council of Canada. 2013. "Driving Electric Vehicle Safety Training Solutions for Canadian First Responders," Available: https://www.scc.ca/en/news-events/news/2013/driving-electric-vehicle-safety-training-solutions-canadian-first-responders

5.0 Electric Vehicle Infrastructure

One of the most significant considerations taken into account by potential EV owners is access to EV infrastructure and supply equipment (EVSE),[31] which principally refers to EV charging stations, attachments, plugs and fittings such as couplers, as well as devices and power outlets needed to charge an EV. Without adequate charging systems and related infrastructure in a given region, it is likely EV adoption will be slower as it is generally understood the level of EV deployment is linked to recharge access.[32]

Although many EV owners charge their vehicles at work or overnight at home, the lack of publicly available EV charging stations is often cited as a barrier to large-scale EV deployment.[33] Without adequate publicly available infrastructure, some consumers may be reluctant to purchase an EV. As EV charging stations available to the public are not as widespread as conventional fuel stations and BEVs are limited from a range standpoint, some consumers may feel that current levels of EV infrastructure are not sufficient to support extended commutes.

5.1 Types of EV Chargers

BEV and PHEV batteries require specialized chargers to recharge. In general, there are three types of EV chargers, which vary in performance capability. This section provides an overview of the types of EV chargers. A comparison of the three types of EV charging stations is found in Table 3.

Table 3: Types of EV Charging Stations

	Level One	Level Two	Level Three
Required Voltage	120 V (AC)	208-240 V (AC)	400+ V (DC)
Charging Time	PHEV: 6-8 hrs BEV: 11-16 hrs	PHEV: 3-4 hrs BEV: 4-8 hrs	PHEV: N/A BEV: 15-30 min (to 80% capacity)
Charger Cost (CAN $)	$0 (often comes with vehicle)	$500-1,000 (Residential) $2,000-4,000 (Commercial)	$30,000-100,000
Km Yield Per Charge Time[29]	5-7km (1 hour)	15-30km (1 hour)[30]	90+km (20 minutes)
Examples of Uses	Home or when other forms of charging not available	Home or at work	Long distance commutes

[29] These are typical rates. The rate in which an electric charge adds range to an EV is dependent upon battery and EVSE types.
[30] Higher amperage charging stations (e.g. 100 amp) will yield higher kilometre rates per hour of charging.
[31] Natural Resources Canada. 2010. "Electric Vehicle Technology Roadmap for Canada: A Strategic Vision for Highway-capable Battery-electric, Plug-in and Other Hybrid-Electric Vehicles," Ottawa: Government of anada, pg. 12.
[32] Axsen, J., S. Goldberg, J. Bailey, G. Kamiya, B. Langman, J. Cairns, M. Wolinetz, and A. Miele. 2015. "Electrifying Vehicles: Insights from the Canadian Plug-in Electric Vehicle Study." Simon Fraser University, Vancouver, Canada. pg. 26.
[33] Natural Resources Canada. 2010. "Electric Vehicle Technology Roadmap for Canada: A Strategic Vision for Highway-capable Battery-electric, Plug-in and Other Hybrid-Electric Vehicles," Ottawa: Government of Canada, pg. 8.

Level One Chargers

Level one chargers plug into standard household outlets or receptacles, and can be used as a backup charging option in instances when more advanced charging options are not available. Level one chargers require 120V and can typically recharge an EV in as little as six or as many as 16 hours. These chargers typically add five to seven kilometres to an EV's range per hour of charging. Prolonged charge times often make level one chargers unattractive to EV owners for daily or regular charging; however, PHEV owners are often more receptive, since their vehicles can operate without electricity.

Level Two Chargers

Level two chargers are the most widespread, preferred and practical form of EV charging, as they provide significantly lower charge times than level one stations, are less costly to purchase and install than level three chargers, and can be installed residentially on standard household electrical systems. Level two chargers require 240V, can charge an EV in three to eight hours, and can add between 15 and 30 kilometres to an EV's range per hour of charging. A level two residential EV charger typically costs between $500 and $1,000 depending on the brand. These chargers most often utilized for residential applications for regular, everyday charging, and in commercial applications for public use.

Level Three Chargers

Level three chargers can recharge an EV in as little as 20 minutes. This form of charger requires 480V, which is double that of level two chargers, and is significantly more expensive than other forms of EV charging.[34] Level three chargers are designed to perform, from a time standpoint, similar to a conventional fuel station pump. These stations provide for extremely fast recharge times compared to level one and two stations; however, since they are significantly more expensive to purchase and install, and since their voltage ratings are typically too high for most households, they are better suited for commercial applications.

5.2 EV Charging Stations

Besides the initial upfront cost of purchasing EV infrastructure, there are additional costs and measures that must be realized to ensure chargers are operating in a safe and optimal manner. These range from installation costs to considerations aimed at improving consumer access and end-user safety.

Residential Charging Stations- Installation Considerations

As mentioned, most EV owners charge their vehicle at home through the use of a level two charger, as their lower cost and voltage requirements are more suitable for residential applications. Level two residential chargers are frequently installed in garages, but can also be installed outdoors, provided the unit is rated for outdoor use.

[34] This figure will vary depending on the capacity of the charging station.

Commercial Charging Station Considerations

Signage – Since both EV owners and pedestrians may come into contact with a public charging station, signage is often erected to warn individuals of the potential hazards associated with operating an electrically charged device.

Shelter – Charging station areas often provide shelter from the elements, where possible. Although charging stations not rated for outdoor use can operate in sheltered areas, such as parking garages, charging stations not rated for outdoor use must not be exposed to the elements.

Safety Equipment – Depending on the jurisdiction, occupational health and safety requirements may specify the installation of equipment, such as wheel stops, to ensure the vehicle does not come in direct contact with electrically energized equipment.

Strategic Placement – EV charging stations are often placed in areas where individuals can easily access them. Particular consideration is given to the needs of individuals with mobility restrictions, as well as others that have difficulty entering and exiting vehicles.

The installation of an EV charger must be performed by a qualified electrical contractor to comply with national, provincial and local electrical codes and regulations. Evidence from other jurisdictions suggests the cost to install a level two charging station can be approximately $2,000 (unit included); however this cost may increase if the electrical service in the home is not sufficient to support a charging station and is in need of an upgrade.[35]

Commercial Charging Stations- Installation Considerations

Similar to residential applications, commercial level two and three charging stations must be installed by a qualified electrical contractor and comply with electrical regulations and standards. However, when commercial charging stations (level two or three) are installed for public use, there are several additional factors that can often lead to higher costs for these installations.

