ELECTRIC VEHICLE INFRASTRUCTURE NEEDS ASSESSMENT AND FORECAST

GOVERNMENT OF THE NORTHWEST TERRITORIES

Final Report

October 30, 2020

ECONOLER

ABBREVIATIONS

AEA	Arctic Energy Alliance
BEV	Battery electric vehicle
CEV	Clean Energy Vehicle Program
AADT	Annual average daily traffic
PSADT	Peak summer average daily traffic
DCFC	Direct current fast-charging
EV	Electric vehicle
GHG	Greenhouse gas
GNWT	Government of Northwest Territories
HFCV	Hydrogen fuel cell vehicle
HOV	High-occupancy vehicle
ICEV	Internal combustion engine vehicles
LEV	Low-emission vehicle
LDV	Light-duty vehicle
NT	Northwest Territories
PEV	Plug-in electric vehicle
PHEV	Plug-in hybrid electric vehicle
VKT	Vehicle kilometres travelled
ZEV	Zero-emission vehicle

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EXECUTIVE SUMMARY

The conversion of conventional gasoline vehicle fleets to electric vehicles (EVs) offers the potential to achieve significant reductions in transportation-related greenhouse gas (GHG) emissions while reducing operating and maintenance costs for vehicle owners. As part of its emissions reduction commitment established under the Paris Climate Agreement, the Government of Canada established two goals, notably that EVs represent 30% of new light-duty vehicle (LDV) sales in 2030 and 100% of new LDV sales in 2040. In its 2030 Energy Strategy, the Government of the Northwest Territories (GNWT) also set a goal of reducing transportation-related GHG emissions by 10% by 2030, in part by accelerating the pace of EV adoption through new EV purchase incentive programs and the development of one or more EV charging corridors in the Northwest Territories (NT).

EV Promotion Policies and Programs from Neighbouring Jurisdictions

The NT presents a challenging market for EV adoption, primarily because of extremely cold winter temperatures and few available public charging stations. Other regions with similar cold temperatures are addressing these challenges, including neighbouring territories and the State of Alaska. These jurisdictions currently have low EV adoption rates – less than 1% of the overall population of light-duty vehicles (LDV) in each region – but they are pursuing a range of programs and policies to advance their EV markets, including promotion and awareness events, public EV charging network development, as well as building codes and incentive programs to support the widespread availability of residential EV charging. These programs and policies offer potential models or partnership opportunities for the NT.

Programs and Policies to Advance EV Adoption	
Northwest Territories	**Neighbouring Regions**
› Arctic Energy Alliance EV Study › Rebate program for EVs and charging stations in hydro communities › Feasibility assessment and implementation of zero-emission vehicle transportation corridors in the NT	› EV public awareness and promotion campaign › Installation of fast-charging stations across Yukon › Investments in public charging stations › Ensure EV availability at local dealerships › Procure EVs for government fleets › Rebate program for EVs and charging stations › Ensure new home constructions are EV ready

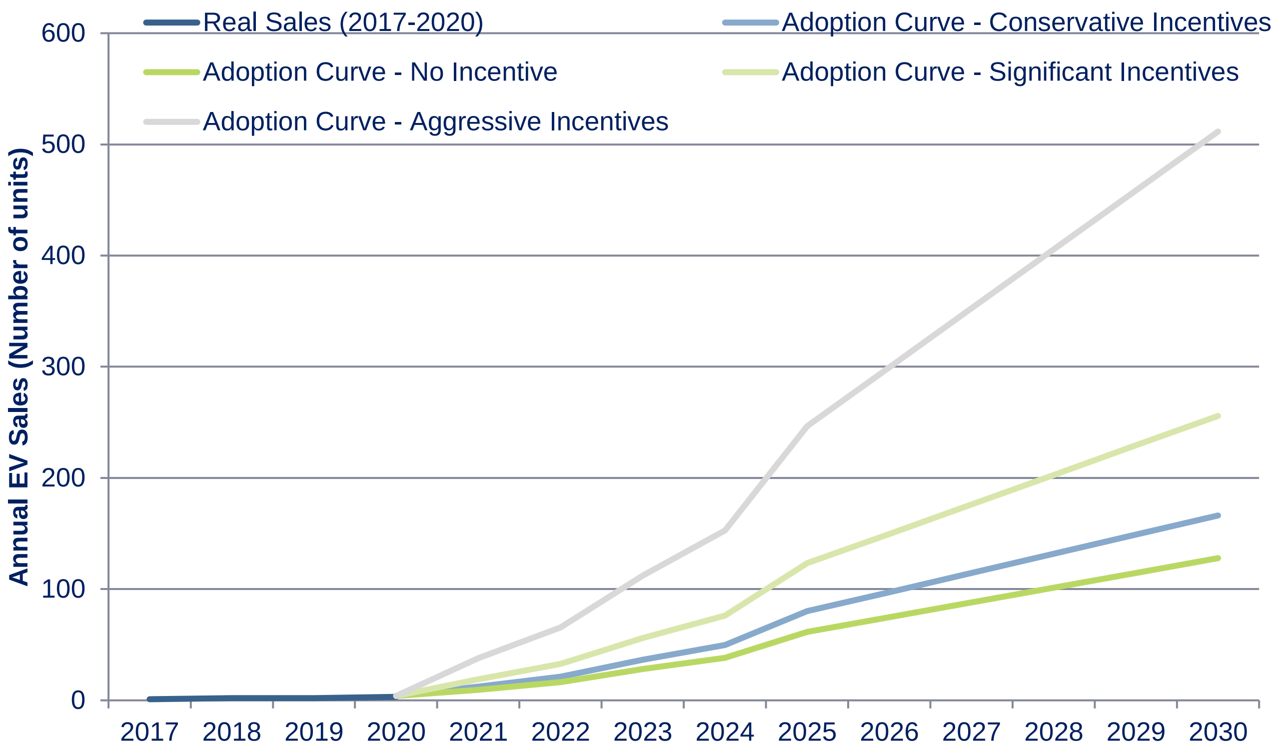
** Past, ongoing, and future initiatives.*

EV Adoption Forecast

The study team prepared a forecast of EV adoption in the NT based on historical sales data and the adoption model prepared for the Province of British Columbia (BC), which the team modified to match conditions in the NT.

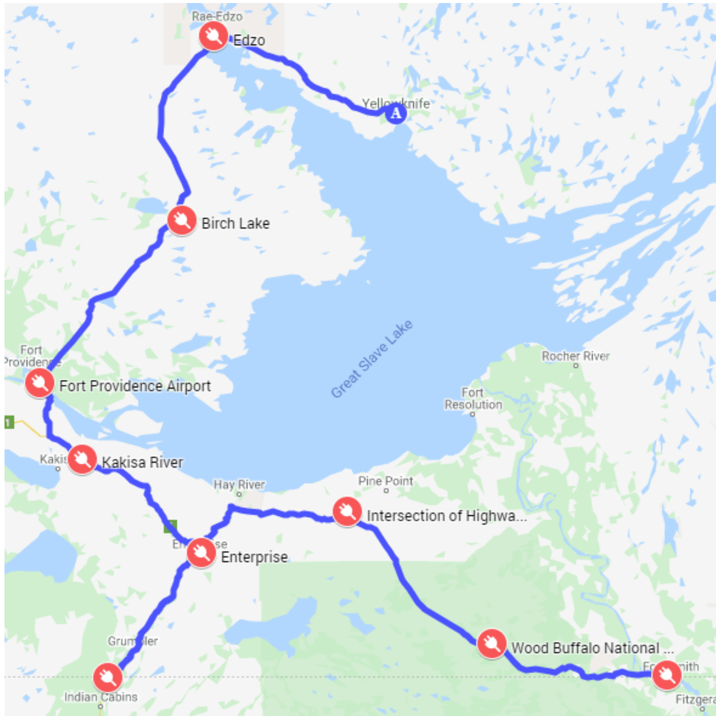
Incentive Scenario	EV Sales as Share of LDV Sales in 2030	Total EV Sales 2013-2030	EVs as Share of NT LDV Population in 2030
No Incentive	5.4%	677	2.9%
Conservative	6.8%	842	3.7%
Significant	10.8%	1,337	5.7%
Aggressive	21.7%	2,658	11.3%

The forecast indicates that EVs will represent between 5.4% and 21.7% of total LDV sales as well as 2.9% and 11.3% of the total LDV population in the NT in 2030, depending on the level of incentive support for EV purchasers. This projection falls short of the Government of Canada goal that 30% of vehicle sales be EVs by 2030, but most incentive scenarios yield steady progress toward widespread EV adoption.



EV Charging Network Requirements

An EV charging corridor along Highways 1 and 3 between Yellowknife and the Alberta border could be developed in several phases between 2021 and 2030, thereby enabling seasonal travel and travel by EVs with maximum ranges of 400 km or more along the corridor in the near term. This would also take advantage of the planned extension of the Talston grid and improvements over time in remote charging station technology to enable year-round EV travel on the corridor.



The results of the analysis present two options for the southern section of the corridor, between Enterprise and the Alberta border. One option follows Highway 1 southwest to the 60th Parallel Territorial Park. The other follows Highways 2 and 5 southeast to Wood Buffalo National Park and Fort Smith.

Environmental and Economic Impacts Analysis

The NT will achieve a reduction in transportation-related GHG emissions of between 219 and 865 tonnes CO_2e in 2030 strictly from travel in the proposed EV highway corridor and between 260 and 1,016 tonnes CO_2e from all travel.

Incentive Scenario	EV Share of Total LDV Population	EV Corridor GHG Emission Reductions (tonnes CO_2e)	Total GHG Emission Reductions (tonnes CO_2e)
No Incentive	2.9%	219	295
Conservative	3.7%	281	378
Significant	5.7%	432	581
Aggressive	11.3%	865	1,163

EV owners will save on average between $544 and $824 per year on fuel and maintenance costs compared to conventional gasoline vehicles. Given that the current average incremental price of EVs is approximately CAD 20,000, EV owners will achieve a net economic benefit under the Significant and Aggressive Incentive scenarios, whereas they will experience a net loss under the Conservative and No Incentive scenarios.

Incentive Program	Net 2030 GHG Reductions from EV Adoption – All Travel (tonne CO_2e)	Total Cost	Cost per Tonne of CO_2e
No Incentive	295	$662,500	$2.56
Conservative	378	$662,500	$2.05
Significant	581	$7,348,872	$14.40
Aggressive	1,163	$27,246,635	$26.67

The total cost to the GNWT for developing the proposed corridor and providing purchase incentives for new EVs ranges from $935,000 under the Conservative scenario – no new incentives from the territorial government – to $27,5 million under the Aggressive scenario.

INTRODUCTION

The conversion of conventional gasoline vehicle fleets to electric vehicles (EVs) offers the potential to achieve significant reductions in transportation-related greenhouse gas (GHG) emissions while reducing operating and maintenance costs for vehicle owners. As part of its emissions reduction commitment established under the Paris Climate Agreement, the Government of Canada established two goals, notably that EVs represent 30% of new light-duty vehicle (LDV) sales in 2030 and 100% of new LDV sales in 2040. In its 2030 Energy Strategy, the Government of the Northwest Territories (GNWT) also set a goal of reducing transportation-related GHG emissions by 10% by 2030, in part by accelerating the pace of EV adoption through new EV purchase incentive programs and the development of one or more EV charging corridors in the Northwest Territories (NT).

The study outlined herein presents a forecast of EV adoption in the NT between 2021 and 2030, and an analysis of a proposed new EV charging corridor along Highways 1 and 3 between Yellowknife and the Alberta border. Section 1 provides a detailed review of EV promotion and development activities from other jurisdictions across Canada, the U.S., and Europe to inform program and policy development in the NT. Section 2 outlines forecasts for annual EV sales and total adoption rates for the 2021-2030 period under three incentive scenarios and a no incentive scenario. The forecasts are based on the methodology applied in the EV adoption forecast for British Columbia, but modified according to a set of influence factors to account for key differences between the context for EV adoption in BC and the NT. Section 3 presents the anticipated EV traffic on the proposed EV charging corridor, a proposed charging network design, and an analysis of the type and number of EV chargers needed at each charging station to meet charging demand on the EV charging corridor. Section 4 details the economic and environmental benefits and costs of developing the EV charging corridor and providing new EV purchase incentives. Section 5 offers for consideration a set of additional programs, policies, and promotional activities to accelerate EV adoption in the NT.

Note: the term plug-in electric vehicles (PEVs) is used herein to refer to both battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) equipped with a battery and a gasoline combustion engine. The term EV is used to refer only to BEVs.

1 GAP ANALYSIS OF EV DEPLOYMENT AND PROMOTION

1.1 Current State of PEV Deployment in the NT

1.1.1 PEV Market and Market Share

With only a handful of EVs registered and currently in use in the region, the NT PEV market is still in its infancy stage. As of spring 2020, 10 plug-in electric vehicles (PEVs) are registered in the Territory, including three battery electric vehicles (BEVs) and seven plug-in hybrid electric vehicles (PHEVs).[1] With a total of approximately 24,000 light-duty vehicles (LDVs) on Northwestern roads,[2] PEVs currently represent only a tiny fraction of passenger vehicle market share in the NT.

Figure 1 presents the population and market share of PEVs by province and territory across Canada. Although it currently lags the leading provinces of Quebec, British Columbia, and Ontario, the population and market share of PEVs on NT roads are similar to other territories and to the provinces located in the Prairies and Atlantic Canada.

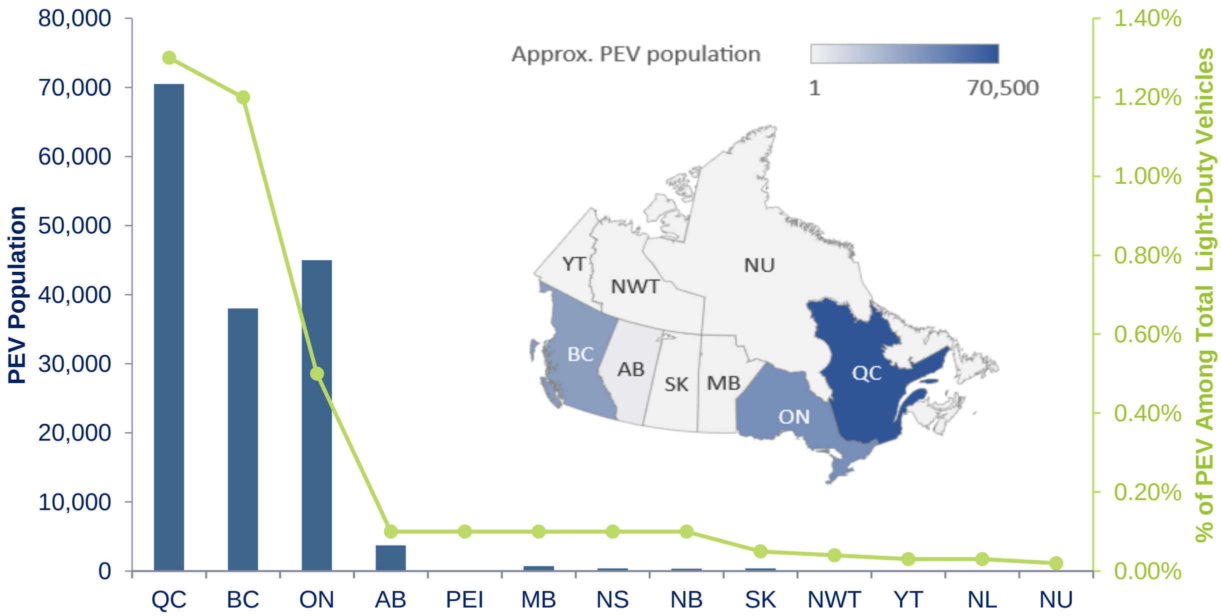


Figure 1: PEV Population and Market Share per Province/Territory (March 2020)[1]

[1] Electric Mobility Canada (2020). *Electric Vehicle Sales in Canada – Q1 2020.*
[2] Statistics Canada (2018 data). *Table 23-10-0067-01 Vehicle registrations, by type of vehicle.*

Canada has seen impressive growth in PEV sales over the past decade, as illustrated in Figure 2 below. As of the first quarter of 2020, the total number of PEVs on Canadian roads reached 159,000, with 2019 sales representing 2.9% of the market share for passenger vehicles. While this year-over-year increase in EV sales demonstrates sustained adoption of PEV vehicles in Canada, nearly 97% of Canadian PEV sales have occurred in three provinces: Quebec, Ontario, and British Columbia. These three provinces have implemented[3] the most comprehensive and mature EV policies and incentive programs in Canada (further discussed in Section 1.3). The rapid adoption of PEVs in these three provinces and the decline of PEV sales in Ontario since their rebate program was discontinued indicate the important effects that such initiatives can have on PEV uptake.

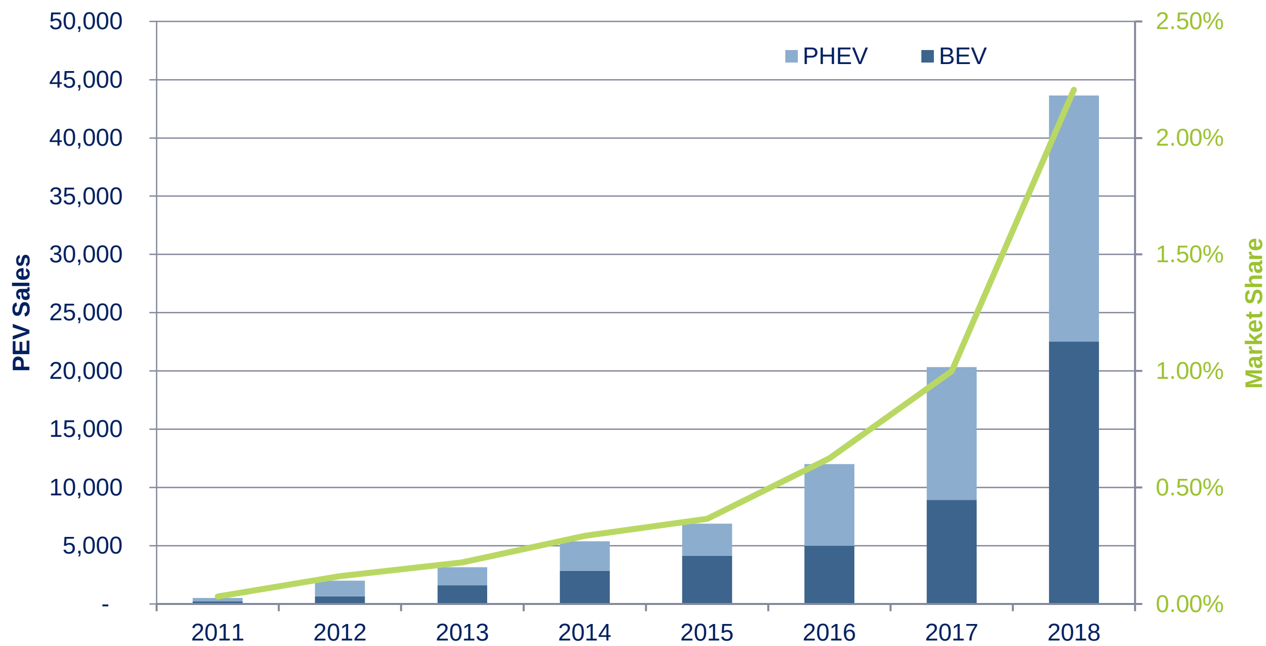


Figure 2: Total PEV Sales and Market Share in Canada (through year-end 2018)[4]

[3] Ontario's Electric and Hydrogen Vehicle Incentive Program was discontinued in July 2018.
[4] Statistics Canada. Table 20-10-0021-01 New motor vehicle registrations.

