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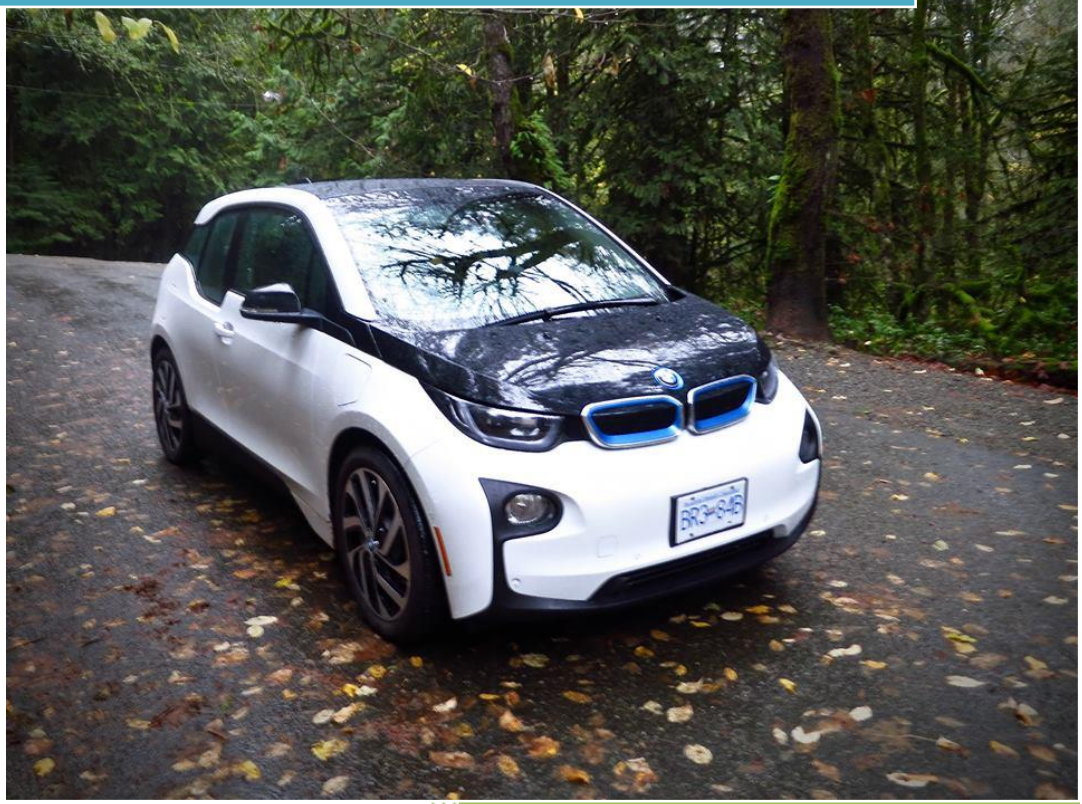
Reporting on Electric Vehicles in Northern B.C. – A Policy Strategy



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Report Limitations

This report is provided for information purposes and is intended for a general guidance. This report was submitted to the Ministry of Energy and Mines as a recommendation only. The findings and recommendations included in this report are those of the author.

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Executive Summary

In 2011, British Columbia launched the Clean Energy Vehicle (CEV) Program, a program designed to encourage the use of plug-in electric vehicles (EV) and provide clean transportation solutions for the province. To date, over $31 million has been allocated for vehicle incentives, infrastructure, fleet assistance, public outreach and awareness, research, training, and economic development. The program has resulted in over 3,300 EVs on the road in B.C. and has helped build Canada's largest charging network.

The majority of EV adoption in B.C. has occurred in the Lower Mainland and Vancouver Island. Northern B.C. has unique challenges that act as a barrier to EV adoption, such as geography, climate, and vehicle type requirements. The purpose of this document is to increase the understanding of these challenges and outline a strategy that will allow the Ministry of Energy and Mines (the Ministry) to support the adoption of EVs in Northern B.C.

For the purpose of this document, Northern B.C. is defined as the area made up by the Cariboo, Nechako, North Coast, and Northeast Development Regions. EVs were defined to include battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs).

There are five sections to this document:

1. A jurisdictional review and an EV market assessment

There are four overarching themes present across the reviewed literature:

1. The importance of outreach and education, both public and within-industry
2. The importance of effective charging infrastructure planning, and its ability to enable longer distance EV travel and decrease "range-anxiety".
3. The limitations of EVs as a result of range-reducing impacts from cold weather and gaps in available model types.
4. The multiple benefits to electrifying transportation, including economic benefits and greenhouse gas emissions (GHG) reductions.

These themes are applied in the resulting strategy: awareness and infrastructure are included as a primary focus in order to mitigate the limitations caused by cold climates and gaps in model types and make the benefits of EVs accessible to northern communities.

An assessment of the current and near-future Canadian EV market confirms a model type gap, with sport utility vehicle (SUV) and minivan EV models only just entering the mainstream market and no concrete claims of light-duty truck models from any vehicle manufacturer.

2. A stakeholder consultation

Consultation[1] with stakeholders from communities in Northern B.C. indicated:

1. Community values tend to center around economic security
2. High-utility vehicles, such as light-duty trucks, are a predominant vehicle type

[1] See Appendix K for details on the consultation process.

3. Long distances between towns results in within-town driving habits and the development of travel hubs between neighbouring cities
4. A consistent interest and support among respondents for policies aimed at making EVs more viable in northern communities

The final strategy reflects these, highlighting the economic benefits of EVs and developing a charging infrastructure plan that accounts for inter-city hubs of travel. The largest of these hubs occur in the Cariboo Development Region, centred around Prince George, and in the Northeast Development Region, encompassing Fort St. John and Dawson Creek and reaching across the Alberta border to Grande Prairie. Further analyses reflected these key messages from stakeholders as well; model type analyses displayed a dominance of light-duty trucks and traffic data revealed the same travel hubs indicated by stakeholders.

Stakeholders also identified three primary barriers to EV adoption:

1. A lack of education and awareness.
2. A lack of charging infrastructure.
3. A lack of high-utility EV models.

3. An analysis of the context of Northern B.C. vehicles and travel patterns as it relates to EVs

Several analyses and assessments were conducted on vehicle types and travel patterns to develop a clear picture of Northern B.C. as it relates to EVs.

A geographic distribution of EVs currently registered in B.C. illustrated the greater frequency of BEVs over PHEVs throughout the province. Every northern Development Region except the North Coast follows this pattern. As only BEV models are equipped to access Level 3 Direct Current Fast Charging (DCFC) stations - PHEV models are currently incompatible with the technology - a greater number of BEV models necessitates the installation of DCFC stations in Northern B.C. There is however, an expectation that northern regions will adopt PHEVs, due to their increased range capabilities, which necessitates the installation of Level 2 charging infrastructure within urban centres and popular travel destinations as well.

Analysing the frequency of vehicle model types in Northern B.C. informed a clearer understanding of the vehicle requirements of those living in the region. There is a strong demand for vehicles of a higher utility (meaning vehicles that are able to carry larger loads and/or travel over rough terrain; includes SUVs, vans, and light-duty trucks). Together, the volume of light-duty trucks and SUVs is more than double the volume of passenger cars in the northern region of the province; there are 41% more light-duty trucks alone than there are passenger cars throughout the entire region. Stakeholder consultations confirmed this, indicating a strong business requirement for high-utility vehicles and a cultural importance of light-duty trucks. This is a significant barrier to the adoption of EVs in Northern B.C., as EVs in these vehicle classes are still largely missing from the current and near-future market.

Northern communities see lower than average commuting times in comparison to the rest of the province. The majority of these commutes (over 80% for five of the eight Regional Districts[2]) are conducted by driving a vehicle. As commutes are so short in duration, ranging from 9-18mins, it is likely that for the average commuter in Northern B.C., their daily route falls within an EVs range (even if that range is reduced significantly due to climate). Such a large proportion of driving over more sustainable methods of commuting (such as transit or cycling) also suggests that the adoption of EVs in Northern B.C. would have a meaningful impact on the reduction of GHG emissions.

Although there are a greater number of light-duty trucks and SUVs in Northern B.C.'s overall fleet, the average Vehicles Kilometers Traveled (VKT) data for the region indicate that small passenger vehicles experience nearly 16% more mileage than light-duty trucks and SUVs. This supports the adoption of EVs, as they would be replacing the vehicles that receive the most mileage, increasing the potential economic benefits in fuel savings and the air quality benefits in reduced tailpipe and GHG emissions.

Mapping out the sites of the highest volumes of Average Annual Daily Traffic (AADT) illustrates the location of two distinct hubs of inter-city traffic. Of the 21 permanent site counts from the Ministry of Transportation and Infrastructure's Traffic Data Program that are located in Northern B.C., six of them see average traffic volumes that surpass 3000 vehicles at least once in the past ten years. Of these, two are centered around Prince George, and one is located at the Alberta border on Highway 2, leading from Dawson Creek to Grande Prairie. These reflect the travel hubs that stakeholders emphasised as being of high priority for northern communities. They also indicate the significance of connectivity to the Alberta border and to surrounding communities to northern drivers.

The number of EVs currently registered in Northern B.C. is low compared to the rest of the province – EV's made up 0.098% of new passenger vehicle sales in 2015 in the region, compared to 0.5% in the rest of the province that same year. If uptake were to increase to 5% of all new passenger vehicle sales represented by EVs by 2020, which is the target the Ministry has set for all of B.C. by the CEV program, Northern B.C. would have an additional 1281 EVs, a large increase from the current number of fewer than 30. If increases in uptake were to remain at the same rate as they have been on average since 2011 however, only approximately 49 new EVs could be expected in Northern B.C. by 2020.

4. A Direct Current Fast Charger (DCFC) Gap Analysis for Northern B.C.

Currently, no Level 3 DCFC infrastructure has been installed in Northern B.C., and the publicly-accessible Level 2 infrastructure that does exist is not sufficient for safe, inter-city EV travel. To address the necessity of inter-city connectivity for Northern B.C., several scenarios were modeled that indicate potential sites for Level 3 DCFC installation that would serve the needs of northern communities and increase EV adoption. As Level 3 infrastructure is necessary for inter-city connectivity, modelling focused on Level 3 deployment; however, Level 2 infrastructure is also a critical component of a viable charging infrastructure plan. Level 2 stations would be required alongside Level 3 stations and in urban centres and popular travel destinations, to serve the needs of PHEV drivers and to increase the safety of a DCFC network.

[2] The B.C. Development Regions are conglomerates of the Regional Districts. Each of the four Development Regions in Northern B.C., as defined by this document, is made up of two Regional Districts.

Scenarios that focus on the locations of high traffic volume, and of the hubs indicated by stakeholders, were developed using a modelling tool that illustrates the range capabilities of EVs while accounting for factors such as temperature and geography.

The first scenario was designed to connect the traffic hub in Prince George. The modelling indicates that 11 DCFC stations are required along Highway 97 leading up to Prince George, and directly west of the city along Highway 16 to Vanderhoof to make EV travel feasible between Prince George and the southern region of the province. This infrastructure deployment serves three of the six sites of high traffic volume.

In the second scenario, eight DCFC stations are required along Highway 97, Highway 29, Highway 2, and Highway 43 (in Alberta) to connect the traffic hub in the Northeast Development Region. This includes two stations located in Alberta, in order to ensure that the high priority route to Grande Prairie is accessible for EV drivers in the region.

A third area of high traffic is located at the B.C. and Alberta border, along Highway 16 leading to Jasper, Alberta. This route would require 3 DCFC stations, one of which is located in Jasper, Alberta, however due to the geographical constraints this route features, it is likely to only be passable in summer months, or for second generation EVs with greater range capabilities.

In order to almost completely connect all of Northern B.C. to the existing DCFC network in the southern region of the province, 44 new DCFC stations are required (including the stations proposed above), three of which are sited in Alberta.

5. Recommendations and Conclusions

The three strategies to support EV adoption in Northern B.C. that this document includes provide four alternate options to focus on:

Option 1: Awareness and strategic infrastructure focused
Option 2: Infrastructure focused
Option 3: Cariboo-specific targeted support
Option 4: Maintain the status-quo

It is recommended that the Ministry aligns any future action with Option 1. An awareness-focused strategy with strategic infrastructure deployment addresses two of the largest barriers. This option features a dynamic education and awareness campaign at its forefront, which reaches all of the major municipalities in Northern B.C. and is tailored specifically to each region.

Along with an awareness campaign, this strategy also includes a strategic two-phased DCFC infrastructure deployment plan, which involves a total of 19 DCFC stations installed along Highway 97 to Prince George and in the Northeast Development Region hub, serving the two areas with the greatest EV adoption and impact potential in Northern B.C. The continuation of vehicle incentives, local auto dealer support, and online education is also included in this strategy.

Without action tailored to the northern regions, it is not likely that Northern B.C. will see a significant increase in EV adoption; the barriers unique to the region are too great. However, the analyses provided

by this document indicate that there is potential for EV adoption Northern B.C. to increase, provided that those challenges are addressed. As this is an initial strategy document only, further research and work with stakeholders is necessary before any specific action is committed to. However, based on the research this document does provide, an awareness-focused approach with strategic infrastructure deployment is recommended as the most effective pathway to support EV adoption in Northern B.C.

Section 1: Introduction and Background Context

a. The B.C. context

The transportation sector in British Columbia accounts for approximately 37% of the province's total greenhouse gas (GHG) emissions. Passenger vehicles represent 38% of the transportation sector's emissions. A transition to zero emission vehicles (ZEVs), including battery electric vehicles, plug-in hybrid electric vehicles, and hydrogen fuel cell electric vehicles, would significantly contribute to B.C.'s goal of reducing GHG emissions. Clean transportation solutions also support economic growth through jobs, technology development, and business opportunities, and supports regional equality and energy security. B.C.'s commitment to supporting ZEV adoption is reflected in its responsibilities as a member of the International ZEV Alliance and of West Coast Electric Fleets, and in its policies, including the Clean Energy Vehicle program.

In August 2016, the provincial government released their Climate Leadership Plan, a document that confirms B.C's commitment to reaching a target of 80% below 2007's GHG emission level by 2050[3]. The Climate Leadership Plan also expressed a commitment to expand the Clean Energy Vehicle program, which is designed to encourage the use of electric vehicles (EVs) in all parts of the province. However, the large majority of EV adoption has occurred in the Lower Mainland and Vancouver Island. The northern region of the province faces a unique set of barriers to EV adoption, which has limited its rate of EV adoption compared to the rest of the province.

b. Acronyms

EV –Electric Vehicle
In this document, EV includes and encompasses all BEVs and PHEVs

GHG – Greenhouse Gas

ZEV – Zero-Emission Vehicle

BEV – Battery Electric Vehicle

PHEV – Plug-in Hybrid Electric Vehicle

FCEV – Hydrogen Fuel Cell Electric Vehicle

DCFC – Direct Current Fast Charger

AADT – Average Annual Daily Traffic

c. Report aim and purpose

This document aims to increase the Province's understanding of the unique challenges that limit Electric Vehicle (EV) adoption in the northern regions of B.C., and provide a pathway that will allow the Ministry

[3] Province of British Columbia. (2016). *Climate Leadership Plan.* Retrieved from https://climate.gov.bc.ca/wp-content/uploads/sites/13/2016/10/4030_CLP_Booklet_web.pdf

of Energy and Mines (hereby referred to as "the Ministry") to overcome these challenges and support electric vehicles in this region. There are five components to this:

1. Provide an overview of the literature and current/near-future market regarding EVs in B.C.
2. Engage with stakeholders such as to better understand the perspectives currently held towards EVs and any associated or perceived barriers that inhibit uptake.
3. Develop a clear picture of the context of EVs in Northern B.C., including the current geographic distribution of EVs, vehicle use and highway use patterns of the region, and future electric vehicle uptake projections.
4. Assess the existing charging infrastructure and develop an early infrastructure strategy that would mitigate any gaps in the existing network.
5. Provide a strategy and list of recommendations as how to best encourage and support the adoption of EVs in Northern B.C.

The findings presented in this document will be used by the Communities and Transportation Branch of the Ministry to inform policy and program development for the Clean Energy Vehicle (CEV) program.

d. Geographic scope

To define what regions are to be considered as "Northern B.C.", this report uses the boundaries that make up B.C.'s Development Regions (Figure 1). The four Development Regions that this document considers to be Northern B.C. include:

- The Cariboo Development Region
- The Nechako Development Region
- The North Coast Development Region
- The Northeast Development Region

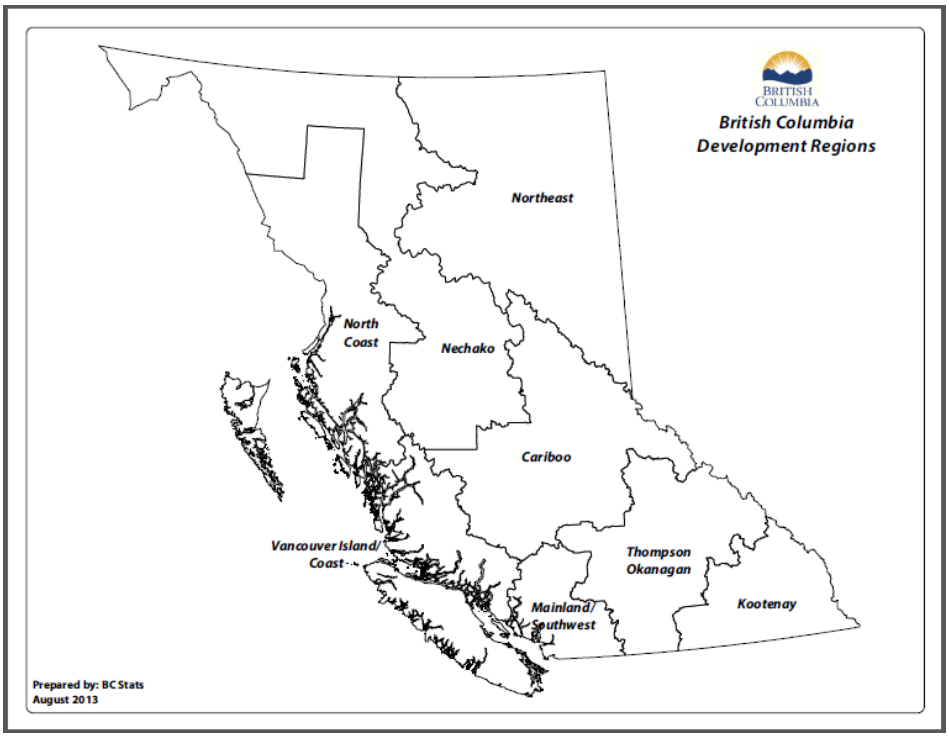

FIGURE 1: BRITISH COLUMBIA'S DEVELOPMENT REGIONS (B.C. STATS 2013)[4]

The Development Regions are aggregations of B.C.'s Regional Districts (Figure 2), and have the same boundaries as the Economic Regions observed by Statistics Canada. Each of the four Development Regions within the focus area is made up of two Regional Districts (Table 1).

TABLE 1: B.C.'S NORTHERN DEVELOPMENT REGIONS AND CORRESPONDING REGIONAL DISTRICTS

Development Region	Regional Districts
Cariboo	Cariboo, Fraser Fort-George
Nechako	Bulkley-Nechako, Stikine
North Coast	Kitimat-Stikine, Skeena-Queen Charlotte
Northeast	Peace River, Northern Rockies

[4] BC Stats. (2013). [Census boundaries development regions reference map]. *British Columbia Development Regions.* Retrieved from http://www.bcstats.gov.bc.ca/StatisticsBySubject/Geography/ReferenceMaps/Census.aspx

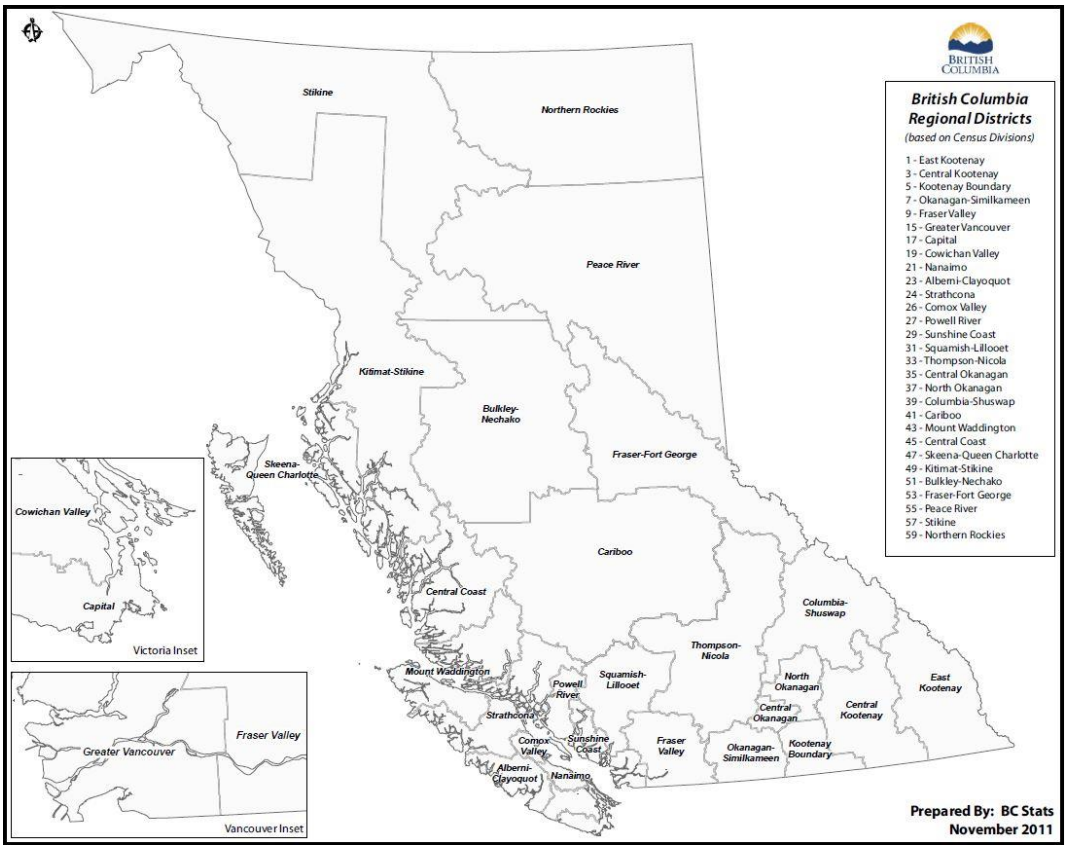

FIGURE 2: BRITISH COLUMBIA'S REGIONAL DISTRICTS (B.C. STATS 2011)[5]

This method of categorizing the north was chosen to simplify vehicle registration data that was provided by the Insurance Corporation of B.C. (ICBC) and analysed to develop a clearer picture of the current vehicle use patterns in the focus region.

Section 2: Jurisdictional and Market Overview Summary

a. Brief literature and BC policy review

To gain a detailed understanding of what is already known about EVs and their context in Northern B.C., a detailed overview of the existing literature and B.C. polices was conducted. The complete review is located in Appendix C.

1. Literature Review

Four overarching themes were present across the reviewed literature:

1. The importance of outreach and education, both public and within-industry.
2. The importance of effective charging infrastructure planning, and its ability to allow longer-distance EV travel and decrease "range-anxiety".

[5] BC Stats. (2013). [Census boundaries regional districts reference map]. *British Columbia Regional Districts.* Retrieved from http://www.bcstats.gov.bc.ca/StatisticsBySubject/Geography/ReferenceMaps/Census.aspx

3. The limitations of EVs from range-reducing impacts from cold weather and from gaps in available model types.
4. The multiple benefits to electrifying transportation, including economic benefits and GHG reductions.

These are important to keep in focus in designing a strategy for Northern B.C. Both awareness and charging infrastructure planning are effective in increasing EV adoption[6,7,8]. Cold temperatures have significant effects on the range of EVs, reducing range by more than half, primarily due to the increased power necessary to heat the passenger cabin[7,9]. The narrow availability of higher utility models of EVs (such as an electric light-duty truck) is also recognized as a limitation[7]. Both of these impact Northern B.C., a region that experiences cold climates and has a need for high utility vehicles. However, the benefits of EVs, including reduced fuel and maintenance costs and improvements in air quality from reduced tailpipe GHG emissions[10], are relevant to Northern B.C. as well.

