



Business Case for Investing in Electric Vehicle Direct Current Fast Charge Station Infrastructure



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This report was developed with information current up to September 2015. Since that time there has been additional fast charging programs announced within Canada. Please contact individual jurisdictions for current information on such initiatives.

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List of acronyms

AB	Alberta
AC	Alternating current
AVERE	European Association for Battery, Hybrid and Fuel Cell Electric Vehicles
AVÉQ	Association des véhicules électriques du Québec
BC	British Columbia
BEV	Battery Electric Vehicle
CAA	Canadian Automobile Association
CCME	Canadian Council of Ministers of the Environment
DC	Direct current
DCFC	Direct current fast charger
DOE	Department of Energy
EDTA	Electric Drive Transportation Association
ELECTRIC	European Long-distance Electric Clean Transport Road Infrastructure Corridor
EMC	Electric Mobility Canada
EPRI	Electric Power Research Institute
EV	Electric vehicle
GHG	Greenhouse gases
HQ	Hydro-Québec
ICE	Internal combustion engine
kW	Kilowatt
kWh	Kilowatt-hour
L2	Level 2
MB	Manitoba
MSWG	Mobile Sources Working Group
NBC	National Building Code
NFLD	Newfoundland and Labrador
NRCan	Natural Resources Canada
NS	Nova Scotia
NWT	Northwest Territories
PEI	Prince Edward Island
PEV	Plug-in Electric Vehicle
PHEV	Plug-in Hybrid Electric Vehicle
OEM	Original Equipment Manufacturer
ON	Ontario
QC	Québec
RFID	Radio frequency identification
SOC	State of charge
TEN	Trans-European Transport Networks
TEPCO	Tokyo Electric Power Company
US	United States
V	Volt
V2G	Vehicle to Grid
VAC	Volts of Alternating Current
VDC	Volts of Direct Current
VEVA	Vancouver Electric Vehicle Association

Executive Summary

Transportation is an important contributor to greenhouse gas (GHG) emissions, accounting for 24% of all emissions in Canada (of which 52% is generated by light-duty vehicles and small trucks)¹. The electrification of transportation offers an important option for reducing air pollutants and GHGs. Given that clean, renewable electricity represents approximately two-thirds of Canada's generation mix², moving to electric mobility is an excellent means of contributing positively to environmental efforts of reducing GHG emissions and other pollutants to improve air quality and health outcomes.

The Canadian Council of Ministers of the Environment (CCME) is an intergovernmental forum, made up of the 14 member governments. The CCME Mobile Sources Working Group (MSWG) was established in 2011 to develop integrated and collaborative approaches to address mobile source emissions. The MSWG works on initiatives to address air pollutants and GHGs from mobile sources as part of the Air Quality Management System. With the growing interest in electric vehicles (EVs) by Canadians and the potential emission benefits that can be achieved through their increased deployment in the transportation sector, the MSWG has identified EV use within the light-duty fleet as an area of interest, with a focus on approaches for infrastructure.

Despite strong year-over-year sales increases of EVs in Canada, approximately 12,500 EVs³ are being used on Canadian roads as of March 2015. This represents less than one-tenth of one percent of the total number of passenger vehicles in Canada.

The sale of EVs is limited by several factors, including the price of EVs relative to their internal combustion engine (ICE) counterparts, limited driving range per charge, long charging time, lack of charging infrastructure and the limited choice of models offered by manufacturers and at dealerships.

Despite the fact that over 90% of EV charging takes place at home or at work, availability of public charging is essential as EV owners worry about running out of electricity before reaching their destinations (known as range anxiety). In fact, range anxiety can act as a significant barrier to an EV purchase⁴.

Public charging infrastructure generally falls into two categories: Level 2 chargers and DC fast chargers (DCFCs). Direct-current (DC) fast charging (typically 208/480 VAC three-phase input) enables rapid charging. EVs equipped with a CHAdeMO, or an SAE DC⁵ fast charge receptacle can add 80 to 110 km of range (more for a Tesla) in approximately 20 minutes.