1.1.2 NT EV Initiatives

Past Initiative – Chevrolet Volt Pilot Project

There were few PEV initiatives in the NT prior to 2020. In 2015, the Arctic Energy Alliance (AEA) conducted a study on the feasibility of driving a PHEV in real-world, extreme cold weather conditions in and around the City of Yellowknife. As part of the study, the AEA leased a 2015 Chevrolet Volt and contracted FleetCarma to monitor the fuel and electricity consumption of the vehicle using a data logger. The results of this study revealed that, despite the average winter range of the vehicle being approximately half of its summer range (35 km in the winter versus 67 km in the summer), the overall range was more than sufficient to accommodate the Yellowknife daily commute of 6.3 km. The study also concluded that, "Even with Yellowknife's higher electricity costs, using an electric vehicle costs less than a conventional vehicle of comparable size."[5]

Current and Future Initiatives

In April 2018, the GNWT released its 2030 Energy Strategy, *A Path to More Affordable, Secure and Sustainable Energy in the Northwest Territories*. Acknowledging the importance of addressing transportation sector emissions to effectively reduce NT's overall GHG emissions, objective #3 of the Strategy aims to "reduce GHG emissions from transportation by 10% per capita" by 2030. To this end, the Strategy includes two actions directly related to PEVs for the short term and the long term:

- **2018-21 Short term:** "Design and initiate a rebate program for low or zero-emission vehicles and charging stations in hydro communities."
- **2021-30 Long term:** "Assess the feasibility and complete Zero-Emission Vehicle Transportation Corridors in the NT."

The AEA launched a pilot program for PEVs and charging infrastructure on June 15, 2020. The program offers rebates of $5,000 for the purchase of BEVs and PHEVs, as well as $500 rebates for Level 2 chargers. As noted in the 2030 Energy Strategy, this rebate program only applies to residents of NT's nine hydro communities.[6] For those residents, this new rebate program, combined with the existing federal government incentives, makes it possible to reduce the purchase price of a new PEV by $10,000. While it is too early, at the time of writing, to assess the impact of this new rebate program on the NT EV market, based on similar initiatives in the three leading Canadian provinces, it can be expected that these rebates will facilitate the uptake of PEVs in the next months.

[5] Arctic Energy Alliance (2016). *Electric Vehicle Study – Chevrolet Volt Plug-in Hybrid Electric Vehicle 2015-16.*
[6] Arctic Energy Alliance (2020). *Rebates on electric vehicles and charging infrastructure.*

1.2 Overview of EV Deployment in Other Cold Weather Jurisdictions

Several barriers to widespread PEV adoption in NT are common across all Canadian jurisdictions, including high purchase costs, a lack of public charging infrastructure, and the limited availability of PEV models. In addition, as a northern Canadian territory, the extreme cold weather in the NT has impacts on PEV range and battery performance, as well as on the service needs for PEV drivers and passengers at charging stations.

Previous studies have demonstrated that cold temperatures can significantly impact vehicle ranges and charging times. As a result, solutions to address these weather-specific challenges need to be considered to facilitate the adoption of PEVs in the NT. With relatively milder winters, Quebec, Ontario, and BC do not face the same weather-specific challenges as the NT. This subsection examines three cold weather jurisdictions in North America and Europe – Yukon, Alaska, and Norway – to highlight the best practices from those regions.

The three selected regions share similarities with the NT in terms of climate and its impact on PEVs and especially BEV range and performance. According to a map, developed by the Alaska Center for Energy and Power, showing the locations where BEV ranges are more likely to be affected by ambient temperature,[7] the three locations share the same EV-friendly score as the NT (i.e. 46 for Yellowknife; 48 for Whitehorse in Yukon; 48 for Anchorage in Alaska; and 46 for Finnmark in Norway).

[7] Alaska Center for Energy and Power (2020). *Electric Vehicle Zone Map*. Last accessed in August 2020 (https://public.tableau.com/profile/mitchell.kitt#!/vizhome/ACEPEVMAP/Home?publish=yes).

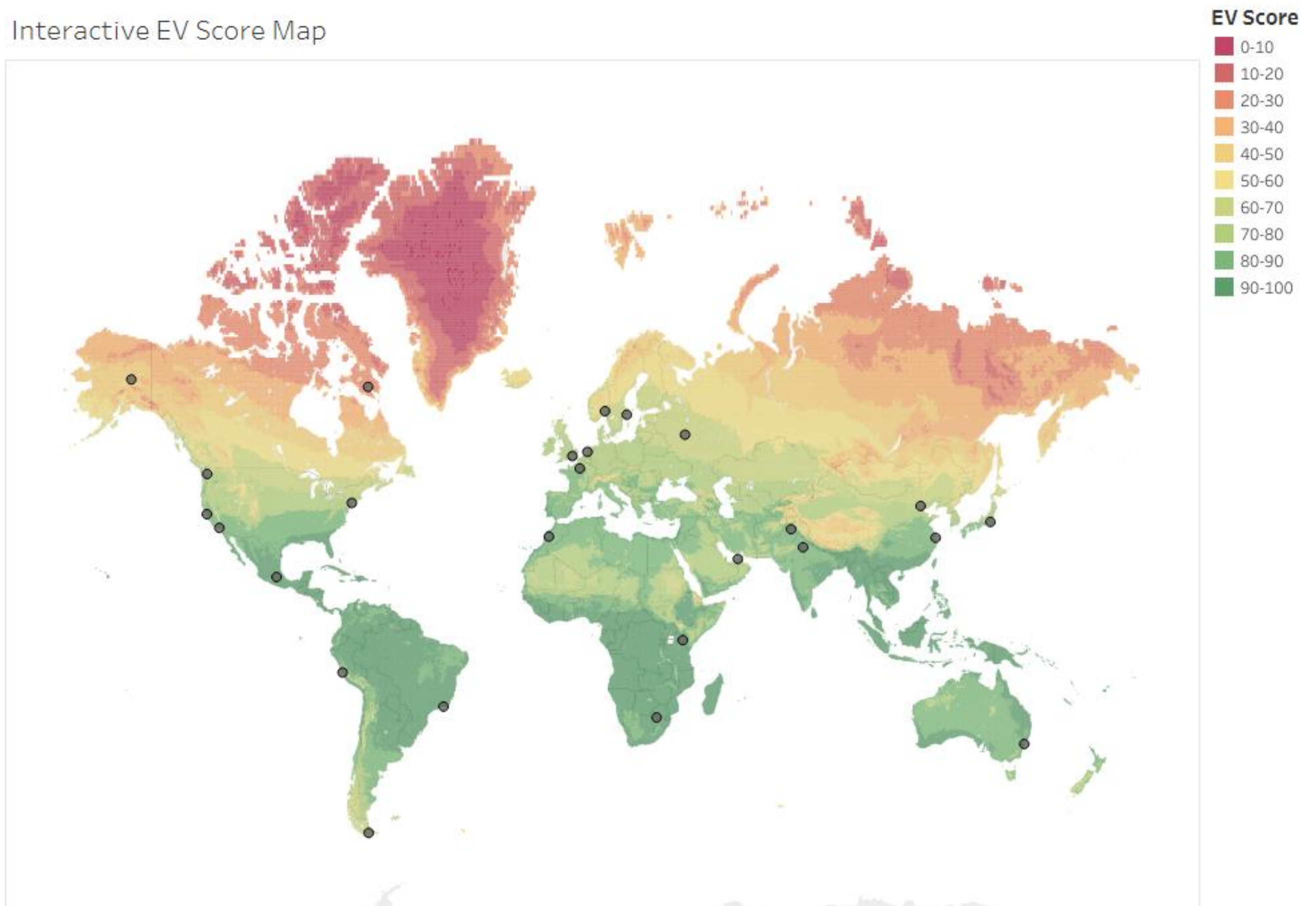


Figure 3: EV Score Map[7]

1.2.1 Yukon

Despite having slightly more public charging stations (13 versus 4 in the NT)[8], the neighboring territory of Yukon is on par with the NT when it comes to PEV ownership and the overall state of the PEV market. Yukon has a total of 12 registered PEVs, including a Chevrolet Spark EV that the Yukon government purchased in 2016 as part of its electric car pilot project. The territorial government has set ambitious targets to expand the PEV market over the next decade and is poised to take leading actions to achieve them. In its first draft climate change strategy, the Yukon government set a target to have at least 6,000 EVs in the territory by 2030.[9]

[8] According to data retrieved from PlugShare as of July 2020.
[9] Government of Yukon (November 2019). *Our Clean Future. A Yukon Strategy for Climate Change, Energy and a Green Economy.*

To reach this target, the strategy sets out the following nine comprehensive actions:

1 Work with local dealerships to ensure enough zero-emission vehicles are available for purchase in Yukon to reach targets that zero-emission vehicles will represent 10% of light-duty vehicle sales in 2025 and 30% in 2030.
2 Ensure half of all new cars purchased by the Government of Yukon are zero-emission vehicles.
3 Provide a rebate to Yukon businesses and individuals who purchase eligible zero-emission vehicles.
4 Continue to install fast-charging stations across Yukon to make it possible to travel between all road-accessible Yukon communities by 2027.
5 Work with the governments of British Columbia, Northwest Territories, and Alaska to explore options for installing electric vehicle charging stations to connect Yukon with BC, the NT, and Alaska.
6 Provide financial incentives to support the installation of electric vehicle charging stations at multi-residential and commercial buildings.
7 Require new residential buildings in the greater Whitehorse area to be built with the electrical infrastructure to support Level 2 electric vehicle charging.
8 Enable private businesses and Yukon public utilities to sell electricity for the purpose of electric vehicle charging.
9 Conduct a public education campaign to raise awareness about the benefits of electric vehicles and how they function in cold climates.

Through these actions, the Government of Yukon intends to encourage and support the deployment of PEVs by improving PEV availability, reducing purchase prices through financial incentives, increasing public charging availability, advancing EV readiness in new buildings, electricity tariff reforms, awareness building, as well as by leading by example through government fleet renewals and property retrofits. The Yukon Territory organized, as part of its first-ever EV Discovery Day on 8 March 2020, discussions on the advantages of EV ownership and a tradeshow with local dealerships and owners to feature EVs. The event was partially funded by Natural Resources Canada’s Zero-Emission Vehicle Awareness Initiative.

As outlined in Subsection 1.3, Yukon’s EV promotion activities are aligned with the best practices of leading jurisdictions for encouraging the adoption of PEVs.

1.2.2 Alaska

Alaska currently has about 650 PEVs on its roads, including approximately 300 BEVs and 350 PHEVs.[10] This represents about 0.36% of the total number of automobiles registered in the State. Compared to Canadian provinces and territories (see Figure 1), the State places fourth behind Ontario and ahead of Alberta.[11] In the U.S., however, Alaska trails other U.S. states in terms of EV market share (ranked 41st out of 50 states). This relatively low PEV penetration rate in the Last Frontier State can be explained by the absence PEV-enabling policies and rebate programs, high EV charging rates, and the absence of charging incentives. Currently, the only PEV rebate incentive program in Alaska is administered by Alaska Power and Telephone (AP&T), which provides a $1,000 credit to customers located in Alaska's Southeast communities if they purchase a BEV.[12] Despite this lack of public incentives, Alaskans have demonstrated increasing interest in PEVs in recent years as more models became available in the state.

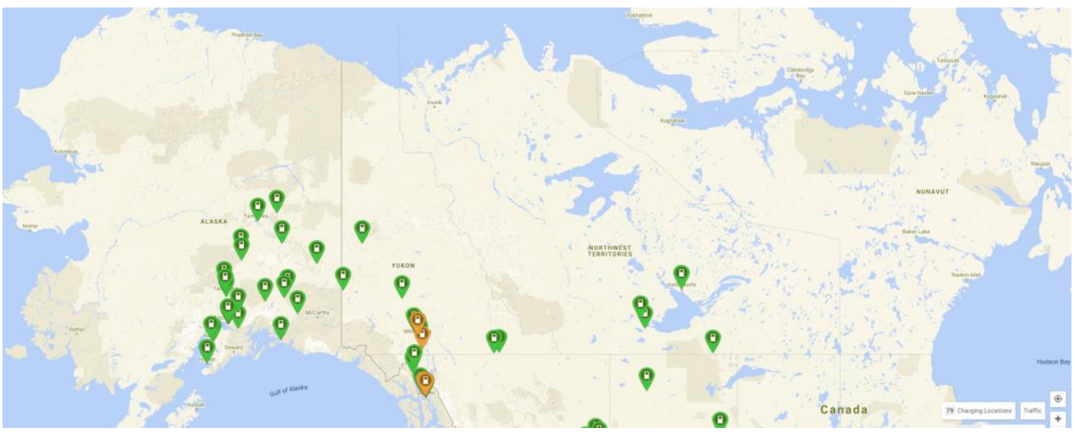


Figure 4: Location of Public Charging Stations in Alaska, Yukon, and NT[13]

As illustrated in Figure 4, Alaska is currently the North American leader in public charging stations north of the 60th parallel. Those installations received a boost in the last year when the Alaska Energy Authority set aside $1.2 million for new public chargers. Thanks to this important investment - the result of a penalty settlement paid by Volkswagen to the federal government - Alaska now has a total of 51 public charging stations and is planning to develop an EV charging network in the next two to three years.

[10] Alliance of Automobile Manufacturers (2019). Advanced Technology Vehicle Sales Dashboard. Data compiled by the Alliance of Automobile Manufacturers using information provided by HIS Markit (2011-2018) and Hedges & Co. (2019). Data last updated 20/08/2019. Retrieved in July 2020 from https://autoalliance.org/energy-environment/advanced-technology-vehicle-sales-dashboard/.
[11] U.S. Department of Transportation Office of Highway Policy Information (2018). State Motor-Vehicle Registrations – 2018.
[12] AP&T (2020). *"AMP-UP" Electric Vehicle Incentive Program*. https://www.aptalaska.com/amp-up/.
[13] PlugShare (July 2020).

1.2.3 Norway

With EVs representing 50% of all new vehicle sales in Norway, the country today leads the way globally in terms of EV ownership. The Norwegian EV success story is the result of strong EV adoption policies that have been in place for over a decade. During that period, as illustrated in Figure 5 below, PEV sales have increased so much that the Norwegian government has estimated that EVs will comprise 100% of new car sales by 2025. The Norwegian government has introduced a substantial package of incentives developed to promote zero-emission vehicles on the market, including: [14]

- Exemption from vehicle purchase/import taxes and the 25% VAT on new car sales and leasing.
- Maximum of 50% of the total amount of road tolls and ferry fares (free before 2018).
- Free or 50% reduced price for municipal parking.
- Access to bus lanes.
- 50% reduced company-car tax.
- Free charging stations in many places.

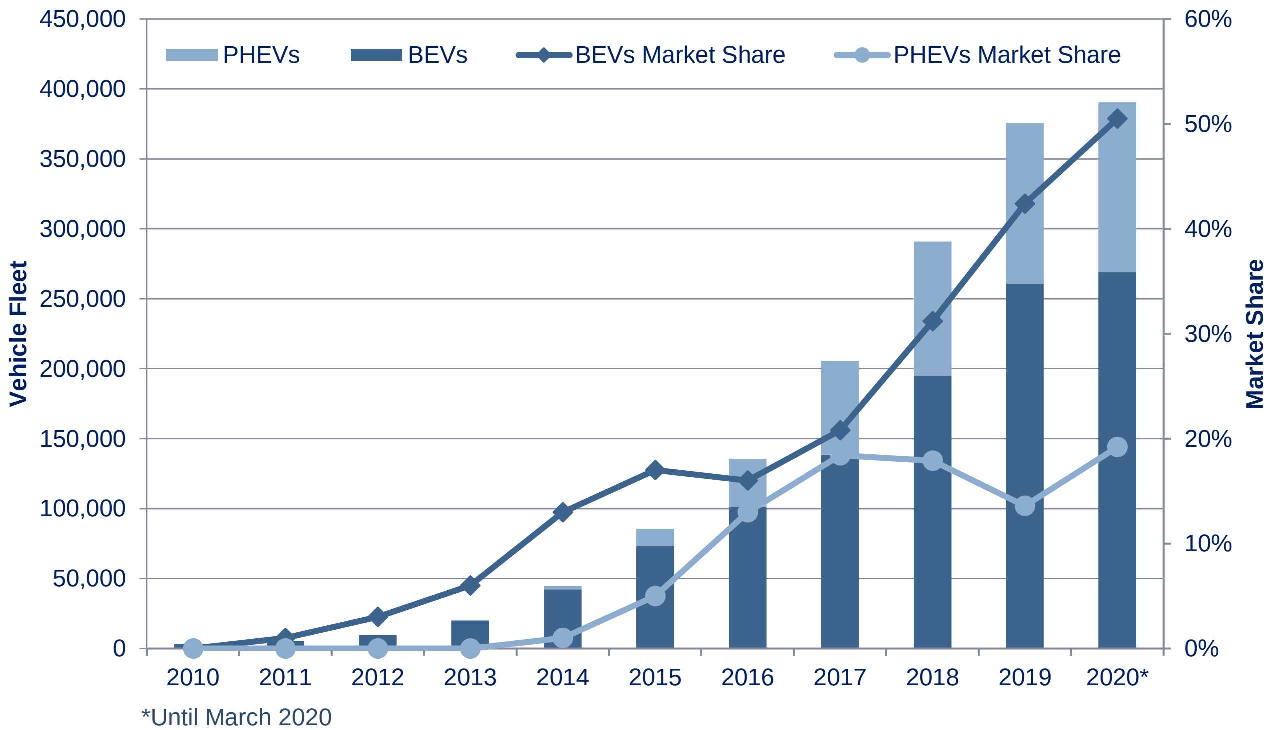


Figure 5: Total PEV Fleet and Market Share in Norway (through March 2020)[15]

[14] Norwegian Electric Vehicle Association (2020). *Norwegian EV Policy*. Retrieved in July 2020 from https://elbil.no/english/norwegian-ev-policy/.
[15] Norway Motor Vehicle Registration and Road Traffic Information Council (2020). Retrieved in July 2020 from the Norwegian Electric Vehicle Association website: https://elbil.no/elbilstatistikk/.