Since each commercial installation is different, it is difficult to derive a specific figure; however, the costs associated with the installation of commercial level two and three charging stations are understood to be higher than residential applications. Apart from electrical work, additional costs are incurred through the general construction process, which may include trenching to run wires underground and the pouring of concrete to form bases for charging stations. Moreover, the significantly higher voltage of level three charging stations (480V) requires specialized electrical components which are more costly.

EV Infrastructure and Multi-Unit Dwellings

In some cases, individuals residing in multi-unit residential buildings require approval from building owners to install EV infrastructure. As a result, if their building is not equipped with, or cannot

[35] Electric Transportation Engineering Corporation. 2009. "Electric Vehicle Charging Infrastructure Deployment Guidelines," pg. 52. This number is an estimate only and does not reflect extenuating circumstances which could increase installation costs. Installation costs will vary depending upon electrician labour rates, the type of charging station purchased, and the current electrical makeup of the home, among other factors.

accommodate EV infrastructure, consumers residing in multi-unit residential buildings may be reluctant to purchase an EV, due to a lack of home charging access.

To enhance charging access for EV owners in multi-unit residential buildings, some jurisdictions have amended local building code requirements to facilitate the installation of EV infrastructure. For example, in 2011, the City of Vancouver made the following revisions to its building bylaws:

- 20 per cent of the parking stalls in every building must include a receptacle for charging EVs; and
- The electrical room must include enough space to install any equipment necessary to provide charging for all residents in the future.[36]

5.3 Public EV Infrastructure in Canada

Although varying permitting and registration requirements across jurisdictions do not allow for an exact number,[37] evidence suggests the number of publicly available EV charging stations in Canada has significantly increased in recent years.[38] One industry organization, Sun Country Highway, introduced approximately 1,000 level two charging stations across Canada over the last three years. Nearly 90 per cent of this charging network is available free of charge to consumers.[39] The goal of this initiative is to develop an extensive charging network along major highways across the nation, to assist EV owners in cross-provincial commutes.

In addition, a number of private businesses, including auto service dealers, hotels, and office buildings and parking garages now provide charging stations for customers, clients and employees. These stations are therefore frequently used by individuals seeking to “top up” their charge while working, shopping or eating. The emerging use of Leadership in Energy and Environmental Design (LEED) - a third party environmental certification tool for buildings - has contributed to the increase in public EV charging stations, as it provides credits towards building certification for their installation.

5.4 EV Infrastructure Demand on Electricity Grids

A common question regarding EVs is how their widespread deployment would impact electricity demand and distribution infrastructure. It is essential to consider these implications for two reasons. First, since EVs draw their energy from the electricity grid, it is important to understand the impact of a large number of these vehicles charging simultaneously. Second, because ratepayers, in some instances, incur the costs associated with infrastructure upgrades and maintenance, it is necessary to gain a fulsome understanding of how EV adoption will influence existing electrical infrastructure and what modifications, if any, are needed to support increased EV charging in a given area.

[36] http://vancouver.ca/home-property-development/electric-vehicle-charging-requirements.aspx (accessed August 24, 2015).
[37] International Energy Agency. 2015. “Hybrid and Electric Vehicle Implementation Agreement, Hybrid and Electric Vehicles: The Electric Drive Delivers,” pg. 146, Available: http://www.ieahev.org/assets/1/7/Report2015_WEB.pdf.
[38] Electric Mobility Canada estimates this number to be over 2000.
[39]Michael Bettencourt. 2014. “EV firm plans 1,000 more charging stations across Canada” *The Globe and Mail,* November 13, 2014, Available: http://www.theglobeandmail.com/globe-drive/culture/technology/ev-firm-plans-1000-more-charging-stations-across-canada/article21556161/.

Demand in Perspective

Research from the United States has shown the average power demand to charge most EVs is between three and six kilowatts of electricity while charging using a residential level two charger, which is equivalent to the draw from a portable air conditioner.[40] However, this research has also shown that some brands of EVs can consume up to 19 kilowatts during an extended charge. While this may not be problematic in isolation, if numerous EV owners concentrated within a given neighborhood charge simultaneously, this "clustering" could exert stress on local electrical distribution infrastructure. The specific energy draw per EV charging will depend on numerous factors, such as vehicle type and the form of EVSE purchased.

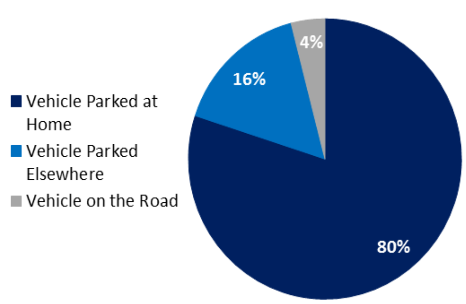
Although not examined in the above research, it is worth noting that level three charging stations require power supplies capable of handling between 25 and 50 kilowatts of electricity, an electricity draw that is over double that of the peak electricity demand of some households.

Consumer Charging Behavior

As previously mentioned, a significant portion of EV owners charge their vehicles at home overnight,[41] a time often referred to as "off peak" (i.e. when demand on the electricity grid is typically low). As illustrated in Graph 1, a vehicle is typically located at an individual's home nearly 80 per cent of the time, making it likely the majority of EV charging will occur in this setting. However, it is also common for EV owners to plug in to public charging stations during the day and "top up" while conducting daily activities. This can potentially exert strain on an electricity grid, as this is often done during peak usage times (i.e. when demand on the electricity grid is high).

More research in this area, as well as consultations with electrical utilities, is needed to better determine the conditions under which widespread EV charging would alter demand and transform an off peak period to a high peak one, and to identify whether and to what extent EVs would impact the electricity grid during peak demand in a given jurisdiction.

Graph 1. Typical Location of a Vehicle



Source: John Bates and David Leibling. 2012. "Spaced Out: Perspectives on Parking Policy," RAC Foundation

Mitigating the Impact of EVs on Electricity Grids

Utilizing a significant number of EV charging stations at the same time has the potential to affect business-as-usual power demands, which may require utilities, in some circumstances, to consider impacts on electricity generation, transmission and distribution systems. With that being said, there are measures and technologies that utilities have used in other jurisdictions to address these issues;

[40] U.S. Department of Energy. 2014. "Evaluating Electric Vehicle Charging Impacts and Customer Charging Behavior." Pg. 4, Available: http://energy.gov/sites/prod/files/2014/12/f19/SGIG-EvaluatingEVcharging-Dec2014.pdf.
[41] A study conducted by the U.S. Department of Energy showed approximately 76 per cent of surveyed individuals charged during off-peak periods.

however, it is important to note that these technologies and measures are not always applicable to the local circumstances of each jurisdiction.