DCFCs enable EV motorists to:

- Travel longer distances: Some DCFCs are located in travel corridors, where they provide range extension to vehicles between major metropolitan areas⁶;

¹ Canada's Emissions Trends, Environment Canada, Oct 2013, http://www.ec.gc.ca/ges-ghg/985F05FB-4744-4269-8C1A-D443F8A86814/1001-Canada%27s%20Emissions%20Trends%202013_e.pdf

² Canadian Electricity Association, <http://powerforthefuture.ca/the-value-of-electricity/electricity-pricing-factors/the-generation-mix/>

³ End of March 2015

⁴ The issue of range anxiety was discussed at the EVE2015 conference where one OEM indicated that range anxiety is the most important reason for not buying an EV. According to a Ford representative at this conference, customers are saying that if they do not know the charging infrastructure is available, they will not buy an EV.

⁵ Also called an SAE J1772 AC/DC combo connector

⁶ <http://www.theevproject.com/cms-assets/documents/127233-901153.q2-2013-rpt.pdf>

- Charge their EVs when home/at work charging is not available or possible⁷ (discussed in section 4.1);
- Charge their EVs in metropolitan areas more quickly than using a Level 2 charger;
- Tolerate a lower state of charge (SOC) in their vehicle, thereby demonstrating a decrease in range anxiety, a common deterrent in the purchase of EVs.

Canada's DC fast charging infrastructure

Approximately half the EVs on Canadian roads are compatible with DC fast charging.

In total, at the writing of this report (May 2015), there are 48 DCFC locations in Canada (including 15 Tesla SuperCharger locations) hosting 139 ports. The DCFCs are concentrated in the country's three most populous provinces: 90% of the DC fast charging locations are in British Columbia (42% of locations), Ontario (19% of locations) and Québec (29% of locations).

Given the size of Canada, a significantly larger number of DC fast charging locations are required to allow an EV driver to travel across the country than would be the case in the United Kingdom or Norway. Despite this fact, the number of DC fast charging locations in Canada is significantly lower than in these two European nations. As presented later in the report in Table 7 (Pg.26), in terms of population that can be served by each DC fast charging location, Canada (and particularly, Ontario) ranks lower than all the other jurisdictions presented.

Numerous stakeholders, including electric utilities, auto manufacturers and other private entities have declared an interest in deploying additional DCFCs in Canada.

Funding of DC fast charging infrastructure in Canada

DC fast charging infrastructure deployment within Canada is in its infancy. With the exception of Tesla and AZRA, network scale deployment has been the work of governments, their agencies or Crown Corporations in Canada. This results from the perceived high risk (despite high financial returns on investment) and significantly longer paybacks than private investors are generally willing to accept. Given the investment required, the relatively small number of EVs and the low incidence of charging, conventional financing of DC fast charging stations (equity, debt or a mixture of both) has been nearly impossible, and is unlikely to change in the foreseeable future.

The successful DC fast charging infrastructure network deployments have been financed in one of the following ways:

1. Highly subsidized by provincial and/or federal government;
2. Private investment made by auto manufacturers aimed at reducing range anxiety and increasing EV sales; and,
3. One innovative investment model inspired by the commercial real estate market and derivative sources of income.

In most cases, the total amount of investment available is relatively small and the process to obtain government funding (if and when it is available) can be rather complicated, onerous and rare. This explains, in large part, the relatively slow rate at which DC fast charging infrastructure is deploying in Canada.

Cost of purchase and installation of DC fast charging stations

The installed cost of DC fast charging stations varies widely depending on a number of factors. The three main cost components are the equipment (or charger), the installation and the real estate (land

⁷ Often the case when the EV owner does not have access to a dedicated parking space.

and amenities).

In the case of the purchase of the DC fast charging equipment, the cost varies depending on the manufacturer, the unit specifications as well as the number of units ordered. While the price of chargers has been declining, most stakeholders⁸ contributing to this research cite 2015 prices of approximately \$30,000 per unit⁹.

The installation cost varies depending on:

- The availability of a suitable source of 3-phase electricity in close proximity;
- The civil work required on site;
- The importance of the aesthetics to the operator;
- The time of the year at which the installation work is performed (a consideration in all provinces except BC);
- The organization managing the project.

Based on the information gathered from Canadian stakeholders involved in the installation of DCFCs, the installation cost can vary widely from \$15,000 to over \$60,000. This does not include the cost or installation of peripheral equipment, such as solar carports and heating pads, to ensure the space is accessible at all times to EV owners.