In addition to these policies, Norway has installed more than 13,600 publicly available charging stations, including 3,800 fast chargers.[16] The Government has a goal to cover main roads and highways with two multi-standard fast-charging stations every 50 km. The rapid expansion of this nationwide charging infrastructure has been possible in the past few years thanks to private investments from fast-charging operators without any governmental support, a sign that the market is beginning to operate on its own.[17]

Finnmark County

While the Norway success story is inspiring in many aspects, it is legitimate to question whether it can be replicated in a cold-weather environment like the NT. The low winter temperature in Oslo, the Norwegian capital, is about -10° C compared to -30° C in Yellowknife. As a result, the impact of cold temperatures on EV maximum ranges will be much greater in the NT than in most of Norway. The northernmost Norwegian county of Finnmark is an exception, where winter low temperatures often drop as low as -25° C. The evolution of the PEV market in that region can therefore be insightful for the NT.

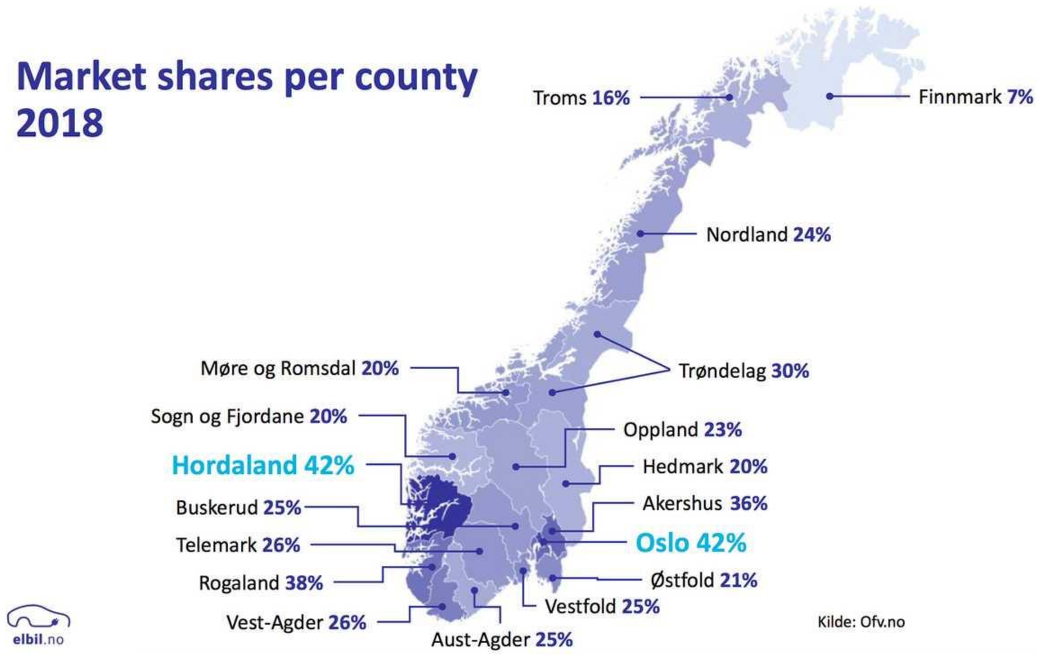


Figure 6: Norway EV Market Share per County (2018)

[16] Norwegian EV Association (2020). EV Statistics. Retrieved in July 2020 from https://elbil.no/elbilstatistikk/ladestasjoner/.
[17] Norwegian EV Association (2017). *Charging infrastructure experiences in Norway – the world's most advanced EV market.*

Of all Norwegian counties, Finnmark has historically been the county with the smallest EV market share in Norway. With the relatively low – but nonetheless significant compared to Canadian jurisdictions – market share of seven percent, the county has been trailing behind the rest of the country in terms of EV sales. The absence of a solid public fast-charging infrastructure has for a long time hindered the penetration of EVs in this Norwegian Arctic district. Emphasized by the impact of cold temperature on EV ranges, the lack of charging points has discouraged many potential EV buyers from making the investment. The situation has, however, evolved in the last two years following the announcement in May 2019 from Enova, Norway's public organization managing its green energy fund, to finance the costs for building the world's most advanced charging network with 17 high-power 150 kW chargers and eight fast chargers spread at key crossroads across the county. EV sales in Finnmark have increased rapidly since then, from seven percent in 2018 to 13% in the first quarter of 2020.[18] In addition to the Enova network of chargers, Tesla announced the development of eight new superchargers inside the Arctic Circle of Norway, Finland, and Sweden in 2020.

Finnmark provides an apt illustration that, with the proper incentives and infrastructure, the benefits of PEV ownership can outweigh the challenges even in cold climate environments. The example of Finnmark county suggests that the NT could experience a rapid increase of PEV market share through aggressive policy implementation and infrastructure development.

1.2.4 Conclusion

Although there has been little investment or activity to foster EV adoption in the NT to date, the market for EVs in the territory is similar to that of neighbouring territories and provinces. Moreover, the NT faces several challenges that the leading Canadian jurisdictions do not, such as extreme winter low temperature, low population density, preference for light trucks for which EV models are not currently available. Nevertheless, the example of Finnmark County suggests that these challenges can be overcome through investment and effective policies.

Table 1 below summarizes the different PEV uptake initiatives - past, ongoing, and announced initiatives – in the NT, Yukon, and Alaska. As outlined, the past and ongoing initiatives remain relatively sparse in all three jurisdictions although Yukon has laid the groundwork, according to its climate change strategy, to undertake some ambitious actions in the next years to encourage the adoption of PEVs and zero-emission vehicles.

[18] Norwegian EV Association (2020). EV Statistics. Retrieved in July 2020 from https://elbil.no/elbilstatistikk/elbilsalg/.

Table 1: Comparison of Past, Current, and Planned PEV Uptake Initiatives in NT and Neighbouring Jurisdictions[19]

Northwest Territories	Neighbouring Jurisdictions
› Arctic Energy Alliance EV Study › Rebate program for EVs and charging stations in hydro communities › Feasibility assessment and implementation of zero-emission vehicle transportation corridors in the NT	› EV public awareness and promotion campaign › Installation of fast-charging stations across Yukon › Investments in public charging stations › Ensure EV availability at local dealerships › Procure EVs for government fleets › Rebate program for EVs and charging stations › Ensure new home constructions are EV ready

** Past, ongoing, and future initiatives.*

1.3 EV Uptake Initiatives from Leading Jurisdictions

This subsection highlights the most successful initiatives implemented by leading jurisdictions in Canada and around the world to increase PEV adoption rates. The matrix of actions presented in Figure 7 below is derived and adapted from the matrix developed by the Government of Ontario in consultation with various stakeholders for the Electric and Hydrogen Vehicle Advancement Partnership (EHVAP).[20] This suite of actions may serve as a basis for the NT to support the deployment of PEVs in the territory.

Each of the four categories of initiatives is described below, using examples from across Canada, the U.S., and Europe.

CHARGING INFRASTRUCTURE	EDUCATION & MARKETING	CONSUMER SUPPORT PROGRAMS	DEALERSHIP & AUTOMAKER PROGRAMS
• Public charging stations support program • Fast-charging network deployment along highway corridors • EV charging requirements in parking lots • EV-ready homes and workplaces • Charging at government locations	• PEV showcase facility • Education/awareness campaign for businesses and the public	• PEV purchase rebate program • Charging station rebate program • Tax exemption/rebate • Reduced license fees on PEVs • Free overnight charging • Free toll lane and bus lane access for PEVs	• ZEV Program • Dealer incentives • Network of ZEV certified dealerships

Figure 7: Matrix of PEV Uptake Actions from Leading Jurisdictions

[19] Neighbouring jurisdictions include Yukon and Alaska. Initiatives put in place in Norway are covered in Subsection 1.3.
[20] Pollution Probe and The Delphi Group (2018). *Accelerating the Deployment of Zero Emission Vehicles: Atlantic Canada and the Prairies.*

1.3.1 Charging Infrastructure

Given the lower driving range of battery powered EVs (BEVs) compared to internal combustion engine vehicles (ICEV), many drivers may not feel comfortable driving long distances without recharge capability. The availability of charging stations provides drivers greater ranges as well as reduced range anxiety, which is often considered the prime barrier to EV adoption. To address this barrier, jurisdictions across North America have taken a variety of actions to encourage the development of charging infrastructure. While some local governments and utilities have taken matters into their own hands to install public chargers (see *Electric Circuit* case study below), others have developed regulations to include requirements for PEV charging in new residential and commercial developments. The City of Vancouver, for instance, requires that one EV-ready stall be installed in single-family homes with garages, 10% of stalls be EV-ready in commercial buildings, and 100% of stalls be EV-ready in multi-unit residential buildings.[21]

Electric Circuit

Hydro-Québec's *Electric Circuit* is a network of public charging stations developed by Quebec's public utility since 2012. Initially based on a public-private partnership model, Hydro-Québec coordinated the deployment and promotion of 240 volt stations in the network, and partners assumed some the purchase and installation costs. Based on this business model, Hydro-Québec provided 50% of the purchase and installation costs of a station and the remainder of the cost was assumed by the relevant partner. Revenue was shared proportionately based on the investment of each party. The business model was revised in 2018, with the utility now paying the full cost of the charging station based on additional revenue from the sale of electricity to PEV customers. The *Electric Circuit*'s mandate has been expanded to include the installation of 400 volt fast chargers. The initiative is now aimed at having at least 1,600 fast-charging stations in service by the end of 2027. In July 2020, the *Electric Circuit* network included more than 2,500 charging stations across Quebec, New Brunswick, and Ontario, including 300 fast-charging stations.[22]

[21] City of Vancouver (2018). *Building Code Bylaw 10908.*
[22] Circuit Électrique (2020). Data retrieved in July 2020 from: https://lecircuitelectrique.com/en/find-a-station/.

1.3.2 Education and Marketing

Education and marketing are critical steps to developing the EV market. PEV consumers in most jurisdictions fall into the early adopter group. For PEVs to move from this early adopter market into the mainstream, a widespread shift in social and technical understanding needs to occur. Many jurisdictions have implemented public awareness and education programs to demystify PEVs and address fundamental misconceptions preventing consumers from considering the purchase of a PEV. The collaborative public outreach campaign *Emotive – the Electric Vehicle Experience* is an example of such a public awareness initiative from British Columbia. The campaign was founded in 2013 by Metro Vancouver, the cities of Surrey and Vancouver, Fraser Basin Council and the Province of British Columbia to raise awareness about zero-emission vehicles (ZEVs) through their tactile and emotional appeal as fun and exciting to drive.[23] A 2014 survey by the World Wildlife Fund found that British Columbians exhibited the highest public awareness about ZEVs in Canada, and the province had the highest number of people who drive a ZEV.[24]

Plug'n Drive EV Discovery Center

Located in Toronto, the EV Discovery Centre is the first facility of its kind in the world focused entirely on providing an experiential learning environment for EVs. As described on its website, its purpose is to:[25]

- Help drivers better understand the environmental and economic benefits of electric transportation.
- Provide a one-stop-destination to test drive a wide variety of the latest EV models from leading manufacturers.
- Provide unbiased and factual information about EV in a sales-free, no-pressure environment.
- Help drivers make the transition from a gasoline/diesel car to an electric car that suits their lifestyle.
- Increase customer confidence in home and public charging by answering questions and exposing consumers to home charging solutions and public charging maps/apps.
- Offer a unique venue for professional and private events.

The EV Discovery Center is the result of a public-private partnership between Plug'n Drive, the Government of Ontario, TD Bank, Ontario Power Generation, Power Workers' Union, Toronto Hydro, Bruce Power, and the auto and charging station sectors.

[23] Charlotte Argue and Eve Hou (2016). *Emotive – Promoting the Electric Vehicle Experience*.
[24] World Wildlife Fund (2014). *Transportation rEVolution: Electric Vehicle Status Update 2014.*
[25] Plug'n Drive (2020). Retrieved in July 2020 from: https://www.plugndrive.ca/electric-vehicle-discovery-centre/.

1.3.3 Consumer Support Programs

Among the most well-known PEV uptake initiatives, consumer support programs and financial incentives represent the most effective ways to influence the sales of PEVs according to an American study.[26] This is no surprise when it is known that the main barrier to the development of the PEV market is the high upfront cost of these vehicles compared to ICEVs. By helping to lower their purchase costs and providing additional usage benefits such as free access to high-occupancy vehicle (HOV) lanes, free parking, and free charging, governments are encouraging consumers to see the several advantages of PEV ownership over ICEV ownership.

The effectiveness of PEV subsidies for the development of this early market can be illustrated by the high penetration of PEVs in jurisdictions offering incentive programs and the instant decrease in EV sales when jurisdictions cancel an existing rebate program. This was the case for Ontario when it saw EV sales plummet following the cancellation of the provincial EV rebate program in September 2018.[27] The same downward trend in EV sales has been observed in Denmark and the Netherlands after the cancellation of tax exemptions on PEVs. These examples demonstrate the importance of financial incentives to support PEV purchases in markets that have not yet reached maturity.

Clean Energy Vehicles for British Columbia (CEVforBC) Program

Introduced in 2011 by the Government of British Columbia, the CEVforBC program is Canada's oldest ZEV rebate program. The program offers point-of-sale incentives on applicable BEVs, hydrogen fuel cell vehicles (HFCVs), investments in charging and hydrogen fuelling infrastructure, as well as additional support for fleets to adopt ZEVs and investments in research, training, and outreach. Managed by the New Car Dealers Association of BC, the program offers up to $3,000 off the purchase price of qualifying new BEVs, up to $1,500 for PHEVs, and up to $3,000 for HFCVs. Over the course of the program, CEVforBC has supported the addition of more than 5,000 ZEVs in BC.

[26] Center for American Progress (2018). *Plug-In Electric Vehicles – Evaluating the Effectiveness of State Policies for Increasing Deployment*.
[27] Electric Mobility Canada (2020). *Electric Vehicle Sales in Canada – Q1 2019.*

1.3.4 Dealership and Automaker Programs

PEV availability is a barrier to widespread adoption in many jurisdictions, including the NT. When deciding on large purchases such as a vehicle, people tend to be pragmatic about conducting their research prior to making a decision.[28] This can take the form of consulting online reviews, having discussions with car dealers, and importantly test driving the vehicle of interest. Currently in NT and in many other jurisdictions, it is difficult for would-be PEV purchasers to discuss the pros and cons of a PEV with sales representatives at dealerships, and there are often no PEV models available to be test-driven. Dealership and automaker programs address this barrier by increasing the availability of PEVs. One of the most effective PEV supply-side policies is the adoption of a regulation referred to as a ZEV mandate, which requires automakers to improve their ZEV offer by earning credits for their sales. About a dozen states in the United States have adopted the ZEV mandate. In Canada, Quebec has adopted the Quebec ZEV Act (see here below). According to a study, manufacturers are targeting these markets and are, as a result, making more PEVs more readily available in those regions.[29]

Quebec ZEV Act

Following the example of California and other U.S. states, Quebec introduced its own version of the ZEV mandate in 2016. Under Quebec's ZEV Act, automakers are required to accumulate credits by providing ZEVs or LEVs to the Quebec market. The credit target is calculated by applying a percentage to the total number of light-duty vehicles (LDVs) each automaker sells in Quebec. The credit requirement varies from one automaker to the next depending on their total sales. Each sale or lease of an eligible ZEV earns credits, the number of which varies according to the vehicle's electric range. The greater the range, the greater the number of credits that the automaker earns. With the gradual increase of the credit target each year (see Figure 8), the ZEV standard is intended to spur the automobile market to develop and market greater numbers of models that rely on increasingly efficient low-carbon technologies.[30]

[28] Pollution Probe and The Delphi Group (2018). *Accelerating the Deployment of Zero Emission Vehicles: Atlantic Canada and the Prairies.*
[29] The International Council on Clean Transportation (2015). *Assessment of Leading Electric Vehicle Promotion Activities in United States Cities.*
[30] Ministère de l'Environnement et de la Lutte Contre les Changements Climatiques (2020). *The zero-emission vehicle (ZEV) standard.* Information retrieved in July 2020 from: http://www.environnement.gouv.qc.ca/changementsclimatiques/vze/index-en.htm.