2. BC policy

Of B.C.'s policies and programs, those that best support clean transportation solutions for the light-duty transportation sector and are most relevant to Northern B.C. include:

1. The Low Carbon Fuel Standard
   A market-based policy that requires a reduction in the carbon intensity of transportation fuels by a specified percentage. This allows a low-carbon and renewable fuel market to build.
2. The Clean Energy Vehicle (CEV) Program[11]
   A program that aims to support the use of ZEV's throughout the province through various means, including providing vehicle purchase incentives, funding charging infrastructure, and funding outreach and awareness through the Emotive[12] campaign.
3. Greenhouse Gas Reductions Target Act
   This legislation sets aggressive targets for reducing greenhouse gases, including an 80% emission-reduction target below 2007 levels by 2050. This provides one rationale of many for the Province to continue supporting clean transportation solutions.

b. EV market assessment

A market assessment was conducted to clearly illustrate the EV market as it currently appears in Canada, and to understand the market's near-future trajectory. A detailed assessment is described in Appendix C.

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[6] Industry Steering Committee. (2009). *Electric Vehicle Technology Roadmap for Canada.* Retrieved from http://publications.gc.ca/collections/collection_2010/nrcan/M154-33-2009-eng.pdf
[7] ICF International. (2016). *Electric Vehicle Investigation.* Retrieved from https://yukonenergy.ca/media/site_documents/Yukon_EV_Investigation_Report.pdf
[8] Community Energy Association. (2013). *Planning for Electric Vehicle Charging Infrastructure: A Toolkit.* Retrieved from http://communityenergy.bc.ca/?dlm_download_category=planning
[9] Hydro Quebec. (2013). *Mitsubishi Electric Vehicle Pilot Project.* Retrieved from http://www.hydroquebec.com/transportation-electrification/pdf/mitsubishi-pilot-project-report.pdf
[10] Pembina Institute. (2010). *Powering the Future.* Retrieved from https://www.pembina.org/reports/powermyride-factsheet.pdf
[11] For more information, refer to http://www.cevforbc.ca/
[12] For more information, refer to http://www.emotivebc.ca/

The significant themes of the assessment were as follows:

1. Although there are more PHEV models available, the majority of registered EVs in the Province are BEV models; 78% of registered EVs are BEVs, and 22% are PHEVS[13].
2. SUV and minivan EV models are just beginning to enter the mainstream market.
3. There have been a few soft claims of light-duty truck EV models made by manufactures; however there is still a clear lack of these higher utility EV models within the current and near-future market.

Section 3: Stakeholder Consultation

a. Consultation purpose

Throughout the research and analysis process, an informal consultation was conducted with stakeholders of four broad groups: residents and governments of Northern communities, vehicle manufacturing associations, EV groups and enthusiasts, and electricity utilities. Consultations occurred primarily through email and over the phone, and approximately 40 individuals were contacted.

The purpose of this consultation was to develop a detailed understanding of the perspectives and attitudes that are currently held towards EVs and charging infrastructure in the northern regions of the province, and any associated or perceived barriers that inhibit EV adoption. This consultation also provided further insight into the EV industry, the location of the province's electricity grid in Northern B.C., and was able to complement and support quantitative data analyses conducted (i.e. within the model-type analysis, the commuting patterns and highway-use assessments).

b. Key themes and lessons learned

1. Northern communities:

Consultation with representatives of Northern communities revealed four key themes:

1. Values of economic security

The key values held by Northern B.C. communities often focus around economic factors, such as jobs and resource development. The economic factors of EV adoption, such as the higher market sale price or the potential fuel savings benefits, are generally of higher priority than environmental factors.

2. The predominance of high utility vehicles

High-utility vehicles, such as SUVs and light-duty trucks, are a common class of vehicle in Northern B.C., which was reflected in the results of the vehicle model-type analysis (Figure 5). One stakeholder describes this as "F150 culture". The importance of high-utility vehicles in the region is two-fold:

(1) They are often required for work-purposes. Several stakeholders noted the need to haul equipment and/or reach remote work sites; one noted that contractors would use a pick-up truck as both their work and personal vehicle and claim the mileage used for work purposes.

[13] Insurance Corporation of British Columbia. (2016). *Annual Vehicle Registration Report* [Data file].

(2) Social pressures: Stakeholders mentioned security concerns of smaller vehicles due to increased highway driving and higher frequencies of commercial vehicles on popular roads, and social stigmas that may discourage owning a smaller vehicle.

3. Isolation resulting in within-town driving and travel hubs between neighbouring cities

The remote nature of Northern communities and the long distances between larger municipalities results in residents remaining in town for the most part, which is reflected through their shorter average commuting times (Figure 7). However, this also means that safe and efficient between-city travel is impossible for an EV without the deployment of supporting infrastructure. Range-anxiety due to a lack of fast-charging infrastructure was emphasised as a key barrier by nearly every stakeholder in this group, as they are necessary for residents of northern communities to travel to neighbouring towns[14]. Travel between neighbouring towns was identified as a priority travel route for all of Northern B.C. In fact, consultation revealed several "hubs" where travel between neighbouring cities is very common, such as

1. The Northeast Hub – covers inter-travel between Fort St. John, Dawson Creek, Tumbler Ridge, and Chetwynd, and extending to Grande Prairie, Alberta
2. The Prince George Hub – covers inter-travel centering around Prince George and including Vanderhoof and Quesnel

These hubs are further supported by the highway-use assessment (Figure 12). Both the stakeholder consultations and the highway-use data suggests that while inter-city connectivity between neighbouring towns is absolutely vital for Northern-B.C., province-wide connectivity may be a lower priority.

4. Consistent interest and support

No respondent was "anti-EV"; rather, many were interested in the potential of EVs in their community and the opportunity to adopt them into municipal fleets.

Consultation also indicated a wide availability of engine block heaters and associated Level 1 outlets in public places throughout the northern region of the province. As emphasised within ICF International's study in the Yukon, the potential for outlets made available for engine block heaters to also be used for Level 1 charging could alleviate some of the concerns over the performance of EVs in cold weather.[15]

Consultation with Northern communities emphasised three main barriers to a wider-EV adoption:

1. A lack of **education and awareness** – there are several negative preconceptions and myths surrounding EVs that are common in Northern B.C., such as the myth that EV's are "fragile". An

[14] PHEVs don't feature the same range limitations as BEVs, however they were not often mentioned as a possible solution over the installation of infrastructure by Northern residents; only two stakeholders in this group mentioned PHEVs as being particularly viable in their region. However, the increased range of PHEVs was often mentioned by EV groups and vehicle manufacturer associations.

[15] ICF International. (2016). *Electric Vehicle Investigation.* Retrieved from https://yukonenergy.ca/media/site_documents/Yukon_EV_Investigation_Report.pdf

unawareness of the cold-weather performance capabilities of EVs is also a significant knowledge gap, and is often a primary barrier to adoption in this region of the province.
2. A lack of **charging infrastructure** – due to the remote nature of B.C.'s northern communities, traveling between cities is significantly difficult without an increase in fast charging infrastructure deployment. Range-anxiety was emphasised as a major barrier to adoption.
3. Lack of **high-utility EV models** – as many northern residents rely on high-utility vehicles for work purposes, the fact that there are currently no comparable electric options within this vehicle class inhibits adoption.

2. Vehicle manufacturing associations, EV groups and enthusiasts, and electricity utilities:

The same barriers highlighted by Northern communities were also emphasised by EV groups and enthusiasts. Connecting Northern B.C. to the existing DCFC network in the south by deploying DCFC stations along Highway 97 was indicated to be especially key in encouraging Northern EV adoption and allowing for provincial-wide travel.

Consultations with vehicle manufacture associations revealed some insight behind the lack of EV models of a higher utility class (e.g. electric pick-up trucks and SUVs). According to vehicle manufacturer associations, high utility EVs are inhibited by battery technology, as a battery large enough to support these kinds of vehicles is currently very unaffordable. While improvements in battery technology will come with time, the industry stakeholders consulted predicted that the first electric trucks and SUVs will arrive as PHEV models.

In terms of the strengths and limitations of B.C.'s current electricity grid, consultations with utilities (namely with B.C. Hydro) noted that non-integrated areas that BC Hydro services face additional challenges that may make EV adoption difficult, such as system limitations, higher energy costs, and lower populations. Regions that rely on diesel generation face increased EV adoption difficulties as well due to the higher GHG impact of electricity use. Most of these areas that are in Northern B.C. are in the Nechako region (close to the Yukon border) and in the North Coast region. Due to the lower population numbers, this study focuses on grid-connected communities.

Section 4: The Northern Context

a. Geographic EV distribution

The geographic distribution of EVs in B.C. was analyzed by using vehicle registration data recorded and provided by ICBC[16]. The ICBC data available for analysis includes the first three characters of a vehicle registration's postal code. Seventeen of these postal codes are considered to be Northern in the context of this document; a detailed table of these postal codes and the Development Region they were classified in is located in Appendix D.

A distribution of EVs based on Development Region (Figure 3), and a distribution of EV type by Development Region (Figure 4), was developed using this data.

[16] Insurance Corporation of British Columbia. (2016). *Annual Vehicle Registration Report* [Data file].

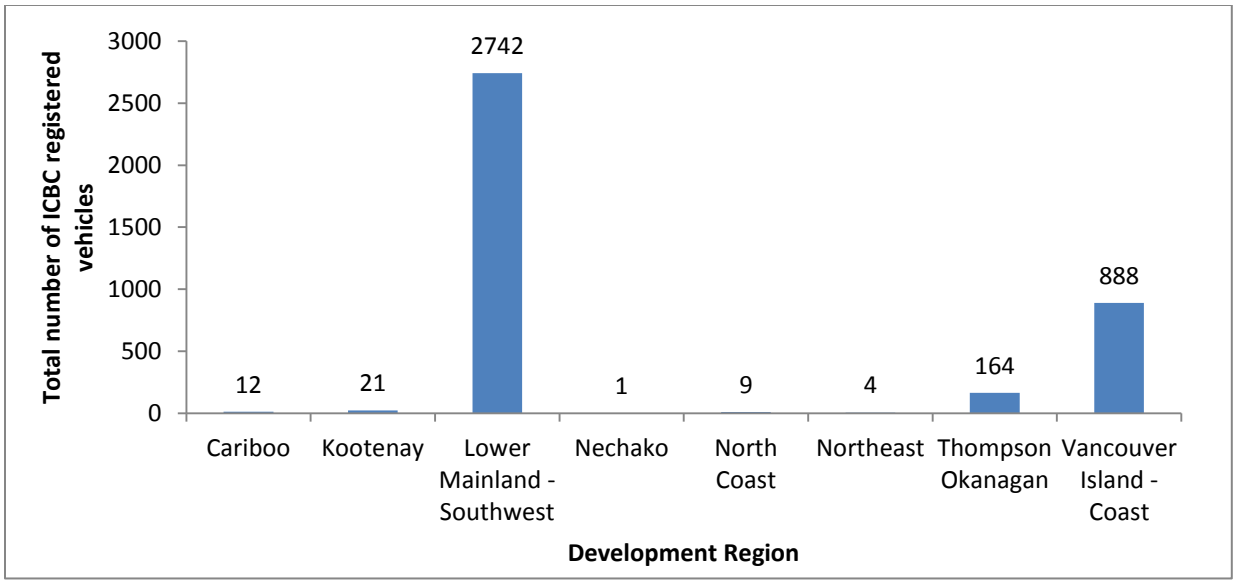
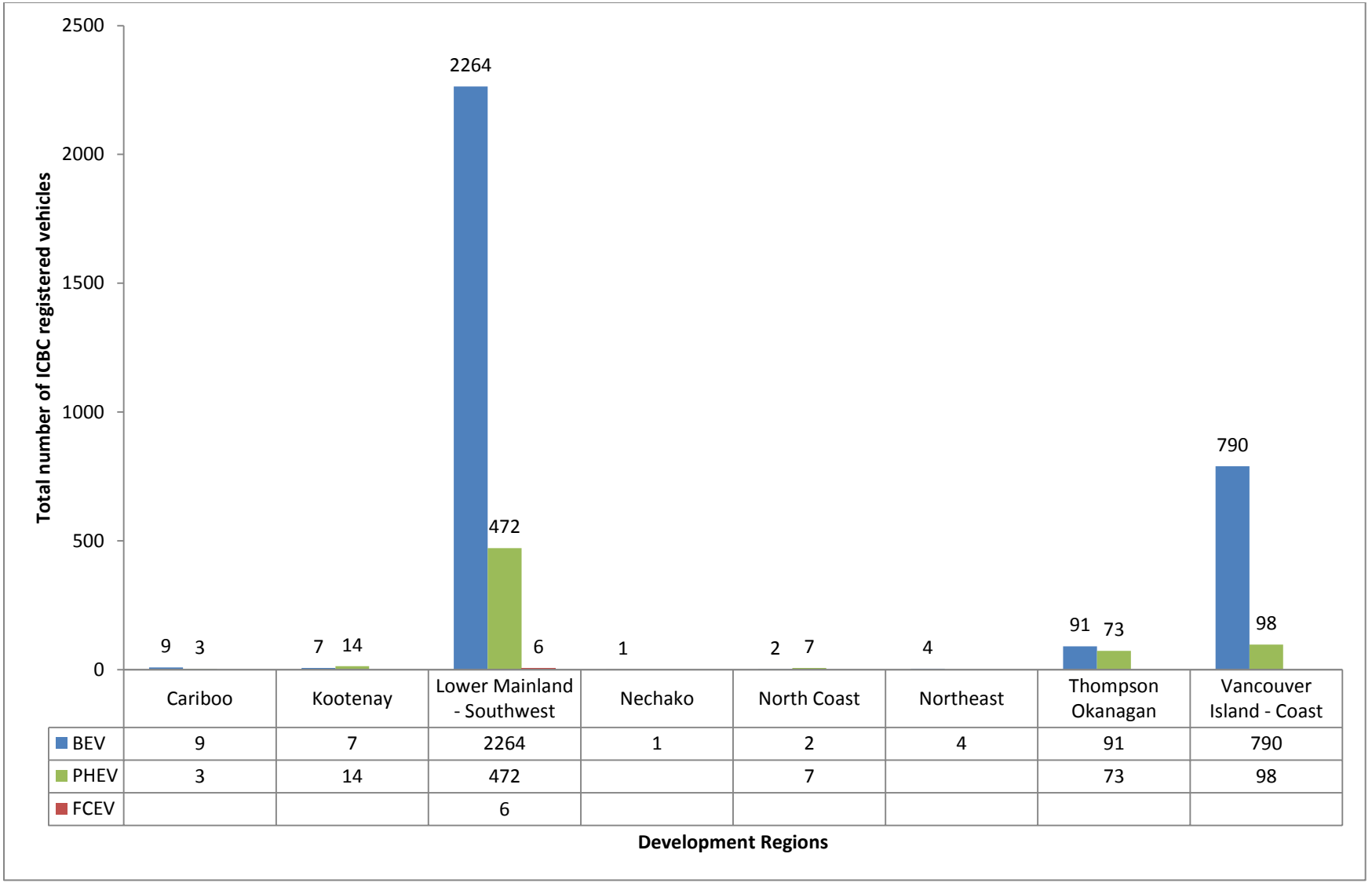


FIGURE 3: GEOGRAPHIC SCOPE OF ICBC REGISTERED EVS FROM OCT 2011 - JUN 2016 (ICBC 2016)

The vast majority of EVs are located in the Lower Mainland and the Vancouver Island regions (Figures 3, 4), illustrating the lack of adoption in the north of the province. For every Development Region except for the Kootenays and the North Coast, BEVs are more frequent than PHEVs (Figure 4). It is important to recognize the comparative demand for BEVs in comparison to PHEVs when developing an EV adoption strategy, as only BEV models are equipped to access DCFC stations currently. It may be ineffective to install a large volume of DCFC stations in regions that are dominated by PHEV models and therefore cannot take full advantage of the Level 3 charging. More BEV models compared to PHEV models necessitates the installation of DCFC stations in Northern B.C., especially in the Cariboo as it is the most southern of the northern regions and therefore would be the first region to connect to the existing DCFC network (which currently stretches across southern Vancouver Island, the Lower Mainland-Southwest, and the Thompson Okanagan). Level 2 stations would also be necessary to support increased PHEV uptake however – further details on a charging infrastructure plan is located in Section 5.



	Cariboo	Kootenay	Lower Mainland - Southwest	Nechako	North Coast	Northeast	Thompson Okanagan	Vancouver Island - Coast
BEV	9	7	2264	1	2	4	91	790
PHEV	3	14	472		7		73	98
FCEV			6					

FIGURE 4: GEOGRAPHIC DISTRIBUTION OF ICBC REGISTERED BEVS, PHEVS, AND FCEVS IN B.C. FROM OCT 2011 - JUN 2016 (ICBC 2016)

b. Current vehicle-use patterns

1. Model-type analysis

Vehicle registration data from ICBC was also used to inform a model-type analysis for Northern B.C. Vehicles were classified into four categories:

1. Passenger car - including any small or mid-size car, such as sports cars, sedans, and coups
2. SUV - including crossover SUVs, compact SUVs, and off-road and heavy duty SUVs
3. Truck - including pickup trucks up to 1 tonne in size
4. Van - including family minivans, full-size vans, and small carrier vans

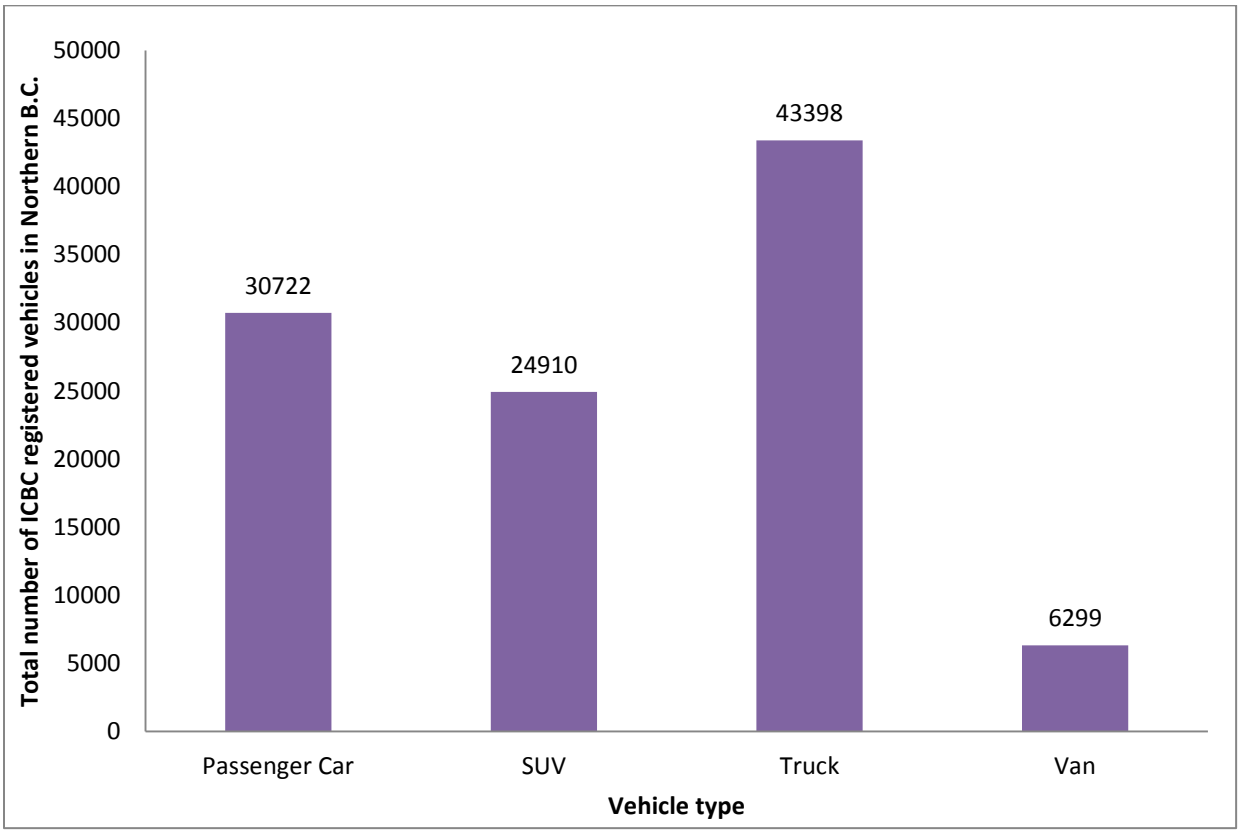


FIGURE 5: DISTRIBUTION OF VEHICLE MODELS REGISTERED BY ICBC FROM OCT 2011 - JUN 2016, IN NORTHERN B.C. (ICBC 2016)

Of the four vehicle types categorized, the most common type in Northern B.C. is trucks, with passenger cars being the second most common, followed by SUVs and vans (Figure 5). The broadness of the SUV category is important to note: vehicles classified as a sports utility vehicle (SUV) cover a wide range of utility, including compact crossover SUVs (i.e. the Kia Soul), off-road SUVs (i.e. the Jeep Wrangler), and full-size SUVs (i.e. the Hummer H2). The majority of SUVs however feature four-wheel drive capabilities and an increased distance between the vehicle cab floor and the road, similar to trucks. Combining the SUV and the truck category would surpass the amount of passenger cars by more than double (Figure 5). In fact, when the distribution of the four vehicle types are separated by Development Region, it

becomes apparent that passenger cars only slightly surpass SUVs in all regions with the exception of the Cariboo (Figure 6).

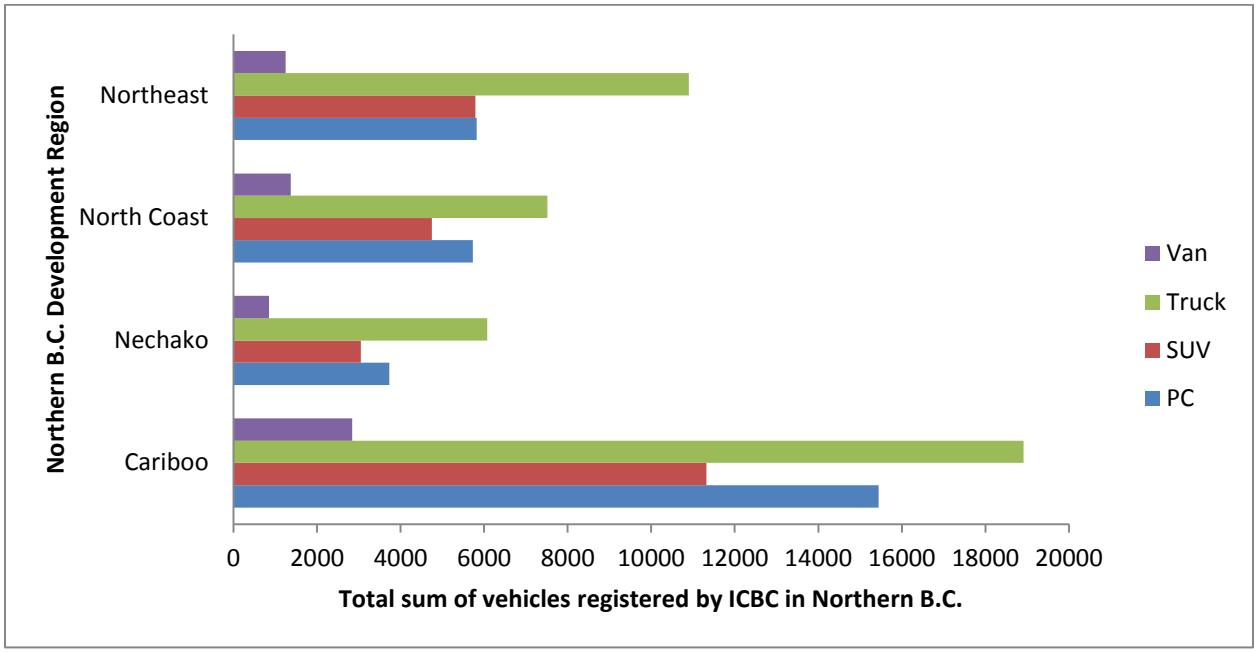


FIGURE 6: DISTRIBUTION OF VEHICLE MODELS REGISTERED BY ICBC FROM OCT 2011 - JUN 2016 ACROSS NORTHERN B.C. DEVELOPMENT REGIONS (ICBC, 2016)

For details on the model type distributions of specific northern postal codes, see Appendix E.