Time-of-Use Measures (TOU) – These instruments offer incentive-based electricity rates, which allow EV owners to take advantage of lower electricity costs during off peak periods. The rationale behind time-of-use measures is that lower costs will encourage EV owners to plug in during times when demand on the electricity grid is at its lowest point. TOU measures are most often employed in areas where the demand for electricity is close to, or exceeds available supply levels.

Smart Chargers and Smart Grid Technology – Investments in smart grid technology and chargers (a form of EV charger with an internal monitoring device) can allow utilities to monitor and collect EV-specific meter data, apply specific costs for EV charging, or control and restrict the availability of charging during certain times. This technology also enables utilities to create a portal to share information with EV owners about their electricity consumption and potential savings, in an effort to influence charging behavior. Smart chargers can be owned by a utility or a consumer.

Case Study: Smart Grid Technology in New Brunswick

In 2012, New Brunswick Power entered into a 10-year agreement with Siemens Canada to integrate smart grid technology into the province's electricity system. This technology enables communications between customers and their homes, power plants and distribution systems. As part of this initiative, NB power installed seven public EV smart chargers in urban centres in the province to better understand consumer charging behavior and any associated shifts in electricity demand.

Electricity grid impacts from EV charging are dependent upon a number of variables. The status and capacity of electrical infrastructure is likely to differ depending on the jurisdiction. As such, the local circumstances of each jurisdiction, coupled with the number of EVs present, will be crucial factors in determining whether and how the grid is likely to be affected.

6.0 EV Uptake in Other Jurisdictions

This section provides an overview of policy initiatives, market dynamics and consumer responses to the deployment of EVs globally and in jurisdictions across Canada and the United States. Examining the progress of EVs and EV infrastructure in regions where early EV adoption has occurred is particularly useful, as this can yield important insights to inform future policy development.

6.1 The EV Landscape Globally

Numerous jurisdictions, in North America and around the world have introduced, or are in the process of introducing measures to increase the uptake of EVs, to develop and support EV infrastructure, and to raise awareness of issues surrounding sustainable transportation. The Electric Vehicles Initiative (EVI) - a multi-government policy forum dedicated to accelerating the adoption of EVs worldwide - consists of 16 nations, including Canada, which represents 95 per cent of the global EV stock. The International Energy Agency estimates spending on EV initiatives by EVI governments totaled US$16 billion between 2008 and 2014, with most spending concentrated on research and development aimed at advancing and improving EV technology.[42]

Preliminary evidence suggests, in most cases, strong government support on both the demand and supply sides has contributed to the rising market penetration of EVs globally.[43] For example, nations such as Norway - which has the highest number of EVs per capita in the world - have introduced tax relief for EV purchases and provided EV owners with benefits not offered to conventional automobile owners, such as exemptions from road tolls and access to bus lanes. This form of top-down support from government has served to given both manufacturers and consumers confidence in the strength of EV market development in these regions.

[42]International Energy Agency. 2015. "Global EV Outlook 2015," Available: http://www.iea.org/evi/Global-EV-Outlook-2015-Update_1page.pdf (accessed July 15, 2015).
[43] International Energy Agency. 2013. Global EV Outlook: Understanding the Electric Vehicle Landscape Until 2020, Available: https://www.iea.org/publications/globalevoutlook_2013.pdf.

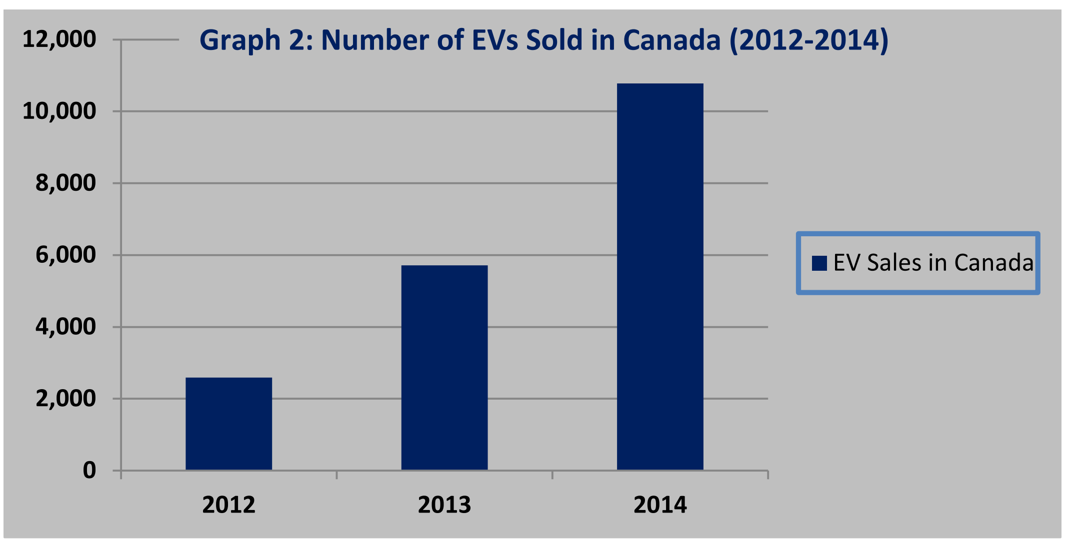
6.2 The EV Landscape in Canada

In recent years, several provincial governments across Canada have introduced financial and non-financial incentives, awareness raising materials, demonstration projects and deployment targets aimed at increasing the uptake of EVs and achieving a market shift towards cleaner forms of transportation. Since 2012, Canadian EV sales have grown by 315 per cent.[44]

The Electric Vehicle Technology Roadmap for Canada

In 2009, the Government of Canada funded a report to examine a number of considerations regarding the future adoption of EVs, such as energy storage, vehicle integration and technological requirements. The report, entitled "The Canadian Electric Vehicle Technology Roadmap," was informed by numerous industry stakeholders and projects by 2018 there will be 500,000 EVs on Canadian roads.

At the end of 2014, nearly 11,000 EVs were registered in Canada, up from 2,591 in 2012.[45] Compared to 2013, the EV market share increased to 0.28 per cent from 0.1 per cent of the light-duty passenger vehicle market, which was estimated at 1.8 million vehicles.[46] Graph 2 illustrates the sale of EVs in Canada from 2012 to 2014.