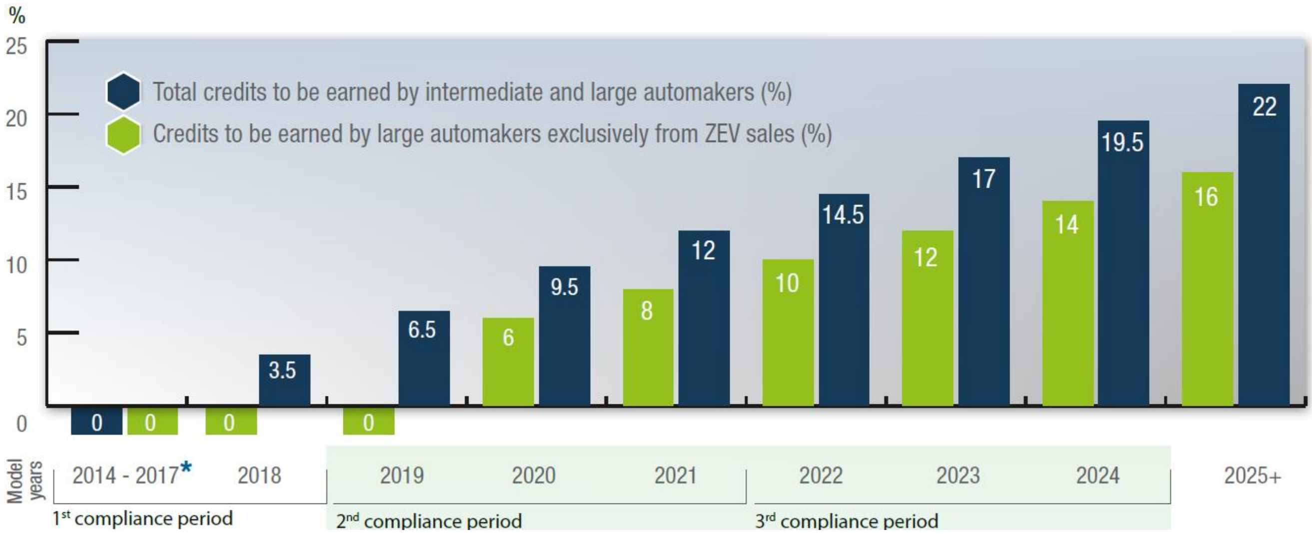


Figure 8: Quebec ZEV Act Compliance Requirements[31]

[31] Ministère de l'Environnement et de la Lutte Contre les Changements Climatiques (2020). *The zero-emission vehicle (ZEV) standard explanatory leaflet.*

2 EV ADOPTION FORECAST

This section presents a forecast of annual EV sales and total adoption rates in the NT for the 2021-2030 period for three incentive scenarios and a no incentive scenario. As illustrated in Figure 1 above, EV adoption in the NT to date has been low, a similar situation to other Canadian provinces and territories outside of Quebec, Ontario, and BC.

2.1 Methodology

To prepare a robust forecast of EV adoption rates in the NT, the study team reviewed actual and modeled EV adoption figures from a range of regions that have key factors in common with the NT. The team selected a model based on its methodological robustness and similarity to conditions in the NT. Next, the team applied a set of influence factors to account for important variations between the model region and the NT. The four influence factors in this analysis were applied as positive or negative coefficients to the model region forecast, based on the relative influence of each factor in the NT compared to the model region. In addition to the influence factors, the team considered four incentive scenarios: No Incentive, Conservative Incentive (based on current conditions), Significant Incentive, and Aggressive Incentive. Finally, the team compared the resulting EV forecast to available information from neighbouring territories. These steps are presented in more detail below.

2.2 Model Region

The Econoler team reviewed EV adoption models and forecasts from a broad range of jurisdictions, including Alberta, British Columbia (BC), Ontario, Quebec, Nova Scotia, and Norway, as well as EV market assessment data from Yukon and Alaska. From these models, the team selected the BC EV adoption model based on its analytical rigour, methodological transparency, and applicability to the NT context.

Table 2 presents a comparison of the context for EV adoption in BC and the NT.

Table 2: Comparison of the EV Adoption Context in BC and the NT

Influence Factor	BC Context	NT Context	Relative Value
Outdoor temperature	Average January low temperature in Vancouver is 2.7° C, in Kamloops it is -5.9° C.	Average January low temperature in Yellowknife is -29.5° C.	Significant difference. Influence factor.
Average trip distance	Large territory and long distance between significant inhabited agglomerations (outside the Vancouver metro area).	Large territory and long distance between significant inhabited agglomerations. No metropolitan area.	Similar
Trip cost	Gasoline vehicle trip is 4.3 times more costly than EV trip.	Gasoline vehicle trip is 1.9 times more costly than EV trip.	Significant difference. Influence factor.
Vehicle purchasing preferences	1) Sport utility vehicles 2) Passenger cars 3) Light trucks	1) Sport utility vehicles 2) Light trucks 3) Passenger cars	Similar.
Charging infrastructure deployment	Charging network has been in development since 2012 and includes more than 1,000 public chargers. BC Hydro operates 70 public fast-charging stations on BC highways.	NT charging infrastructure will be deployed along selected corridor (Highways 1 and 3) between 2021 and 2030.	Significant difference. Influence factor
Average salary and the cost of living	Avg. weekly salary: $1,126 Consumer Price Index: 132.6.	Avg. weekly salary: $1,590 Consumer Price Index: 139.1.	Similar. Salaries and cost of living are slightly higher in the NT.
Availability of EVs, trained mechanics	Sales volume in metro Vancouver enables widespread access to vehicles, parts, and trained mechanics.	EVs available from one NT dealership in 2020, anticipated two or more in 2021. Availability of trained mechanics unknown.	Significant difference in availability of EV models and trained mechanics. Influence factor.

One significant difference between the BC and NT contexts is overall population, and urban area population in particular. The NT does not have a metropolitan area that approaches Vancouver's scale. Likely consequences of this difference include:

- Higher availability of EVs and trained mechanics in the Vancouver metro area;
- Increased exposure to EVs;
- Shorter trip distances in the metro area.

The study team considered other potential influence factors, such as frequency of long-distance trips, awareness about the benefits of EVs, and incremental vehicle cost, and determined these to be similar between the model region and the NT situation.

2.3 Influence Factors

There are clear differences between BC and the NT that are likely to impact the pace of EV adoption in each region. The study team identified four factors with the greatest likelihood to impact the rate of EV adoption in the NT relative to the BC adoption model. These four factors are: extreme cold temperatures, trip cost (the relative cost of operating an EV compared to a gasoline vehicle), EV charging infrastructure deployment, and availability of EV parts and trained service professionals.

The team determined the direction (positive or negative) and the magnitude of each influence factor on forecasted EV adoption in the NT, based on a comparison of that factor in the BC and NT contexts. Taking cold winter temperatures as an example, the NT experiences extreme cold temperatures relative to generally milder winter temperatures in BC. Cold temperatures reduce the maximum range of EVs and may contribute to range anxiety, so the team assigned this factor a negative influence on EV adoption in the NT, with a coefficient of -0.5.

Table 3 presents the set of influence factors with the direction and magnitude of their influence on the EV adoption forecast model for the NT.

Table 3: EV Adoption Influence Factors

Influence Factor	Direction of Influence	Coefficient
Extreme weather temperature	Negative	-0.50
Charging infrastructure deployment	Negative Coefficient will be applied only for three years (2021-2023), until the NT charging infrastructure is fully deployed along highway corridor	-0.50
Availability of EVs, parts, and trained and mechanics	Negative	-0.25
Trip cost[32]	Negative	-0.20

The selected influence factors all reflect a relatively more challenging context for EV adoption in the NT than in the BC model region. Extreme cold weather and the temporary disparity in charging infrastructure deployment were assigned the largest coefficients, reflecting their significant impacts on EV operation and visibility. The availability of EVs, replacement parts, and trained mechanics is another factor that is likely to hamper EV adoption in the NT relative to BC, although this may be addressed through programs or policies targeting automobile dealerships and mechanics (See Section 5 for details). Trip cost – the cost ratio of operating an electric vehicle compared to a gasoline vehicle based on a dollars per km metric – is also assumed to have a negative influence on EV adoption in the NT relative to the BC model, although its magnitude is lower than the other three factors. This is because, although EVs in the NT are less expensive to operate on a $/km basis than gasoline vehicles, EVs have a substantially less cost advantage than EVs in BC.

[32] Trip cost refers to the cost ratio of operating an electric vehicle compared to a gasoline vehicle based on a dollars-per-km metric.

2.4 EV Purchase Incentives

To determine the expected effects that different incentive levels can have on EV adoption rates, the study team reviewed the experience of other Canadian and U.S. jurisdictions to identify cases where EV incentives had changed without major corresponding changes in other key factors such as EV availability, charging infrastructure, and promotional programs. Ontario's recent experience with EV sales before and after sunsetting its EV purchasing incentives in 2018 provides a valuable case study in the influence that purchase incentives have on EV sales. The team also examined the impact of the Transport Canada EV rebate program using pan-Canadian EV sales data from before and after the incentive was available to assess the impact of new EV incentives beyond the Ontario context.

These two case studies informed the assumptions used to model three incentive scenarios and one no incentive scenario on EV adoption in the NT, namely No Incentive, Conservative Incentive, Significant Incentive, and Aggressive Incentive.

Ontario Electric and Hydrogen Vehicle Incentive Program

Ontario launched its Electric and Hydrogen Vehicle Incentive Program in 2010. Under the program, participants received on average of $10,000 as an incentive toward the purchase of a new EV. More than 15,000 participants received incentives under the Ontario program between 2010 and 2018.

The Ontario incentive program was closed in July 2018. In the third quarter of 2018, Ontario saw a 55% drop in EV sales across the province. Between the end of the incentive program and the launch of the Transport Canada incentive program in May 2019, there were 50% fewer EV sales in Ontario compared to the same period one year prior.

Transport Canada Electric Vehicle Rebate Program

Transport Canada launched its pan-Canadian EV rebate program in May 2019, offering a $5,000 incentive toward the purchase of a new EV. EV sales rose across Canadian markets in the second quarter of 2019. However, the increased sales rate did not continue beyond the second quarter in all markets, suggesting that the lower incentive amount may have a lower or more temporary impact compared to the $10,000 incentive formerly available in Ontario. After the initial boost in the second quarter of 2019, EV sales increased only marginally in other Canadian markets with provincial incentive programs: BC ($3,000 per vehicle) and Quebec ($8,000 per vehicle).

Modeling Assumptions for the NT

Based on the Ontario and pan-Canada case studies and the relatively high cost of living in the NT, the study team assigned initial incentive scenario values as follows:

- Conservative Incentive: $5,000/vehicle;
- Significant Incentive: $10,000/vehicle;
- Aggressive Incentive: $15,000/vehicle.

The Arctic Energy Alliance (AEA) launched an EV incentive pilot program on June 15, 2020, offering $5,000 toward the purchase of a qualifying new EV or charging station. Considering that most NT light-duty vehicle owners are eligible under this program, the study team included the additional $5,000 incentive in its incentive scenario baseline, effectively increasing the value of each incentive level by $5,000 (see Table 4 for details). The team also included a No Provincial Incentive scenario to address the possibility that the Transport Canada and AEA incentive programs could be withdrawn.

Table 4 presents the three incentive scenarios along with the no incentive scenario, their value for EV purchasers, cost to the provincial government,[33] and their assumed impact on EV adoption rates.

Table 4: Incentive Scenarios

Scenario	Incentive Value for Purchasers	2020-2030 Incentive Program Cost	Influence on EV Adoption
No Incentive	$0	N/A[34]	No impact
Conservative Incentive (current situation since June 2020)	$10,000	N/A	30%
Significant Incentive	$15,000	$6,690,000	100%
Aggressive Incentive	$20,000	$26,580,000	300%

The influence of the Conservative Incentive scenario on EV adoption in the forecast is based on the change in EV sales in Ontario before and after the end of the provincial incentive program in 2019. The influence of the Conservative incentive scenario on EV purchases in the NT is less than in Ontario for two reasons: (1) the cost of living in the NT is substantially higher than in Ontario, so the relative value of the $10,000 incentive is less than in Ontario; (2) in 2019, Ontario had supporting policies and charging infrastructure in place, thus reducing non-price barriers to EV adoption and increasing the likely impact of purchase incentives.

Note that the forecast considers that the 23,600 light-duty vehicles (personal vehicles, commercial vehicles, and service vehicles) in the NT will remain the same until 2030.

2.5 NT EV Adoption Forecast

Based on the modeling assumptions and incentive scenarios described above, the EV adoption forecast for the NT indicates a wide range of outcomes in 2030, depending largely on the availability and amount of incentives for EV purchasers. For each incentive scenario, Table 5 below outlines the projected number of EVs that will be sold in the NT in 2030, the total number of EVs sold in the NT between 2013 and 2030, and the share of the NT light-duty vehicle (LDV) population comprised of EVs in 2030.

[33] Incentive program cost values include incentive costs only and do not include program administration costs.
[34] Existing programs for EV purchasers: Transport Canada Electric Vehicle Rebate Program ($5,000), and Arctic Energy Alliance rebates on electric vehicles and charging infrastructure program ($5,000).

Table 5: Summary of EV Sales by Incentive Scenario

Incentive Scenario	EV Sales as a Share of LDV Sales in 2030	Total EV Sales 2013-2030	EVs as a Share of NT LDV Population
No Incentive	10%	677	2.9%
Conservative	13%	875	3.7%
Significant	19%	1,337	5.7%
Aggressive	39%	2,658	11.3%

The forecast estimates that EV sales will represent between 10% and 39% of total LDV sales in the NT in 2030. Although this falls short of the pan-Canadian goal of EVs representing 30% of total LDV sales by 2030 under most incentive scenarios, it nonetheless exhibits dramatic progress over the 2021-2030 period.

Figure 9 illustrates in more detail the projected number of EVs sold in the NT from 2021-2030 for each incentive scenario described above.

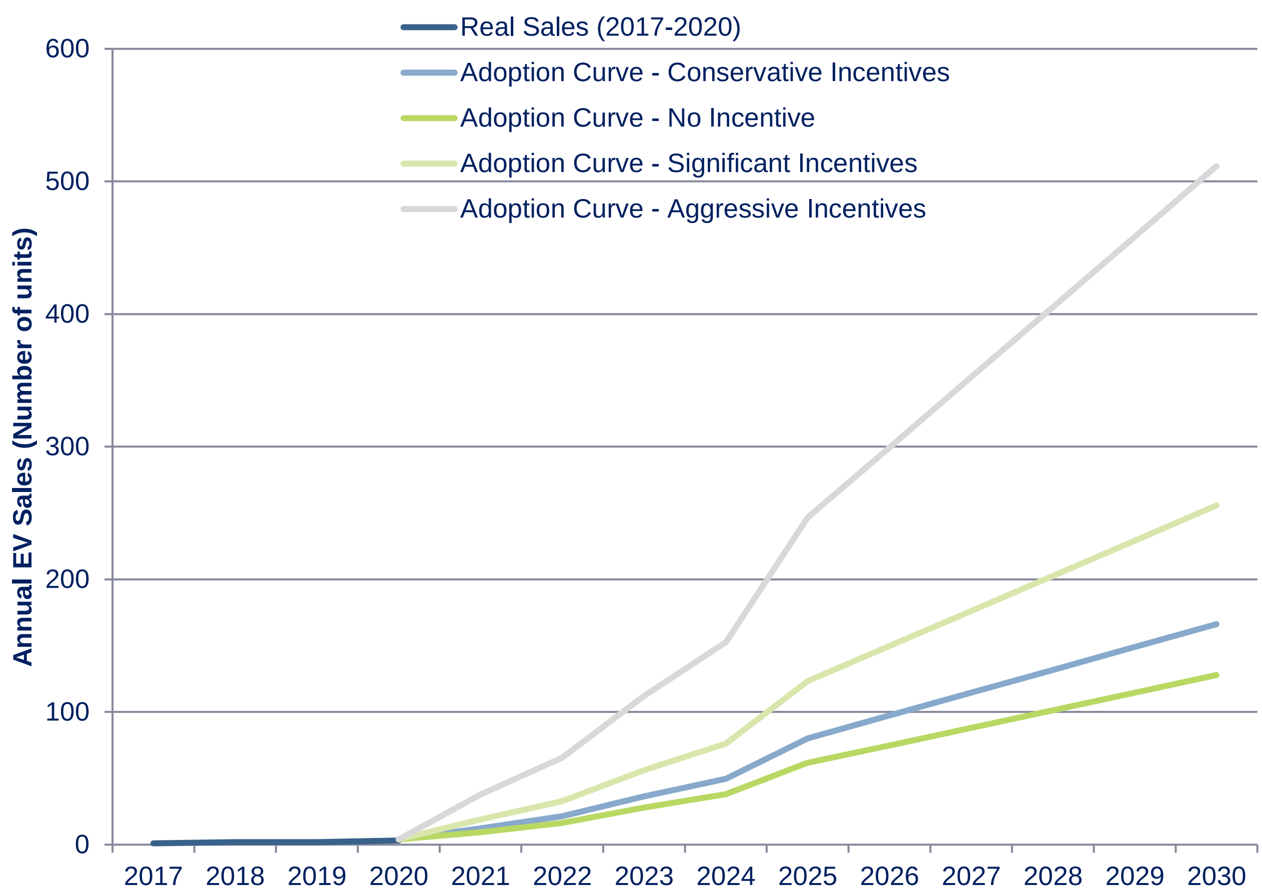


Figure 9: Annual Light-Duty Vehicle Sales Forecast by Incentive Scenario

Figure 9 reveals several inflection points at which EV sales are expected to increase or decrease relative to previous years:

- 2020 – EV sales increase based on new purchase incentives available from the AEA and the GNWT (under the Significant and Aggressive Incentive scenarios), and the initiation of Phase 1 of the new EV charging corridor.
- 2022 – EV sales increase due to the completion of the EV charging corridor, reducing range anxiety as a concern for potential EV purchasers.
- 2024 – EV sales increase, particularly in the higher incentive scenarios, due to the anticipated release of the first electric light truck models. NT residents demonstrate a strong purchasing preference for light trucks, and the model anticipates pent-up demand will result in a sharp increase in EV sales in 2024.
- 2025 – The rate of EV sales decreases as pent-up demand for new light truck models is exhausted. The overall rate of EV sales remains slightly higher than in years prior to 2024, accounting for the availability of light trucks in the market.

Figure 9 also indicates that the forecast is highly sensitive to the role of purchase incentives on EV adoption, particularly for incentive amounts beyond $10,000. This is based on two factors:

- Real and forecasted data on EV purchases from other Canadian jurisdictions indicate high sensitivity to the addition or removal of purchase incentives. These data are discussed in Section 1 and Subsection 2.4 above.
- The Conservative Incentive scenario reduces the incremental cost of a new EV, but most EV owners will nonetheless experience an overall financial loss compared to the purchase of a gasoline vehicle over the lifetime of their vehicle. The Significant Incentive scenario reduces the average simple payback of a new EV to approximately seven years, meaning that most EV owners will experience a financial benefit over the vehicle's lifetime. The Aggressive Incentive scenario enables EV owners to begin accruing financial benefits immediately upon purchasing an EV. For more detail on the impacts of purchase incentives on EV simple payback periods, see Subsection 4.1 below. The latter two incentive scenarios serve to financially justify EV ownership, which is not the case under the Conservative Incentive scenario, leading to a meaningful increase in EV sales over time.