With 41% more light-duty trucks than passenger vehicles on the road in Northern B.C., a clear demand for vehicles that are larger, more durable, and more capable of going off-road is apparent. This demand is also emphasised by stakeholders – there is a strong culture of high-utility vehicles in the northern region of the province that is not reflected in the regions that have seen the greatest EV adoption (i.e. the Greater Vancouver Area and the Capital Regional District). This is a significant barrier to the adoption of EVs in Northern B.C., as there is a lack of EV models available with this level of utility within both the current and the near-term market (as described in Section 2).

2. Commuting patterns

An assessment of current commuting patterns of residents of Northern B.C. was conducted by analysing data from Statistics Canada's 2011 National Household Survey (NHS)[17]. The 2011 NHS data outlines the average commuting duration for B.C.'s Census Municipality Areas (CMAs), and common modes of transportation for B.C.'s Regional Districts. Data for Northern B.C. was collected and illustrated, in Figures 7 and 8, respectively. There was no data available that outlined these patterns per individual Development Region. Data from the Victoria and Vancouver regions were also included to provide contrast.

[17] Statistics Canada. (2011). *National Household Survey* [Data file]. Retrieved from https://www12.statcan.gc.ca/nhs-enm/2011/dp-pd/prof/search-recherche/lst/page.cfm?Lang=E&TABID=1&GEOCODE=59

As depicted in Figure 7, residents of northern municipalities experience shorter commutes than those residing in Victoria or Vancouver. While both Victoria and Vancouver see commutes averaging over 20 minutes in length, all seven CMAs in the northern region of the province do not experience commuting times longer than 18 minutes (Figure 7). The majority of commuters in Northern B.C. (over 80% of all commuters in five of the eight Regional Districts in the north) do so by driving a vehicle (Figure 8). It can be assumed, therefore, that the average commute for residents of Northern B.C. is a drive that is less than 20 minutes in length.

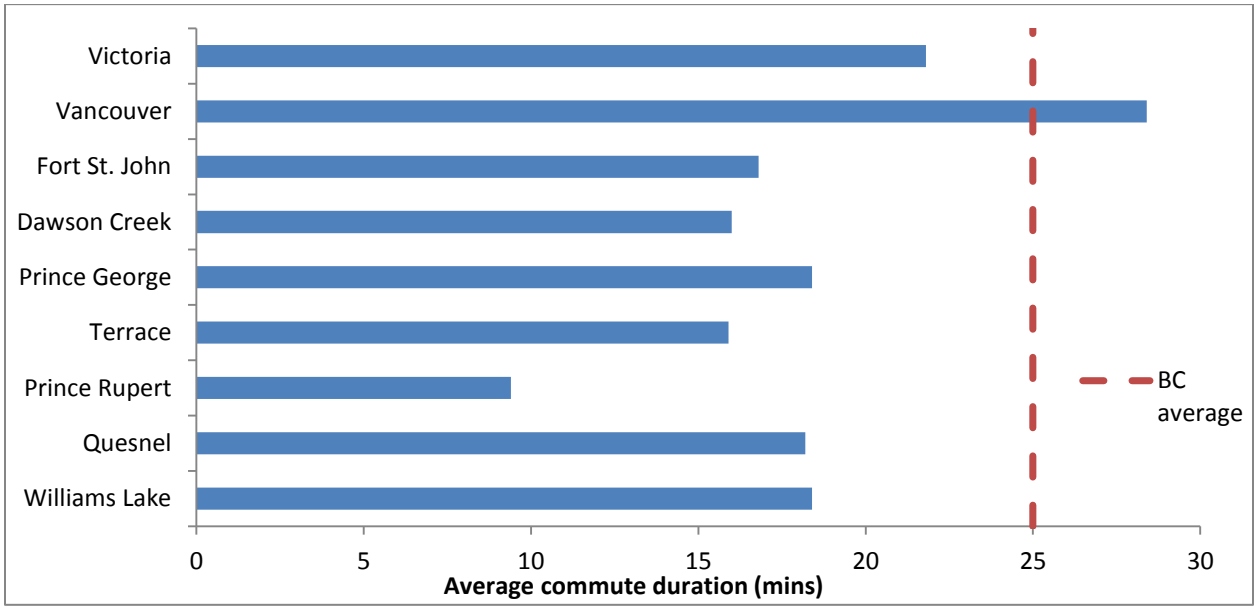


FIGURE 7: AVERAGE COMMUTING DURATION (MINUTES) FROM HOME TO WORK FOR BC CENSUS MUNICIPALITY AREAS (NHS, STATISTICS CANADA 2011)

While the range of an EV depends on a multitude of factors, including external temperature, topography, and driving behaviour, the fact that the average commute throughout Northern B.C.'s CMAs involves a short drive is encouraging for increasing EV adoption; it suggests that for the average commuter living in a CMA in the northern region of the province, their daily commute falls within a EVs range (even a reduced range brought on by colder temperatures).

As previously mentioned, Northern B.C. sees a greater proportion of commuters who drive versus those who cycle or take transit than we see in the Capital Regional District or the Greater Vancouver district (Figure 8). This suggests that supporting the adoption of EVs in Northern B.C. would have a meaningful impact on the province's efforts to decrease GHG emissions as such a large proportion of the North's population commutes via a personal vehicle. Something to note is the high percentage of commuters who walk in the Stikine and the Skeena-Queen Charlotte Regional Districts, resulting in fewer drivers in comparison to the other six northern regions (Figure 8). This could suggest that these districts are already engaged in sustainable transportation modes, and encouraging EV adoption would have a smaller environmental and economic impact.

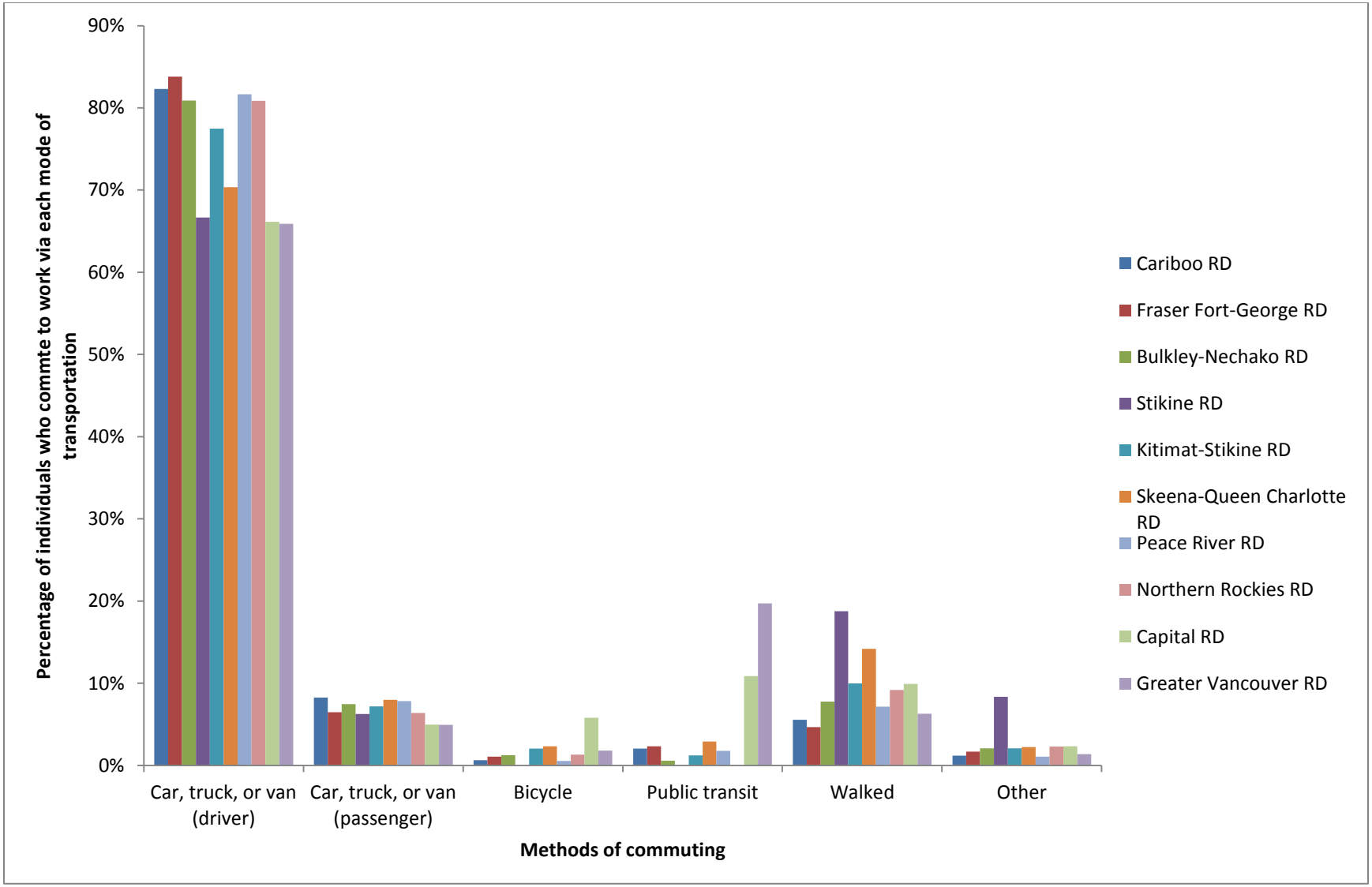


FIGURE 8: PERCENTAGE OF INDIVIDUALS WHO COMMUTE FROM HOME TO WORK VIA SPECIFIC MODES OF TRANSPORTATION WITHIN BC REGIONAL DISTRICTS (NHS, STATISTICS CANADA 2011)

3. Vehicles Kilometers Traveled (VKT) analysis

The Community Energy and Emissions Inventory (CEEI) collects and publishes data that represents the energy consumption and GHG emissions from the on-road transportation sector, among others, for local governments. To discover and illustrate the level of use that differing vehicle classes receive in the northern region of the province, average Vehicles Kilometers Traveled (VKT) data from 2010 for the eight Regional Districts that make up Northern B.C. was collected[18]. Details on how the data was collected and analysed is included in Appendix F.

Small passenger cars see the largest VKT values in Northern B.C., approximately 16% larger than the average VKT of light trucks, vans, and SUVs (Figure 9). This is true for all four Development Regions (Figure 10) and every Regional District as well, with the exception of the Cariboo Regional District (Figure 11). Even in the Cariboo Regional District however, small passenger cars have an average VKT value only slightly under large passenger cars and light trucks, vans, and SUVs, with the latter two classes almost even (Figure 11).

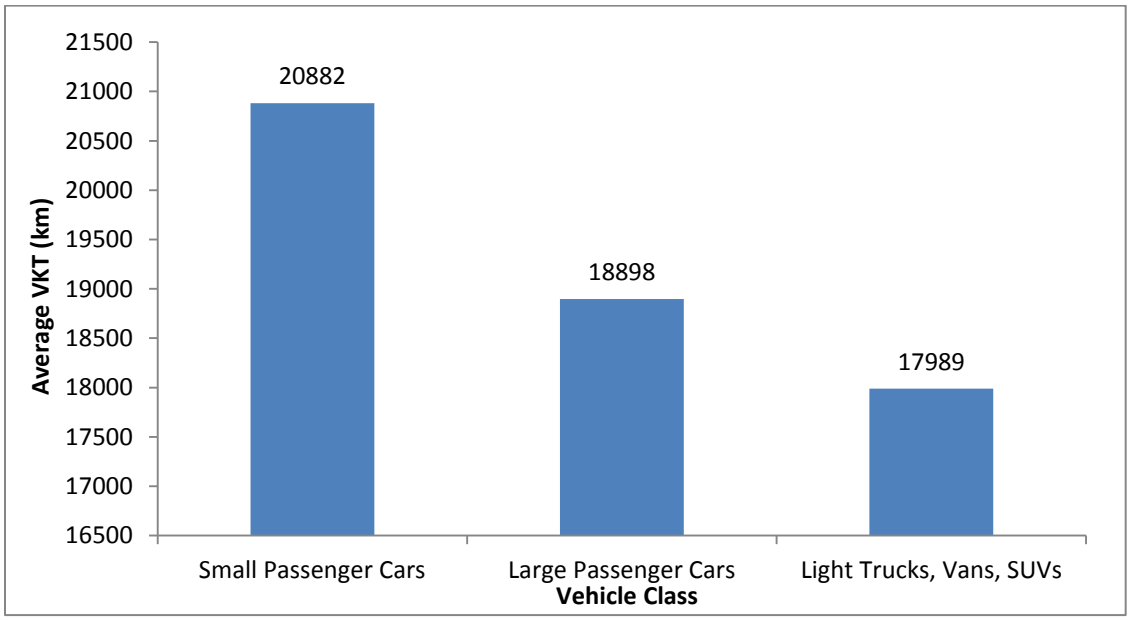


FIGURE 9: AVERAGE VKT (KM) OF THE VEHICLE CLASSES IN THE LIGHT-DUTY FLEETS OF B.C.'S NORTHERN DEVELOPMENT REGIONS (CARIBOO, NECHAKO, NORTH COAST, AND NORTHEAST) IN 2010 (CEEI 2014)

[18] Community Energy & Emissions Inventory. (2014). *Complete 2007 and 2010 CEEI dataset* [Data File]. Retrieved from http://www2.gov.bc.ca/gov/content/environment/climate-change/reports-data/community-energy-emissions-inventory

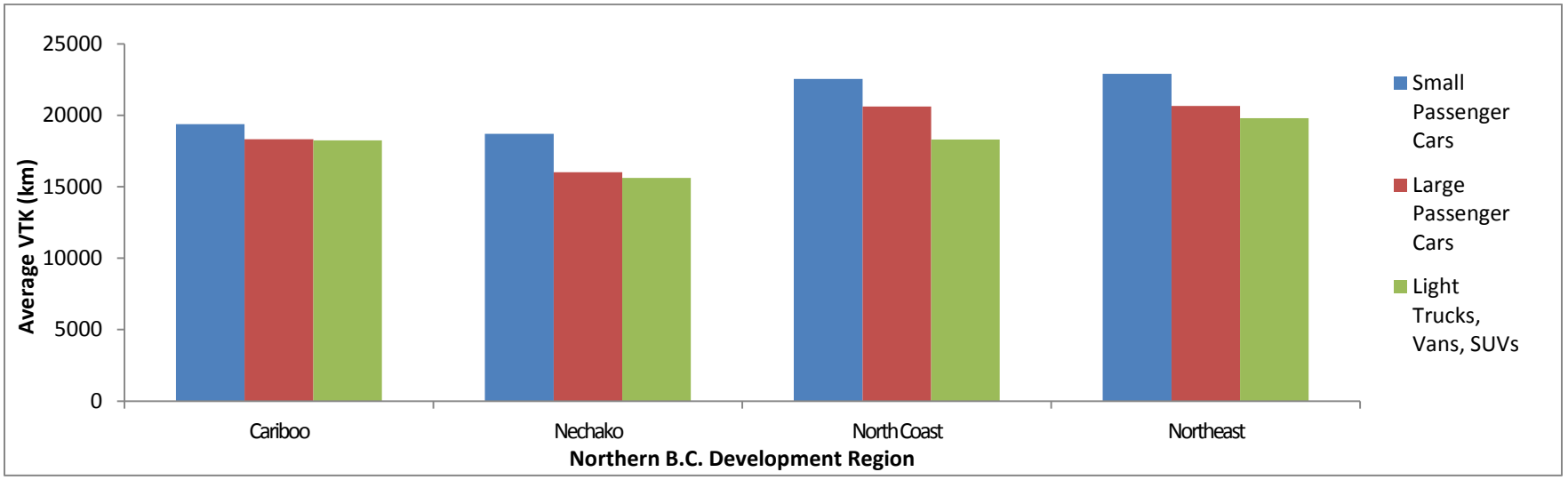


FIGURE 10: AVERAGE VKT (KM) OF VEHICLE CLASSES IN THE LIGHT-DUTY FLEETS OF NORTHERN B.C. DEVELOPMENT REGIONS IN 2010 (CEEI 2014)

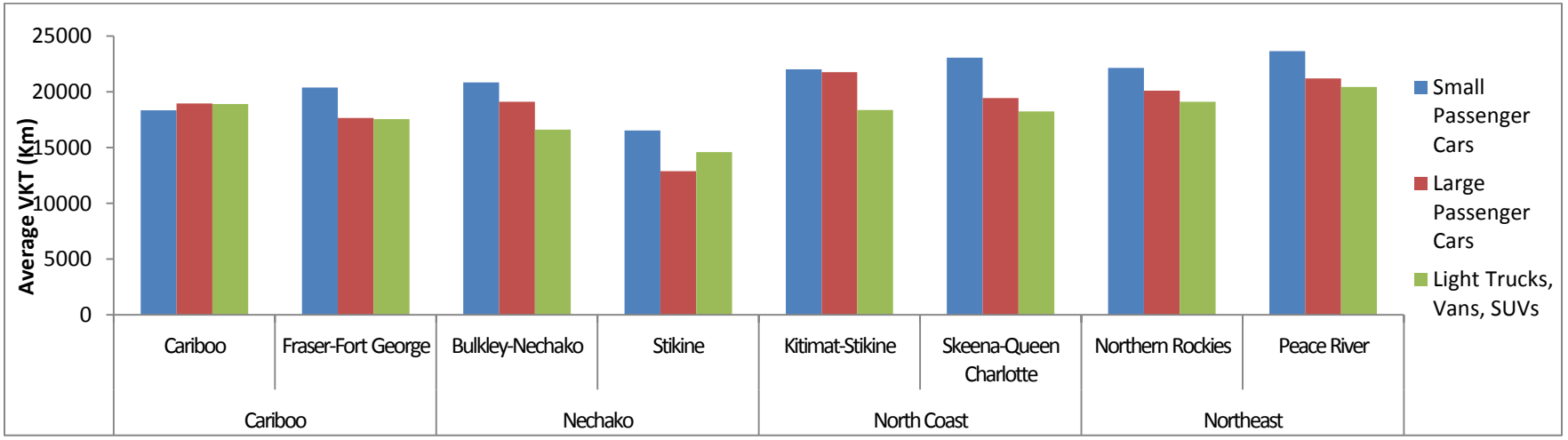


FIGURE 11: AVERAGE VKT (KM) OF VEHICLE CLASSES IN THE LIGHT-DUTY FLEETS OF NORTHERN B.C.'S REGIONAL DISTRICTS IN 2010 (CEEI 2014)

Despite there being a greater amount of light-duty trucks in Northern B.C.'s overall fleet, as illustrated in Figure 5, this data suggests that small passenger vehicles are driven further distances on average, experiencing greater usage and mileage than light duty trucks. As small passenger cars are readably replaceable with EV models currently on the market, there is an immediate opportunity to provide meaningful economic and air quality benefits through reduced fuel costs and reduced tailpipe emissions by supporting EV adoption in the northern region of the province.

c. Highway-use assessment

In order to develop a fuller understanding of the vehicle use patterns in Northern B.C., a highway-use assessment was conducted using transportation data from the Ministry of Transportation and Infrastructure's (MOTIs) Traffic Data Program[19]. Data collected at MOTI's permanent count sites, which includes data on traffic volumes, speed, and vehicle classification that is collated in daily, monthly, and annual reports, were analysed to determine the priority travel corridors in the north. There are 21 permanent count sites[20] located within the focus region, whose locations are illustrated on Figure 12 with green and white dots. Data from ten-year annual reports (containing information from 2006-2015) was analysed for each of the 21 sites.

Of the 21 permanent sites, only six record Average Annual Daily Traffic (AADT) values that surpass 3000 vehicles for at least one year between 2006 and 2015. These six sites with large AADT volumes are denoted with green dots in Figure 12, and their names are typed in bold; the other 15 sites are denoted with white dots.

The six sites with the largest AADT volumes are (from the most southerly to the most northerly):

1. P-41-2NS – Highway 97, south of Quesnel
2. P-41-1NS – Highway 97, south of Prince George
3. P-23-2EW – Tete Jaune Cache junction, leading into Alberta
4. P-42-2EW – Highway 16, east of Vanderhoof
5. P-43-1NS – Highway 2, leading into Alberta
6. P-44-1NS – Highway 97, north of Fort St. John

These priority corridors illustrate the importance of connectivity between the B.C. and Alberta border (seen at sites P-23-2EW between Tete Jaune Cache and Jasper, and P-43-1NS between Dawson Creek and Grande Prairie), and the routes leading to and surrounding Prince George. Site P-42-2EW between Prince George and Vanderhoof is especially a point of interest, as it saw the largest AADT volume out of all 21 sites. The site immediately west to it however between Vanderhoof and Burns Lake (P-45-1EW) did not see the same high volume. This suggests that individuals are travelling primarily between Prince George and the Vanderhoof and Fort St. James area, and that this is a significant route for locals of the region.

[19] B.C. Ministry of Transportation and Infrastructure. (2016). [Interactive map of traffic count sites with corresponding traffic data reports]. *Traffic Data Program GIS Application.* Retrieved from https://prdoas3.pub-apps.th.gov.bc.ca/tsg/

[20] See Appendix L for details on the 21 permanent count sites in Northern B.C.

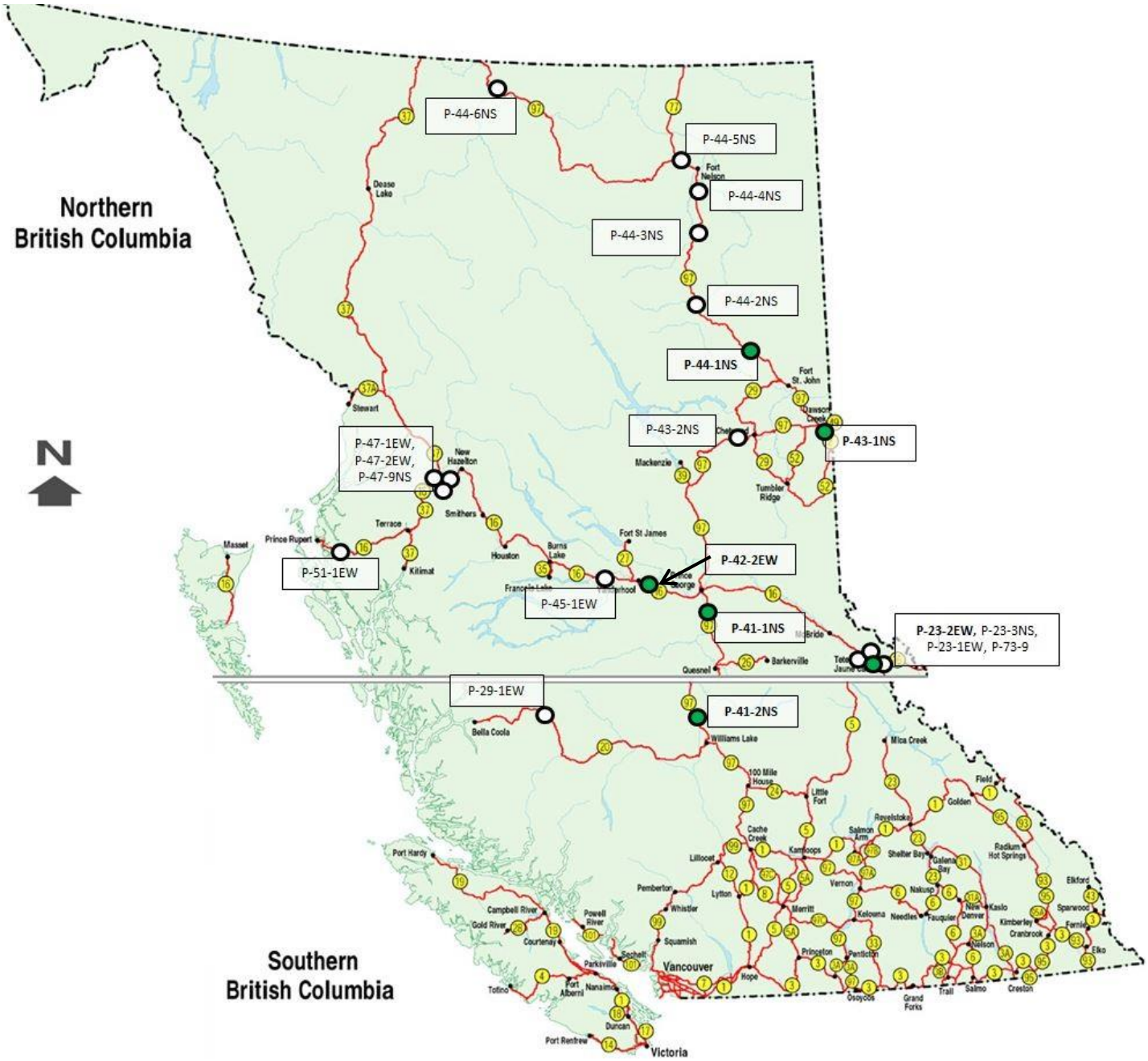


FIGURE 12: THE LOCATIONS OF THE 21 PERMANENT SITE COUNTS FROM MOTI'S TRAFFIC DATA PROGRAM[19] LOCATED IN NORTHERN B.C. SITES THAT SEE AN AADT GREATER THAN 3000 FOR AT LEAST ONE YEAR BETWEEN 2006-2015 ARE IN GREEN AND WRITTEN IN BOLD; ALL OTHER SITES ARE IN WHITE. BACKGROUND MAP PROVIDED BY MOTI[21].