Currently, over 95 per cent[47] of EVs in Canada are registered in the provinces of Quebec, British Columbia and Ontario. These provinces have been the most active in offering financial and non-financial incentives towards the purchase of EVs and EV infrastructure in Canada.

[44] International Energy Agency. 2015. "Hybrid and Electric Vehicle Implementation Agreement, Hybrid and Electric Vehicles: The Electric Drive Delivers," pg. 120, Available: http://www.ieahev.org/assets/1/7/Report2015_WEB.pdf.
[45] International Energy Agency. 2015. "Hybrid and Electric Vehicle Implementation Agreement, Hybrid and Electric Vehicles: The Electric Drive Delivers," pg. 120, Available: http://www.ieahev.org/assets/1/7/Report2015_WEB.pdf.
[46] Ibid. pg 146.
[47] Electric Mobility Canada. "Advancing Electric Transportation," Presentation delivered February 26th, 2015.

Quebec

In October 2015, to supplement its overall efforts to reduce GHG emissions and dependence on fossil fuels, Quebec released an action plan entitled "Propulser le Québec par l'électricité" (Propelling Quebec Forward with Electricity). Under this plan, Quebec has set a target to have 100,000 EVs on Quebec roads by 2020. In achieving this target, Quebec projects it will reduce GHG emissions by 150,000 tonnes annually. This plan will be supplemented by $425 million dollars in funding over its five year duration, including for initiatives such as EV and EV infrastructure subsidies, demonstration projects, and investments in research and development[48]

Case Study: *Branché au Travail* Program

In 2014, the Province of Quebec launched the *Branché au Travail* program. Pursuant to this program, individuals, businesses, municipalities and non-profit organizations are eligible to apply for financial assistance up to $5,000 towards the purchase and installation of a workplace charging station. In order to receive funding, proponents must commit to keep the station in service for a period of three years and offer free charging to employees. This program will remain in effect until December 31, 2016.

In January 2012, the Provincial Government introduced the Drive Electric Program. This program offers a rebate on the purchase or lease of all BEVs and PHEVs up to $8,000, with rebate amounts calculated according the capacity of the vehicle's battery.[49] In addition, this program provides financial assistance of up to $1,000 towards the purchase and installation of a level two home charging station. In 2014, the sale of 2,398 EVs and installation of 1,094 charging stations were supported by this initiative,[50] which will remain in force until December 31, 2016.

In an effort to lead by example, since 2014, a government directive requires departments, agencies and crown corporations to replace any existing light-duty vehicle or meet any new light-duty vehicle need with either a BEV or PHEV. At the end of 2014 there were approximately 350 EVs in the Government of Quebec's vehicle fleet.

Quebec possesses one of the most extensive public EV charging networks in Canada. Its network, dubbed the "Electric Circuit," currently consists of 364 charging stations; eight of which are of the level three variety. In 2015, the province has partnered with over 100 organizations and is expected to introduce another 150 level two chargers (240V) into the network. By 2016, the province plans to have 785 publicly available level two charging stations, including 60 level three charging stations,[51] 25 of which will be funded entirely by Nissan.[52]

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[48] John Meagher. 2015. "Quebec announces five-year car-electrification program," *Montreal Gazette,* October 10, 2015, Available: http://montrealgazette.com/news/local-news/quebec-announces-five-year-car-electrification-program
[49] This was set at a minimum of 7kW for 2015.
[50] International Energy Agency. 2015. "Hybrid and Electric Vehicle Implementation Agreement, Hybrid and Electric Vehicles: The Electric Drive Delivers," pg. 144, Available: http://www.ieahev.org/assets/1/7/Report2015_WEB.pdf.
[51] John Meagher. 2015. "Quebec announces five-year car-electrification program," *Montreal Gazette,* October 10, 2015, Available: http://montrealgazette.com/news/local-news/quebec-announces-five-year-car-electrification-program
[52] Kevin Mio, "Quebec's EV Charging Network Gets a Major Boost," *Montreal Gazette,* January 16, 2015, Available: http://montrealgazette.com/business/local-business/quebecs-ev-charging-network-gets-a-major-boost

British Columbia

In addition to the financial assistance provided by the Government of British Columbia under its Clean Energy Vehicle program (see box below), the British Columbia SCRAP-IT Program, which is administered by a not-for-profit organization that receives grants and contributions from government and program partners, also provides financial incentives for the purchase of EVs. Under this program, if an individual retires any vehicle and in turn purchases an EV, he or she is eligible to receive $3,250 in incentives ($3,000 from SCRAP-IT and a $250 point of sale discount from a participating dealership). When combined with the CEV program, consumers can receive up to $8,250 towards the purchase of an EV.

In June 2014, to further advance the mandate of its CEV program, the Government of British Columbia launched Emotive BC: The Electric Vehicle Experience. This public outreach program is led by "Plug in British Columbia"; an initiative co-chaired by its Ministry of Energy and Mines and B.C. Hydro to lay the groundwork for EV related infrastructure in the province and to raise EV awareness.

In an additional effort to make EVs and other alternative fuel vehicles more attractive to consumers, in its 2015 Budget the Government of British Columbia committed to implement phase two of the CEV program. This phase of the program will distribute $10.6 million from its Innovative Clean Energy Fund, and includes:

- $7.5 million for point-of-sale incentives for electric and hydrogen fuel cell vehicles.
- $1.59 million for investments in charging infrastructure and hydrogen fuelling infrastructure.
- $1 million for incentives for commercial fleet purchases of clean energy vehicles.
- $500,000 for research, training, and public outreach on clean energy transportation technology.

Case Study: British Columbia Clean Energy Vehicle (CEV) Program

Since the introduction of its CEV program, the uptake of EVs and EV infrastructure in British Columbia has increased markedly. The CEV program provides point of sale incentives of up to $5,000 towards the purchase or lease of an EV. Phase one of the CEV program, which spanned from 2011 to 2014, saw 950 EVs purchased and over 1,000 charging stations deployed, which will result in nearly 57,000 tonnes of direct emissions reductions over a 15 year period.

The principal goal of the CEV program is to foster consumer action such that clean energy vehicles achieve a five per cent share of new light duty vehicle purchases in the province by 2020. To achieve this goal, over 700 public charging stations have been established in the province, which currently stands as the most in any jurisdiction in Canada.

This stage of the program is slated to operate until either March 31, 2018 or when all available funds are exhausted.