Figure 10 below presents the increasing share of total LDV population in the NT comprised of EVs between 2017 and 2030.

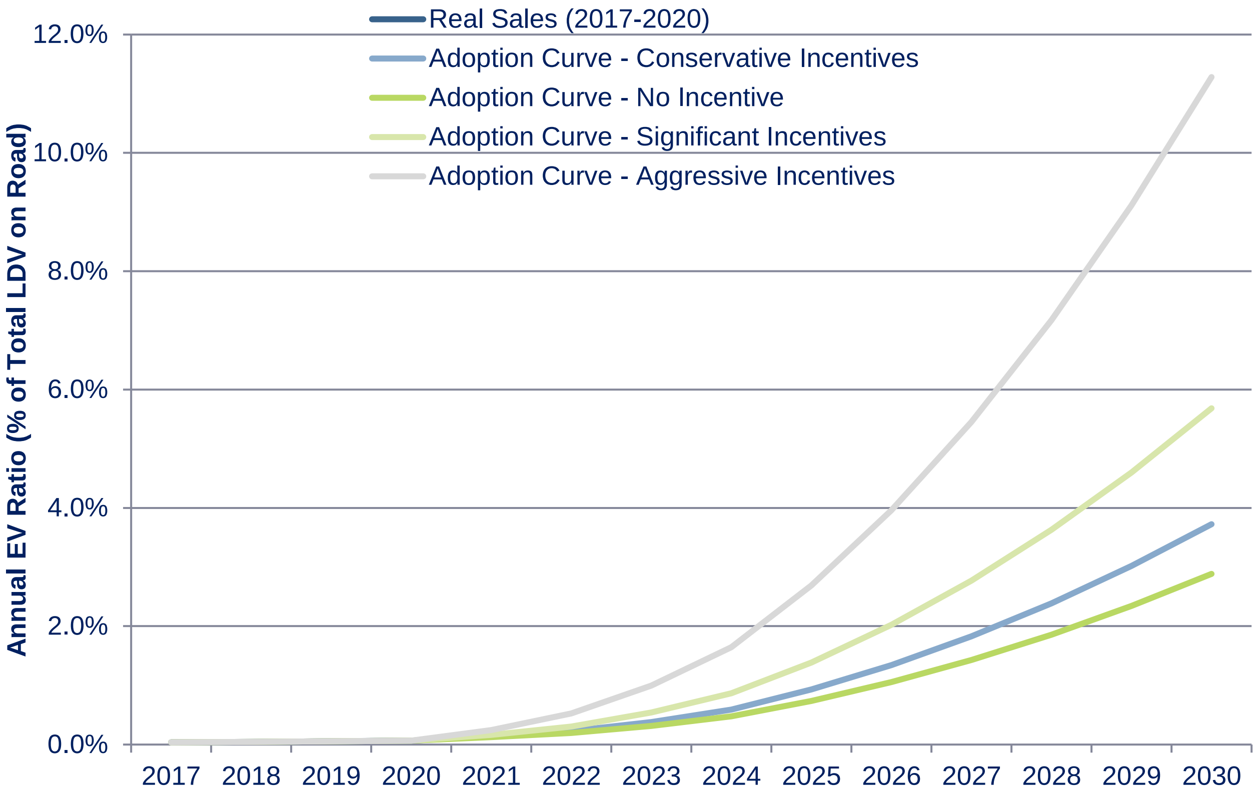


Figure 10: EVs as a Share of NT Total LDV Population

Figure 10 indicates that, although EVs are likely to represent a small percentage of the overall LDV population in the NT in all but the Aggressive Incentive scenario, EVs will rise steadily as a share of the overall population by 2030 under the Conservative Incentive scenario and will do so substantially earlier under the Significant and Aggressive Incentive scenarios.

The 2040 forecast is presented in Table 6. Considering this forecast represents a 20-year period, it should be mentioned that many external parameters could affect the precision of the sales values. Nonetheless, we consider it is possible to meet Canada's goal that 100% of all new light-duty vehicles be zero-emission (hybrid, electric, or hydrogen) vehicles by 2040.

Table 6: EV Sales Forecast for 2040

Incentive Scenario	EV Sales as a Share of LDV Sales in 2040	Total EV Sales 2013-2040	EVs as a Share of NT LDV Population
No Incentive	20%	2,688	11%
Conservative	26%	3,489	15%
Significant	39%	5,360	23%
Aggressive	79%	10,703	45%

3 ANALYSIS OF CHARGING NETWORK REQUIREMENTS

A reliable and convenient network of direct current fast-charging (DCFC) stations along the main travel corridors is essential to enabling the adoption of BEVs in the NT. Long distances between communities and from southern markets mean that goods and people must travel much farther than in most southern jurisdictions. Long-distance travel is known to be a critical barrier to PEV adoption, and especially BEV adoption, and this is exacerbated by drivers' range anxiety. Range anxiety poses a particular challenge in the NT where extreme cold weather can reduce EV ranges by as much as 50%. The most effective means of addressing this issue and serving EV owners is to provide easy access to EV charging. The proposed EV charging corridor along Highways 1 and 3, extending from Yellowknife to the Alberta border, includes the most important and busiest roads of the NT, thereby connecting the capital and largest city in the NT to Alberta and communities located on the south shore of Great Slave Lake.

This section presents a simplified transportation network analysis to determine the requirements for a new DCFC charging network along the Highway 1 and 3 corridor. This analysis addresses: (1) the spacing and number of DCFC stations necessary to provide charging coverage across the corridor; and (2) the number of chargers to match the forecasted demand and minimize queuing during periods of high traffic. The challenges pertaining to the deployment of this fast-charging network are also addressed in Section 0, while an assessment of the grid impacts in terms of power consumption and peak load is outlined in Subsection 3.5.

This analysis is focused on light-duty vehicles, including passenger vehicles, vans and SUVs, and light trucks. The analysis does not address heavy trucks, as few models are currently available and sales of these vehicles is low throughout North America. A recent report from the research firm Wood Mackenzie estimated the number of electric trucks currently operating in North America to be fewer than 2,000.[35] The report indicates that US sales are expected to rise beginning in 2025, when new legislation in California will require that 10% of heavy truck sales be electric trucks. This segment is important to consider for the long-term, however vehicle maximum ranges and charging requirements are not as yet sufficiently standardized to enable near-term planning for widespread operation of electric trucks.

3.1 DCFC Highway Corridor Coverage Calculations

3.1.1 Station Spacing

An important consideration for planning an effective DCFC network is the spacing between consecutive DCFC stations.[36] Range estimates for most BEV models on the market under typical driving conditions are available through both Natural Resources Canada (NRCan Fuel consumption ratings search tool)[37]

[35] Wood Mackenzie, August 2020: https://www.woodmac.com/press-releases/us-electric-truck-sales-set-to-increase-exponentially-by-2025/.
[36] The analysis focuses on BEVs rather than PEVs since it is expected that PHEVs will not use DCFC stations during long-distance trips but will rather prefer the faster refueling option of conventional gas stations.
[37] NRCan (2020). *Fuel consumption ratings search tool.* Last accessed August 2020. https://fcr-ccc.nrcan-rncan.gc.ca/en.

and other online resources.[38] Based on these resources, the average maximum range for a new BEV today is estimated at about 300 km. While this range is valid under normal conditions, the effective range of a vehicle varies based on ambient and road conditions as well as driving style. Moreover, battery capacity tends to slowly degrade over time, negatively affecting the real driving range of BEVs. In addition to these technical considerations impacting the effective range of BEVs, consumer travel logistics and convenience play significant roles in how far a BEV driver is willing to drive on a single charge. Drivers typically prefer to stop at a charging station to recharge before their batteries are fully depleted, resulting in an arrival allowance. Charging rates at DCFC stations decrease between 80-90% of battery capacity due to limitations imposed by battery manufacturers to protect and prolong battery life. Drivers are therefore likely to depart from DCFC stations prior to fully charging their vehicles to save time, resulting in an early departure penalty. To capture these behavioural effects, the study team assumed that a typical BEV will have an arrival allowance of 20 km and that drivers will depart from the DCFC station with an 80% charge.[39]

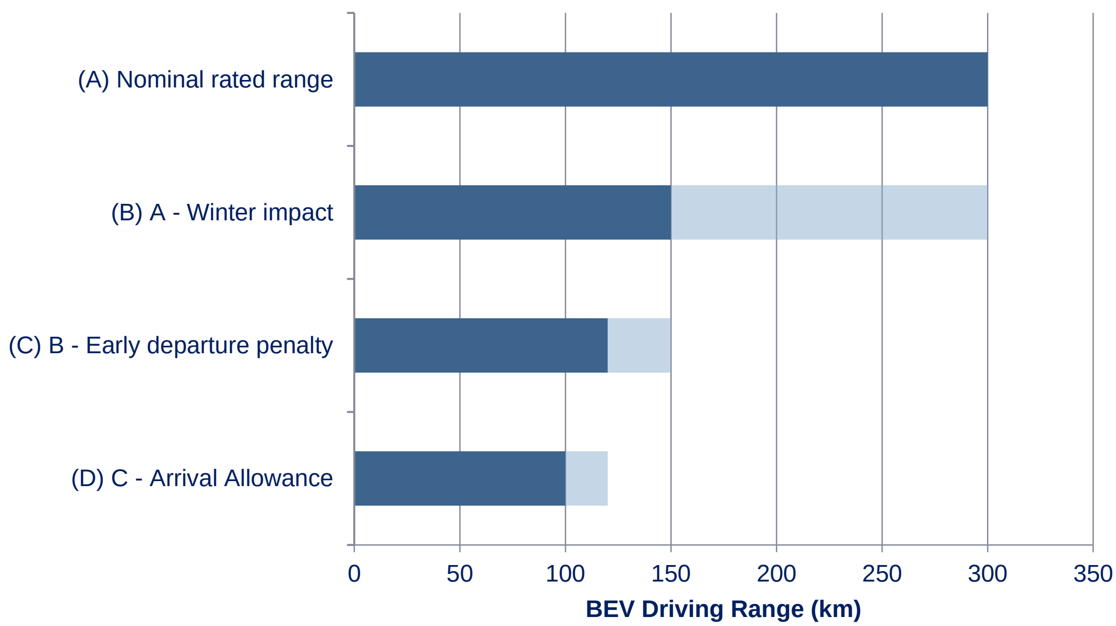


Figure 11: Impact of Environmental and Behavioural Constraints on Effective BEV Range

Given these behavioural considerations and the assumed adverse impact of cold temperatures on driving ranges (50% reduction in range due to use of cabin climate controls and reduced battery performance), the study team estimated that a typical 300 km range-rated BEV will have an effective winter driving range of 100 km, as depicted in Figure 11 above. A reliable and convenient charging

[38] Electric Vehicle Database (2020). *Range of full electric vehicles*. Last accessed August 2020. https://ev-database.org/cheatsheet/range-electric-car.

[39] The methodology used here is based and adapted from a study conducted by the U.S. Department of Energy (September 2017). *National Plug-in Electric Vehicle Infrastructure Analysis.*

network must therefore minimally provide access to charging at 100 km intervals. This spacing is similar to most fast-charging networks in North America. According to a nearest-neighbour analysis performed on the Tesla Supercharger station locations publicly available in the U.S. and Canada,[40] the average Tesla station spacing is about 108 km. This spacing is also similar to Electrify America's average station spacing of 70 miles (113 km) for its DCFC corridor network.

While the proposed station spacing is based on an average BEV nominal driving range of 300 km, most electric models that enter the market in the next ten years are likely to have improved ranges, such that the average nominal range for new models will likely be in the order of 400 km to 500 km by 2030. There are currently a handful of models on the market with extended ranges above 400 km (Tesla 2020 long-range models, 2020 Chevrolet Bolt EV, and 2020 Hyundai Kona Electric). These models, however, tend to be more expensive and are not representative of the current EV fleet. Moreover, current BEV models are expected to still be on the road for the next five to ten years, meaning that many EVs will still have maximum ranges between 200 km and 300 km in 2030.

3.1.2 Charging Station Geography

The proposed charging station locations for the new EV charging corridor along Highways 1, 3 and 5 are presented in Figure 12.

[40] U.S. Department of Energy (September 2017). National Plug-in Electric Vehicle Infrastructure Analysis.

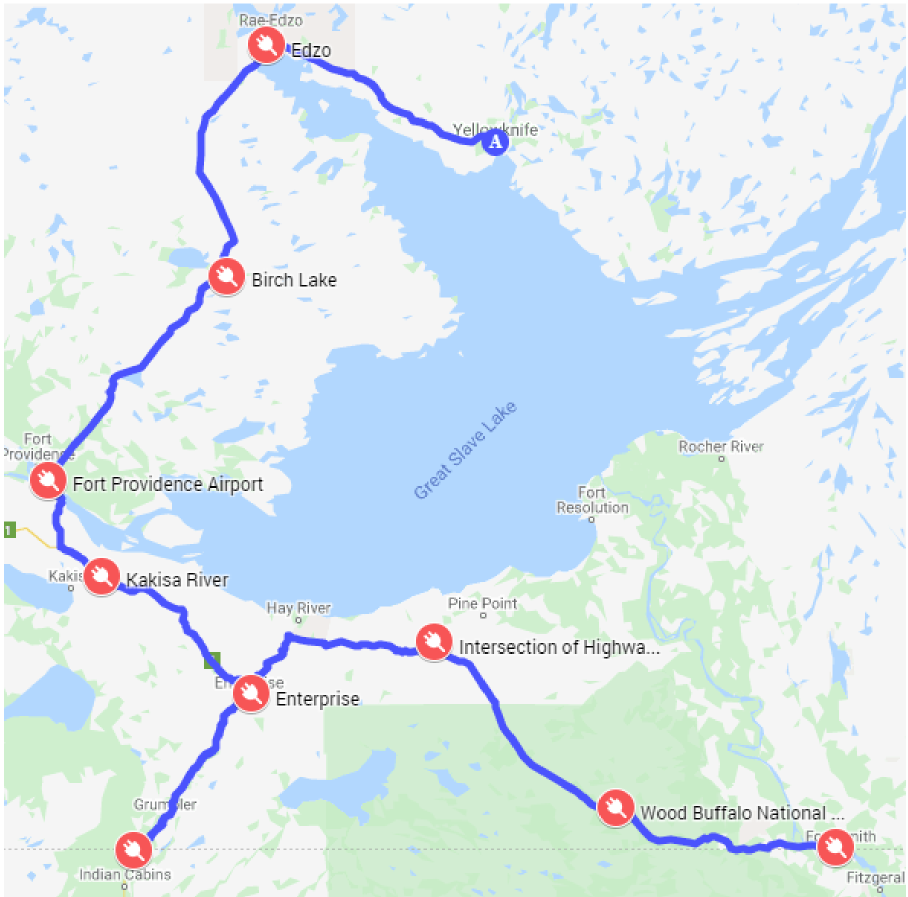


Figure 12: DCFC Station Proposed Locations

The analysis presents two options for the southern section of the corridor, between Enterprise and the Alberta border. One option follows Highway 1 Southwest to 60th Parallel Territorial Park. The other follows Highways 2 and 5 Southeast to Wood Buffalo National Park and Fort Smith.

As noted above, the average spacing between the stations is approximately 100 km, except for the station located next to the Kakisa River crossing. This station is located 57 km away from the proposed station at Fort Providence Airport and 77 km from Enterprise. Given that the distance separating Fort Providence and Enterprise is about 134 km, the charging station in Kakisa represents a reasonable midway point. The distance and driving time between each proposed charging station are indicated in Table 7 below.

Table 7: Highway Segments Covered by DCFC Stations

Highway Segment	Distance (km)	Driving Time[41]
Yellowknife - Behchokǫ̀	101	1 hr 31 min

[41] Driving Time refers to time spent in transit between the stations and does not include charging time.

Highway Segment	Distance (km)	Driving Time[41]
Behchokǫ̀ - Birch Lake	100	1 hr 28 min
Birch Lake - Fort Providence Airport	108	2 hr 6 min
Fort Providence Airport - Kakisa River	57	38 min
Kakisa River - Enterprise	77	48 min
Enterprise - 60th Parallel Park	85	1 hr
Enterprise - Intersection of Highways 5 & 6	94	1 hr
Intersection of Highways 5 & 6 - Wood Buffalo National Park	100	2 hr 12 min
Wood Buffalo National Park - Fort Smith	103	1 hr 37 min

The nearest EV charging station to the NT on the Alberta side of the border is located in High Level, at the intersection of Highways 35 and 58. This is 191 km – approximately 2 hours driving time – from the proposed charging station location at 60th Parallel Provincial Park.

This analysis does not propose adding a new DCFC station in Yellowknife since it can be assumed that the city represents either the origin or destination of most long-distance trips along Highways 1 and 3. The study team assumed that most EVs traveling to or from Yellowknife would charge either at home or at other available community charging locations. Approximately 90% of charging in urban centers takes place at home and non-residential Level 2 community chargers are out of the scope of this study; hence, the number of required Level 2 chargers was not assessed.

3.2 DCFC Highway Corridor Demand Calculations

The number and location of DCFC stations required to cover the proposed EV charging corridor are presented in the previous subsection based on a station spacing of 100 km. The utilization of these stations, however, will depend on their location and traffic flow in their vicinity, as well as on the EV adoption rate. The analysis in this subsection estimates the number of chargers required at each station to respond to the anticipated charging demand.

3.2.1 DCFC Power Level and Charge Rate

DCFC stations provide power and charge rates significantly higher than their Level 2 counterparts. Thanks to their minimum charge rate of 50 kW (versus 7 kW for Level 2 chargers), the charging time is reduced from five hours to about 30 minutes on average, making this type of charger the best suited for long-distance journeys. In recent years, DCFC technologies have undergone major transformations, leading to new types of chargers capable of providing charge rates ranging from 75 kW to 400 kW. These very high-power chargers, instantiating a concept referred to as high-power charging (HPC), can cut charging time to as little as 10 or 20 minutes. Most DCFC stations installed today are rated at 50 kW except for Tesla Superchargers that provide up to 120 kW of power.