[21] B.C. Ministry of Transportation and Infrastructure. (2016). [Simple maps of major highway routes in B.C.]. *Numbered highways in British Columbia (simple map).* Retrieved from http://www.th.gov.bc.ca/popular-topics/maps/bcmaps.htm#numbered

The locations of the six sites of high AADT volume reflect the traffic hubs indicated by stakeholders. Site P-43-1NS that sees high levels of traffic is located within the Northeast travel hub on Highway 2 leading into Grande Prairie, a route stressed as being one of high priority for residents in Fort St. John and Dawson Creek. Sites P-41-1NS and P-42-2EW surrounding Prince George see high levels of traffic as well, confirming the importance of connectivity between neighbouring cities that stakeholders from the area emphasised.

The most northerly site of high AADT volume was P-44-1Ns, north of Fort St. John (Figure 12). However, it is important to note that only 41% of the traffic passing this site is classified as "type 1 vehicles" by MOTI, defined as vehicles between 0 - 6m in length (which encompasses all passenger cars, SUVs, light-duty trucks, and vans)[22]. This is low compared to the 73% of traffic composed of type 1 vehicles at site P-42-2EW between Prince George and Vanderhoof. 28% of traffic at site P-44-1NS consists of "type 2 vehicles" (vehicles 6 - 12.5m in length) – type 2 vehicles make up less than 10% of the traffic at site P-42-2EW. This suggests that a significant amount of traffic passing this site is made up of commercial transport vehicles, and out of this report's scope.

The most southerly high traffic site, P-41-2NS located south of Quesnel, also saw a relatively low proportion of traffic coming from type 1 vehicles in comparison to some of the other high traffic sites, making up only 62% of the overall volume[22]. In comparison, type 1 vehicles at site P-41-1NS located north Quesnel, occupies 70% of the roadway. A decrease in type 1 vehicles south of Quesnel suggests a low occurrence of light-duty passenger vehicles travelling between Northern and Southern B.C. in comparison to the level of travel exhibited by these vehicles on routes surrounding Prince George and the Northeast hub.

d. Future vehicle replacement and EV uptake projections

To determine the volume of annual vehicle sales in Northern B.C., ICBC's vehicle registration data was again referred to[23]. The data was filtered to only include passenger cars – this resulted in some light-duty trucks, vans, and SUVS being omitted from this assessment, but as the vast majority of current and near-term EV models are passenger cars, it is assumed that the potential to replace conventional vehicles with EVs is the greatest among new passenger vehicle sales.

Table 2 displays the volume of annual passenger car sales, EV sales volumes, and the percentage of EV uptake in Northern B.C. These estimates were made using the model year data recorded by ICBC; more details on the methodology are included in Appendix G.

Annual sale estimates were calculated for all of Northern B.C. (i.e. the Cariboo, Nechako, North Coast, and Northeast Development Regions) for the years 2011-2015 (Table 2). 2011 was the earliest year included as it is the year the CEV program first launched, and that mass market EVs were broadly available. The ICBC registration data used only includes registration information up to the end of the second quarter of 2016 (June 30th); as such, the number of passenger cars with a 2016 model year was doubled to project 2016's annual sales volume (Table 2).

[22] See Appendix L.
[23] Insurance Corporation of British Columbia. (2016). *Annual Vehicle Registration Report* [Data file].

TABLE 2: ANNUAL SALES VOLUMES OF PASSENGER CARS IN NORTHERN B.C. ACCORDING TO MODEL YEAR OF REGISTERED VEHICLES (ICBC, 2016)

Year	Passenger cars	EVs	Total	EV %
2011	5866	0	5866	0.000%
2012	6462	6	6468	0.093%
2013	7035	5	7040	0.071%
2014	7731	2	7733	0.026%
2015	7160	7	7167	0.098%
2016	3659*2 = 7318	6		
		Total: 26		

The data in Table 2 was then extrapolated to project future sales volumes of passenger vehicles and EVs in Northern B.C., illustrated in Table 3. Several scenarios of varying EV penetration into passenger vehicle market sales for Northern B.C. were also developed. A detailed explanation of these processes is located in Appendix G.

TABLE 3: PROJECTION OF PASSENGER CAR VEHICLE SALES IN NORTHERN B.C. FROM 2016-2020, AND POTENTIAL EV UPTAKE SCENARIOS (ICBC, 2016)

Year	Annual sales projection	Static 0.098% EV uptake	12% annual increase	0.5% EV for 2020	1% EV for 2020	2% EV for 2020	5% EV for 2020
2016	7318.0	7.1	7.8	13.1	20.4	35.0	78.9
2017	7713.7	7.5	8.7	20.0	35.4	66.2	158.8
2018	8130.9	7.9	9.7	27.6	52.0	100.8	247.1
2019	8570.5	8.4	10.9	36.0	70.2	138.8	344.5
2020	9034.0	8.8	12.2	45.2	90.3	180.7	451.7
Total		**39.8**	**49.3**	**141.7**	**268.3**	**521.5**	**1281.0**

If the percentage of EV penetration into passenger vehicle sales that occurred in 2015 (0.098%) was to remain constant over the next five years, EV sales in Northern B.C. wouldn't expect to exceed 9 sales a year for the next five years (Table 3). A more realistic projection sees a growth in the percentage of sales that are EV models. According to the available ICBC data on registered vehicles, Northern B.C. has been seeing an approximate average annual increase of 12% in its EV fleet since 2012. While this appears to be a relatively high increase, as the number of EVs are of such a small magnitude this rate would only result in an additional 49 vehicles to Northern B.C.'s EV fleet by 2020 (Table 3).

However, there is an opportunity for large increases in the magnitude of EVs in the north. As of the end of June 2016, there are 26 EVs registered in Northern B.C. (Table 2). By increasing uptake from 0.098% to 0.5% of all passenger vehicle sales, in five years Northern B.C. could expect to add an additional 142 vehicles to their current fleet, an increase of over five times the current amount (Table 3). A further

increase in EV uptake to 1% of all new passenger vehicle sales is predicted to result in 268 additional EVs after five years, which rises to 522 EVs if uptake increases by another percent (Table 3).

By raising uptake to 5% of all new sales, which is the CEV program's 2020 target uptake level for B.C. as a whole, 1281 new EVs can be expected to arrive in Northern B.C. in five years (Table 3).

Section 5: Level 3 Charging Infrastructure

a. Methodology

Currently, data shows a preference for BEV models over PHEV models in Northern B.C. (Figure 6), which supports the decision to focus charging infrastructure modeling on DCFC deployment which can currently only be accessed by BEV models and is also currently unavailable for northern residents. In addition, DCFC planning is more intensive than Level 2 or 1 infrastructure planning, as the ranges of BEVs is heavily influenced by extreme climates and geography, characteristics that are unique to the North. This document does however acknowledge the potential for northern EV adoption to favour PHEVs in the future, especially as the EV market in the North is only in its early stages. In order to plan for this possibility, it is important to note the necessity of Level 2 infrastructure investments. Level 2 installations could follow a similar planning method as what is used in the rest of B.C., resulting in publicly available Level 2 stations deployed in locations where vehicles are parked for prolonged periods of time (i.e. urban centre parking lots, parking spaces at popular travel destinations, etc.). In addition, Level 2 infrastructure is also valuable as support for Level 3 stations for BEVs travelling longer distances – as emphasised in the Fraser Basin Council's DCFC Gap Analysis[24], installing Level 2 stations alongside DCFC station is an important support system in case a DCFC station were to break down. It is assumed that all of the below infrastructure scenarios include supporting Level 2 stations installed with DCFC deployment.

To analyse the existing charging infrastructure in Northern B.C. and to conduct an infrastructure gap analysis, a modelling tool developed by Kelly Carmichael, Research Analyst with BCIT, was used. This tool, the "EV Infrastructure Planning Assistant," illustrates the range capabilities and limitations of various EV models by factoring in level of charging infrastructure, road characteristics (elevation, topography), temperature adjustments, battery capacity, age of the vehicle, passenger load, speed, EV energy consumption, and battery charging curves. The lines that connect stations are colour-coded:

1. Blue lines indicate that the design vehicle is able to travel that route at posted speed limits without any danger of running out of charge.
2. Yellow lines indicate that the design vehicle is able to travel that route at posted speed limits, but may arrive at the destination with a low battery warning.
3. Red lines indicate that the design vehicle is able to travel that route at posted speed limits, by may arrive at the destination with a very low battery warning.
4. Black lines indicate that the design vehicle is only able to travel that route at posted speed limits in one direction (likely downhill).

[24] Fraser Basin Council. (2015). *A Gap Analysis for B.C.'s Electric Vehicle Direct Current Fast Charging Network.* Retrieved from http://pluginbc.ca/wp/wp-content/uploads/2015/10/BC-DCFC-Gap-Analysis-Report-FBC_Aug-2015.pdf

A detailed explanation of the tool is included in Appendix H.

In mapping out various scenarios, the design vehicle chosen was a 2016 Nissan LEAF (having a 30kWh battery capacity). A BEV was chosen over a PHEV model to ensure the analysis accounts for their increased range limitations, and the 2016 LEAF model was chosen specifically to better reflect the trajectory of future technology improvements. With second generation EVs beginning to enter the market, such as the 2017 Chevrolet Bolt and the 2017 Nissan LEAF, EV ranges will increase. As current EV adoption in Northern B.C. is so low, it is assumed that the majority of EVs that will be adopted into the region will be newer models with larger ranges. The 2016 LEAF features a range capability that closer resembles these new EVs, while still planning for some current models.

For all mapping scenarios (unless otherwise stated), temperature was set at -20°C. As average temperature lows in Prince George tend to fall between -5°C and -20°C, this setting was chosen to account for winter travel and ensure any "worst case" scenarios were planned for. Vehicle age was set at two years, the age 2016 LEAF models will be in 2018, when second generation LEAF models are likely to fully reach B.C. markets, and vehicle passenger load was set at one, to allow some flexibility.

The Ministry has identified four guiding principles for DCFC deployment, as follows:

1. Connect priority travel corridors across the province, where "priority travel corridors" are defined as travel corridors that either have a large volume of commuter traffic, support cross jurisdictional travel, or support tourism within B.C.
2. Ensure infrastructure deployment allows for safe travel in the province.
3. Support regions with dense plug-in electric vehicle adoption.
4. Maximize population areas served.

These principles are used as a framework for the following gap analysis. These principles were used to guide a gap analysis of B.C.'s current DCFC network conducted by the Fraser Basin Council in 2015, and stakeholders involved agreed that they were appropriate[25]. Due to low EV adoption rates and smaller population sizes, the third and fourth principles were not as heavily referenced as the first and second in this Northern region gap analysis.

b. Existing charging infrastructure

There is currently a limited volume of charging infrastructure available in the focus region. There are approximately 37 Level 1 and 2 public chargers currently available in Northern B.C., hosted by 17 separate communities[26]. As there are no Level 3 DCFC stations installed north of Highway 1, all EV charging in Northern B.C. currently occurs with Level 1 (110V) or Level 2 (240V) infrastructure, significantly increasing the length of any attempted trip. The various Level 1 and Level 2 stations that are currently installed are insufficient for a EV to travel further north than the village of Clinton under the set conditions (Figure 13), or past Williams Lake in optimal summer weather of 21°C (Figure 14). It is

[25] Fraser Basin Council. (2015). *A Gap Analysis for B.C.'s Electric Vehicle Direct Current Fast Charging Network.* Retrieved from http://pluginbc.ca/wp/wp-content/uploads/2015/10/BC-DCFC-Gap-Analysis-Report-FBC_Aug-2015.pdf

[26] The locations of existing charging infrastructure were determined by referring to plugshare.com

clear that in order to make EV travel viable to and from, and within, the northern region of the province, further charging infrastructure deployment is necessary.

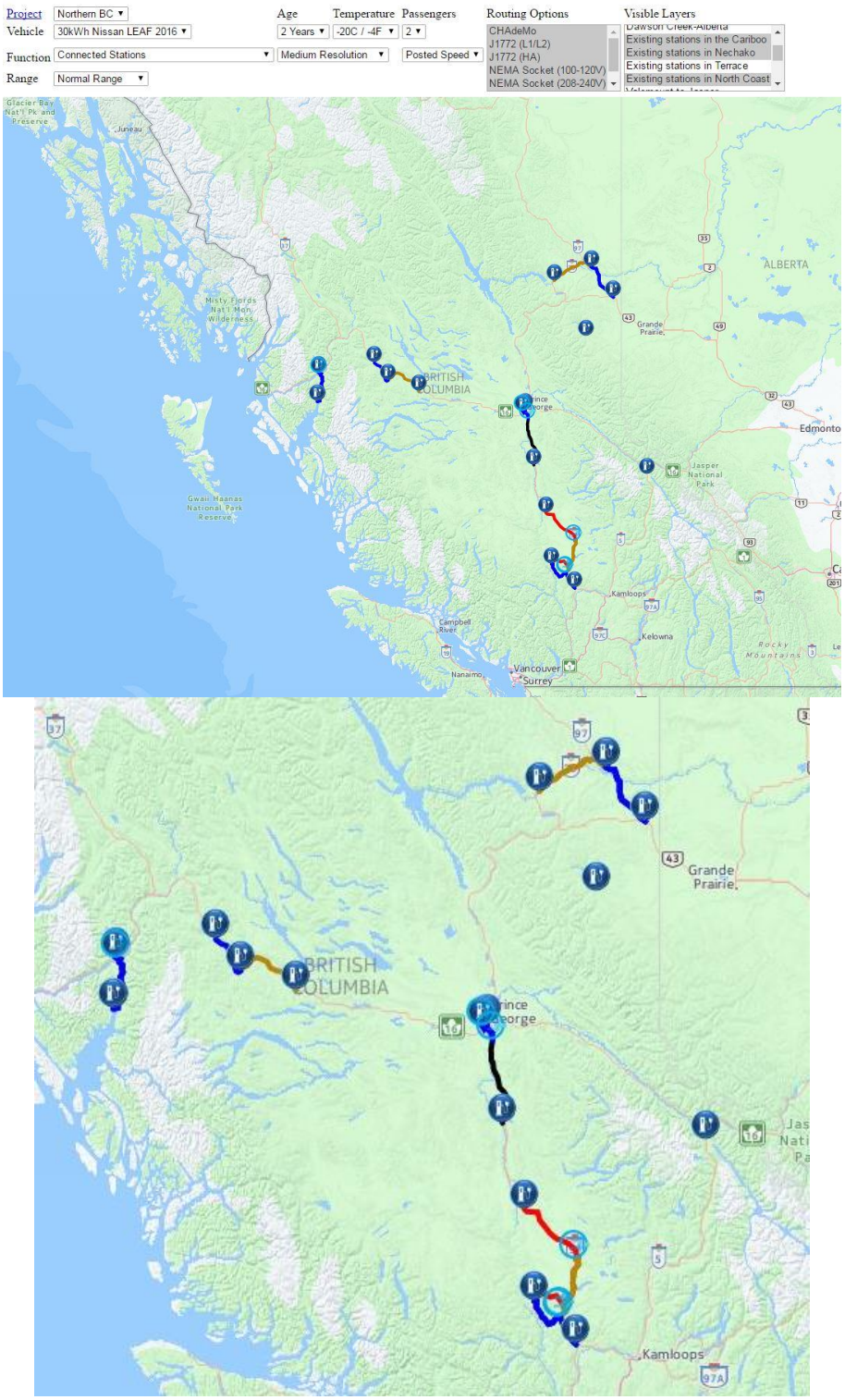


FIGURE 13: CHARGING INFRASTRUCTURE CURRENTLY INSTALLED IN NORTHERN B.C. – BELOW IMAGE IS A CROPPED VERSION OF THE ABOVE, FOCUSING SPECIFICALLY ON THE EXISTING INFRASTRUCTURE

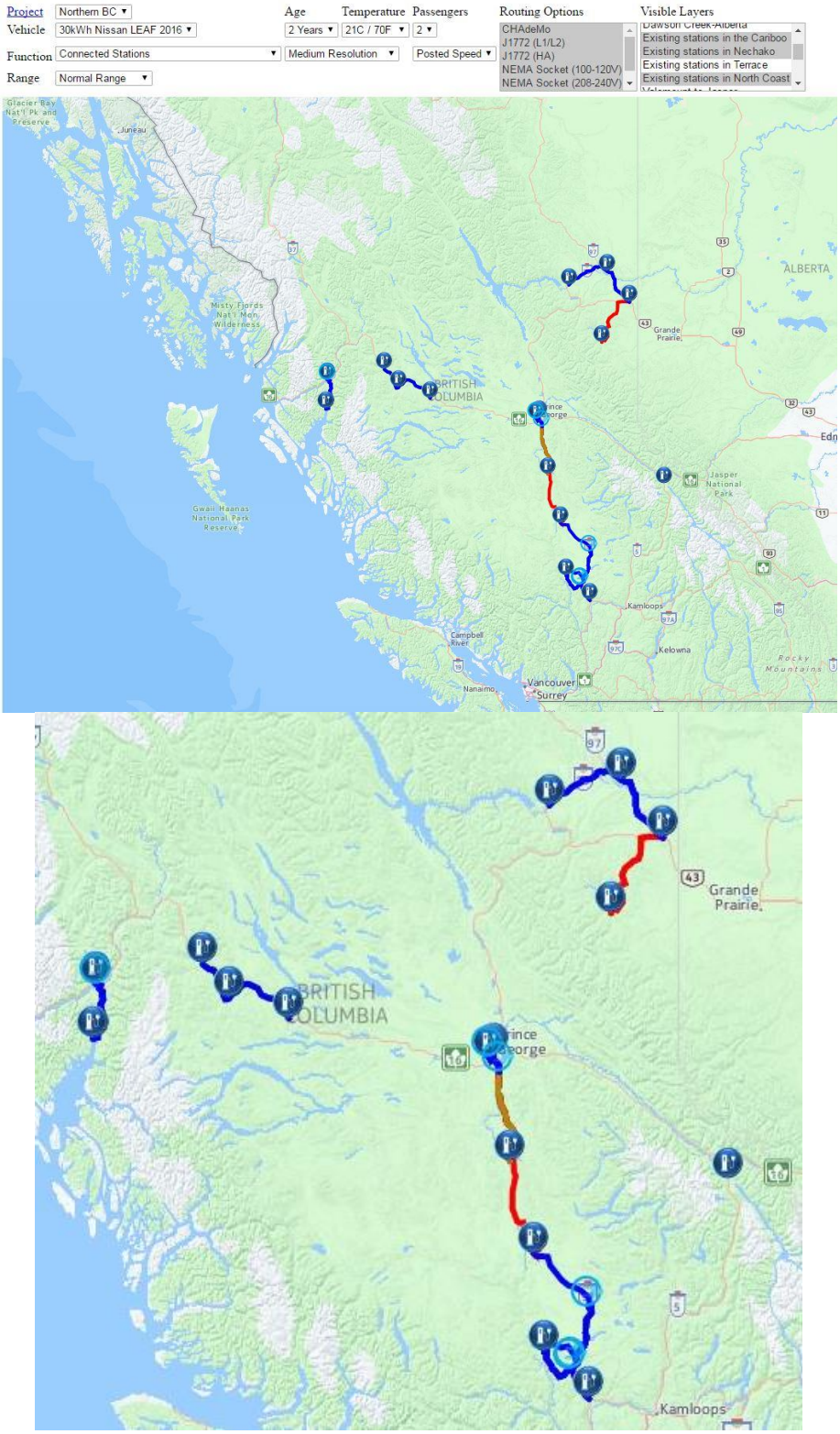


FIGURE 14: CONNECTIVITY OF EXISTING CHARGING INFRASTRUCTURE CURRENTLY INSTALLED IN NORTHERN B.C. UNDER OPTIMAL TEMPERATURE CONDITIONS – BELOW IMAGE IS A CROPPED VERSION OF THE ABOVE, FOCUSING SPECIFICALLY ON THE EXISTING INFRASTRUCTURE

c. Infrastructure gap analysis

As inter-city connectivity was indicated by stakeholders as a priority for Northern residents, it was determined to be the highest priority for increasing charging infrastructure availability in Northern B.C. By connecting large municipalities to neighbouring communities, travel beyond one's own town becomes feasible for Northern EV drivers. To achieve this, all modeled scenarios involve Level 3 DCFC station installation. In order to maximize population served, locations of high traffic volume identified in the highway-use assessment (Figure 12) were focused on.

Further details on the locations of each DCFC site indicated in the gap analysis below are located in Appendix I.

1. Highway 97 to Prince George

Highway 97 leading up to Prince George hosts two of the six areas of high traffic in the focus region (Figure 12). Analysis shows it is necessary to electrify this route to connect the existing DCFC network in B.C. with Northern B.C. With the design vehicle and designated settings, nine DCFC stations are required to allow for safe travel from the existing network ending in Kamloops and Spences Bridge to Prince George (Figure 15). In addition, two additional stations are required west of Prince George along Highway 16 to Vanderhoof, a corridor indicated as a high priority by MOTI's traffic data reports (Figure 12).

In this modeled scenario, stations are sited in all of the larger cities and towns, beginning in Cache Creek and followed by Clinton, 100 Mile House, Williams Lake, Quesnel, and Prince George (Figure 15). Three station locations are identified in smaller communities: Lac La Hache, McLesse Lake, and Hixon (Figure 15). These communities are located in areas where the distance between larger cities is too great to travel safely, and were specifically highlighted due to their availability of amenities. The station in Lac La Hache for example, while near the station in 100 Mile House is also one of the only locations between 100 Mile House and Williams Lake that feature a gas station, restaurants, and motels in one site.