Ontario

Similar to Quebec and British Columbia, Ontario's EV program is driven by a blend of financial and non-financial incentives. In July 2010, the Government of Ontario introduced a point-of-purchase grant, ranging from $5,000 to $8,500, towards the purchase or lease of an EV, depending on the vehicle's battery capacity. To supplement this initiative, in January 2010, the province introduced an EV charging incentive, which provides up

Case Study: Ontario Green License Plates

Ontario EV owners are given green licence plates, which allow them to access preferential parking spaces, public charging stations at transit stations and in government parking lots, as well as access to high occupancy lanes, irrespective of the number of passengers in the vehicle, until June 30, 2016.

to $1,000 towards the purchase and installation of a level two home charging station.

Ontario has pledged that, by 2020, five per cent, or one in 20, of all vehicles driven in the province will be electrically powered. As of June 1, 2015, 4,496 EVs have been registered in Ontario, while 3,414 EV and 776 charging station rebates have been awarded. Currently, there are approximately 400 publicly available charging stations in Ontario.[53]

6.3 EV Landscape in the United States

In his 2011 State of the Union address, President Obama set an ambitious goal to have 1 million EVs on the road in the United States by 2015. This goal was aimed at building leadership in United States technologies, in order to reduce its reliance on fossil fuels. To achieve this goal, President Obama proposed a series of efforts to support EV adoption through improvements to tax credits, investments in research and development, and competitive programs to encourage communities to invest in EV infrastructure.[54]

The United States is home to the most EVs in the world, eclipsing over 280,000 at the end of 2014. In addition, the United States also houses one of the most extensive publically-available EV infrastructure networks in the world, which includes 1,693 level one, 8,376 level two and 759 level three fast charging stations.[55]

To foster EV and EV infrastructure growth, a mix of incentives, rebates and tax credits are employed by federal, state and local governments. Pursuant to the *American Recovery and Reinvestment Act* of 2009, the federal government in the United States provides a tax credit of up to $7,500 towards the purchase of a qualified EV, with funding rates determined according to the capacity of the vehicle's battery. However, some American states, such as Colorado, Nebraska, North Carolina, Virginia, and Washington, have introduced additional registration fees for BEVs, premised on the fact that BEV owners do not contribute to road maintenance through the traditional method of gasoline taxes.[56]

California

One of the most progressive states in the United States, with respect to EV deployment, is California. Over the past 20 years California has been active in investing resources to support EV technology advancements and in developing EV specific policy initiatives, including the development of a Zero-Emission Vehicle (ZEV)[57] Action Plan. In March 2012, Governor Jerry Brown issued an executive order directing the state government to help accelerate the market for ZEVs in California. This executive order established a path toward 1.5 million ZEVs in California by the year 2025. Currently, 40 per cent[58] of EVs within the United States are found in California, with EV ownership recently surpassing 120,000 vehicles in the state.

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[53] http://www.mto.gov.on.ca/english/vehicles/electric/electric-vehicle-incentive-program.shtml (accessed July 21, 2015).

[54] U.S. Department of Energy. 2011. "One Million Electric Vehicles by 2015: February 2011 Status Report," Available: https://www1.eere.energy.gov/vehiclesandfuels/pdfs/1_million_electric_vehicles_rpt.pdf (accessed July 21, 2015).

[55] International Energy Agency. 2015."Hybrid and Electric Vehicle Implementation Agreement, Hybrid and Electric Vehicles: The Electric Drive Delivers," pg. 279, Available: http://www.ieahev.org/assets/1/7/Report2015_WEB.pdf.

[56] Ibid.

[57] Zero Emission Vehicles in this instance includes BEVs, PHEVs and hydrogen fuel cell powered vehicles.

[58] Government of California. 2013. "2013 ZEV Action Plan," Available: http://opr.ca.gov/docs/Governor's_Office_ZEV_Action_Plan_(02-13).pdf

To promote the uptake of alternative methods of transportation, such as EVs, California has introduced rebates of $2,500 for BEVs and $1,500 for PHEVs. Additional incentives for EV owners include access to carpool lanes, regardless of the number of passengers in the vehicle, as well as insurance discounts of between five and 10 per cent, depending on the insurer.

In order to lead by example in its own operations, as part of its executive order, the Government of California mandated that 10 per cent of state agency light-duty vehicle purchases by 2015 and 25 per cent by 2025 be Zero Emission Vehicles.[59]

Case Study: Multi-State Zero-Emission Vehicle (ZEV) Action Plan

One of the most significant state-level EV policy developments in recent years was the release of the Multi-State Zero-Emission Vehicle (ZEV) Action Plan. This plan established a vision for 3.3 million ZEVs on American roads by 2025, and is a collaboration between states representing one quarter of all new car sales in the US, including: California, Connecticut, Maryland, Massachusetts, New York, Oregon, Rhode Island, and Vermont.

In 2013, the governors of these states signed a memorandum of understanding outlining a coordinated commitment to foster the successful implementation of state ZEV programs. Among other actions, the governors committed to:

- Promote the availability and effective marketing of all plug-in electric vehicle models in their states.
- Lead by example through increasing ZEVs in state, municipal, and other public fleets.
- Promote workplace charging.
- Promote access, compatibility and interoperability of the plug-in electric vehicle charging network.
- Remove barriers to ZEV charging and fueling station installations.

[59] https://www.gov.ca.gov/news.php?id=17463 (accessed July 25, 2015).

6.4 An Overview of EV Policies and Initiatives across Jurisdictions

As illustrated in the preceding sections, there are a number of ways in which governments and private sector entities have attempted to influence consumer behavior and promote the uptake and raise awareness of EVs. Table 5 table provides an overview of the types of policies and initiatives that have been utilized in jurisdictions across North America and around the world.