HPC stations allow for a lower number of chargers to be installed per station thanks to a faster turnover of EVs. Compared to 50 kW chargers, HPC chargers are significantly higher cost and often require upgrades to the local distribution network to accommodate the higher power demand. For these reasons, this study only considers DCFC technologies with a nominal power level of 50 kW.

3.2.2 Traffic Volume

The NT Department of Infrastructure collects traffic data at a number of permanent and seasonal counting stations located along most of the highway network and winter roads. These stations provide hourly information on traffic for the complete year, or selected portions of the year for counters located on winter roads or other seasonal access roads.[42] Data are reported annually in the Northwest Territories Highway Traffic Report in the form of average annual daily traffic (AADT)[43] estimates and peak summer average daily traffic (PSADT),[44] as outlined in Table 8, for the highway segments previously identified.

Table 8: AADT and PSADT of Main Segments of Highways 1, 3 and 5

Highway Segment	AADT				PSADT			
	2016	2017	2018	Average	2016	2017	2018	Average
Yellowknife - Behchokǫ̀	680	690	860	**743**	780	790	1190	**920**
Behchokǫ̀ - Birch Lake	370	380	260	**337**	510	520	520	**517**
Birch Lake - Fort Providence Airport	370	380	260	**337**	510	520	520	**517**
Fort Providence Airport - Kakisa River	530	540	540	**537**	730	740	750	**740**
Kakisa River - Enterprise	530	540	540	**537**	730	740	750	**740**
Enterprise - 60th Parallel Park	460	470	470	**467**	620	640	630	**630**
Enterprise - Intersection of Highways 5 & 6	250	260	260	**257**	190	350	340	**293**
Intersection of Highways 5 & 6 - Wood Buffalo National Park	130	90	90	**103**	90	90	90	**90**
Wood Buffalo National Park - Fort Smith	120	180	170	**157**	150	240	240	**210**

The average daily traffic flow values presented in Table 8 represent the total traffic flow including all classes of vehicles, from motorcycles and light-duty passenger cars to heavy-duty multi-trailer trucks. Traffic by vehicle class along the proposed EV charging corridor is available for the Deh Cho Bridge, as

[42] Government of Northwest Territories (2018). *Northwest Territories Highway Traffic Report – 2018*.
[43] Estimate of the mean daily traffic for a period of one year.
[44] Estimate of the mean daily traffic for the months of June, July, and August (definition from the NWT highway traffic report). According to this definition, the term summer average daily traffic (SADT) might be preferred.

illustrated in Figure 13 below. According to these data, passenger cars (Class 2) account for six percent of annual traffic whereas pickups, panels, and vans (Class 3) account for 36% of annual traffic. It was assumed, for this study, that the traffic per vehicle class on the Deh Cho Bridge is representative of the traffic along the different segments of Highways 1 and 3. Based on this assumption, light-duty vehicles represent about 42% of the traffic flow along the proposed charging corridor.

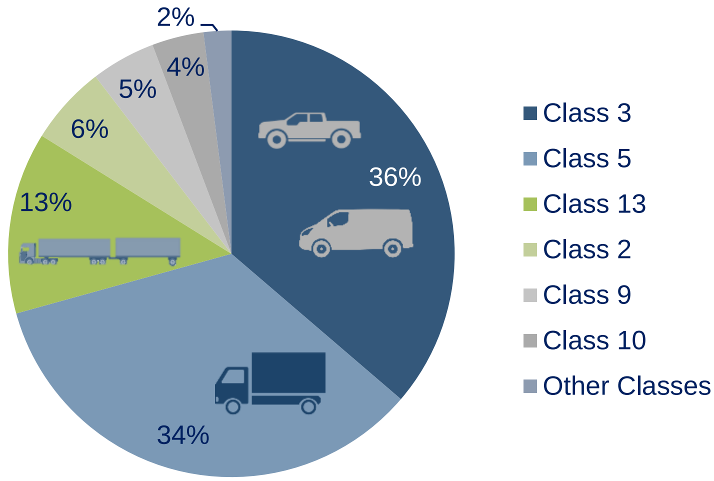


Figure 13: Distribution of Annual Traffic on the Deh Cho Bridge by Vehicle Class[45]

These values are used in the next subsection to determine the required number of chargers for each station.

3.2.3 Number of Chargers per Station

The number of chargers required per station depends on two main factors: (1) the peak hour traffic flow at each location; and (2) the number of EVs that each fast charger can serve in one hour. The former can be determined using the traffic flow data presented above, while the latter is based on the DCFC power capacity and estimated energy consumed by a given EV along each segment of the proposed charging corridor.

Based on the data in Table 8 above, the maximum traffic flow always occurs in the summer season. The number of chargers per station was calculated based on the summer peak time. While the PSADT represents the average daily traffic flow for an average summer day, the peak hour traffic flow for a typical peak summer day still needed to be determined. The study team used the results of a study performed by NRCan[46] that provides peak day ($F_{peakday}$) and peak hour traffic flow ($F_{peakhour}$) factors for different typical highway locations. $F_{peakday}$ represents the ratio of the peak day traffic flow to the

[45] Government of Northwest Territories (2018). *Northwest Territories Highway Traffic Report – 2018*. Vehicle Classifications are presented in Appendix I.
[46] Wu, Y. & Ribberink, H. (2020). *Methodology to Estimate the Need for Direct-Current Fast-Charging Stations along Highways in Canada*. Journal of Transportation Engineering.

average summer traffic flow, while $\mathrm{F_{peakhour}}$ represents the ratio of the peak hour traffic flow to the average peak day traffic flow. In addition to these parameters, the fraction of vehicles on the highway ($\mathrm{F_{LDV}}$) that are light-duty EVs ($\mathrm{F_{EV}}$) was also used to determine the number of EVs traveling along each highway segment during the peak hour of the peak summer day ($\mathrm{TR_{EV}}$) based on the following equation:

$$TR_{EV} = PSADT \times F_{peakday} \times F_{peakhour} \times F_{LDV} \times F_{EV}$$

On the other hand, the maximum number of EVs that each DCFC can charge in one hour ($DCFC_{Cap}$) is determined as follows:

$$DCFC_{Cap} = \left(DCFC_{av-pwr} \times EV_{eff}\right)/HWY_{km}$$

Where HWY_{km} = length of highway segment; EV_{eff} = average distance in km that a typical EV can drive with 1 kWh; $DCFC_{av-pwr}$ = actual power that each DCFC can charge in one hour (as opposed to nominal power). DCFC stations with a nominal power of 50 kW may be expected to provide an average power discharge of 40 kW. This accounts for the tapering off of the power discharge level as the battery approaches capacity, as well as time lost driving up, connecting, disconnecting, paying, and driving away from the charging station. A typical EV consumes around 0.2 kWh/km, which corresponds to $EV_{eff} = 5$ km/kWh under normal conditions (summer conditions). Based on these equations and assumptions, the study team estimated the number of chargers required at each station, $DCFC_{Req}$ as follows:

$$DCFC_{Req} = TR_{EV}/DCFC_{Cap}$$

The results are presented in Table 9 below for each of the six segments of the proposed EV charging corridor.

Only one charger is required at each charging station to accommodate the forecast peak traffic occurring during the summer months. The relatively low traffic volume of light-duty vehicles along Highways 1 and 3 ($\mathrm{F_{LDV}}$ = 42%), coupled with the predicted low penetration of EVs by 2030 ($\mathrm{F_{EV}}$ = 5.7%), results in a relatively low number of EVs traveling along the corridor until 2030 inclusively. The study team estimated that on average nine EVs will travel along the charging corridor during the summer peak day. Given this, one charger is sufficient to serve the charging demand anticipated at each station.

With the proposed DCFC power level and station spacing, the study team estimated that it would take from 18 to 30 minutes for an EV to charge during the summer, while charging time would double during the winter months.

Table 9: Number of DCFC Stations Needed and Average Charging Time for the Different Segments of Highways 1, 3 and 5

Highway Segment	Distance (km)	PSADT	$F_{peakday}$	$F_{peakhour}$	F_{LDV}	F_{EV} (2030)	TR_{EV} (2030)	$DCFC_{Cap}$	$DCFC_{Req}$	Charging Time (hr)	
										Summer	Winter
Yellowknife - Behchokǫ̀	101	920	1.1	8.2%	42%	5.7%	2.0	2	**1**	0.5	1.0
Behchokǫ̀ - Birch Lake	100	517					1.1	2	**1**	0.5	1.0
Birch Lake - Fort Providence Airport	108	517					1.1	2	**1**	0.5	1.1
Fort Providence Airport - Kakisa River	57	740					1.6	4	**1**	0.3	0.6
Kakisa River - Enterprise	77	740					1.6	3	**1**	0.4	0.8
Enterprise - 60th Parallel Park	85	630					1.4	2	**1**	0.4	0.9
Enterprise - Intersection of Highways 5 & 6	94	293					0.6	2	**1**	0.5	0.9
Intersection of Highways 5 & 6 - Wood Buffalo National Park	100	90					0.2	2	**1**	0.5	1.0
Wood Buffalo National Park - Fort Smith	103	210					0.5	2	**1**	0.5	1.0

Table 9 shows that there is significantly more travel on the highway segment between Enterprise and 60th Parallel Provincial Park than on the segment between Enterprise and Fort Smith. Because the GNWT's goal is to develop a charging network to serve travelers between Yellowknife and the Alberta border, and more drivers use the route along Highways 1 and 3 between Yellowknife and 60th Parallel Provincial Park, the remainder of the study analysis assumes the selection of this route for the charging network corridor.

3.3 Challenges to Charging Infrastructure Development

There are two main challenges typically associated with the development of a network of DCFC stations: (1) the availability of commercial land to install DCFC stations; and (2) proximity of electric distribution lines to charging stations. These are briefly explored below.

3.3.1 Retail Land Use Availability

A common strategy for the deployment of DCFC stations is to locate stations on existing commercial and retail sites situated along the highway and at interchanges. Installing chargers near restaurants, convenience stores, and gasoline stations has the advantage of providing shelter and convenient services to people while their EV is charging. These locations also have the advantage of including the necessary electric infrastructure, which can significantly reduce charger installation costs. Experience in Canada to date indicates that most businesses welcome the opportunity to add a charging station on their premises, even if they do not directly benefit from the revenues generated by the charger since the presence of these chargers has the potential to attract additional customers.

Commercial lands are sparse along the segments of Highways 1 and 3 between Yellowknife and the Alberta border. Three of the proposed charging station locations do not have retail lands in their direct vicinity. To address this, relocating the proposed station along Highway 3 in Behchokǫ̀ where commercial services are available could be considered. The proposed location next to the Kakisa River crossing could also be relocated further west, in the Kakisa community next to the existing gas station. In both cases, these changes would each add approximately 10 km to one corridor segment. While not ideal, these stations would still be within the effective driving range of most EVs. There are no commercial properties within 100 km of the proposed charging station locations in Birch Lake, at the Highways 5 and 6 intersection, and in Wood Buffalo National Park. These charging stations would most likely be installed directly alongside the highway, such as at an existing rest station.

3.3.2 Proximity to Electric Distribution Lines

To minimize the capital cost associated with DCFC station installations, it is desirable to locate these stations close to existing electrical distribution lines. For most of the six proposed locations, this does not represent a significant obstacle because the grid appears to be easily accessible and within reach. For two locations, Birch Lake and the 60th Parallel Territorial Park, however, this may a challenge. Both locations are more than 100 km from the nearest electrical grid access. Extending the distribution lines would be extremely costly and potentially unfeasible over such distances.

A potential solution for the Birch Lake charging station would be to have an off-grid DCFC station powered with solar panels. This type of technology exists but is only now starting to reach the market in a limited extent. The first several solar-powered DCFC installations in North America were deployed by Envision Solar in California in June 2020.[47] This autonomous charger technology is an islanded installation that requires no connection to the grid and no trenching. According to Envision Solar, this system features 20 kW solar panels, 150 kWh battery capacity, and is able to provide charging at more than a 50 kW charging rate. While the installation is said to be snow proof, its performance has not been tested in northern Canadian winter conditions. Nonetheless, the technology may offer an alternative solution for rural locations with no grid access such as Birch Lake.

The charging stations at 60th Parallel Territorial Park, Highway 5 & 6 intersection, and Wood Buffalo National Park share similar challenges to the Birch Lake location. At 60th Parallel Provincial Park, despite a NT Parks Visitor Centre being in the direct vicinity of the proposed charging station, the building is powered through an on-site fossil fuel generator. Powering the DCFC charger with this generator may be neither feasible nor advisable since this would not align with the underlying clean principle for encouraging the use of EVs. The installation of solar panels or any other on-site renewable energy, such as wind turbines, could represent a better solution.

For all four of the proposed locations, if solar-powered off-grid solutions are considered, it is expected that the available charging capacity will be reduced during the winter months compared to the summer months. This reduction in capacity might prevent the use of these stations during the winter, unless the solar installation is oversized to be able to provide the necessary charge during months with lower solar irradiance. Oversizing would, however, not be a cost-effective option due to the reduced traffic during the winter months. Instead, a better option would be to consider only seasonal accessibility to the DCFC stations at these two locations. The stations could be used only during the summer months, in a similar way to the 60th Parallel Territorial Park's Visitor Information Center that is open from mid-May to mid-September.

[47] Envision Solar (2020). Envision Solar deploys solar-powered EV DC fast charging for the Shandon California Rest Area on U.S. Highway 46 East. Last accessed in August 2020: https://www.envisionsolar.com/envision-solar-deploys-solar-powered-ev-dc-fast-charging-for-shandon-california-rest-area-on-u-s-highway-46-east/.

3.4 EV Charger Characteristics and Installation Considerations

3.4.1 Summary of EV Charging Levels

There are three common levels of EV charging (excluding the proprietary Tesla Supercharger):

- Level 1: Charging from a standard 120V wall outlet, typically in residential applications. Most EV models are equipped with the ability to charge from a standard wall outlet. Level 1 charging has a maximum input power of 1.9 kW.
- Level 2: Charging from a 240V dedicated outlet. Level 2 charging requires a separate EV charger, installed by a qualified electrician. Typically installed in residential and business applications, where cars are parked for several hours. Level 2 charging has a maximum input power of 19.2 kW.
- DCFC: Fast charging typically used in public charging stations, particularly suited for long-distance EV corridors, as these chargers are capable of delivering a full battery charge for most EV models in approximately 1 hour. See Table 10 for a summary of technical specifications of common DCFC models in Canada.

3.4.2 DCFC Characteristics

There are three types of DC fast chargers: CHAdeMO (type of charger used mostly by Asian cars), Combined Charging System (CCS) that is compatible with most European and American EVs, and the Tesla Supercharger (only for Tesla models). Tesla also sells adapters so that Tesla users can recharge their car using CHAdeMO chargers. Important considerations for DCFC model selection include the following:

- All major DCFC charger manufacturers in North America offer multi-standard units that enable charging via CCS or CHAdeMO from the same unit. When selecting a DCFC model, this should be considered so that all EVs can use the stations.
- Preference should be given to chargers that are winter proof (range of operation from -40° C to 40° C) and that have been tested in real Canadian winter conditions.
- Most DCFC stations require communication with a back-end network for payment. This communication typically relies on a cellular network and a data plan.

See Table 10 for a summary of the specifications for the three most common DCFC chargers in Canada (excluding Tesla). A fourth model featuring a maximum output power of 175 kW is also presented for reference as more and more jurisdictions are starting to consider DC chargers with increased charging capacities and reduced charging time.

Table 10: Specifications of Leading EV Charger Models

Charger	ABB Terra 54	ELMEC EV Duty 3	AddÉnergie Smart DC-V2	ABB Terra 124
Charging Standard	CCS, CHAdeMO (option)	CCS, CHAdeMO	CCS, CHAdeMO	CCS, CHAdeMO
Max. Output Power	54kW	54kW	54kW	120 kW
Operating Temperature Range	-35°C – 55°C	-40C – 40°C	-40C – 40°C	-35°C – 55°C
Communication Protocol	Open Charger Point Protocol 1.6, via cell modem or LAN	Open Charger Point Protocol 1.6 via RJ45 Ethernet port	Zigbee via cellular modem	Open Charger Point Protocol 1.6, via cell modem or LAN

3.4.3 Installation Considerations

Things to consider when installing DCFC stations, outside of those discussed elsewhere in this report, include:

- Coordination with the local utility regarding the EV rate structure and time of use prices
- Station design and construction[48]
- Charger communication protocol and requirements (cellular network or ethernet connection)
- Certified electrical contractors are generally qualified to work on DCFC circuits, without the additional certification and training that may be required if the circuit was rated “high voltage”. In Canada, the “high voltage” rating occurs for voltages above 750 V13. Each provinces’ Safety Authority’s Electrical Safety Program has been responsible for regulating electrical safety in each province, including all types of electrical equipment and installation and should be consulted to determine appropriate contractor qualifications.[49]

3.5 Grid Impact

For the proposed network of DCFC stations connected to the grid, the impacts on peak demand and energy consumption need to be considered to inform decisions relative to grid capacity and assess if the current grid can support the additional EV load. This section provides a summary of the grid impact assessment.

3.5.1 Peak Demand

Peak demand represents the highest rate of electricity use during a period of time. For the proposed network of fast chargers, peak demand simply corresponds to the nominal power of the DCFC stations,

[48] The *Canadian EV infrastructure deployment guidelines 2013*, section 6, includes useful design drawings for public DCFC charging stations.
[49] CEATI International, *Canadian EV infrastructure deployment guidelines 2013*

which is 50 kW, since each station would have only one direct current charger. This additional load could be accommodated by the existing generation and distribution infrastructure in most of the communities for which new DCFC charging stations are proposed as shown in Table 11.