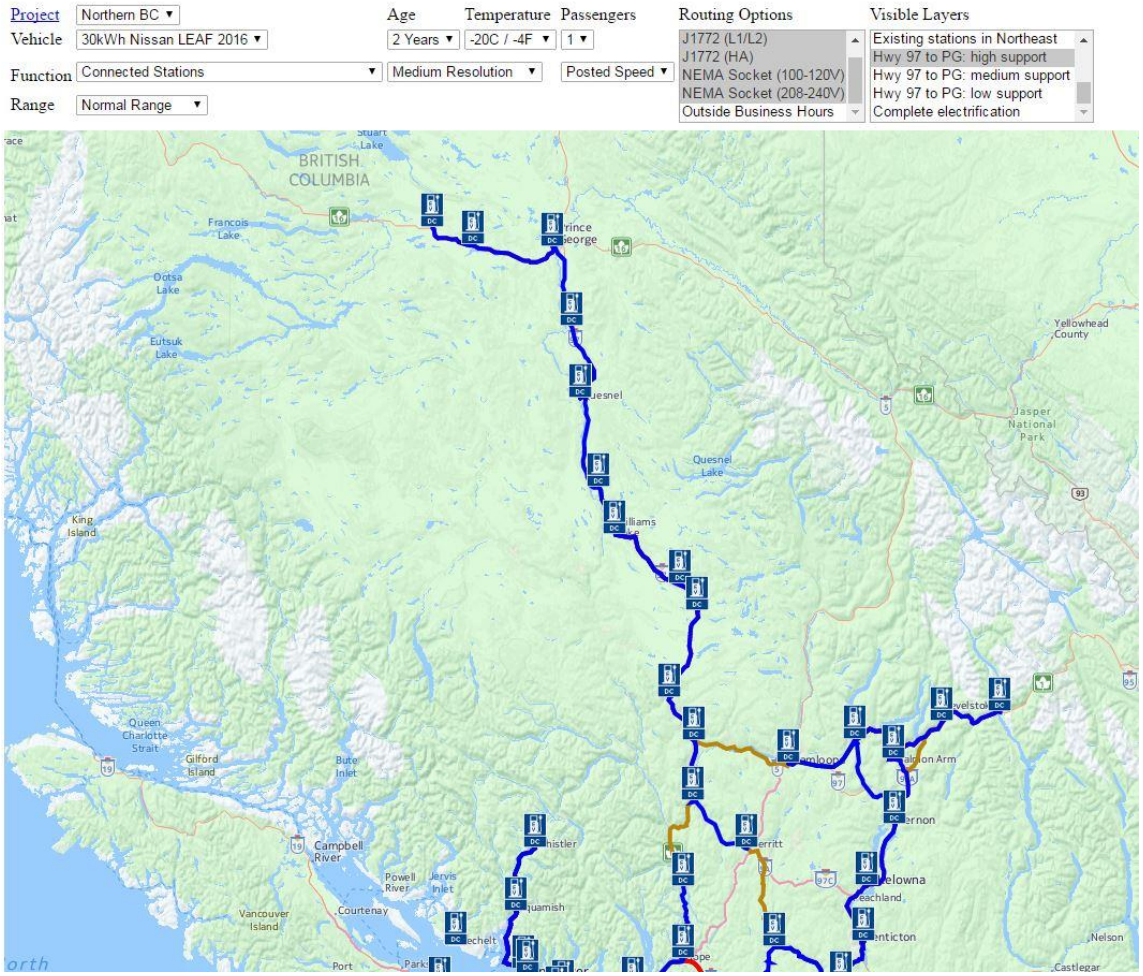


FIGURE 15: PROPOSED DCFC LOCATIONS ALONG HIGHWAY 97; NINE DCFC STATIONS ARE NEEDED TO CONNECT PRINCE GEORGE TO THE EXISTING CHARGING NETWORK, WITH TWO ADDITIONAL CONNECTING VANDERHOOF

To support high traffic volumes and connect Vanderhoof to Prince George the model identifies two additional stations required, one in Vanderhoof and another at a B.C. Ministry of Transportation and Infrastructure rest area between the two cities (Figure 15, 16). With the constraints set in this analysis, the design vehicle is unable to travel between Prince George and Vanderhoof without stopping to charge someplace between. This portion of Highway 16 features few communities or areas of development. Satellite data indicates this rest area as the only location that could potentially serve as a safe and capable site. It features street lighting and flush toilets, but an on-the-ground site assessment would be necessary to confirm that this location is capable of hosting a DCFC station.

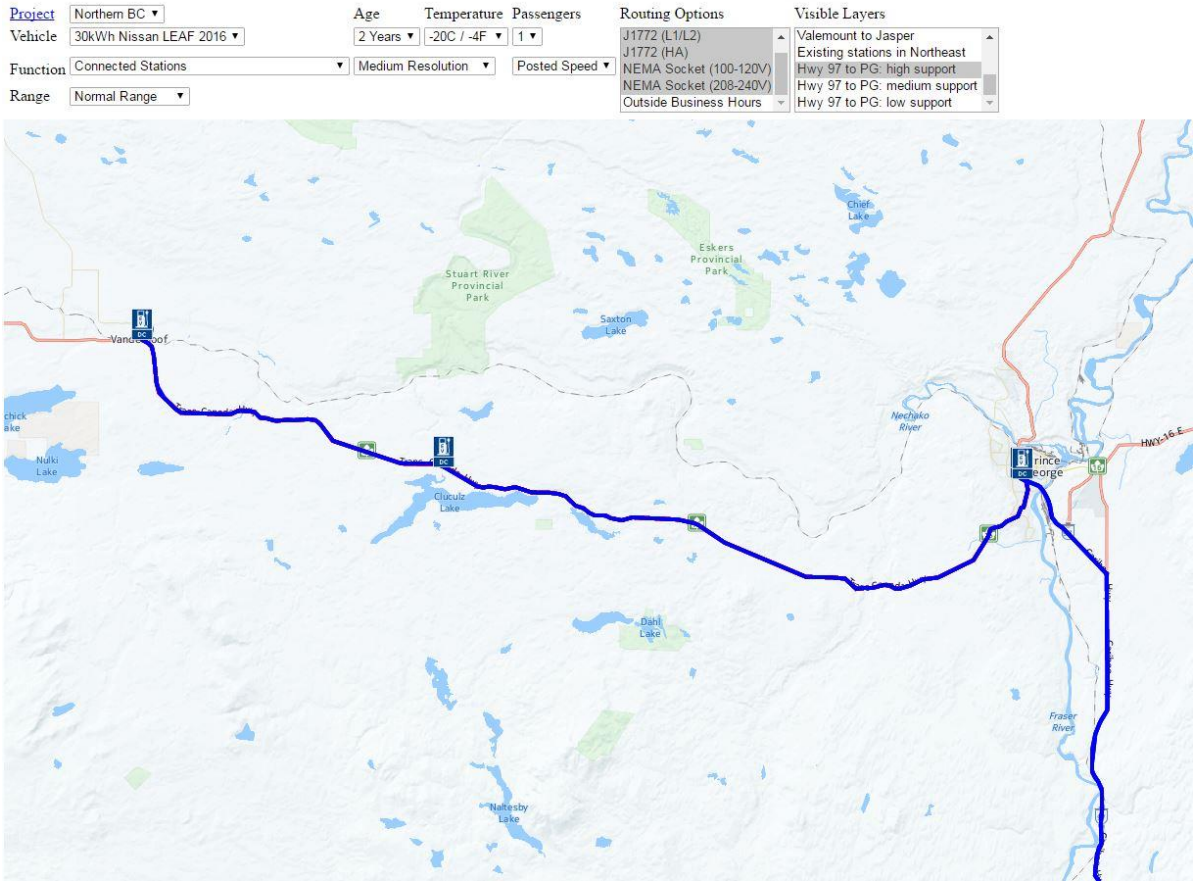


FIGURE 16: PROPOSED DCFC LOCATIONS CONNECTING VANDERHOOF TO PRINCE GEORGE; THIS PORTION OF HIGHWAY 16 WAS IDENTIFIED AS AN AREA OF HIGH PASSENGER TRAFFIC VOLUME

2. Dawson Creek to Grande Prairie and the Northeast "Hub"

Highway 2, leading from Dawson Creek into Alberta is another identified site of high traffic volume. Stakeholder consultation with residents and City officials of Fort St. John and Dawson Creek confirmed this route to Grande Prairie, Alberta as being one of high priority, and further indicated a "hub" of inter-city travel occurring around the neighboring cities of this region. Therefore, in order to serve the residents of the area, this travel hub would require DCFC installation.

To service the route to Grande Prairie, a station would be required in both Fort St. John and Dawson Creek to ensure reasonable travel time for those driving from Fort St. John or between the two cities (Figure 17). To safely travel to Grande Prairie however, two additional stations are required to be installed in Alberta: one in Hythe, optimal due to its centralized location and availability of amenities, and one in Grande Prairie (Figure 17). These sites were determined by the model to be the most efficient locations to service this route.

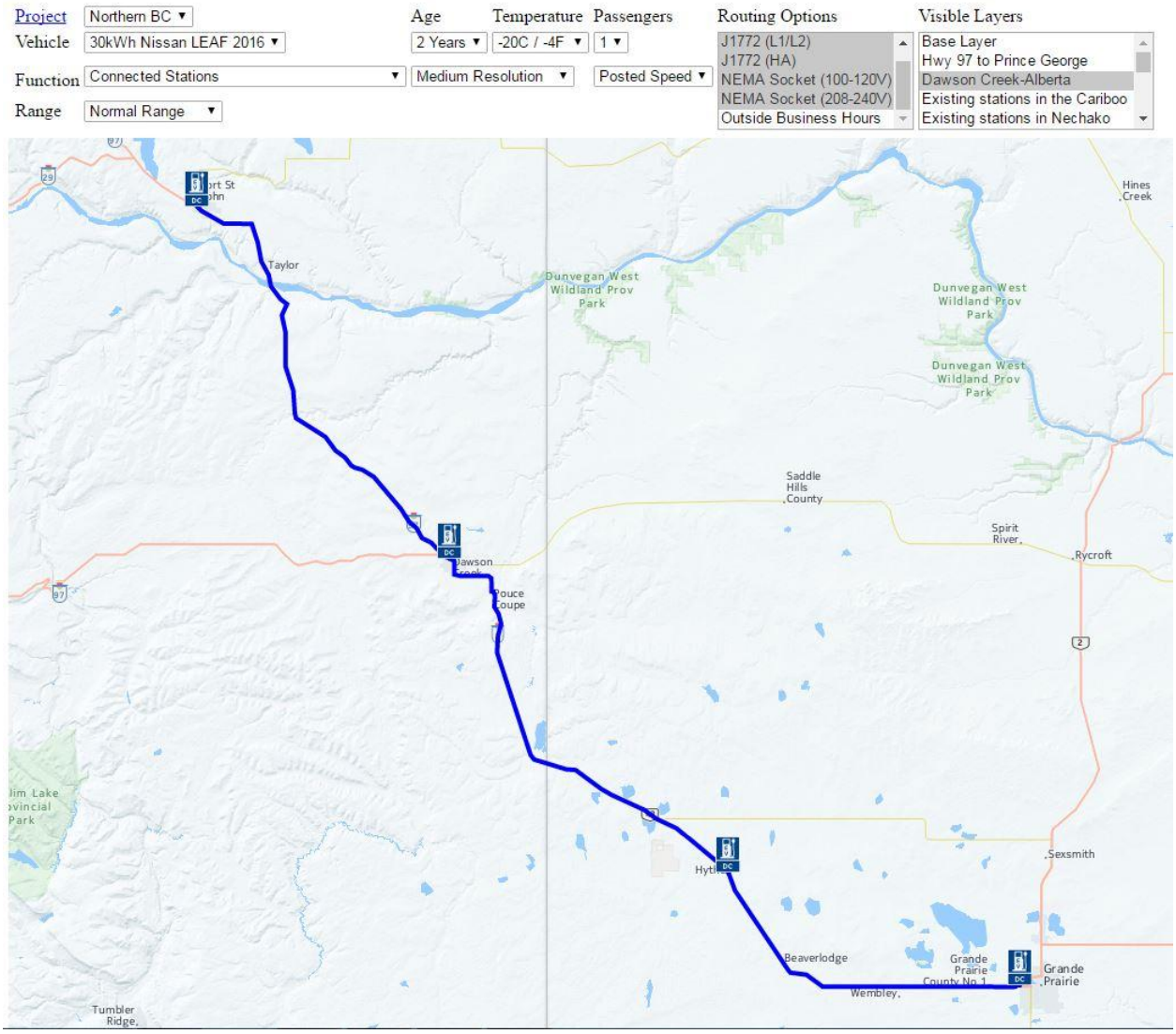


FIGURE 17: PROPOSED LOCATIONS OF DCFCS REQUIRED TO CONNECT B.C. WITH GRANDE PRAIRIE, ALBERTA

Consultation with the province of Alberta is necessary to make this priority route accessible for EV drivers of Fort St. John and Dawson Creek. If this proves not to be feasible, on-the-ground assessments would be necessary to identify where along Highway 2 a DCFC could possibly be installed, if a location does exist. This installation would likely come with a high financial cost. The township of Tomslake is a possible site.

In addition to these four stations, another four are required to complete the Northeast hub, located in Hudson's Hope, Chetwynd, Tumbler Ridge, and Groundbirch (Figure 18). The site at Groundbirch features a gas station, however on-site assessment will be necessary to confirm its capacity to support a station. Under the set conditions, the model suggests the route between Fort St. John and Hudson's Hope results in a low battery warning (indicated by the yellow line); this warning only appears at these conditions and the route becomes passable if either the design vehicle is one year younger, temperatures rise to -10°C, or if there is one less passenger. The route to Tumbler Ridge on the other

hand is more difficult for an EV to take safely, indicating a low battery warning (with a yellow line) even if conditions improve moderately (Figure 18). Other potential DCFC sites that lie between Tumbler Ridge and Chetwynd are minimal, meaning this route should only be encouraged for second generation EVs with increased ranges.

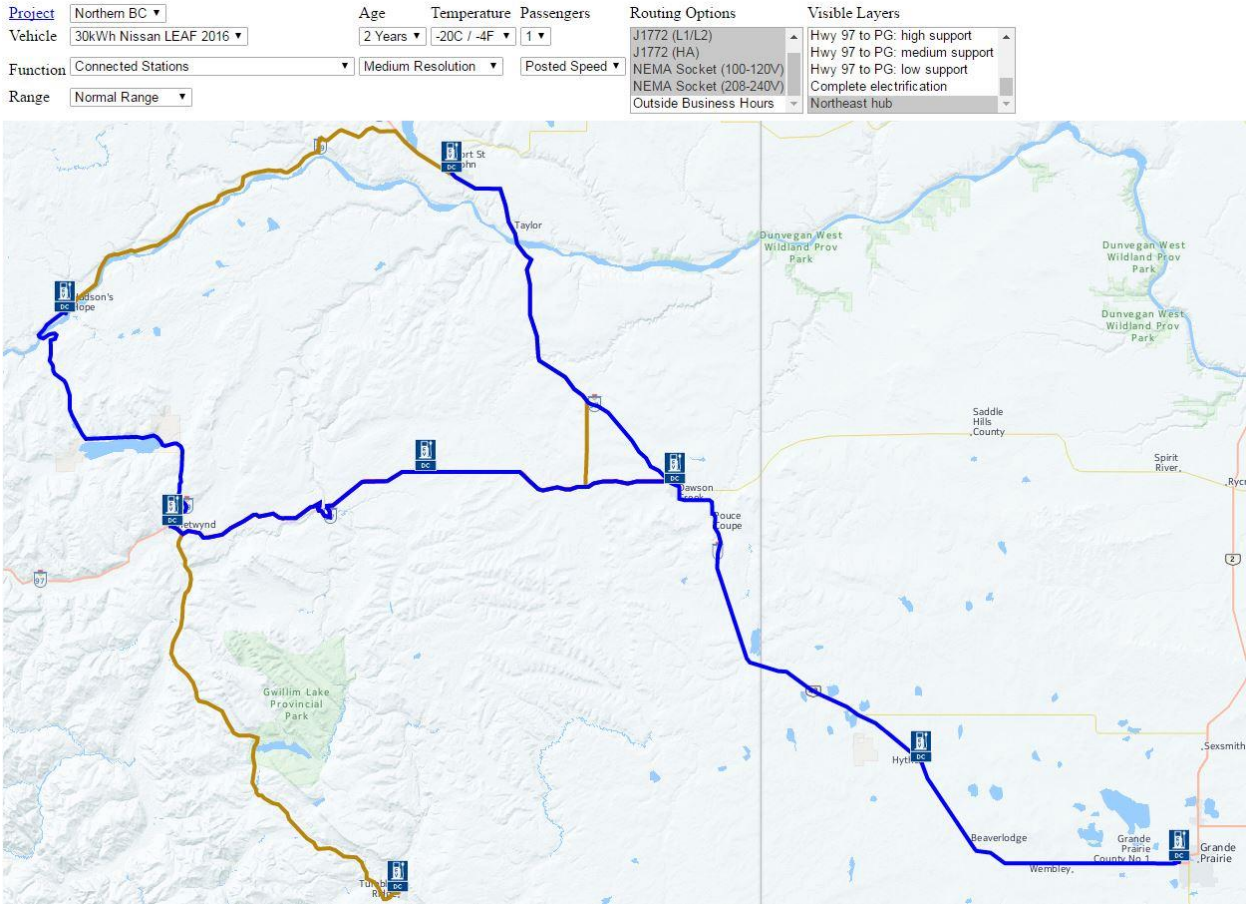


FIGURE 18: EIGHT PROPOSED DCFC SITES TO CONNECT THE NORTHEAST HUB OF NEIGHBOURING CITIES

3. Valemount to Jasper

There is a site of high traffic volume that passes the Tete Jaune Cache junction going into and out of Alberta (Figure 12). This route along Highway 16 directly flows into Jasper National Park.

There are a handful of Level 1 and 2 stations in Jasper, and there is a public Level 2 station available in Valemount. Level 3 stations would be required in both of these locations in order to ensure travel time remains reasonable (Figure 19). In addition, a third station is required between Valemount and Jasper in order to ensure safe travel (Figure 19).

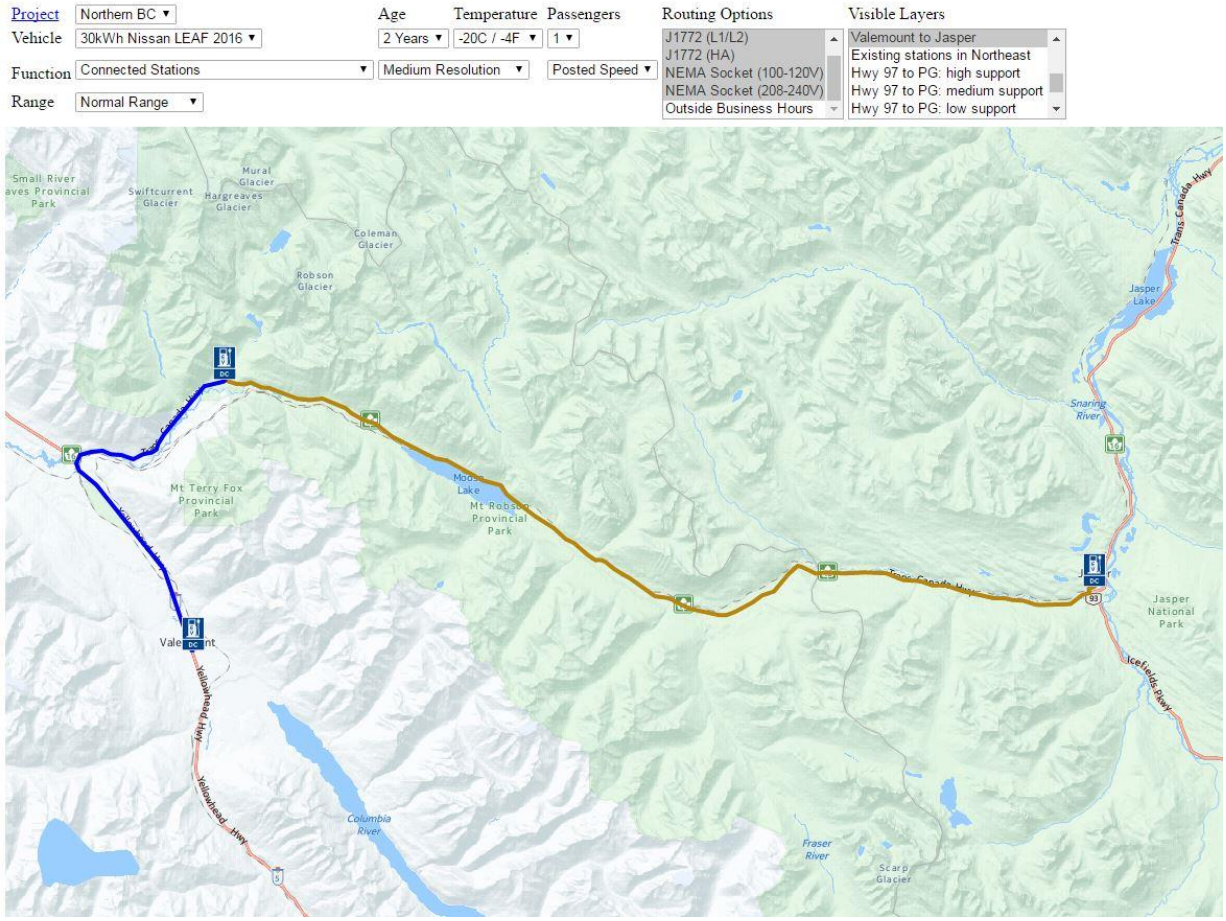


FIGURE 19: PROPOSED LOCATIONS OF DCFC STATIONS TO CONNECT B.C. TO JASPER NATIONAL PARK – THREE STATIONS ARE NECESSARY, HOWEVER DUE TO GEOGRAPHICAL CONSTRAINTS LIMITING WHERE STATIONS CAN BE INSTALLED, A LOW BATTERY WARNING RESULTS AT LOW TEMPERATURES (THE YELLOW LINE)

There are geographical restraints to connecting this route. Within B.C., a DCFC could be located at the Mount Robson B.C. Visitor Centre (Figure 19). However, under the conditions previously set, this would result in an EV driver arriving to Jasper with a low battery warning (indicated by the yellow line in Figure 19). Unfortunately, there is a lack of sites with the potential of supporting a DCFC east of the Visitor Centre. Connecting this route to the EV network in low temperatures safely may only be feasible with second generation models that feature improved ranges. Until then, if DCFC stations are installed at the modeled locations, this route should be emphasised as a summer-only route; when temperatures rise to 0^{o}C the route becomes passable for the design vehicle (indicated by the blue line in Figure 20).

As with the Grande Prairie connection, consultation with the province of Alberta would be necessary in order to site a DCFC station in Jasper, a site which is necessary to complete this route.

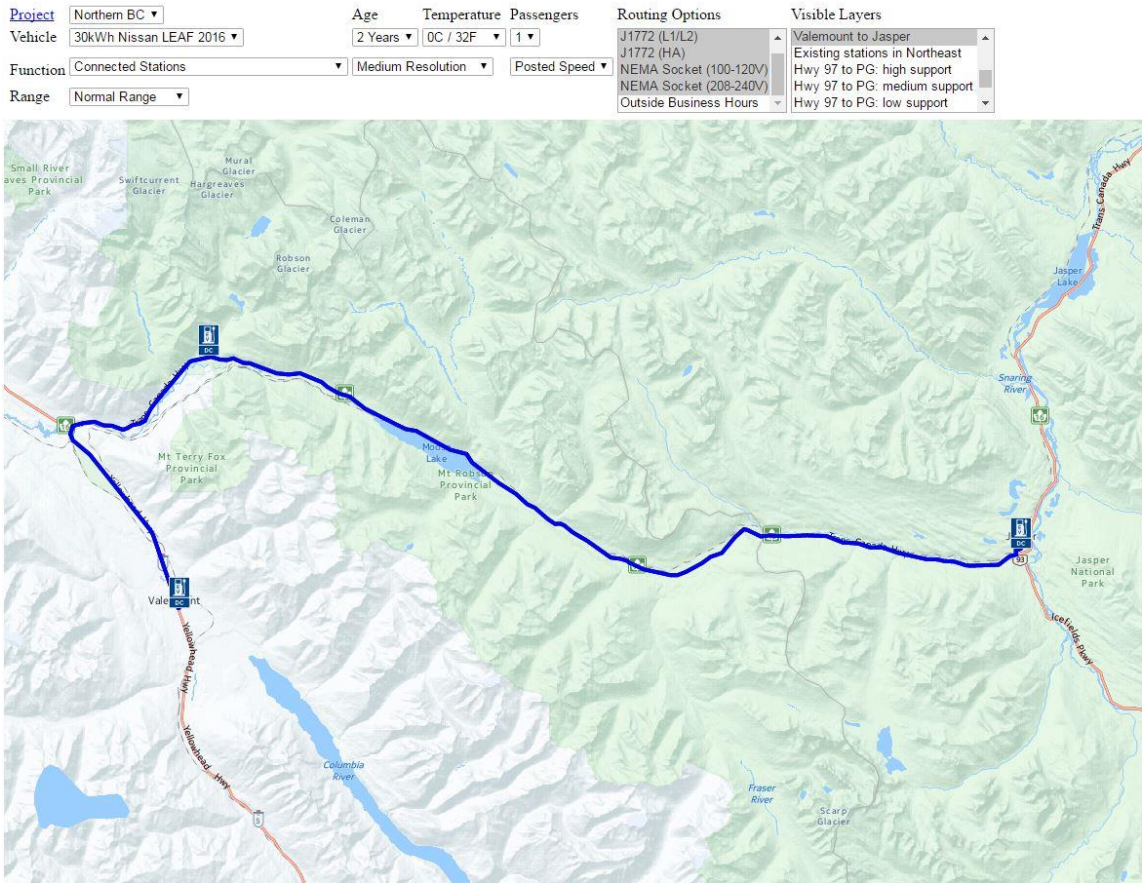


FIGURE 20: BY ADJUSTING THE TEMPERATURE SETTINGS TO 0°C (WITH ALL OTHER SETTINGS THE SAME), IT BECOMES SAFE TO TRAVEL ALONG HIGHWAY 16 TO JASPER NATIONAL PARK

4. Complete Electrification

In the long term, all major highways in Northern B.C. will have to see a significant increase in infrastructure installation in order to make travel with BEV as feasible as traveling with a gasoline vehicle is in B.C. This situation would see the same infrastructure as illustrated in the above three scenarios (including the three stations located in Alberta). In addition, infrastructure is required to connect Prince George and Fort St. John along Highway 97, to electrify Highway 16 to reach west to Prince Rupert and east to Valemount, and to electrify Highway 20 to reach Bella Coola.