Table 5. EV Policies and Initiatives Across Jurisdictions

Policy or Initiative	Example of Jurisdiction(s) Employing Policy or Initiative	Example
Point of purchase incentives	British Columbia, Ontario, Quebec, California	British Columbia's Clean Energy Vehicle program, when combined with the SCRAP IT initiative, provides consumers incentives of up to $8,250 towards the purchase of an EV.
Tax exemptions and credits	Germany, Japan, Norway, United Kingdom, United States	In Norway, battery electric vehicles are exempt from the nation's 25 per cent value-added tax system at the point of purchase.
Awareness raising initiatives	British Columbia, Manitoba	June 2014, the Government of British Columbia launched Emotive BC: The Electric Vehicle Experience, a campaign that raises awareness of plug-in electric vehicles in B.C.
Demonstration projects	British Columbia, Manitoba, Nova Scotia	In 2011, N.S. Power launched the ShareReady program to determine if Nova Scotia was ready for electric vehicles. In partnership with a local dealer, the ShareReady team shared 10 all-electric Nissan LEAF vehicles with 9 local organizations.
Residential charging incentives	British Columbia, California, Ontario, Quebec	The Government of Quebec provides financial assistance of up to $1,000 towards the purchase and installation of a level two home charging station.
Workplace charging incentives	Quebec	The Government of Quebec, through its Branché au Travail program, provides assistance up to $5,000 towards the purchase and installation of a workplace charging station.
Access to high occupancy vehicle lanes	California, Ontario	The state government in California provides windshield decals for EV owners to place on their windshield, which grants them access to high occupancy vehicle lanes.
Green licence plates	Ontario	Ontario provides EV owners with green licence plates, which allow them to access to benefits such as preferential parking locations.
Insurance discounts	California	Insurance companies in California offer insurance discounts of between five and 10 per cent depending on the insurer, for EVs.
Research and development funding	Quebec, United States	Pursuant to the *American Recovery and Reinvestment Act 2009*, the Federal Government in the United States earmarked $2.4 billion for EV research and development, which included: • $1.5 billion in grants for battery development and manufacture. • $500 million for EV component development and manufacture. • $400 million to demonstrate EV technology.

7.0 Current State of EVs in Newfoundland and Labrador

To date, the number of EVs on the road in Newfoundland and Labrador is comparable to other jurisdictions in Canada that have not introduced incentives towards the purchase of EVs.[60] As of December 2014, 34 BEVs, including passenger and courier vehicles, and 239 HEVs and PHEVs combined are registered in the province. By comparison, there are approximately 321,795 registered active passenger vehicles in Newfoundland and Labrador.

Currently, the Government of Newfoundland and Labrador does not offer financial or non-financial incentives towards the purchase of EVs or EV infrastructure. However, the Newfoundland and Labrador Credit Union, via its Eco-Friendly Vehicle Loan Program, offers a rebate of 2.5 per cent for consumers and three per cent for account holders, to a maximum of $1,500 when obtaining a loan to purchase an EV.[61] Additionally, in its *Greening Government Action Plan* released in January 2015, the Government of Newfoundland and Labrador committed to examine the scope for a demonstration project for EVs in its own operations.

Case Study: Provincial Government Provides Funding for EV Charging Stations

In February of 2015, through the Newfoundland and Labrador Green Fund, the Provincial Government provided $52,000 to Green Rock E.V.S. to supply and install five residential and 14 commercial EV charging stations.

7.1 An Analysis of EV Considerations for Newfoundland and Labrador

Financial Considerations

EV purchases may displace purchases of conventional cars over time. This may result in changes to the net costs that consumers' incur (that is, consumers could be better or worse off as a result of buying an EV).

Table 6: Cumulative Costs Incurred Per EV (NPV $2015 Basis)

	After 5 years	After 10 Years	After 15 Years
Conventional Car	$49,100	$69,700	$85,200
Electric Vehicle	$53,500	$64,100	$72,100
Difference	-9%	+8%	+15%

A cost-benefit analysis was completed to examine changes in individuals' costs incurred[62] (see Table 6).

[60] For example, current penetration figures from provincial automobile databases estimate that Nova Scotia has 30 registered EVs while New Brunswick has 28.

[61] Newfoundland and Labrador Credit Union. "Eco-Friendly Vehicle Loan Rebate," Available: https://www.nlcu.com/Home/ProductsAndServices/YourFinancing/VehicleLoans/EcoFriendlyVehicleLoanRebate/

[62] The base case for the analysis, assumes that an EV costs, on average, $35,000, an EV charger costs $1,500, and a comparable conventional car (that is, a conventional car that would otherwise not be purchased) costs $20,000 (all costs are before taxes).

Based on several assumptions,[63] on a net present value basis (that is, constant 2015 dollars), this analysis shows that an individual is expected to be nine per cent worse off from a lifecycle cost perspective if s/he owns an EV for a five year period. If s/he holds the car for 10 years, s/he is expected to be eight per cent better off. For comparison, if s/he owns the car for 15 years, s/he is expected to be 15 per cent better off.

Sensitivity analyses were then conducted, the results of which are set out in Table 7 below.

Table 7: Change in Individuals' Well-Being Per EV (NPV $2015)[64]			
	After 5 years	10 Years	15 Years
Base Case	-9%	+8%	+15%
Cost of ICE car is increased by 10% relative to Base Case	-4%	+11%	+17%
Cost of ICE is increased by 10% and cost of EV is reduced by 10% relative to base case	+2%	+15%	+21%
Fuel cost is decreased by 10% relative to base case	-11%	+6%	+13%
Fuel cost is increased by 10% relative to base case	-7%	+10%	+17%

- First, the cost of the conventional vehicle was increased by 10 per cent. This reflects the fact that many conventional vehicles have optional winter packages and different transmissions which may cost more. In this scenario, individuals are expected to be worse off by four per cent after five years from a lifecycle costing perspective but 11 per cent and 17 per cent better off after 10 and 15 years respectively.

- Second, an alternative scenario combined a 10 per cent increase in the cost of an ICE outlined above, with a 10 per cent reduction in the cost of an EV on the assumption that technology deployment occurs at a rate that results in lower prices for EVs. In this case, an individual is expected to be two per cent better off after five years, and 15 per cent and 21 per cent better off after 10 and 15 years respectively.

- Third, a sensitivity analysis was conducted using different energy costs.
  - If the cost of fuel for an ICE was decreased by 10 per cent, an individual is expected to be 11 per cent worse off after five years but six and 13 per cent better off after 10 and 15 years respectively.

[63] It is assumed that a purchaser makes a $5,000 down payment and that the balance is repaid over five years at a 3.0 per cent interest rate. It is also assumed that a car is driven 20,000 km each year and that a higher than average number of kilometers is urban driving. Residual trade-in value is not included. Operating costs considered include energy purchases (after regenerative braking for an EV), of $1.40/litre for gas after taxes and 19 cents per kwh after taxes, maintenance, and insurance. The projection period is assumed to start in 2018. Lastly, inflation is projected at two per cent; an eight per cent discount rate is applied on consumer spending and 3.5 per cent discount rate to government spending.

[64] No sensitivity scenarios were developed to reflect changes in interest rates, inflation and discount rates.

- By comparison, if the cost of fuel for an ICE was increased by 10 per cent, an individual is expected to be seven per cent worse off after five years but 10 per cent and 17 per cent better off after 10 and 15 years respectively.