Table 11: Electricity Generation and Load in NT Communities[50]

Community	Installed Generation (kW)	2014/2015 Consumption (GWh)	2014/2015 Peak Load (kW)	Available Load in 2010 (kW)
Behchokǫ̀ (Snare Grid total)	29,990 (diesel) 45,050 (hydro)	184.5	38,589	36,451
Enterprise (Taltson Grid total)	7,050 (diesel) 18,000 (hydro)	62.6	12,800	12,250
Fort Providence[51]	1,725 (Diesel)	Not available		
Kakisa[52]	421 (Diesel)	Not available		

The proposed station at Kakisa River Provincial Park would represent a significant new load: a 50kW DCFC charger would consume more than 15% of available generation resources in that community[53]. Given the potential impact of a new DCFC charger on the local generation assets and distribution grid, a Level 2 charger should be considered for the proposed charging station at Kakisa River Provincial Park. Level 2 chargers require 80A service (compared to 200A for DCFC), and have a maximum output power of 19.2 kW. Level 2 chargers are typically used in residential and business applications, where vehicles are parked for sevaral hours. Compared to DCFC, which is capable of delivering a full charge in 1-2 hours, Level 2 charging typically requires 6-8 hours to deliver a full charge.

3.5.2 Energy Use

In terms of energy use, the monthly and annual energy consumption of the charging stations depends on the average traffic of EVs as well as the amount of energy required to travel along the different highway segments. The monthly and annual energy use per station are presented in Table 12 based on the assumptions that an average EV consumes around 0.2 kWh/km under normal conditions and 0.4 kWh/km under winter conditions.

Table 12: Average Monthly and Annual Energy Use per Station

Highway Segment	Distance (km)	EV AADT*	EV PSADT**	Monthly Energy Use (kWh)		Annual Energy Use (MWh)***
				Summer	Winter	

[50] Northwest Territories Power Corporation (2016). *Power System Plan.*
[51] Fort Providence Switching Diagram, Northland Utilities, Ltd.
[52] Dory Point Switching Diagram, Northland utilities, Ltd.
[53] NT Energy (2013). *A Vision for the NWT Power System Plan.*

Yellowknife - Behchokǫ̀	101	2	22	13,270	21,784	236
Behchokǫ̀ - Birch Lake	100	1	12	7,379	2,234	42
Birch Lake - Fort Providence Airport	108	1	12	7,969	2,234	44
Fort Providence Airport - Kakisa River	57	2	18	6,024	5,677	69
Kakisa River - Enterprise	77	2	18	8,137	5,677	76
Enterprise - 60th Parallel Park	85	2	15	7,648	4,293	62

* Average number of EVs during an average winter day; **Average number of EVs during an average summer day;

***Based on nine winter months and three summer months.

3.6 Proposed Rollout Plan

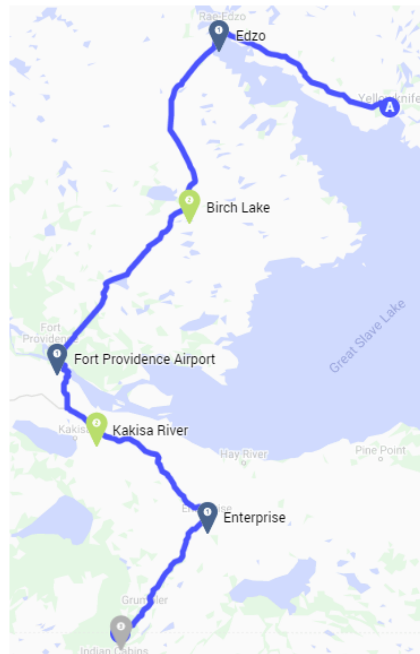
This analysis presents two options for the southern section of the corridor, between Enterprise and the Alberta border. The study team recommends that the EV corridor be developed along the route following Highway 1 Southwest to 60th Parallel Territorial Park, rather than the route along Highways 2 and 5 Southeast to Wood Buffalo National Park and Fort Smith. This recommendation is based on two primary factors: traffic flow and charging availability on the Alberta side of the border.

› Traffic flow: As Table 12 shows, there is very little traffic traveling between Wood Buffalo National Park and Enterprise and points north. The traffic between Fort Smith and the National Park appears to be mainly local, supplemented by travelers from Alberta. The traffic volume between 60th Parallel Provincial Park and Enterprise is significantly greater. Developing the EV corridor along this route would enable it to serve more drivers, particularly in summer months.
› Charging station availability: the nearest public charging station on the Alberta side of the border is located in High Level, at the intersection of Highways 35 and 58, 191 km from the proposed station at 60th Parallel Provincial Park. This station is also the nearest to Fort Smith, but at a distance of 591 km.

The study team considered the opportunity of developing the proposed EV charging corridor over three phases between 2020 and 2030. The goal of this exercise was to reduce the amount of investment needed to implement a network of charging stations capable of supporting EV travel between Yellowknife and the Alberta border during the summer months. A phased charging network rollout would have the additional advantage of allowing time for EV technology to advance and enable greater maximum ranges for new vehicles.[54] The proposed three-phase rollout is presented in Table 13.

[54] Four EV light truck models are anticipated to arrive on the market in 2022, with maximum ranges between 483 km and 805 km.

Table 13: Phased Rollout Plan for EV Charging Corridor

Phase	Legend	Charging stations	Rollout Time Horizon	Stations Map
1		Behchokǫ̀	2021-2022	
2		Birch Lake	2024-2026	
1		Fort Providence Airport	2021-2022	
2		Kakisa River	2024-2026	
1		Enterprise	2021-2022	
3		60th Parallel Park	2025-2030	

* The Big River Service Centre is another potential location for the proposed charging station at Fort Providence.

Phase I, to be developed in 2021-2022, includes charging stations at Behchokǫ̀, Fort Providence Airport, and Enterprise. These stations would enable EVs with maximum ranges of at least 300 km to travel the corridor for approximately half of the year; the distance between the Behchokǫ̀ and Fort Providence Airport stations is 208 km.

Phase II, to be developed between 2024-2026, would include the proposed charging stations at Birch Lake and Kakisa River. The timing would have the advantage of allowing not only the off-grid solar charging technology to mature and be proven in northern Canadian winter conditions, but also time for the planned extension of the Taltson electric grid to the Kakisa River Crossing to serve that location with 100% hydroelectric power.

Phase III, to be developed between 2025-2030, is the installation of the charging station at the 60th Parallel Park and would allow time for the extension of Alberta's charging network on the southern side of the territorial border.

4 ECONOMIC AND ENVIRONMENTAL IMPACT ASSESSMENT

Accelerating the adoption of EVs in the NT will entail a number of costs and benefits for EV purchasers, society as a whole, government, and potentially private-sector businesses. The primary benefits of EV adoption are reducing transportation-related GHG emissions, which benefits EV owners and non-purchasers equally, and fuel and maintenance savings that accrue to EV owners. The primary costs are the incremental purchase costs of EVs, charging infrastructure development, and any additional promotional programs. There are additional costs for gasoline retailers in the form of reduced sales, and new charging revenues for electricity providers.

This section presents an analysis of the most important benefits and costs of EV promotion in the NT and the development of a new EV charging corridor along Highways 1 and 3, from the perspective of EV purchasers, the NT government, and NT society as a whole.

4.1 Costs and Benefits for EV Purchasers

Purchasers of new EVs can expect to pay an initial incremental cost of approximately $20,000 before incentives and reap fuel and maintenance savings over time. Fuel savings depend on the ratio of the charging price to gasoline price and can vary significantly by location. The analysis presented below assumes an EV charging cost of $20 per hour based on charging network costs in Alberta. Given the cost of electricity in the NT, this cost represents the low end of likely charging prices, assuming that the GNWT will initially operate the proposed charging network. If the network is privatized and operated for profit, the charging price is likely to range between $25 and $30 per hour. Table 14 presents the initial incremental cost and annual savings for EV purchasers.

Table 14: Cost-Benefit Summary – EV Purchasers

Type of Cost/Savings	Unitary Value ($)	Annual Value ($/year)
Incremental cost of EV (No Incentive)	$20,000	N/A
Charging cost on the network[55]	$20 per hour	$1,184
Gasoline savings - SUV owners[56]	Average $14 per 100 km	($978)
Gasoline savings - passenger car owners[53]	Average $11 per 100 km	($1,258)
Maintenance savings[57]	N/A	($750)
Annual savings – Passenger car owners	N/A	**$544**
Annual savings – SUV owners	N/A	**$824**

[55] Assumes DCFC stations charge at 40 kW. Based on DCFC rates on the Alberta Flo charging network.
[56] This estimation is based on the total average highway travel of 6,666 km/year calculated in this report and the average Yellowknife commuting distance of 6.3 km/day (2,300 km/year), from the *Yukon EV Investigation Report* (page 17). The total of 8,966 km/year is the same for SUV and passenger car drivers.
[57] Estimates of EV maintenance costs and savings relative to gasoline vehicles range widely and are mostly based on anecdotal information. The study team chose $750 per year as a credible intermediate value.

This analysis was made considering travel on the electrified corridor along Highways 1 and 3 as well as commute local travel, with 75% of the distance travelled on highways (total average of 8,966 km/year/driver). Based on forecast gasoline prices for the NT and estimated vehicle maintenance savings, EV owners who are former passenger car and SUV owners will save between $544 and $824 per year respectively. Although meaningful, these savings fall short of the incremental purchase cost, assuming a 10-year useful lifetime. This points to the important role of government incentives to economically justify EV purchases. Table 15 outlines the impact of purchase incentives on the simple payback period for new EVs purchased and operated in the NT.

Table 15: EV Payback Period by Incentive Scenario

Incentive Scenario	Incremental Cost After Incentives ($)	Payback Period
No Incentive	$20,000	29 years
Conservative	$10,000	15 years
Significant	$5,000	7 years
Aggressive	$0	0 years

Without incentives, EV owner operational savings are very unlikely to fully recoup the incremental purchase cost over a vehicle's lifetime. Under the Conservative Incentive scenario – equivalent to the current situation in the NT – it will take 15 years to pay back the incremental cost, meaning that most drivers are unlikely to see an overall financial benefit from EV ownership. The Significant Incentive scenario, which reduces the incremental purchase cost of a new EV to $5,000, results in a payback period of seven years. Under this scenario, most EV owners will receive an overall financial benefit from purchasing and operating an EV over its lifetime. The Aggressive Incentive scenario reduces the incremental purchase cost to zero, causing economic benefits to immediately begin accruing for EV owners.

4.2 GHG Emission Reductions

EVs cause no direct emissions and lower total emissions (direct and indirect emissions) than gasoline vehicles because of a more efficient drivetrain and lower carbon density in fuel. While all EVs take advantage of a more efficient drivetrain compared to gasoline vehicles, the emission reduction benefit from the carbon density of the vehicle's fuel source is highly dependent on the fuel mix of the local electricity grid. EVs fueled by electricity generated from carbon-free sources such as hydroelectricity and solar have lower total emissions than EVs fueled by electricity generated from natural gas, coal, or diesel.

The electricity grid fuel mix along the proposed EV charging corridor is highly location dependent. Some areas like Yellowknife, Behchokǫ̀, and Enterprise have very low carbon density, while areas such as Birch Lake, Fort Providence, and Kakisa River have higher carbon density because their electricity is produced by diesel generating facilities. Table 16 presents the GHG emissions associated with electricity generation at each of the proposed charging stations along the EV charging corridor.

Table 16: GHG Emission Intensity of Proposed EV Charging Points

Charging Point	Fuel Type[58]	Ratio	GHG Emissions ($g\ CO_2e/kWh$)
Yellowknife	Hydroelectric plant + diesel plant during peak load period	96%	0
	Diesel plant	4%	774
Behchokǫ̀	Hydroelectric plant + diesel plant during peak load period	96%	0
	Diesel plant	4%	774
Birch Lake	Solar plant	100%	0
Fort Providence	Diesel plant	100%	774
Kakisa River[59]	Diesel plant	100%	774
Enterprise	Hydroelectric plant	100%	0
60th Parallel Park	Solar plant	100%	0

Using the carbon density of the electricity generation mix for each of the proposed charging points, traffic data for the number of trips along the Highways 1 and 3 corridor, and the share of EVs in the overall light-duty vehicle population,[60] the study team estimated the annual GHG emission reductions that would be achieved in 2030 under the Significant Incentive scenario. The results of the analysis are presented in Table 17 below.

[58] *Canada—National Inventory Report - 1990-2014* - Part 2, Section A6.1.2, p. 195.
[59] A proposed extension of the Teltson grid would provide access to 100% hydroelectric power at Kakisa River. Source: *A Vision for the NWT Power System Plan*.
[60] As shown in Figure 1, the current EV share of the total vehicle population in Alberta is less than 0.1%, not significantly different from the current EV share in the NT. As such, the study team did not modify the forecast EV share (see Section 3) for northbound travel.

Table 17: Annual Emission Reductions from EV Travel on Highways 1 and 3 Corridor, Significant Incentive Scenario

Highway Stretch	Distance (km)	Annual Traffic[61] (trips)	EV Ratio of Vehicle Fleet[62]	Net 2030 GHG Reductions (tonnes CO_2e)	Total EV Travel Distance (km)
Yellowknife - Behchokǫ̀	101	313,900	5.7%	188	750,019
Behchokǫ̀ - Birch Lake	100	94,900	5.7%	57	224,505
Birch Lake - Fort Providence Airport	108	94,900	5.7%	36	242,465
Fort Providence Airport - Kakisa River	57	146,500	5.7%	7	197,548
Kakisa River - Enterprise	77	197,100	5.7%	53	359,035
Enterprise - 60th Parallel Park	85	171,550	5.7%	90	344,960
Total Annual GHG Emission Reductions in 2030				**432 tonnes CO_2e**	

Under the Significant Incentive scenario, EV travel along the Highways 1 and 3 corridor between Yellowknife and the Alberta border would result in a net annual reduction of 432 tonnes of CO_2e. It is important to note that this estimate does not include the emission reductions resulting from travel within local communities or between communities not served by Highways 1 and 3 between Yellowknife and the Alberta border. When non-highway travel is considered the total annual net emissions reduction is 581 tonnes of CO_2e. Table 18 below outlines the annual emission reductions in 2030 for each incentive scenario.

Table 18: Emission Reductions by Incentive Scenario[63]

Incentive Scenario	EV Share of Total LDV Population[64]	Annual GHG Emission Reductions – Highway Travel (tonnes CO2e)	Annual GHG Emission Reductions – Highway Travel & Commute Travel (tonnes CO2e)
No Incentive	2.9%	219	295
Conservative	3.7%	281	378
Significant	5.7%	432	581
Aggressive	11.3%	865	1,163

[61] Source: *Northwest Territories 2019 Highway Traffic Report.*
[62] In 2030, assuming the Significant Incentives scenario.
[63] This estimation is based on the total of highway travel calculated in this report and the average Yellowknife commuting distance of 6.3 km/day, from the *Yukon EV Investigation Report* (page 17). This is a conservative estimate, as total annual vehicle kilometres travelled (VKT) is 8,966 km, significantly lower than the overall average VKT in Canada of 15,200 km. If this value is used instead of the 8,966 applied in Table 17, the Annual GHG reduction in 2030 under the Significant incentive scenario would be 865 tonnes CO_2e.
[64] Note that LDVs make up 42% of total vehicle traffic, based on data from the Deh Cho bridge toll gantry.

Several studies[65] have demonstrated that the driving habits of EV drivers change significantly compared to the habits of ICEV drivers. EV vehicle drivers tend to use their EV more than ICEV by using it for trips they would usually take on foot or by bicycling. This could be explained by the ecological nature of the vehicle, which emits less GHG, which removes any user guilt for using the EV.

Considering that these short trips do not replace ICEV use, there is no impact on GHG emission reductions. Since those short trips are probably all made for home-to-local market or home-to-work travel, there is no impact on the charging network either. People will use their home charging station for such short-distance travel.

4.3 Costs for the GNWT

Direct costs to the GNWT for accelerating EV adoption through the development of a new EV charging corridor and additional promotional activities depend significantly on two factors: (1) the financing structures for EV charging infrastructure development; and (2) the amount and availability of new EV purchase incentives provided by the GNWT. For the purpose of this analysis, the study team made several important assumptions:

- The GNWT will assume the costs of developing EV charging infrastructure along the proposed EV charging corridor.
- The GNWT will operate the EV chargers along the new corridor, and will sell charging to users at cost or at a low profit margin, maximizing operating savings for EV owners and generating no new revenue for the GNWT.
- The cost to the GNWT to provide each kWh delivered is included. Because most part of the highway travels are made between 9 am and 4 pm (outside of the daily electricity peak periods), demand (kW) was not considered in estimating the costs for the GNWT.
- The GNWT will assume no new costs from the continuation of the EV purchase incentives available from Transport Canada or the Arctic Energy Alliance (totalling $10,000 in available incentives for EV purchasers in the NT).

Table 19 presents a summary of the EV charging infrastructure and operating costs that will accrue to the GNWT under the Conservative Incentive scenario over the 2021-2030 period. Note that inflation was not considered in the cost and the revenue calculations. Appendix II presents the detailed energy rates considered for this cost and revenue analysis.

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[65] Source: *Helmbrecht, Magnus & Olaverri Monreal, Cristina & Bengler, Klaus & Vilimek, Roman & Keinath, Andreas. (2014). How Electric Vehicles Affect Driving Behavioral Patterns. Intelligent Transportation Systems Magazine, IEEE. 6. 22-32. 10.1109/MITS.2014.2315758.*
Elodie Labeye, Myriam Hugot, Corinne Brusque, Michael Regan. The electric vehicle: A new driving experience involving specific skills and rules. Transportation Research Part F: Traffic Psychology and Behaviour, Elsevier, 2016, 37, pp. 27-40. ff10.1016/j.trf.2015.11.008ff. ffhal-01375560v2f.

Table 19: Summary of GNWT Costs for EV Infrastructure and Operating Cost

Type of Expenditure	2021-2030 Total Cost	2021 Forecasted Cost	2022 Forecasted Cost	2023 Forecasted Cost
Charging station purchase and installation	$905,000	$120,000	$60,000	0
Maintenance and access (spare parts, shoveling)	$30,000	$1,000	$2,000	$2,000
Electricity purchase – Conservative Scenario	$612,117	$2,750	$5,671	$9,826
Incentives - Conservative	$0[66]	$0	$0	$0

Assuming the Conservative Incentive scenario, direct costs to the GNWT will total approximately $1,550,000 over 10 years. Incentives are a critical factor in accelerating EV adoption rates, as outlined in Section 2, but the available funding for EV incentives is limited, and governments must find a way to balance EV adoption against competing priorities.

Table 20 presents the total costs that would accrue to the GNWT over the 2021-2030 period for charging infrastructure development and maintenance, and electricity purchases to cover driver needs at all charging stations. The table also provides the total income from EV drivers using the charging stations over the same period. The data presented therein are compared to each incentive scenario, along with the forecast ratio of EVs on NT roads in 2030.