The result is 44 new DCFC stations north of the existing network, 41 of which are located in B.C. and 3 which are sited in Alberta, with the most southerly station located in Cache Creek (Figure 20).

Locating sites that could support a station was challenging for many of these stations, especially those along Highway 20 and 16. A few connecting corridors result in low or very low battery warnings under the set conditions, indicated by yellow and red line respectively, due to a lack of capable sites (Figure 21). Stations that are sited in locations with questionable capacity to support a station are indicated by a purple star on Figure 21. These sites mostly consist of B.C. Ministry of Transportation and Infrastructure rest areas and small general stores located along the highway. They are far from nearby towns, and their

actual capacity to support a Level 3 charging station while also ensuring safe travel will require an on-the-ground assessment to determine.

A lack of capable sites, along with a significant drop in population and low passenger vehicle traffic volumes, also resulted in the decision to avoid siting Level 3 charging infrastructure further north than Fort St. John or in Haida Gwaii.

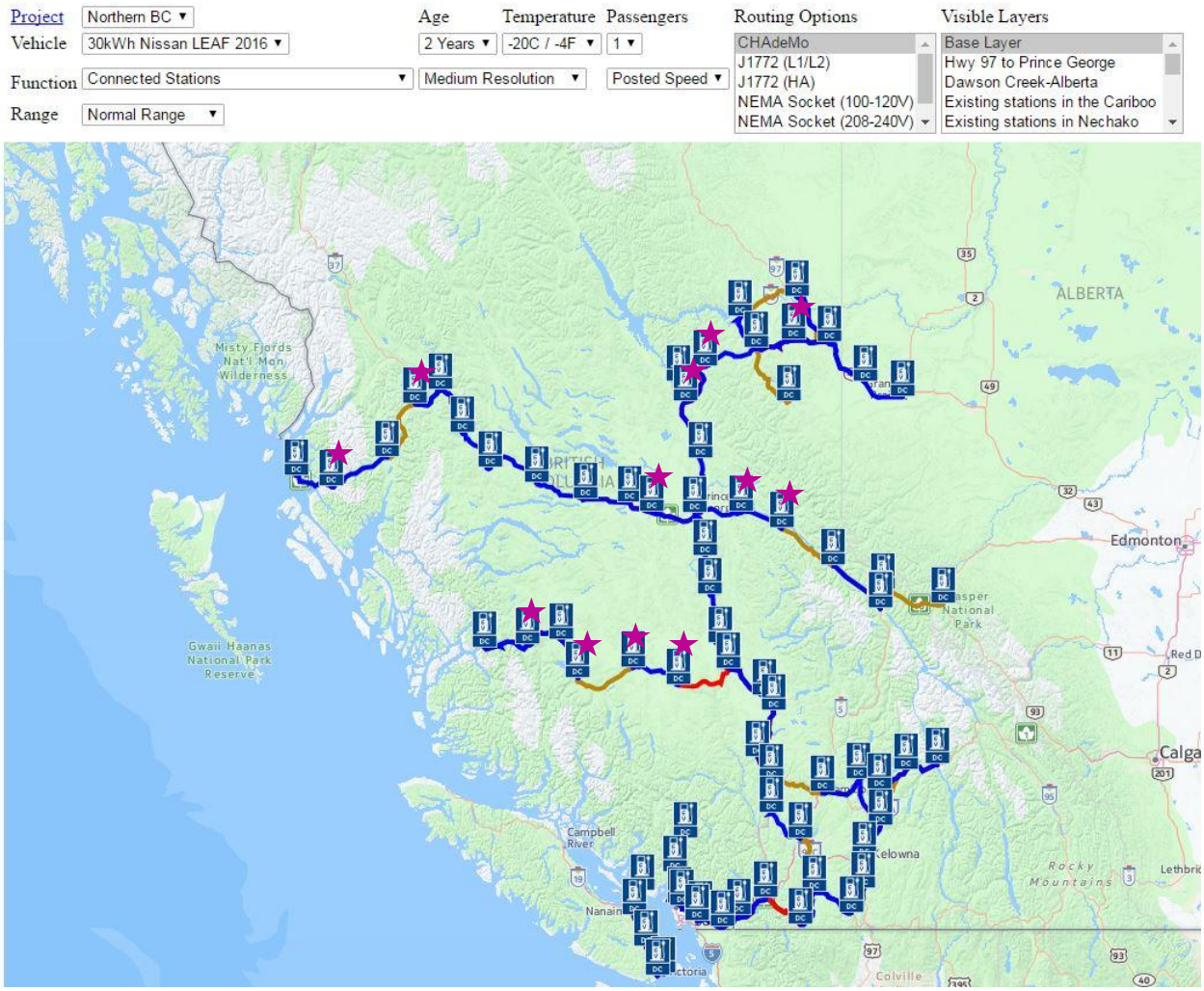


FIGURE 21: A FUTURE PROJECTION OF THE LOCATIONS OF THE 44 DCFC STATIONS NECESSARY TO INTEGRATE NORTHERN B.C.'S MAJOR REGIONS INTO THE EXISTING EV CHARGING INFRASTRUCTURE NETWORK. STATIONS WITH A PURPLE STAR ARE IN LOCATIONS WITH QUESTIONABLE CAPACITY TO SUPPORT A STATION

Section 6: Final Recommendations and Conclusions

It is clear that in order to see an increased adoption of EVs in the northern region of the province, increased and targeted support is necessary. Based on the research and analysis detailed above, below are four proposed strategies each aimed at targeting a specific barrier that inhibits EV adoption in Northern B.C. Option 1, focused primarily on the education and awareness barrier, is the recommended option.

Option 1 – Awareness and strategic infrastructure focused (recommended option)

To address one of the largest and most cost-efficient barriers, it is recommended that an awareness-focused strategy is implemented, with a sub-focus on strategic infrastructure deployment. This strategy emphasises a public education and awareness campaign, but also includes a strategic infrastructure component, in addition to addressing affordability and dealership barriers, and online engagement. It can be broken down into four distinct actions:

Action I. Dynamic Awareness Campaign:

Education and awareness is one of the most significant barriers to EV adoption in Northern B.C. To address this effectively, an education and awareness campaign led by communities or organizations local to Northern B.C. and supported by the Province to make use of the existing Emotive campaign, is required. This campaign is recommended to occur in all of the Census Municipality Areas in Northern B.C., focusing especially on the communities that will host Level 3 charging infrastructure, indicated below in Action II of this Option. The campaign must be tailored specifically to different Northern regions; for example, campaigns in regions where engine block heater outlets are readily available should include their uses for Level 1 charging. Outreach efforts should in general focus on dispelling myths associated with EVs, and the economic benefits of owning an EV, such as reduced fuel and maintenance costs.

As myths and stigmas were revealed to be prevalent in Northern B.C., an Emotive campaign design with Northern B.C. should include a "myth-busting" component, specifically focusing on the ability of EVs to perform in cold weather along with their ability to provide an enjoyable driving experience. It is important that northern municipal governments and/or northern organizations deliver the outreach and awareness, to ensure that outreach reflects the needs of the community and has a "locally-owned" presence. It is also recommended that EV enthusiasts/owners local to the region are invited to participate in campaigns, to allow northern residents to learn about EVs from a local owner. However, provincially funded outreach materials branded under Emotive should be used to allow for cost efficiencies and a base standard of information to be shared, and to leverage the extensive and highly successful Emotive social media campaign. Ride and drives that allow residents of northern communities to test-drive an EV, in summer and winter conditions, would also be a key component of a successful campaign.

Action II. Two Phase DCFC Infrastructure Deployment

The lack of Level 3 charging infrastructure to connect northern communities to their neighbouring towns and cities is another substantial barrier to EV adoption in the North, and it is unlikely that adoption rates will increase without significant DCFC station installation. However, as Level 3 infrastructure installation is the most financially constraining of the infrastructure types, this strategy recommends that stations are deployed in a staggered, two phased program:

Phase 1 involves the installation of eleven DCFC stations along Highway 97 and Highway 16, connecting Prince George and Vanderhoof to the existing DCFC network in Southern B.C., as illustrated in Figure 15. This phase includes three of the six high traffic volume sites in Northern B.C. and would connect the

Cariboo to the existing fast charging network in Southern B.C. The Cariboo also has the largest population of the four northern Development Regions[27], maximizing the amount of people served by this phase of infrastructure deployment.

Phase 2 involves the installation of eight DCFC stations that services the Northeast hub, as depicted in Figure 18. This phase takes both stakeholder consultation and results from the highway-use assessment into account, and covers one of the largest high traffic volume sites while also ensuring travel between neighbouring cities is accessible. The Northeast Development Region is also predicted to see the second greatest growths in population in comparison to the rest of the province[27], giving this phase a large impact potential. As both stakeholder consultation and a highway-use assessment indicate that connecting neighbouring cities is of higher priority than connecting the entire province, it is recommended that this phase is completed before stations are installed along Highway 97 to connect this hub to Prince George (a route that will likely be more difficult to complete due to mountainous terrain). This phase also requires working together with Alberta, in order to ensure that the route to Grande Prairie is completed.

Connecting Prince George and Vanderhoof in phase 1 and connecting the Northeast hub in phase 2 serves the areas of the largest traffic volumes[28] and the areas of the largest populations[27] of Northern B.C. Therefore, these routes have the greatest impact potential on EV adoption rates and are of high priority to connect to the existing fast charging network.

Both phases will feature Level 2 station installation accompanying DCFC deployment such as that every DCFC station installed includes a supporting Level 2 station installed alongside it. This is to ensure safety in the case of a DCFC becoming inoperable for a period of time. Further Level 2 installation is recommended to be kept as a potential priority if outreach and further consultation reveals PHEVs to be more viable and/or of a greater interest in the region.

Action III. Incentive Continuation and Dealer Support

Affordability of EVs remains a barrier to Northern B.C., so it is recommended that the incentives offered through the CEV program continue to be offered. It is also recommended that work is done specifically with auto dealers in Northern B.C. to ensure that they are aware of training and certification support that is currently available, and it ensure that they will stock EVs in line with actions to support EV uptake in Northern B.C. Surveys with dealers would be necessary to determine what kind of region specific support would be most valuable. It is recommended that some direct support is included, such as dealers hosting ride and drives for their communities. It is also recommended that surveys with local electricians are conducted to determine how best to support any training required for EV infrastructure installations.

[27] See Appendix J.

[28] The permanent sites P-43-1NS (Hwy 2 to Grande Prairie) and P-42-2EW (Hwy 16 between Prince George and Vanderhoof) are the only two sites in the focus region that experience AADT volumes that exceed 4000 vehicles – see Figure 12 and the highway use assessment discussion in Section 4.

Action IV. Online support

Lastly, an update to the existing PluginBC website (pluginbc.ca) to include a section specific for EV buyers living in rural areas of the province, including Northern B.C., should be made available. This would create a "one-stop-shop" for Northern residents, and other B.C. residents in rural communities interested in learning more about EVs, including information on the locations of dealers in their region, information on engine block heaters as Level 1 charging options, and strategies for cold weather management.

Option 2 – Infrastructure focused

This strategy proposes greater investment in infrastructure, emphasising the deployment of Level 3 charging infrastructure as the primary means to increase EV adoption. Like Option 1, this option also includes education, affordability, and online-support components, and is composed of four distinct actions:

Action I. Four Phase DCFC Infrastructure Deployment

Installing fast charging infrastructure to connect northern communities to each other and the rest of the province is a critical component of increasing EV adoption in Northern B.C. This strategy suggests focusing resources on this barrier, and describes a four-phase infrastructure deployment strategy that will result in a near-complete integration of Northern B.C. into the current DCFC network.

The first two phases of this strategy are identical to the two phases of Option 1 (Action II). Phase 3 connects Prince Rupert to Prince George, with the installation of nine DCFC stations along Highway 16, west of the station in Vanderhoof (locations illustrated in Figure 21). After the Cariboo, the North Coast Development Region has the most EVs already registered in the North (Figure 3) and they also see some of the shortest commuting times (Figure 7). Connecting the largest municipalities of this region would service a population that may already be optimal for EV adoption.

Lastly, phase 4 involves connecting phase's 1 and 2 with four DCFC stations along Highway 97, between Prince George and Chetwynd (their locations are illustrated in Figure 21). Several of these stations are located in areas whose capability to support a station is questionable, meaning that this phase would likely be more costly to implement. However, it is necessary in order to connect the most northern of the Census Municipality Areas to the rest of the province.

Level 2 stations are recommended to be installed alongside each DCFC station deployed in all four phases, to effectively support inter-city travel.

The connection to Jasper (Figure 19) is a lower priority for several regions. Connecting this junction to Prince George along Highway 16 would be costly due to a lack of supporting sites (Figure 21), the route features geographical constraints (Figure 19), and it was revealed as a site more significant for residents of Southern B.C. rather than Northern B.C. through stakeholder consultation. It is recommended that if this location were to be connected to the EV DCFC network, a connection to Kamloops through Highway 5 would be of higher priority than a connection to Prince George through Highway 16. Highway 20 leading to Bella Coola is also of lower priority, due to its lack of supporting sites (Figure 21) and its lower population.

Action II. Specialized Awareness Campaign

An education and awareness campaign, while not the primary focus, is still a key component of this option and must be tailored at least to Northern B.C. as a whole, focusing in general on economic benefits and addressing EV myths and cold weather management. It is recommended that the campaign make use of the provincially funded outreach material and successful social media presence branded under Emotive for cost efficiencies and to ensure a base standard of relayed information, however it is important that outreach is delivered by local EV enthusiasts, governments, and/or organizations. This will create a stronger local presence, and ensure that all outreach reflects the needs of the specific community. This campaign would have an additional focus of educating community members specifically of the new charging infrastructure to be installed following Action I of this option, to raise awareness and excitement about the travel routes they make accessible for EV drivers. Ride and drives are recommended to occur in the communities that will be hosting new DCFC stations. All campaign events are fewer in number than those featured in Option 1, and would likely only occur in summer months.

Action III. Incentive Continuation and Dealer Support

Identical to Alternate 1, this action involves continuing the incentives offered by the CEV program, and working specifically with auto dealers in Northern B.C. to ensure that they are aware of the trainings and certifications available to them. Surveying northern dealers to determine what kinds of support would be most valuable is recommended. It is also recommended that local electricians are surveyed to determine how best to support any training required for EV infrastructure installations.

Action IV. Online Support

An update to the existing PluginBC website (pluginbc.ca) to include a section specific for EV buyers living in rural areas of the province, including Northern B.C. is also recommended in this option, creating a "one-stop-shop" for Northern residents interested in learning more about EVs.

Option 3 – Cariboo-specific targeted support

Unlike Option 1 and 2, which focuses on distributing resources throughout Northern B.C., Option 3 adopts a more targeted approach, focusing specifically on the Cariboo Development Region due to its higher likelihood of supporting increased EV adoption in the nearer term. This final strategy is the least financially constraining. It also contains four distinct actions, which are as follows:

Action I. Awareness Campaign

While it is still recommended that an education and awareness campaign is crafted specifically for Northern B.C., delivered by local governments and/or organizations of the region, this option cuts back on the reach this campaign would have. Ride and drives would only occur in the larger communities of the Cariboo region, and the number of events that use Emotive branding elsewhere in Northern B.C. would decrease. The campaign would focus instead on creating a strong presence in the Cariboo, led by local governments and EV enthusiasts to craft outreach in a manner that reflects the needs of the region.

Action II. Single Phase DCFC Infrastructure Deployment

This option focuses solely on connecting Prince George and Vanderhoof to the existing fast charging network in Southern B.C. through the deployment of eleven DCFC stations (locations illustrated in Figure 15). This would serve three of the six sites of high traffic volume in Northern B.C. It would connect the most populous Development Region in Northern B.C. to the existing network, bringing B.C. significantly closer to province-wide electric travel. In addition, the city of Prince George hosts nearly one third of the passenger cars registered in Northern B.C.[29], and also features the only two institutions in Northern B.C. that are members of the West Coast Electric Fleets[30], suggesting that Prince George is the most likely location in Northern B.C. to see a significant increase in the number of EVs purchased.

All DCFCs installed would also feature Level 2 charging infrastructure installed alongside it, to provide additional security and support for all EV drivers in the region.

Action III. Incentive Continuation and Cariboo Industry support

It is recommended that the incentives provided by the CEV program continue to be offered, in order to address the affordability barrier that restricts EV adoption in Northern B.C. In addition, it is recommended that efforts are made to survey auto dealers specific to the Cariboo region, and local electricians, to determine what methods of support would be the most valuable to them in the effort to increase EV adoption and assist in EV infrastructure installation. Some direct support from Cariboo dealers in the form of community ride and drives is encouraged.

Action IV. Online Support

Including a section specific to EV buyers living in rural areas of the province, including Northern B.C. to the current PluginBC website (pluginbc.ca) is also recommended, which would assist in addressing the awareness barrier by creating a "one-stop-shop" for Northern residents interested in EVs.

Option 4 – Maintain the Status Quo

While not recommended, maintaining the current status quo remains an option moving forward. This would result in no northern-specific awareness campaign and very limited, if any, Emotive presence in this region of the province. It would also result in no new infrastructure deployment, resulting in the charging map illustrated in Figures 13 and 14, with no Level 3 stations installed to connect neighbouring cities and allow for inter-city travel. Incentives would continue, however auto dealers in Northern B.C. would not be sufficiently engaged to obtain an EV certification and advertise them. The PluginBC website would also lack a section specific to northern residents, further failing to address the existing awareness barrier. Maintaining the status quo is likely to result in the 12% increase in EV market sales penetration that Northern B.C. has so far been experiencing, resulting in just under 50 EVs added to the northern fleet by 2020 (Table 3).

Conclusion

Northern B.C. faces challenges including, but not limited to, gaps in education and awareness, a lack of supporting Level 3 infrastructure, and EV models that do not fulfill the level of utility that matches

[29] See Appendix E.

[30] The City of Prince George and the University of Northern British Columbia are both on-ramp partners of West Coast Electric Fleets; see http://www.westcoastelectricfleets.com/ for a complete list of partners.

demand. While it is true that the Ministry's ability to fully address all of these challenges is limited, especially those involving the diversity of EV model supply, it is also true that there are actions available that will better support current and future EV owners in Northern B.C.

Several characteristics of Northern B.C. encourage the support of increased EV adoption. Shorter commuting times on average suggest that, even in colder temperatures with a reduced range, current EV models are sufficient for the typical commute of Northern residents (Figure 7). VKT data indicates that small passenger cars are experiencing greater mileages than larger vehicles of higher utility, such as trucks (Figure 9), despite there being an overall greater number of trucks and SUVs in the region (Figure 5). This suggests that replacing a greater percentage of passenger cars with EVs would allow for significant economic benefits (lower fuel costs), and environmental and air quality benefits (decreased GHG and tailpipe emissions) within Northern B.C. Level 3 charging infrastructure deployment that connects the existing network to Prince George in its first phase would serve three of the six high-volume traffic sites (Figure 12), the most populous region of Northern B.C.[31], and the only institutions in Northern B.C. that are members of the West Coast Electric Fleets[32]. Prince George also hosts approximately one third of the North's passenger cars[33], resulting in it being the most likely place to see significant increases in the number of EVs registered in Northern B.C. provided that the existing infrastructure and awareness barriers are targeted. Lastly, stakeholder consultation revealed a large amount of interest in supporting EV adoption from residents and local governments throughout the region, suggesting that any efforts made by the province will experience some local support.

All of the above suggests that a strategy that fully supports EV adoption in Northern B.C. is likely to lead to significant increases in adoption rates. While the diversity of EV model types is largely out of the province's hands, awareness and infrastructure barriers are not, and targeting these is the most effective way to increase the percentage of EV penetration into new vehicle sales from the current 0.098% (Table 2). An increase to 5% by 2020 would result in 1281 new EVs, a significant improvement on the 26 EVs currently in the region (Table 3). This kind of increase supports local economic development and energy security, it continues to provide regional equality, and it reflects B.C.'s CEV program goals and their climate leadership goals.

A strategy that aligns with Option 1 would provide B.C. with the most effective pathway to mitigate the existing barriers and meaningfully increase the level of EV adoption in Northern B.C. Focusing on awareness, in addition to ensuring infrastructure support to the regions with the greatest impact and adoption potential and addressing affordability barriers, would distribute resources efficiently while still meaningfully supporting EV adoption throughout the focus region. Maintaining the status quo would not result in a significant or impactful increase in the adoption of electric vehicles in Northern B.C. as it fails to address the barriers and challenges that are specific to the northern region of the province.

[31] See Appendix J.
[32] See http://www.westcoastelectricfleets.com/partner-fleets/
[33] See Appendix E.

Appendix A: Definitions and Acronyms

Greenhouse Gases (GHGs)

GHGs refer to gases that absorb infrared radiation and trap heat in the atmosphere, contributing to the greenhouse effect. Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (NO_2), and water vapour are all examples of GHGs.

Electric Vehicle (EV)

EV is a term that, in this document, refers to both a battery electric and plug-in hybrid electric vehicle.

Zero-Emission Vehicle (ZEV)

A ZEV refers to a vehicle that has does, or has the potential to, produce zero tailpipe GHG emissions. In this document, ZEVs include battery electric, plug-in electric, and hydrogen fuel cell electric vehicles.

Battery Electric Vehicle (BEV)

A BEV is an EV that runs solely with an electric motor and battery, with no support from an internal combustion engine. It must be plugged into an external electricity source to recharge. They are a zero-emission vehicle that requires no gas or oil changes, and can be charged using a standard plug and outlet.

Plug-in Hybrid Electric Vehicle (PHEV)

A PHEV is an EV that has an electric motor and battery in addition to a supporting internal combustion engine. It operates using its electric motor first, which must be plugged into an external source to recharge, and then can access its gasoline engine when the battery charge is low. The gas engine can recharge the battery and/or replace the electric motor completely. PHEVs have fewer emissions than hybrids or gas-only vehicles, but more than BEVs. Currently in North America, PHEVs are not equipped to be compatible with DCFCs.

Hybrid Electric Vehicle (Hybrids)

Hybrids have both an internal combustion engine and an electric motor and battery that work together simultaneously. Hybrids cannot be plugged into an external electricity grid to recharge; all of their power results from gasoline and regenerative braking. They are not considered to be EVs due to their increased GHG emission production.

Hydrogen Fuel Cell Electric Vehicle (FCEV)

FCEVs use hydrogen gas as their power source. They are ZEVs, with their sole waste product being water. Hydrogen is used to power a fuel cell, which then produces electricity to power their motor. They cannot be plugged into an external power source to recharge; instead their fuel tank must be refilled with hydrogen.

Trickle Charge -Level 1 Charging

Level 1 charging involves plugging in an EV to a standard 110V plug. It is the slowest of the charging levels, adding about 5-7km or range per hour.

Home/work and public charging stations –Level 2 Charging

Level 2 charging uses a SAE J1772 plug with a voltage of 240V. It will add about 15-30km of range per hour, usually resulting in a full charge in 4-6 hours, depending on battery size. These stations can be purchased and installed in residential and commercial buildings.