This analysis shows that, from an individual perspective and in the absence of any subsidies or tax breaks that would lower the upfront purchase cost, the additional capital costs to purchase an EV are not expected to be recouped within a five year period, but will likely be recouped within a ten year period, unless the cost of an EV decreases by 10 per cent and the cost of an ICE automobile is increased by 10 per cent. In this case, an individual would be two per cent better off after five years

Legislative and Regulatory Considerations

As outlined, BEVs (and PHEVs when operating using electricity) require electricity obtained from charging stations connected to the electricity grid to operate. The sale of electricity in Newfoundland and Labrador is governed by the *Electrical Power Control Act 1994 (EPCA),* and the *Public Utilities Act (PUA*). An EV charging station which does not supply power for compensation is not a public utility or a retailer under these acts, and therefore does not fall within their purview.

Section 14.1 of the EPCA grants Newfoundland and Labrador Hydro the exclusive right to sell electrical power to retailers on the island portion of the province. A retailer is defined in the EPCA as a public utility (as defined in the PUA) which buys or generates power and whose primary business is the sale or resale of power to arm's length customers. If an EV charging station operation was established in the province, where the primary business of the operation was the sale or resale of power to EV customers, the provider could be considered a retailer under the EPCA, and therefore, certain legislative and regulatory implications could apply. This will require further consideration as the uptake of EVs increases in the province.

Level of EV Infrastructure

Industry information suggests approximately 47 level two charging stations are now present on the island portion of the province; however, there are currently none in Labrador. At present, most charging stations are housed near private sector businesses, recreation complexes, and in parking garages in the Avalon Peninsula. Additional stations installed by Sun Country Highway are present in Clarenville, Gander, Grand Falls-Windsor, Deer Lake, Stephenville and Channel-Port aux Basques. To date, there have been no level three charging stations installed in the province. Table 8 provides a more detailed overview of EV charging stations in Newfoundland and Labrador.

Table 8: EV Charging Stations in Newfoundland and Labrador[65]		
City/Town	**# of Charging Stations**	**Location(s)**
Channel-Port aux Basques	**1**	St. Christopher's Hotel
Clarenville	**2**	Hickman Motors (**1**) Solar Winds Energy (**1**)
Deer Lake	**1**	Woodward Auto
Gander	**1**	Hickman Motors
Grand Falls-Windsor	**1**	Riverfront Chalets and Rafting
Marystown	**2**	Marystown Recreation Complex
Mount Pearl	**9**	Lindsay Construction (**8**) Green Rock E.V.S. (**1**)
Paradise	**2**	Paradise Sports Complex
St. John's	**27**	Hampton Inn and Suites (**2**) Water Street Parking Garage (**16**) Hickman Motors- Chevrolet Cadillac (**1**) Fortis Building (**8**)
Stephenville	**1**	Bennett Properties

EV Dealer Offerings

Evidence at this time suggests there are few automobile dealers in the province that sell EVs. Potential factors influencing this may include lack of consumer demand, the costs associated with upgrading dealership infrastructure to accommodate EV servicing, as well as the increased costs of training EV service technicians. However, despite this, consumers in the province have purchased pre-owned, warrantied EVs through Green Rock E.V.S., which currently stands as the province's only all electric dealer.

Additionally, some dealers have indicated that they are making investments and preparations as needed, to ensure if consumer demand for EVs increases in the province they will be in a position to supply and maintain their own manufacturer's EV models.

[65] These numbers are as of October 8, 2015, and were informed via conversations with Green Rock EVS, local businesses, and the Canadian Automobile Association's EV charging station locator map.

Climatic Considerations

While EV battery technology has continued to evolve, providing for extended kilometre ranges than in years past, cold weather conditions can still affect an EV's battery performance. As outlined previously, studies have shown that in conditions of -6°C, an EV battery's output can be reduced by nearly 40 per cent.

In 2014, there were 42 days in St. John's in which the mean daily temperature dropped below -6°C Moreover, in Happy Valley-Goose Bay there were 130 days in which the mean daily temperature dropped below this threshold. As a result, this could potentially be a barrier to EV adoption by consumers. However, other regions which have comparable or lower temperatures, such as Norway and Quebec, have high levels of EV deployment. Norway has the highest number of EVs per capita in the world, while nearly half of EVs sold in Canada are in Quebec.

Environmental Considerations

As discussed previously, the amount of GHGs related to an EV's operation, when operating on electricity, depends on the fuel used to generate the electricity used for charging. While the amount of GHG emissions associated with an EV prior to 2018 in the province will be a function of GHG emissions from incremental electricity generation at the Holyrood Generating Station, upon completion of the Muskrat Falls hydroelectricity project in 2018, Newfoundland and Labrador's electricity consumption will be 98 per cent renewable and GHG emissions free.

This has three implications for future EV adoption. First, given the significant power generating capacity of this facility, the province will possess enough excess clean electricity to power a significant number of EVs per year. Second, because nearly all of this electricity will be produced GHG emissions free, there would be virtually no GHG emissions as a result of EV owners plugging into the grid. Third, as EVs displace ICE automobiles, local air quality is expected to improve.

By comparison, a comparable ICE is expected to emit about 3.8 tonnes of GHGs per year. The expected GHG reduction per 1,000 EVs will be in the order of 3.8 kilotonnes per year. This is the equivalent of 0.6 per cent of all GHG emissions from light-duty ICE vehicles per year in the province. However, as fuel consumption ratings improve for conventional cars, this difference may decline over time.

Geographical Considerations

Newfoundland and Labrador is a relatively large province in which approximately 40 per cent of the population live on the Avalon Peninsula, 55 per cent live in over 350 coastal communities on the island portion of the province, and five per cent live in coastal and central Labrador communities. Moreover, long distances between rural communities, in the context of harsh climatic conditions and night driving hazards (e.g. animals on highways) have resulted in a propensity for many consumers to invest in relatively larger vehicles.

As outlined, BEVs operate in a limited range capacity of between 100 and 335 kilometres.[66] As a result, in order to drive long distances, it is essential BEV owners have access to EV infrastructure, such as

[66] The average range for BEVs sold in Canada is approximately 150km.

charging stations, at various points throughout their commute. Currently, 80 per cent of publicly available EV charging stations are concentrated in St. John’s and surrounding areas. Combined with geographical considerations, the current level of publicly available EV infrastructure represents a potential barrier to prospective EV ownership in the province.

Conversely, the topography of Newfoundland and Labrador may allow the regenerative braking features of an EV to become more beneficial to EV owners than in areas of more uniform elevation. When braking while driving down an area of steep elevation, the kinetic energy that is normally lost while braking in an ICE is rerouted to the electric battery, which can serve to increase the EV’s range.