Table 20: Total GNWT Costs and Revenues by Incentive Scenario[67]

Incentive Scenario	Total Cost 2021-2030[68]	Total Income 2021-2030[69]	EVs as a Share of NT LDVs in 2030	Net 2030 GHG Reductions from EV Adoption - Highway and Commute Travel (tonnes CO_2e)	Cost per Tonne of CO_2e
No Incentive	$1,418,119	$689,183	2.9%	295	$2,471
Conservative	$1,547,117	$873,202	3.7%	378	$1,785
Significant	$8,550,883	$1,325,974	5.7%	581	$12,442
Aggressive	$29,358,652	$2,624,123	11.3%	1,163	$22,992

66 Assumes that the GNWT will take on no additional costs beyond current spending, which includes the $5,000 Arctic Energy Alliance incentives currently available to EV purchasers in the NT.

67 All incentive scenarios in the table include the costs for installation and maintenance of EV charging stations, and the cost of purchased electricity.

68 Assumes that the Government cost will be $0.405/kWh on an annual average for electricity provided to drivers along the highway corridor. See Appendix II for detail.

69 The charging price for drivers will be fixed at $20/hour.

In consideration of the need to balance the goal of accelerating EV adoption against other priorities, the study team encourages the GNWT to consider offering EV purchase incentives aligned with the Significant Incentive scenario, specifically an incremental or stackable $5,000 purchase incentive for qualifying EVs in addition to the two $5,000 incentives currently available from Transport Canada and the Arctic Energy Alliance. This scenario results in a significant acceleration of EV adoption over the 2021-2030 period compared to the Conservative Incentive scenario. It also enables EV owners to achieve a small economic benefit over the lifetime of their vehicle by reducing the average payback period for a new EV to just over seven years, which is under the generally agreed upon 10-year lifespan for a charging station and an EV.

As long as the incremental cost of EVs remains similar to the actual difference with an equivalent fossil fuel vehicle, any incentive program offering less than the Significant Incentive scenario will lead to a decrease in purchasing power for would-be EV owners. Moreover, considering that charging costs over $20/hour at public charging stations will void all monetary benefits for EV owners, increasing the charging price to finance the charging network infrastructure deployment is not recommended.

5 ACTIVITIES TO PROMOTE EV ADOPTION IN THE NT

This section includes a set of recommended promotional activities, programs, and policies to accelerate the adoption of EVs in the NT. The recommendations are based on EV promotion activities in other Canadian and U.S. jurisdictions, and the information is drawn from published materials and discussions with other experts. These recommendations address barriers to EV adoption in the NT, such as public awareness and exposure, promotion and support from auto dealers, and access to charging at home and at work. The study team focused its recommendations on low-cost activities and programs to enable the territorial government to test a variety of strategies and identify the most effective.

5.1 Promotional Activities

EV Discovery Day

One of the promotional activities held by the Government of Yukon was an EV Discovery Day that included panel presentations on how electric vehicles perform in the northern winter, how to operate and maintain EVs, and other topics. Local EV owners shared their experiences, and the government provided an EV from its fleet for participants to explore and test drive. Similar events have been held in BC, Ontario, and Quebec.

The Yukon EV Discovery Day was supported by a grant from NRCan's Zero-Emission Vehicle Awareness Initiative that provides up to $50,000 in funding "for innovative projects that aim to increase consumer awareness of zero-emission vehicles and infrastructure."

Data are not available to demonstrate the impact of EV discovery days and similar promotional events, but participants and organizers indicated that there is value in hearing from EV owners about the benefits and drawbacks and in providing the opportunity for people to test drive an EV outside of a sales environment.

Larger-scale promotional activities could take the form of a public awareness campaign such as *Empowered* in BC, or a permanent educational facility like the Plug'N Drive Discovery Center in Ontario (see Subsection 1.3.2 above for details).

Lead by Example with Government Fleets

Government-owned and operated vehicle fleets provide an opportunity to increase awareness about EVs by getting them out into communities on government business. Government leadership also helps by growing the market for EVs, charging infrastructure, and service technicians. Other provincial governments have made commitments to target EVs in their fleet procurement; Quebec has committed to procuring 1,000 EVs for its vehicle fleet by 2020, and Yukon Territory has committed to ensuring that 50% of new fleet procurements are EVs.

Greening Government Fleets[70] is a useful guide from NRCan on strategies and programs for provincial and territorial governments to integrate EVs into their vehicle fleet procurement processes.

5.2 Policies to Advance EV Adoption

EV Sales Targets for Dealerships

Purchase incentives and charging infrastructure development are important tools to increase EV adoption rates, but adoption will be slowed without the support of auto dealerships stocking and promoting EV models. Quebec, BC, and the state of California offer examples of how policy may be used to influence auto manufacturers and dealerships to market and sell EVs. As discussed in Subsection 1.3.4 above, these jurisdictions have set manufacturer and dealer targets for EV sales based on each manufacturer's number of total vehicles sold in the jurisdiction. Quebec has set a target that increases gradually each year, while BC recently established an EV sales target of 10% of total vehicle sales in 2025 with the ultimate goal of reaching 100% EV sales by 2040.[71]

Building Code Updates to Enable Residential Charging

Building codes are another mechanism governments may use to address barriers to EV adoption. Beginning in 2018, Ontario required that new, single-family homes be equipped with the electrical infrastructure to accommodate Level 2 EV charging.[72] Under this code, new homes must include a 200 A electrical panel as well as a conduit and outlet box sized to accommodate a Level 2 EV charger. The code requires new buildings with parking to install not only Level 2 chargers for 20% of their parking spaces, but also the infrastructure to add chargers to all parking spaces in the future.

The Yukon Territory 2030 Energy Strategy also includes a plan to require new residential buildings to be equipped with the infrastructure to enable Level 2 charging, similar to Ontario. As of this writing, that building code update is not yet published.

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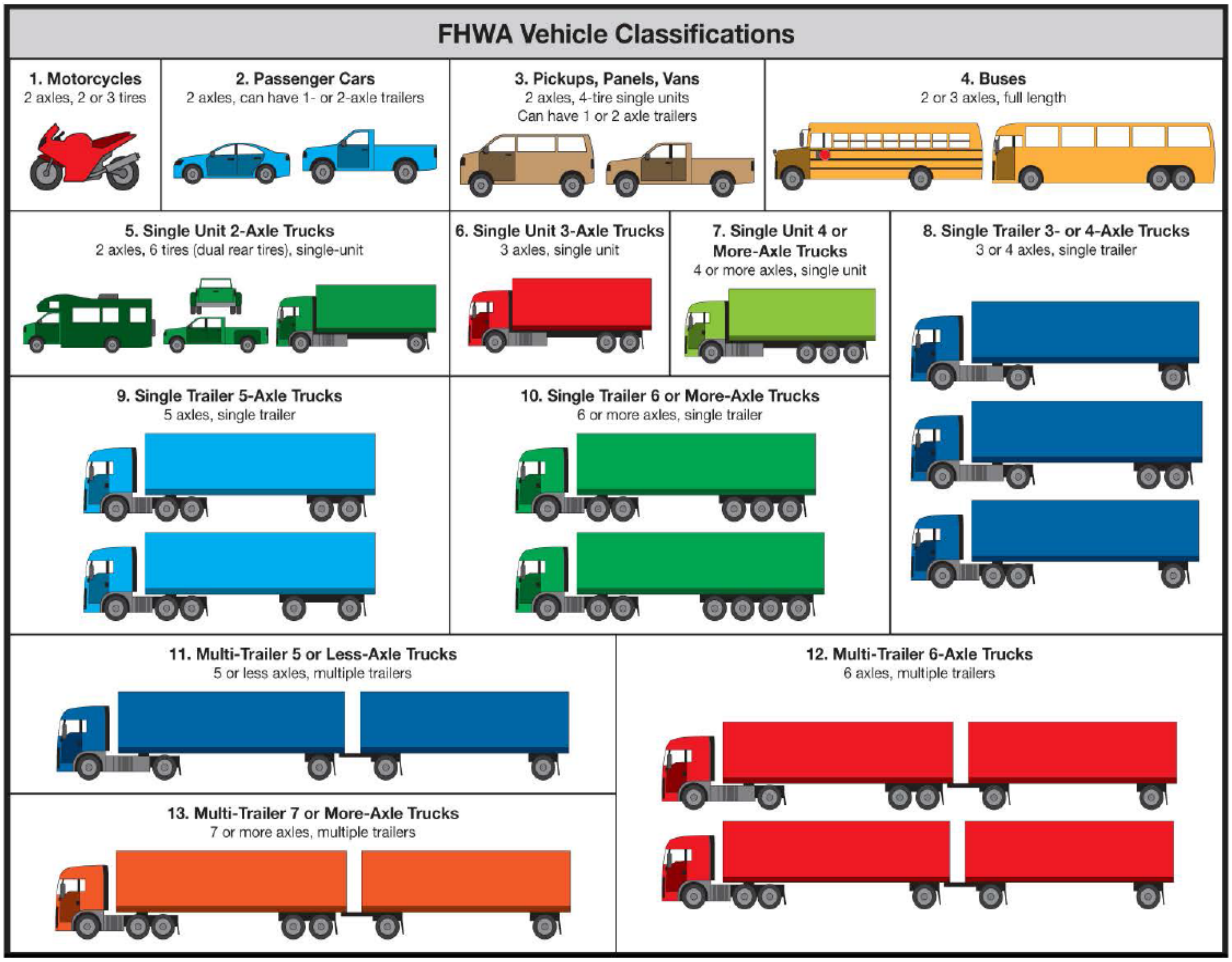
[70] Greening Government Fleets, Natural Resources Canada, 2017: https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/pdf/transportation/NRCan_GreeningGovFleets_e.pdf.
[71] For details on the Quebec ZEV Act, see Ministère de l'Environnement et de la Lutte Contre les Changements Climatiques (2020). *The zero-emission vehicle (ZEV) standard.* Information retrieved in July 2020 from: http://www.environnement.gouv.qc.ca/changementsclimatiques/vze/index-en.htm.
[72] Ontario Ministry of Municipal Affairs, *Technical Support for Electric Vehicle Charging Requirements in the Building Code*: https://www.ohba.ca/wp-content/uploads/2018/04/qs-as-ev-requirements-houses-en-secured.pdf.

APPENDIX I
UNITED STATES FEDERAL HIGHWAY VEHICLE CLASSIFICATIONS



APPENDIX II
UTILITY RATES AND ENERGY COST

The table below provides detailed calculation method for the electricity cost that the GNWT will have to provide to EV drivers.

Table 21 : Electricity Cost estimation for Period 2019-2020

2007-2008 Fiscal Year	Electricity consumed (kWh)	Ratio of the Total Consumption (%)	Generation Cost ($)	Average Cost ($/kWh)	Ratio of the Total cost (%)
Hydro Communities	233,000,000	75.2	47,100,000	0.202	48.5
Thermal Communities	77,000,000	24.8	50,000,000	0.649	51.5
Total	310,000,000	100	97,100,000	N/A	100
2019-2020 Fiscal Year	**Ratio of the Total cost (%)**	**Generation Cost ($)**	**Ratio of the Total Consumption (%)**	**Electricity consumed (kWh)**	**Average Cost ($/kWh)**
Hydro Communities	48.5	51,917,310	75.2	228,776,687	0.223
Thermal Communities	51.5	55,121,524	24.8	75,604,312	0.729
	100	107,046,000*	100	304,381,000**	
2019-2020 Fiscal Year	**Average Cost ($/kWh)**	**Ratio of the Total VKT (%)**	**Average Cost ($/kWh)**		
Hydro Communities	0.223	0.64	0.405 $/kWh		
Thermal Communities	0.729	0.36			

Source: https://www.inf.gov.nt.ca/sites/inf/files/electrical_review_discussion_paper.pdf
* Northwest Territories Power Corporation 2018-19 Annual Report of Finances, page 11.
** Northwest Territories Power Corporation 2018-19 Annual Report of Finances, page 2 (Schedule 2).

Charging stations in hydro communities represent 64% of the VKT in the EV charging corridor. The average electricity cost for government-procured electricity is considered to be $0.405/kWh. Supporting refences are shown in the following figures.

EQUITABLE COST DISTRIBUTION

ELECTRICITY COSTS

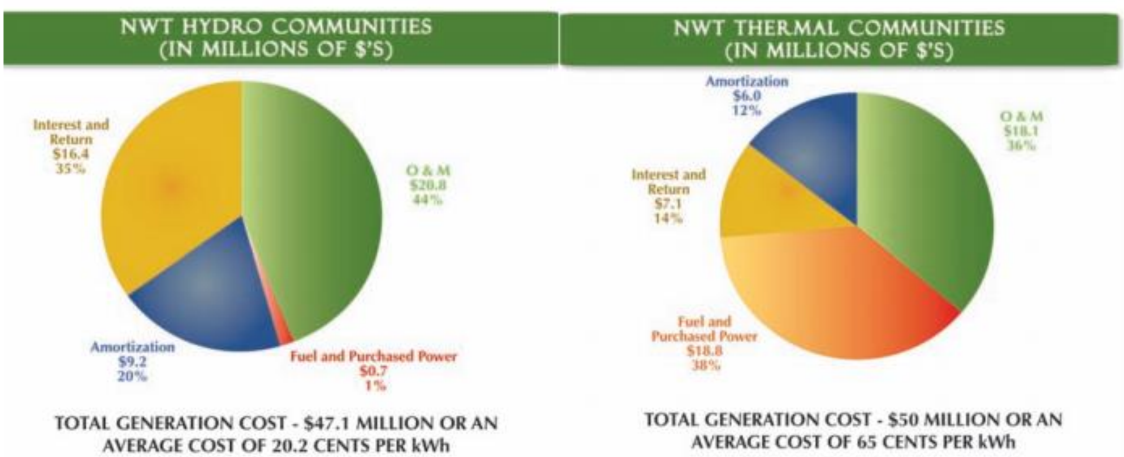
While the objective is to realize a number of cost savings during this exercise, the NWT electricity system will remain an expensive one to operate and maintain.

During the 2007/2008 fiscal year, the total cost to run the NWT electricity system was nearly $100 million with approximately half of that cost required to service hydro communities and the balance to service diesel communities. The total costs for both hydro and thermal communities are illustrated in the two pie charts below and are broken down as follows:

- 20.2 cents average cost X 233 million kWh = $47M for hydro communities, and
- 64.9 cents average cost X 77 million kWh = $50M for thermal communities.

At present, the PUB establishes an electricity rate for each individual community, and class of service within that community, directly related to its cost of generating electricity. This means that communities with a higher unit cost of generating electricity must pay a higher rate for that electricity.

This method of rate design has given rise to much discussion over the years. It has been suggested that existing community based rates do not reflect historical federal government investments in hydro and therefore the costs of the system are not equitably distributed.



Source: Northwest Territories Power Corporation and Northlands Utilities Ltd.

Source: https://www.inf.gov.nt.ca/sites/inf/files/electrical_review_discussion_paper.pdf

Figure 14: Electricity Generation Costs for 2007-2008 Fiscal Year

Schedule 2.0

NORTHWEST TERRITORIES POWER CORPORATION
2018-19 REPORT OF FINANCES
SUMMARY OF GENERATION, SALES, AND REVENUE
NTPC SUMMARY

Line no.	Description	2017-18 Actual	2018-19 Forecast	2018-19 Actual
	SALES AND REVENUE			
	Residential			
1	Sales (MWh)	42,414	45,677	42,732
2	Customers	6,769	6,720	6,791
3	Av. MWh Sales/Cust.	6.27	6.80	6.29
4	Revenue (000s)	26,379	28,609	26,955
5	Cents /kWh	62.19	62.63	63.08
	General Service			
6	Sales (MWh)	59,007	57,961	60,511
7	Customers	1,890	1,868	1,894
8	Av. MWh Sales/Cust.	31.22	31.03	31.95
9	Revenue (000s)	38,127	38,359	40,362
10	Cents /kWh	64.61	66.18	66.70
	Wholesale			
11	Sales (MWh)	192,604	193,790	195,035
12	Customers	2	2	2
13	Revenue (000s)	40,309	41,026	41,185
14	Cents /kWh	20.93	21.17	21.12
	Industrial			
15	Sales (MWh)	4,493	6,100	5,454
16	Customers	1	1	1
17	Av. MWh Sales/Cust.	4493	6100	5454
18	Revenue (000s)	899	1,359	1,196
19	Cents /kWh	20.02	22.28	21.94
	Streetlights			
20	Sales (MWh)	662	916	649
21	Revenue (000s)	641	883	693
22	Cents /kWh	96.84	96.40	106.85
	Total Community			
23	**Sales (MWh)**	**299,180**	**304,444**	**304,381**
24	Customers	8,662	8,591	8,688
25	Revenue (000s)	106,356	110,236	110,391
26	Cents /kWh	35.55	36.21	36.27

Source: https://www.inf.gov.nt.ca/sites/inf/files/electrical_review_discussion_paper.pdf

Figure 15: Total energy sales for 2018-2019 Fiscal Year

The following table presents the calculation of the electricity rate for an EV driver charging his car at home.

Table 22 : Residential Electricity rate calculation

NWT Residential Electricity rates (March 2019)	Consumption ($/kWh)	Note	Demand ($/kW)
Yellowknife	0.2127		8.10
Kakisa	0.3165	For each kWh exceeding 100 kWh per month	14.00
Behchokǫ̀ /Dettah	0.3497	For each kWh exceeding 100 kWh per month	Not available

Sources: https://www.nwtpublicutilitiesboard.ca/regulation/current-utility-rates
https://www.nwtpublicutilitiesboard.ca/sites/default/files/attachments/NTPC%20Rate%20Schedules%20with%20NWT%20Stabilization%20Fund%20Rate%20Rider%20-%20October%201%202019.pdf

Hypothesis for home charging

All electricity used for charging vehicle will be consumed in the "over 1000 kWh per month" rate category. Thus, only the higher electricity rate applies. Home charging should be made with Level 1 charger (7.5 kW). The charging should not occur during peak period of the day. Charging cost should not be impacted by peak demand rate. The average value is then $0.293/kWh. The value considered to calculate driver’s home charging cost is set to $0.300/kWh in Section 4 of the report.

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