Direct Current Fast Chargers (DCFCs) –Level 3 Charging

Level 3 charging is the most powerful, and therefore the fastest, of the charge levels. DCFC stations can charge an EV to 80% of its capacity in approximately 20 to 30 minutes. They tend to have usage fees, and are significantly more expensive to install and operate than level 1 or 2 charging. Not all EVs are equipped to access DCFCs; no PHEVs currently on the market can use them, and only some BEVs can.

Appendix B: EV Level 2 and DCFC Compatibility List

[See separate attachment: "EV Level 2-DCFC Compatibility"]

Appendix C: Jurisdictional and Market Overview

a. Brief literature and BC policy review

1. Literature review

Reports and studies within the current literature were reviewed to understand what is already known about EVs and develop a clear idea of how challenges specific to Northern B.C. (i.e. colder temperatures, geographic constraints, widely-spaced communities, etc.) may impact adoption.

It was found that a large amount of reviews have been conducted in a short period of time. The oldest document read was published in 2009. The research done for this report does not reflect the volume of studies that exist – academic studies especially are abundant.

Many of the documents reviewed were guides intended to help policy makers and municipal governments design and implement their own charging networks and electric vehicle programs. Several themes were common throughout the literature, including:

1. Importance of outreach and awareness, both public and within industry

Supporting awareness and outreach initiatives is listed as the primary recommendation for the Yukon to increase EV adoption by ICF International[34]. It is also one of the four core strategic initiatives recommended by the Industry Steering Committee to increase adoption across Canada in their 2009 EV Technology Roadmap report[35]. Awareness includes both public awareness, and within-industry awareness via providing trainings and certification for the future EV industry (electricians, auto dealers, etc.).

[34] ICF International. (2016). *Electric Vehicle Investigation.* Retrieved from https://yukonenergy.ca/media/site_documents/Yukon_EV_Investigation_Report.pdf

[35] Industry Steering Committee. (2009). *Electric Vehicle Technology Roadmap for Canada.* Retrieved from http://publications.gc.ca/collections/collection_2010/nrcan/M154-33-2009-eng.pdf

2. The importance of effective charging infrastructure planning, and its ability to increase the range of EVs and decrease "range-anxiety"

The importance of designing a fluid and dynamic charging infrastructure network has been the focus of several policy guides and documents. "Range anxiety", the fear of being unable to reach a destination in an EV before running out of charge, is one of the largest barriers to EVs entering the mainstream vehicle market. The establishment of a reliable network of charging stations is an effective way to reduce range anxiety[36]. The Vancouver Electric Vehicle Association (VEVA) lists the installation of fast charging stations along intercity highways as their primary recommendation for encouraging EV adoption, such as to make travel throughout the province as feasible as it is in a conventional vehicle[37]. The Fraser Basin Council called for an "EV Tourism Approach" when designing an improved DCFC network in BC within their B.C. DCFC Gap Analysis, which is defined as prioritizing connecting high-adoption regions to close-by and popular destinations[38]. The Victoria EV Club also recommended prioritizing inter-city corridors to allow for between-city travel within their report to the B.C. government[39].

The Fraser Basin Council also emphasised the importance of ensuring that charging infrastructure is accessible, safe, and convenient for EV drivers. This includes a proximity to amenities such as restaurants and 24/7 washrooms, ensuring stations are well-lit and secure at all times, and providing back-up stations at a lower charging level in case the primary station is not operating properly, especially for stations located away from urban areas (i.e. creating redundancy in the infrastructure network).

The Transportation, Infrastructure and Public Space (TIPS) lab from UBC mentions other considerations to planning an effective charging infrastructure network as well, such as allowing for local economic development through the proximity of stations to local commerce, the visibility of the station and signage, and the opportunity to strengthen community vision by incorporation a charging infrastructure network to a community's overall development, sustainability, and/or transportation plan[40].

3. The limitations of EVs from range-reducing impacts from cold weather and from gaps in available model types.

[36] Community Energy Association. (2013). *Planning for Electric Vehicle Charging Infrastructure: A Toolkit.* Retrieved from http://communityenergy.bc.ca/?dlm_download_category=planning

[37] Vancouver Electric Vehicle Association. (2016). *Encouraging Electric Vehicle Adoption*

[38] Fraser Basin Council. (2015). *A Gap Analysis for B.C.'s Electric Vehicle Direct Current Fast Charging Network.* Retrieved from http://pluginbc.ca/wp/wp-content/uploads/2015/10/BC-DCFC-Gap-Analysis-Report-FBC_Aug-2015.pdf

[39] Victoria EV Club. (2016). *Priorities for DC Fast Charging Locations on Vancouver Island – 2016 Update.* Retrieved from http://victoriaevclub.com/wp-content/uploads/2016/09/Priorities-for-DCFCs-on-Vancouver-Island-VEVC-August-2016.pdf

[40] The Transportation, Infrastructure, and Public Space Lab. (2014). *Evaluation of Fast Charging Stations Locations.* Retrieved from http://www.tipslabubc.com/images/documents/FastChargingStations_FinalReport_WEB.pdf

ICF International's report overviewing EV's in Yukon Territory emphasised the significant impacts cold temperatures have on vehicle performance, with range decreasing by over half and more than double the energy being necessary to charge.[41]

A cold vehicle system has two impacts. First, auxiliary power consumption increases as drivers heat cabins and operate the defogger. Second, the efficiency of vehicle components decreases as the battery gets colder and the engine's internal friction increases. Both impacts reduce range, however heating the cabin has the greater impact as battery power used to heat the cabin cannot be used to propel the vehicle.

The limited availability of electric light-duty trucks was also highlighted as a hurdle to EV adoption in the Yukon, as light duty- trucks make up 60% of new vehicle registrations, as was the lack of dealerships currently selling EVs in the territory.

4. The multiple benefits to electrifying transportation, including economic benefits and GHG reductions.

Economic benefits to transferring from a conventional gas vehicle to an EV are emphasised throughout the literature. ICF International's focus on the Yukon noted that the higher than average gas and diesel prices in the territory would result in higher fuel savings for drivers that switch to an EV. The Pembina Institute states that in B.C., an individual can expect to save $1200 a year on fuel by driving an EV.[42] Electric motors also require less maintenance than fossil fuel engines do, which provides further economic benefit.

Climate benefits through reductions in GHG emissions are also commonly cited. The Yukon, like B.C., derives the majority of its power generation from clean hydropower (for Yukon Energy customers), meaning that by driving an EV it is possible to significantly reduce the GHG emissions of the transportation sector.

2. Relevant case studies

There have been several studies conducted in regions with a climate similar to Northern B.C. In Winnipeg, the Electric Vehicle Technology and Education Centre tested the range and energy consumption of a Chevrolet Volt (a PHEV) in cold temperatures. [43] It was found that between -3°C and 20°C, the relationship between temperature and vehicle range is linear, with range decreasing by 2.1km for every °C decreased. However, when temperature dropped below -3°C, electric travel range plateaus and averaged at 36.6km in total. Overall however, cold weather had a significant impact to the vehicle's performance, decreasing total range by more than half and causing energy consumption to more than double in comparison to performance in optimal temperatures.

[41] ICF International. (2016). *Electric Vehicle Investigation.* Retrieved from https://yukonenergy.ca/media/site_documents/Yukon_EV_Investigation_Report.pdf
[42] Pembina Institute. (2010). *Powering the Future.* Retrieved from https://www.pembina.org/reports/powermyride-factsheet.pdf
[43] Delos Reyes, J.R.M., Hoemsen, R., & Parsons, R.V. (2015). Cold weather travel range and energy consumption of the Chevrolet Volt PHEV. *IEEE Xplore, 15668575,* 1-6. doi: 10.1109/VPPC.2015.7352911

Hydro Quebec has also conducted cold temperature tests on EVs. A Mitsubishi i-MiEV (a BEV) was found to lose 40% of its range when temperatures were below 0°C. [44] Increasing in-car heating was primarily responsible for the loss of range, causing a loss of 13km when temperatures fell between 0 and 10°C. This also caused energy consumption to increase during the winter months. Hydro Quebec also looked at charging impacts, and found that ambient temperature and battery temperature influences charging time, which slows as temperatures of either decrease.

The North Sea Region Electric Mobility Network piloted a project to test CHAdeMO DCFCs in Gothenburg, Sweden. They found that a Citroen C-Zero (a BEV unavailable in Canada) would only reach a 20% charge when plugged into a DCFC if the battery temperature was less than 10°C.[45] If the vehicle's battery was between 10°C to 20°C, it typically would reach a 40% charge. There were also difficulties from a user perspective with charging in cold temperatures. The cable was reported to feel "like a pipe" and it was sometimes difficult to return the plug to the charging station. A need to shelter the station from the elements was reported, with issues arriving from the air inlet being jammed with snow, and the cooling fans being damaged by precipitation.

ICF International's study in the Yukon specifically looked at engine block heaters as a potential EV charging source.[46] They noted that not only do engine block heaters require similar electricity load and connections as Level 1 charging infrastructure, they also tend to feature weatherized outlets, are estimated to require a similar amount of energy consumption if plugged into an EV as they currently do for gasoline vehicles, and are already readily available throughout the territory. Engine block heaters therefore have the possibility to offset some of the loss of range EVs experience in cold weather.

3. BC policy

B.C has a number of policies and programs currently in place that contribute to a reduction of GHG emissions in the light-duty transportation sector. One of which is B.C.'s Low Carbon Fuel Standard[47], a market-based approach which has required a reduction in the carbon intensity of the well-to-wheels lifecycle of transportation fuels by 10% below 2010 levels by 2020. It establishes a sustainable market for low-carbon and renewable fuels, stimulating a market transformation of B.C.'s transportation fuel supply. The 2016 Climate Leadership Plan has built on this program, investing over $8 million in five year period to increase the standard to 15% reductions by 2030, which is projected to reduce annual GHG emissions by 3.4 million tonnes.

B.C.'s Clean Energy Vehicle (CEV) program[48] aims to support the use of EVs throughout B.C. by providing incentives off the pre-tax market price for battery electric, fuel cell electric, plug-in hybrid electric, and

[44] Hydro Quebec. (2013). *Mitsubishi Electric Vehicle Pilot Project.* Retrieved from http://www.hydroquebec.com/transportation-electrification/pdf/mitsubishi-pilot-project-report.pdf
[45] North Sea Region Electric Mobility Network. (2012). *Experiences from the Gothenburg fast charging project for electric vehicles.* Retrieved from http://archive.northsearegion.eu/files/repository/20130716113751_FastCharge_Pilot_GOTHENBURG.pdf
[46] ICF International. (2016). *Electric Vehicle Investigation.* Retrieved from https://yukonenergy.ca/media/site_documents/Yukon_EV_Investigation_Report.pdf
[47] For more information, see http://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/transportation-energies/renewable-low-carbon-fuels
[48] For more information, see https://www.cevforbc.ca/

hydrogen fuel cell vehicles. These incentives can be combined with B.C.'s SCRAP-IT program incentives, which together can reach up to $8,250 off the sticker price of a new EV. The CEV program has also funded charging infrastructure which has resulted in the installation of 30 DCFC stations across the province with more in development, and the largest charging infrastructure network in Canada. Since 2011, over $31 million has been invested in the program, which has resulted in over $100 million in EV sales and over $10 million in infrastructure investments. The 2016 Climate Leadership Plan calls for an expansion of the CEV program, which will support B.C.'s responsibilities as a member of the International ZEV Alliance[49] and West Coast Electric Fleets[50].

"Emotive: the electric vehicle experience[51]" is an outreach and awareness campaign that branches off from the CEV program. Active since 2013, the goal of the campaign is to raise awareness on the electric vehicle experience, namely how enjoyable EVs are to drive. Emotive has been a successful brand for outreach at community events, and is the branding of an impactful social media campaign.

In addition to the above program expansions, the Climate Leadership Plan calls for an increased support in EV charging development by allowing local governments to require new buildings to install EV charging infrastructure through regulations, and facilitating station installation in strata buildings and developments through policies. This will mostly involve building code amendments, likely to be similar to Vancouver's EV-ready building code requirements. The Plan also calls for an amendment to the Clean Energy Act, increasing the clean/renewable requirement from 93% to 100%, meaning that 100% of electricity acquired by BC Hydro in the integrated grid must be clean or renewable.

b. EV market assessment

1. Current Canadian EV market

- 25 models currently available.
    - 10 BEVs
    - 14 PHEVs
    - 1 FCEV
- 19 of the 25 available models are eligible for a CEV program incentive.
- The majority of registered EVs in the Province are BEVs – 78% of all EVs in B.C. are BEVs, and 22% are PHEVs[52].
- The most common models are the Tesla Model S[53] and the Nissan LEAF.

2. Near-Future Market Assessment[54,55]

Concrete claims: vehicles that have already made it into production, or have been guaranteed to be produced by manufacturers.

[49] For more information, see http://www.zevalliance.org/
[50] For more information, see http://www.westcoastelectricfleets.com/
[51] For more information, see http://www.emotivebc.ca/
[52] Insurance Corporation of British Columbia. (2016). *Annual Vehicle Registration Report* [Data file].
[53] As of March 2, 2016, incentives are only available to vehicles with a market sale retail price under $77,000, meaning the Tesla Model S is no longer eligible for an incentive. The Nissan LEAF however still qualifies.
[54] Note that the EV technology is developing rapidly and this future market assessment represents a snapshot of how the market appeared at the end of 2016.
[55] Near-future market information was largely obtained using resources at http://www.greencarreports.com/

- Of the EV models confirmed to enter production by 2017, the most influential include:
    - The 2017 Chrysler Pacifica Hybrid – a PHEV minivan, and the first EV minivan to enter the mainstream market.
    - The 2017 Chevrolet BOLT – a BEV passenger can with a projected range of 320km.
    - The 2017 Mitsubishi Outlander – a PHEV SUV with all-wheel drive, which could be the only non-luxury PHEV SUV on the United States market.
    - The Tesla Model 3 – the first Tesla model to feature a price tag that is on-par with non-luxury EV models, and potentially eligible for a CEV incentive.
    - The second generation Nissan LEAF – the newest model of one of the most popular EVs, featuring a 60kWh battery and a range of at least 321km.
- Both the 2017 Chrysler Pacifica and the 2017 Chevrolet BOLT are currently listed as eligible vehicles for the CEV program.

Soft claims: concept vehicles and models that have so far only been discussed or proposed by manufacturers.

- The Chevrolet Colorado ZH_2 – a FCEV truck jointly-developed by General Motors and the United States Army.
- A Volkswagen BEV hatchback concept vehicle.
- A Class 8 Commercial FCEV semi-truck by Nikola One.
- An EV pickup and semi-truck announced by Tesla.

There is a clear lack of light-duty truck models within the current EV market and near-future market. This gap has been recognized by vehicle manufacturers, with several making soft claims to develop models in the future. However there is yet to be any concrete claims of future electric trucks.

Appendix D: Geographic EV Distribution Methodology

Vehicle registration data recorded and provided by ICBC was used to analyze the geographic distribution of EVs that are currently registered in the province. The data stretched from October 2011 to June 2016, and information on the make, model, model year, and fuel source of every vehicle was available. These fields were used to isolate the EVs. The postal code, down to the first three characters, is also recorded for each record to identify where in the province the registration has taken place. It was found that 17 B.C. postal codes fall within the Cariboo, North Coast, Nechako, and Northeast Development Regions (Table X). Matching the postal codes to the Development Region they fall within allowed for a geographic distribution of EVs throughout the province (Figure 3 in the main document). The same data was also used to distribute EVS by EV type within each Development Region (Figure 4 in the main document).

TABLE D1: NORTHERN BRITISH COLUMBA POSTAL CODES

Postal Code	Area Name	Urban or Rural	Development Region
V0C	Northern B.C.	Rural	Northeast (with slight overlaps into Nechako and North Coast)

V0J	Omineca and Yellowhead	Rural	Nechako (with slight overlaps into North Coast)
V0L	Chilcoltin	Rural	Cariboo
V0T	Inside Passage and Haida Gwaii	Rural	North Coast
V0V	Lower Skeena Region	Rural	North Coast
V0W	Atlin Region	Rural	Nechako
V1G	Dawson Creek	Urban	Northeast
V2G	Fort St. John	Urban	Northeast
V2G	Williams Lake	Urban	Cariboo
V2J	Quesnel	Urban	Cariboo
V2K	Prince George (North)	Urban	Cariboo
V2L	Prince George (East Central)	Urban	Cariboo
V2M	Prince George (West Central)	Urban	Cariboo
V2N	Prince George (South)	Urban	Cariboo
V8C	Kitimat	Urban	North Coast
V8G	Terrace	Urban	North Coast
V8J	Prince Rupert	Urban	North Coast

Postal codes in B.C. that begin with "V0" are categorized as rural regions. Unlike urban postal codes, which only cover a single (or a component of a single) city, rural postal codes encompass large geographic regions with multiple towns and communities within them. Several rural postal codes stretched across Development Region boundaries, such as V0C and V0J (Table D1). In order to develop a geographic EV distribution, all postal codes were recorded as representing a single region, including the few that stretch across two or three. Decisions were made based on the region that includes the most populous town, or the region that the majority of the postal code represents.

Appendix E: Vehicle Model Type Analysis – Details

To inform the model type analysis, vehicle registration data was put through several filters. Any record that was incomplete or unclear (e.g. missing model type) was disregarded. Only vehicles listed as "Passenger" or "Commercial" under the vehicle type description fields are considered, leaving out "Motorhome" and "Motorcycle". The majority of vehicles categorized as trucks within this analysis were listed under the "Commercial" field. Other vehicles that were disregarded include large commercial

vehicles (e.g. semi-trucks), modified and “u-built” vehicles, ATVs, snowmobiles, 3-wheeled vehicles, limos, taxis, farm and industrial vehicles, and other vehicle types that don’t fall within the four defined categories. In addition, any vehicle with a model year of 1989 or older was not included.

The purpose of these filters was to restrict the scope of the model-type analysis to vehicles that serve as a primary personal vehicle, and therefore could potentially be replaced by an EV model. They also shape the analysis so as that it illustrates the vehicle-use patterns of individuals and families rather than of industry. With the above filters in place, 81% of all the vehicle registration data remained to be included in the final analysis.

Focusing in on the distribution of vehicle models throughout the individual postal codes in Northern B.C. shows the same pattern (Figure E1). Several areas (postal codes V8C, V1J, V1G, V0W, V0V, V0T, V0L, and V0C specifically) feature a distribution that sees the number of SUVs as only slightly less, or in a few cases equal to or greater, than the number of passenger cars. For all 17 postal codes trucks remain the dominant model with the sole exception of V2M, Prince George West Central (Figure E1).

The dominance of trucks increase when moving north through the region. The Northern B.C. region (postal code V0C) features one of the clearest truck-majorities, and it includes communities as far north as Fort Nelson (Figure E1). The Omineca and Yellowhead region (V0J) also sees a clear truck dominance, which includes regions in the northern interior such as Fort St. James, Vanderhoof, and Smithers (Figure E1). This trend is not only isolated to rural regions; Fort St. John (V1J) and Dawson Creek (V1G), two northern urban areas, also see a relatively large difference between the volume of trucks and passenger cars/SUVs (Figure E1). The Prince George regions (V2N, V2M, V2L, and V2K) on the other hand see less of a clear truck dominance, as does Prince Rupert (V8J) (Figure E1) In fact, Prince George hosts approximately one third of the passenger cars in the entire Northern B.C. light-duty fleet (Figure E1).

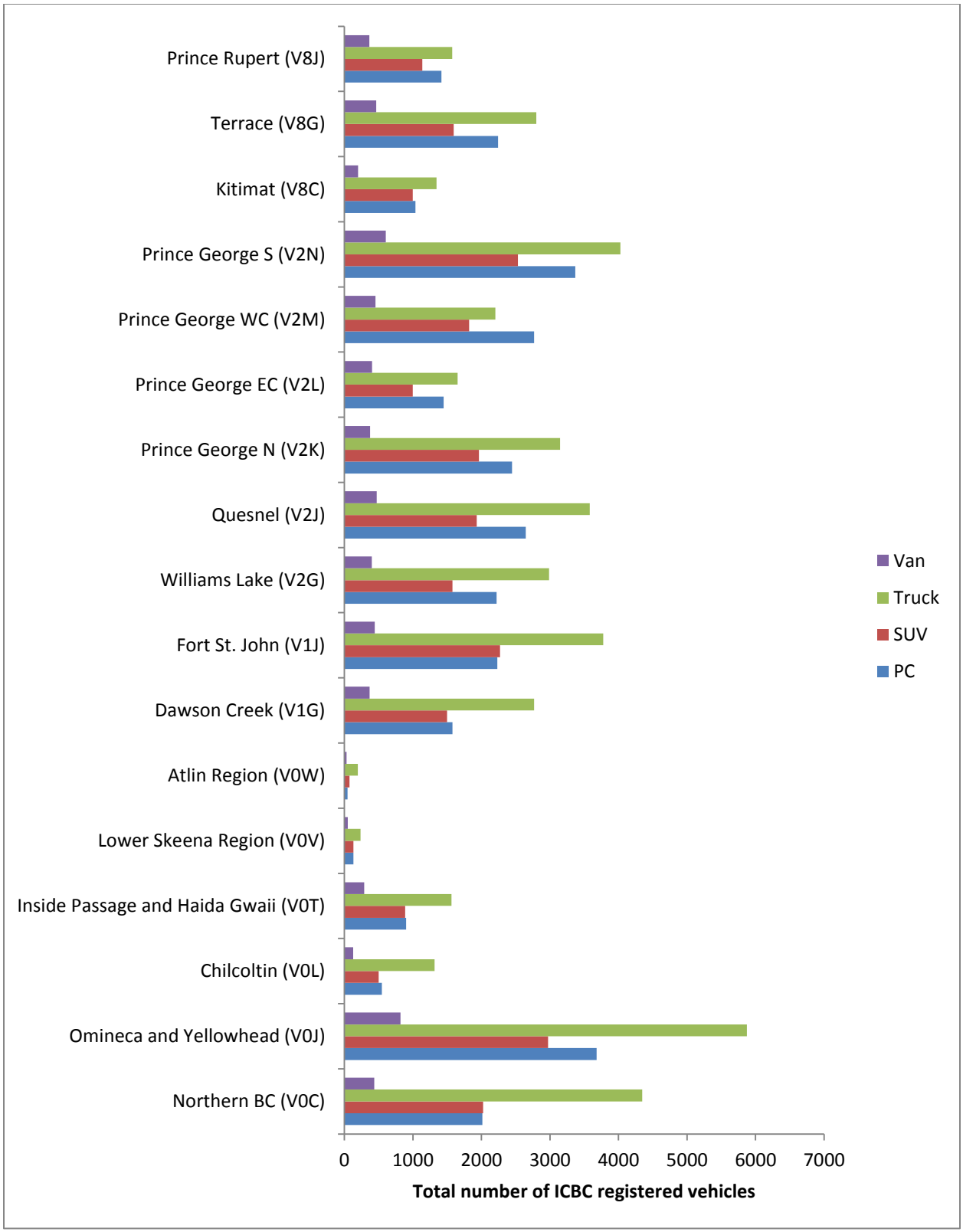


FIGURE E1: DISTRIBUTION OF VEHICLE MODELS REGISTERED IN NORTHERN B.C. FROM OCT 2011 – JUN 2016 BY POSTAL CODE (ICBC 2016)

Appendix F: Vehicles Kilometers Traveled Analysis - Methodology

The CEEI does not categorize their data by Development Region, so data from the Regional Districts was collected. VKT data is included for multiple vehicle classes, which is then further categorized into vehicle fuel types. Only data on relevant vehicles classes were collected for analysis (small passenger cars, large passenger cars, and light trucks, vans, and SUVs), and within those vehicles of all fuel types were combined and averaged. Many of the Regional Districts have two available CEEI reports: one for the district, and one for the district's unincorporated areas. VKT data from these two reports were averaged, as to result in a single average VKT value per vehicle class for each Regional District (Figure 11 in the main document). To arrive at the average VKT per vehicle class for each of the four Development Regions, the average VKT values for each Development Regions two Regional Districts were averaged.