EV Impacts on the Electricity Grid

As mentioned, one of the most common questions surrounding EVs is how their widespread use is likely to impact the electricity grid. Since EVs draw their energy from the electricity grid, a growing number of these vehicles plugging in at the same time could increase demand peaks and total annual energy consumption levels in the province. As a result, it is important to understand how addressing these changes might require supply infrastructure improvements and how any new system costs could affect electricity rates.

At present, electrical utilities indicate that the current level of EVs in the province will not adversely impact the electricity grid. However, if EV market share increases significantly over time there could be implications over the longer-term given the charging loads required.

Any associated system impacts are expected to be more a function of EV market share as opposed to the type(s) of EV charging stations utilized, as the highest capacity charging stations (level three) require considerably less time to charge, which may reduce the likelihood all charging systems being used at similar times of the day or night. It is expected that any distribution or system level impacts could be minimized by encouraging EV owners to charge during off peak periods. By encouraging consumers to charge in this way, the utilization of existing utility assets would increase and the need for capacity upgrades would be reduced.

In the event that the bulk of EV charging, at higher levels of EV market penetration, coincides with system and distribution level peaks, utilities may need to consider mitigation options, such as time of use measures to alter charging periods. However, it is important to note that in a Newfoundland and Labrador context, this would require significant metering technology changes.

8.0 Key Findings

Throughout this report numerous considerations surrounding EVs, as well as EV technology, infrastructure and current market developments were examined. The following summarizes the key findings of this report.

- **There are three types of electric vehicles, which vary in scope and performance capability –** In general, there are three types of EVs (BEVs, PHEVs and HEVs). The key difference between these vehicles is related to their method of propulsion (i.e. electricity, petroleum or through electric batteries.

- **There are technological features unique to EVs that distinguish them from ICE automobiles –** EVs possess unique features such as electric motors, electric battery packs and regenerative braking. In general, while these features can lead to lower maintenance and operating costs relative to conventional ICE automobiles, they also result in decreased range and performance in colder climates.

- **EV sales have grown domestically and globally in recent years –** EV sales have grown in Canada, the United States and abroad and currently account for 0.28 per cent of the light-duty automobile market in Canada.

- **There are a number of reasons why interest in EVs is increasing –** Interest in EVs has increased due to numerous factors including the environmental benefits associated with EVs, performance features such as instant torque and smooth operation, their lower operating cost over ICE vehicles, and the financial and non-financial incentives available in some jurisdictions.

- **EVs can reduce GHG emissions and improve local air quality** – When powered by electricity generated by renewable energy sources, EVs produce no emissions when being driven or while charging. This can reduce GHGs from the transportation sector and help tackle climate change, as well as improve local air quality.

- **There are key technological considerations surrounding EVs –** While EV technology has continued to evolve through advances in research and development, when operating on electricity, EVs remain limited from a range standpoint. Additionally, while EV battery costs have decreased significantly in recent years, and while lifespans are increasing, some consumers remain concerned about the longevity and replacement costs of an EV's battery. Conversely, due to fewer moving parts and regenerative braking, an EV requires less frequent maintenance than an ICE automobile.

- **EVs require specialized infrastructure to operate –** This infrastructure includes both residential and publicly available EV charging stations of the level one, two and three variety. In general, higher level chargers can recharge an EV's depleted battery more quickly. Level two charges are the most common and widespread, as they provide for lower charging times in comparison to level one chargers and are far less expensive to purchase and install than level three chargers. In most cases, it is more expensive to install EV charging stations in a public setting than in residential applications.

- **EV infrastructure is becoming more widespread –** Evidence suggests that the level of EV infrastructure in Canada is continuing to increase. While EV battery capacity has increased in recent years, which has extended EV driving range, without the necessary EV infrastructure in place, some consumers may continue to be reluctant to purchase an EV. As such, a variety of publicly available charging stations of various capacities is expected to be needed to support EV growth and to reduce consumer concerns.

- **Evidence suggests that consumers' knowledge and awareness of EVs, while increasing, remains limited –** Consumers are generally perceived by those in the automobile industry as lacking a full understanding of the capabilities of EVs relative to ICE automobiles.

- **Governments have played an active role in fostering EV adoption amongst consumers in some jurisdictions –** Jurisdictions in Canada, North America and around the globe have employed a number of policy instruments in an effort to stimulate EV adoption by consumers. While market forces are likely to play a significant role in the pace of EV adoption over time, governments can play a role in raising awareness of EVs and can exert top down leadership.

- **Incentives are often effective in overcoming barriers to EV adoption –** Evidence from jurisdictions across Canada, the United States and Europe suggests a mix of financial and non-financial incentives are often utilized in order for EVs to compete against ICE automobiles and to overcome higher initial capital costs, as ICE vehicles already exist in a well-established and mature market where consumer awareness is high and purchase prices are lower than EVs.

- **EVs are now on the road in Newfoundland and Labrador –** At present, there are 34 passenger and courier BEVs and 239 HEVs and PHEVs in Newfoundland and Labrador. Evidence at this time suggests there are few automobile dealers in the province that sell EVs; however, some dealers have indicated that they are making incremental investments to ensure they can sell and accommodate EV servicing in the event consumer demand increases. Currently, the Government of Newfoundland and Labrador does not offer financial or non-financial incentives to support EV deployment.

- **EV Infrastructure is present in Newfoundland and Labrador –** Currently, industry information suggests there are approximately 47 EV charging stations which are present in various areas of the province. While electrical utilities do not expect grid impacts from EV infrastructure at current levels of EV market penetration, the effects of EVs on the local electricity grid and their impacts on generation, transmission and distribution infrastructure over the longer term will need to be examined.

Annex 1: Acronyms

AC	Alternating current
BEV	Battery electric vehicle
CEV	Clean Energy Vehicle Program
EV	Electric vehicle
EVI	Electric Vehicles Initiative
EPCA	Electrical Power Control Act
EVSE	Electric vehicle supply equipment
GHG	Greenhouse gas
HEV	Hybrid electric vehicle
ICE	Internal combustion engine
IEA	International Energy Agency
kW	Kilowatt
kWh	Kilowatt hours
LEED	Leadership in Energy and Environmental Design
MRD	Motor Registration Division
MURB	Multi-unit residential building
PHEV	Plug-in hybrid electric vehicle
POS	Point of sale
PUA	Public Utilities Act
RPM	Rotations per minute
ZEV	Zero emission vehicle

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