Appendix G: Future Vehicle Replacement and EV Uptake Projections - Methodology

Annual vehicle sales estimates (Table 2 in the main document) were made by determining the volume of vehicles with a corresponding model year within the vehicle registration data provided by ICBC. To determine the number of passenger cars sold in 2015 in Northern B.C. for example, all of the registered passenger cars with a 2015 model year were totaled. It is acknowledged that model year does not always correlate with year of sale. Cars from the year previous may remain on dealership lots and sold in the current year, and cars from the upcoming year are often released and begin being sold in the fall of the current year. In addition, used car sales tend to involve the sale of cars of an older model year than the current. However, in order to simplify calculations and reduce chances of over-inflating numbers, model year is assumed to represent the year of sale.

To determine the current percentage of EV uptake in Northern B.C., the number of EVs sold in a current year was divided by the total number of passenger cars sold that year (Table 2 in the main document). Just as with total vehicle sales, the number of EVs sold in a certain year was calculated by taking all EVs registered with a corresponding model year. The resulting amount was then divided by the total passenger car sales amount and converted to a percentage. EV sales penetration percentages were calculated for 2011-2015 for Northern B.C. as a whole.

Projections for passenger vehicle sales numbers in Northern B.C. were estimated by taking the average increase in sales annually from 2011-2015, and applying that increase over the following five years (with the exception of 2016). In Northern B.C., passenger vehicle sales increased by 5.4% on average; therefore it was assumed that in 2017 total sales would be 5.4% greater than sales in 2016, and so on.

Six projections of future EV uptake were extrapolated. To extrapolate a scenario where the current rate of growth in EV sales for Northern B.C. continues, the average change in the number of EV sales from 2012 to 2015 was taken and applied for the following five years. The resulting change was a 57.8% increase. However, this value includes 2014, which sees an abnormally low number of EVs sold (Table 2 in the main document); 2014 is also the year where no CEV incentives were made available, which is a likely explanation behind this anomaly. If 2014 is ignored, Northern B.C. sees an increase of 12% in the

number of EVs sold, which is a more realistic projection and the one used in Table 3 in the main document.

The last four scenarios display the potential amount of EV uptake in Northern BC if the percentage of EV sales penetration were to increase to 0.5%, 1%, 2%, or 5% by 2020 (Table 3 in the main document). For each scenario, a linear increase in percentage from the 2015 EV uptake of 0.098% of passenger vehicle sales occurs each year such as that the final percentage goal is reached in 2020. For example, to achieve a 0.5% EV sales penetration in 2020, each year must see an increase of 0.18 percentage points from 0.098%. While EV uptake is generally a non-linear function, Northern BC sees relatively low magnitudes of EV uptake allowing linear increases to be assumed for simplicity.

Appendix H: DCFC Infrastructure Gap Analysis – Site Locations

The following table is a complete list of all the sites indicated within the DCFC infrastructure gap analysis as potential station locations. Whether a site features a gas station or not is noted because gas stations often have three-phase power access, which is necessary for the installation of a Level 3 charging station.

TABLE H1: THE LOCATION AND FEATURES OF EVERY SITE INDICATED AS A POTENTIAL LOCATION FOR A DCFC STATION IN THE NORTHERN B.C. CHARGING INFRASTRUCTURE GAP ANALYSIS. THE STRATEGIES THAT INCLUDE EACH STATION AND THE FIGURES THEY APPEAR IN ARE INCLUDED

Site Location	Site features	Strategies that include site	Figure number in document
Cache Creek	Multiple chain restaurants and gas stations; features Level 2 charging infrastructure; connects to the existing DCFC network	Option 1 (phase 1), Option 2 (phase 1), and Option 3	Figure 15, Figure 21
Clinton	Gas stations and restaurants	Option 1 (phase 1), Option 2 (phase 1), and Option 3	Figure 15, Figure 21
100 Mile House	Multiple chain restaurants and gas stations	Option 1 (phase 1), Option 2 (phase 1), and Option 3	Figure 15, Figure 21
Lac la Hache	Small retirement community, a few restaurants and a gas station	Option 1 (phase 1), Option 2 (phase 1), and Option 3	Figure 15, Figure 21
Williams Lake	Largest urban centre between Kamloops and Prince George; features Level 2 charging infrastructure	Option 1 (phase 1), Option 2 (phase 1), and Option 3	Figure 15, Figure 21

McLeese Lake	Small restaurant and general store nearby	Option 1 (phase 1), Option 2 (phase 1), and Option 3	Figure 15, Figure 21
Quesnel	Multiple chain restaurants and gas stations; features Level 2 charging infrastructure	Option 1 (phase 1), Option 2 (phase 1), and Option 3	Figure 15, Figure 21
Hixon	Small community, with an available gas station and restaurant	Option 1 (phase 1), Option 2 (phase 1), and Option 3	Figure 15, Figure 21
Prince George	Largest city in Northern B.C. with multiple chain restaurants and gas stations; features Level 2 charging infrastructure; local University and the City are members of the West Coast Electric Fleet	Option 1 (phase 1), Option 2 (phase 1), and Option 3	Figure 15, Figure 16, Figure 21
Cluculz lake (BC rest area)	Sited at a rest area with street lighting and flush toilets; capacity to support a site requires further assessment	Option 1 (phase 1), Option 2 (phase 1), and Option 3	Figure 15, Figure 16, Figure 21
Vanderhoof	Multiple chain restaurants and gas stations	Option 1 (phase 1), Option 2 (phase 1), and Option 3	Figure 15, Figure 16, Figure 21
Fort St. John	Multiple chain restaurants and gas stations; features Level 2 charging infrastructure	Option 1 (phase 2) and Option 2 (phase 2)	Figure 17, Figure 18, Figure 21
Dawson Creek	Multiple chain restaurants and gas stations; features Level 2 charging infrastructure	Option 1 (phase 2) and Option 2 (phase 2)	Figure 17, Figure 18, Figure 21
Groundbirch	Gas station with attached general store; capacity to support a site requires further assessment	Option 1 (phase 2) and Option 2 (phase 2)	Figure 18, Figure 21
Chetwynd	Multiple chain restaurants and gas stations	Option 1 (phase 2) and Option 2 (phase 2)	Figure 18, Figure 21
Hudson's Hope	Multiple restaurants and gas stations; features Level 2 charging infrastructure	Option 1 (phase 2) and Option 2 (phase 2)	Figure 18, Figure 21

Tumbler Ridge	Multiple chain restaurants and gas stations; features Level 2 charging infrastructure	Option 1 (phase 2) and Option 2 (phase 2)	Figure 18, Figure 21
Hythe, Alberta	Small community, with available gas stations and restaurants	Option 1 (phase 2) and Option 2 (phase 2)	Figure 17, Figure 18, Figure 21
Grande Prairie, Alberta	Multiple chain restaurants and gas stations; features Level 2 charging infrastructure	Option 1 (phase 2) and Option 2 (phase 2)	Figure 17, Figure 18, Figure 21
Fraser Lake	Multiple restaurants and gas stations	Option 2 (phase 3)	Figure 21
Burns Lake	Multiple chain restaurants and gas stations; features Level 2 charging infrastructure	Option 2 (phase 3)	Figure 21
Houston	Multiple chain restaurants and gas stations; features Level 2 charging infrastructure	Option 2 (phase 3)	Figure 21
Smithers	Multiple chain restaurants and gas stations	Option 2 (phase 3)	Figure 21
New Hazelton	Multiple restaurants and gas stations	Option 2 (phase 3)	Figure 21
Junction of Hwy 16 and Hwy 37	Sited by a Petro Canada gas station; capacity to support a site requires further assessment	Option 2 (phase 3)	Figure 21
Terrace	Multiple chain restaurants and gas stations; features Level 2 charging infrastructure	Option 2 (phase 3)	Figure 21
Telegraph Point (BC Rest Area)	Sited at a rest area; capacity to support a site is unlikely without significant cost	Option 2 (phase 3)	Figure 21
Prince Rupert	Multiple restaurants and gas stations	Option 2 (phase 3)	Figure 21
Bear Lake	Gas station with attached general store	Option 2 (phase 4)	Figure 21
Junction of Hwy 97 and Hwy 39	Sited at a gas station with an attached restaurant; capacity to support a site requires further assessment	Option 2 (phase 4)	Figure 21

MacKenzie	Multiple restaurants and gas stations	Option 2 (phase 4)	Figure 21
West Pine River (BC Rest Area)	Sited at a rest area; capacity to support a site is unlikely without significant cost	Option 2 (phase 4)	Figure 21
Valemount	Multiple restaurants and gas stations; features Level 2 charging infrastructure	Not featured in an enclosed strategy	Figure 19, Figure 20, Figure 21
Mount Robson B.C. Visitor Centre	Visitor centre with street lighting and a gift shop	Not featured in an enclosed strategy	Figure 19, Figure 20, Figure 21
Jasper, Alberta	Large tourism centre; multiple chain restaurants and gas stations; features Level 2 charging infrastructure	Not featured in an enclosed strategy	Figure 19, Figure 20, Figure 21
Bowron River (BC Rest Area)	Sited at a rest area; capacity to support a site is unlikely without significant cost	Not featured in an enclosed strategy	Figure 21
Slim Creek (BC Rest Area)	Sited at a rest area with street lighting and flush toilets; capacity to support a site requires further assessment	Not featured in an enclosed strategy	Figure 21
McBride	Multiple restaurants and gas stations	Not featured in an enclosed strategy	Figure 21
Hwy 20, at the junction with Hanceville cut off road	Sited at a general store with an attached gas station; capacity to support a site is questionable	Not featured in an enclosed strategy	Figure 21
Hwy 20, at the junction with Redstone Reserve road	Sited near a small community on First Nations land; capacity to support a site requires further assessment	Not featured in an enclosed strategy	Figure 21
Off of Hwy 20, north of Clearwater Lake	Sited at a local lodge; capacity to support a site requires further assessment	Not featured in an enclosed strategy	Figure 21
Anahim Lake	Available restaurant and general store; year-round airport	Not featured in an enclosed strategy	Figure 21

Off of Hwy 20, east of Stuie	Sited at a local lodge; capacity to support a site requires further assessment	Not featured in an enclosed strategy	Figure 21
Bella Coola	Available gas stations and a restaurant	Not featured in an enclosed strategy	Figure 21

Appendix I: EV Infrastructure Planning Assistant

[See separate attachment: "EV Planner – Infrastructure Planning Assistant Tool"]

Appendix J: Population Charts

Below are the projected current and future populations of B.C.'s Development Regions. While the Cariboo Development Region has the largest population of Northern B.C. (Figure J1), the Northeast Development Region is projected to see the greatest percentage growth over the next five years within the north (Table J1).

TABLE J1: THE PERCENTAGE POPULATION GROWTH OF B.C'S DEVELOPMENT REGIONS PROJECTED OVER FIVE YEARS (BC STATS)[56]

Development Region	2016 population	2020 population	% Growth
BC	4740124	4979289	5%
Mainland/southwest	2919482	3086660	6%
Vancouver Island/Coast	797976	833416	4%
Thompson-Okanagan	552585	577780	5%
Kootenay	147578	149599	1%
Cariboo	154141	156449	1%
Northeast	70831	74710	5%
North Coast	56484	58238	3%
Nechako	41047	42437	3%

[56] BC Stats. (2016). *Population projections* [Data set]. Retrieved from http://www.bcstats.gov.bc.ca/StatisticsBySubject/Demography/PopulationProjections.aspx

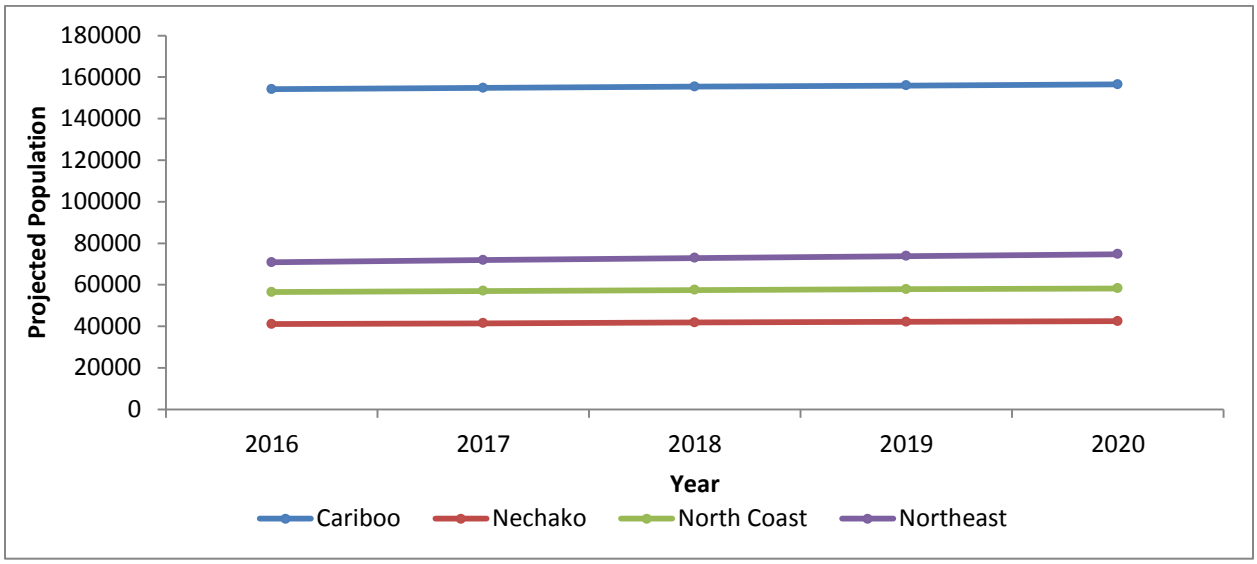


FIGURE J1: THE PROJECTED POPULATION CHANGES IN B.C.'S NORTHERN DEVELOPMENT REGIONS OVER FIVE YEARS (BC STATS)57

Appendix K: Stakeholder Consultation Details

37 individuals were reached out to throughout the stakeholder consultation process. Some individuals referred other potential contacts, and some were unable to complete the entire consultation. The Northern communities that were contacted include:

Dawson Creek
Fort St. James
Fort St. John
Prince George
Prince Rupert
Quesnel
Smithers
Terrace
Williams Lake

Consultations occurred over the phone and through e-mail and were based on a set of questions that differed depending on which "group" each stakeholder belongs to. These questions are listed below:

Northern B.C. Residents and Governments

1. In your opinion, what are the key values held by your community? (e.g. economic and job security values, environmental values, community wellness values, etc.)
2. In your community, what are personal vehicles most commonly used for? (e.g. commuting to work/local areas, long-distance traveling, heavy-duty hauling, etc.)

[57] BC Stats. (2016). *Population projections* [Data set]. Retrieved from http://www.bcstats.gov.bc.ca/StatisticsBySubject/Demography/PopulationProjections.aspx

3. Where would you say the priority travel corridors are (i.e. major roads and highways most heavily used and depended on)?
4. Are you aware of any charging infrastructure that currently exists in your community and/or your neighbouring communities? If so, how popular is it/how often is it used? If not, do you see an interest around increasing charging infrastructure availability?
5. As of now, do you see a market or an interest in electric and plug-in vehicles in your community? If not, what do you think needs to happen to increase awareness and stir discussion? If you do, what do you think the main barrier to adoption is?
6. Would you in any way be able to support a public Level 2 charger (240V, takes 4-8hrs to charge) or a DC fast charger (takes 15-30mins to charge) within your community? (i.e. portion of installation costs, support in siting and location planning, etc.)
7. Are engine block heaters a common occurrence in households and workplaces in your community?
8. Do you have any additional comments regarding electric vehicles in your community?

Vehicle Manufacturer Associations

1. What are some of the current barriers to producing a wider variety of clean energy vehicle models? (i.e. electric light duty trucks, etc.)
2. Do you have any insight on the future of clean energy vehicle technology that you can share? What direction is the industry going towards? And how close are we to a future where electric vehicles enter the mainstream?
3. What kinds of policies and regulations would you need/like to see in order to improve clean energy vehicle technology and make these vehicles more competitive in the auto market?
4. Do you have any other comments on barriers to northern electric vehicle adoption, from your perspective?

EV Groups and Enthusiasts

1. Do you know of any interest in electric vehicles, or clean-energy vehicles, in Northern B.C?
2. Do you have some personal experience driving in colder temperatures and along challenging geographic routes (i.e. mountain highways) in an electric vehicle? How would you characterize that experience? What were the main challenges, and what elements would have improved it (i.e. improved technology, increased charging infrastructure, better located infrastructure, etc.)?
3. Which routes and highways do you see as being the most crucial to electrify if we are to increase adoption in Northern B.C?
4. In your opinion, how close are we to a selection of electric vehicles that is competitive in variety to conventional vehicles?
5. Do you have any other comments on barriers to northern/rural electric vehicle adoption, from your perspective?

Utilities (BC Hydro)

1. In a general sense, what regions of B.C. are currently limited in grid-connectivity? Where in the northern regions of B.C. is it the most and least feasible to install Level 3 charging infrastructure? In other words, where should we prioritize expanding DCFC network connectivity?
2. Are you aware of any communities that are not using electricity generated by BC Hydro at all (excluding those serviced by FortisBC and Nelson Hydro)?
3. Do you have any other comments on barriers to northern/rural electric vehicle adoption, from your perspective?

Appendix L: Permanent Traffic Count Sites in Northern B.C.

The Ministry of Transportation and Infrastructures (MOTIs) Traffic Data Program monitors traffic at various locations throughout B.C. Permanent count sites provide data on traffic volumes, and speed and classification data for a portion of the sites, in daily, monthly, and annual reports. Below are details from the ten year annual reports of the 21 permanent count sites located in Northern B.C. The six sites with AADT ranges that surpass 3000 vehicles are written in bold (Table L1). Figure 12 within the main document provides a map of their locations.

The ranges under AADT and SADT represent the lowest and highest volume of traffic that occurred from 2006-2015. For some sites, data is missing for one or more of the years between 2006 and 2015(Table L1). Type 1 vehicles are within 0-6m in length (including most passenger cars, SUVs, light-duty trucks, and vans), type 2 vehicles are 6-12.5m long, type 3 vehicles are 12.5-22.5m long, and type 4 vehicles are 22.5-35m long.

TABLE L1: AADT, SADT, AND VEHICLE COMPOSITION DATA FROM PERMANENT SITE COUNTS WITHIN MOTI'S TRAFFIC DATA PROGRAM IN NORTHERN B.C. THE SIX SITES WITH THE LARGEST AADT VOLUMES ARE INCLUDED IN BOLD. DATA WAS COLLECTED FROM ANNUAL REPORTS FROM 2006 – 2015 (MOTI, 2016)

Site Name	Annual Average Daily Traffic (AADT)	Summer Average Daily Traffic (SADT)	Vehicle class distribution (if available)[58]
P-29-1EW: Anahim	139 – 198 vehicles	196 – 346 vehicles	71% = type 1 23% = type 2
P-41-2NS: Marguerite	**2,743 – 3,008 vehicles**	**4,031 – 4,363 vehicles**	**62% = type 1 15% = type 2 14% = type 3**
P-41-1NS: Stone Creek	**3,527 – 3,994 vehicles (2007 and 2015 data missing)**	**4,638 – 5,120 vehicles (2007, 2012, and 2013 data missing)**	**70% = type 1 12% = type 2 11% = type 3**
P-23-3NS: Tete Jaune	2,261 – 2,731 vehicles (2012 and 2013 data missing)	4,090 – 4,502 vehicles (2006, 2012, and 2013 data missing)	n/a
P-23-1EW: Tete Jaune	1,000-1,093 vehicles (2012 and 2013 data missing)	1,567 – 1,692 vehicles (2012 and 2013 data missing)	n/a
P-73-9: Tete Jaune	1,131 – 1,343 vehicles	2,050 – 2,293 vehicles(2006 data	n/a

[58] Not all permanent site counts records vehicle class distribution information. There are five vehicle types in total; only types with a size greater than 10% are included in Table L1.

	(2013 data missing)	missing)	
P-23-2EW: Tete Jaune	**2,625 – 3,066 vehicles (2013 data missing)**	**4,832 – 5,326 vehicles**	**n/a**
P-42-2EW: Bednesti	**3,998 – 4,065 vehicles (includes 2013, 2014, and 2015 data)**	**4,866 – 5,449 vehicles (includes 2009, 2013, 2014, and 2015 data)**	**73% = type 1**
P-45-1EW: Pipers Glen	2,482 – 2,869 vehicles (2012 and 2015 data missing)	3,244 – 3,647 vehicles (2012 and 2015 data missing)	75% = type 1 12% = type 2
P-47-1EW: Kitwanga	1,250 – 1,479 vehicles (2014 data missing)	1,808 – 2,057 vehicles (2014 data missing)	n/a
P-47-9NS: Kitwanga	740 – 832 vehicles (includes 2006-2011 data)	977 – 1,225 vehicles (includes 2006 – 2010 data)	n/a
P-47-2EW: Kitwanga	1,306 – 1,587 vehicles (2014 data missing)	1,869 – 2,162 vehicles (2014 data missing)	n/a
P-51-1EW: Prince Rupert	891 – 1,159 vehicles	1,373 – 1,694 vehicles	78% = type 1 10% = type 2
P-43-2NS: Willow Flats	997 – 1,551 vehicles (2013, 2014, and 2015 data missing)	1,335 – 1,906 vehicles (2013 and 2015 data missing)	65% = type 1 17% = type 2
P-43-1NS: Tupper	**3,313 – 4,100 vehicles (2012 data missing)**	**3,866 – 4,764 vehicles**	**69% = type 1 15% = type 3**
P-44-1NS: Inga Lake	**1,730 – 3,186 vehicles (includes 2008, 2009, and 2012-2015 data)**	**2,205 – 3,679 vehicles (includes 2008 and 2011-2015 data)**	**41% = type 1 28% = type 2 19% = type 3 13% = type 4**
P-44-2NS: Sikanni	784 – 1,077 vehicles (2006 and 2007 data missing)	1,062 – 1,583 vehicles (2007 and 2007 data missing)	55% = type 1 13% = type 2 24% = type 3
P-44-3NS: Prophet River	671 – 929 vehicles (2006, 2007, and 2011 data missing)	946 – 1,210 vehicles (2006, 2007, and 2011 data missing)	44% = type 1 22% = type 2 22% = type 3

P-44-4NS: Andy Bailey	672 – 985 vehicles (2006 and 2007 data missing)	962 – 1,264 vehicles (2006 and 2007 data missing)	42% = type 1 22% = type 2 18% = type 3 18% = type 4
P-44-5NS: Formula	699 – 1,055 vehicles (2006 and 2007 data missing)	916 – 1,297 vehicles (2006 and 2007 data missing)	36% = type 1 34% = type 2 20% = type 3
P-44-6NS: Fireside	350 – 472 vehicles (2006 and 2007 data missing)	569 – 699 vehicles (2006, 2007, 200, and 2012 data missing	n/a

Appendix M: Summary of Literature Reviewed

In addition to the sources included in footnotes and directly mentioned within Appendix C, several other sources were reviewed which helped to shape this document. Below is a table that includes some of these documents. This is not a complete list, but the sources presented here were key for research.

Document title	Source	Date
The BC Electric Vehicle Infrastructure Project: DC Fast Charging	BC Hydro, BC Government	2014
Canadian Electric Vehicle Infrastructure Deployment Guidelines	ECOtality North America, CEATI International Inc.	2014
EV City Casebook	Urban Foresight Limited, the Electric Vehicles Initiative, the International Energy Agency's Implementing Agreement	2014
City of Fort St. John Transportation Master Plan	Urban Systems Ltd., City of Fort St. John	2015
The Beginners Guide to Electric Vehicles	Emotive: the electric vehicle experience	2016
Electrifying Vehicles: Insights from the Canadian Plug-in Electric Vehicle Study	The Simon Fraser University Sustainable Transportation Research Team	2015
Going the Distance: Commuting Patterns in BC	BC Stats	2006
Electric Mobility Policies in the North Sea Region Countries	North Sea Region Electric Mobility Network	2012

The BC EV Smart Infrastructure Project: DCFC Station Usage	Powertech	2015
Population Statistics	Insurance Corporation of BC	2015
Future DCFC Charging Locations in British Columbia – Issues and Recommendations	Victoria Leaf Club	2015
Design Guidelines and Standards: BC Public Electric Vehicle Charging Stations	The University of British Columbia Transportation, Infrastructure and Public Space (TIPS) Lab	2013
Review of Nissan Leaf (Electric Car) Pilot Program – briefing note	The City of Prince George	2016