The cost of real estate can also vary widely, ranging from zero¹⁰ to several thousands of dollars per square meter in major urban centers.

Criteria used to determine location for DCFC installation

The criteria used to determine the location for the installation of a DCFC vary by network. Given the current scarcity of stations and the varied motivations of network owners, these are not necessarily indicative of how all future locations will be selected.

Generally speaking, the siting criteria reflect the realities of the population dispersion and motorist travel patterns within each jurisdiction¹¹. At a very basic level, a key criterion is urban versus highway location. While the latter is strategic and necessary to permit longer-distance travel, the former provides greater visibility and can play an important role in public education and awareness.

Current and future utilization of DCFCs

The utilization of DC fast charging stations is low for two principal reasons:

- Relatively limited number of EVs in Canada;
- The large majority of recharging is being completed at home, and to a lesser extent, at work.

While DC fast charging stations located closer to, or in, urban areas may be used more frequently than those located on highways¹², chargers located on highways play an important role in EV adoption by providing EV owners with the safety net required to make longer distance travel (limiting range anxiety).

⁸ Public electric utilities and DC fast charging network operators.

⁹ Prices cited range from \$25,000 to \$40,000 per unit.

¹⁰ Example: in the case where the real estate is granted by a third party without charge.

¹¹ During the EV2015VÉ Conference breakout session on charging infrastructure, it became clear that not all provinces have the same realities with respect to population concentration and distribution. Further, traffic patterns vary considerably, depending on the activities of residents (example: in BC, travel of residents of the greater Vancouver area to attractions and activities inland or up the coast).

¹² Source: AddEnergie presentation at the EV2015VÉ Conference. According to AddEnergie, the DC fast charger used most frequently in Québec is one situated in Montréal (on average, 5 charge sessions per day).

As more EV models are introduced with longer range¹³, it would be reasonable to expect that EV adoption will increase. More EVs will result in greater use of the DC fast charging infrastructure available. However, a report from the Electrical Power Research Institute (EPRI) indicates that as the range of EVs increases, the percentage of the vehicle population using DC fast charging decreases.

EPRI's analysis has important implications on the future use of DCFCs and their ability to generate enough revenue from charging alone to cover the cost of purchase, installation, operation and maintenance of the stations.

Measured and unmeasured co-benefits

Numerous potential benefits are associated with the deployment of a DC fast charging network; some are more easily measured than others. Following is a list of some of these benefits.

- In addition to the revenue generated from the charging session, “peripheral” revenues from the sale of products in nearby retail establishments
- Installing a DC fast charging station along with the other building and equipment at a service station is attractive to station operators that lease such locations. A survey conducted by the Québec association of EV owners (AVÉQ) determined that an EV driver who stops for a charge will spend between \$3 and \$14 on food, drink or other products while the vehicle is charging.
- Cross-promotions targeting EV owners offer an opportunity to generate additional revenues. The station's network operator can therefore generate additional revenues by partnering with businesses that wish to target their products and services to a segment of the population that is relatively more educated and relatively more affluent than the average¹⁴. For the EV owner, this increases the value of being a member of the network and being an EV driver.

For many, DC fast charging is a visible message of the organization's pro-environment stance. Beyond the above-noted benefits, DC fast charging contributes to reducing GHG emissions and air pollutants by encouraging consumers to purchase and use EVs instead of their ICE counterparts. These environmental benefits are also associated with health benefits.

Finally, DCFCs can increase the revenues of Canadian electric utilities that generate electricity in Canada and provide jobs for Canadians.

Business case evaluation

To develop the business case, we took into consideration:

- Canadian motorist travel behaviours (distances driven);
- Technology improvements leading to significantly improved range at reasonable vehicle prices;
- Current and projected costs associated with the purchase and installation of the DC fast charging station;
- Variable costs for maintenance and operation of the station;
- Projected number of EVs in Canada (five scenarios);
- Projected number of DCFCs.

¹³ Based on OEM announcements, at least four (4) EV models with a range of at least 300 km, priced at approximately \$40,000, will be available in 2017.

¹⁴ Suzanne Goldberg presentation at the EV2015VÉ Conference: What BC's Electric Vehicle Owners Tell Us About Driving and Charging. Preliminary analysis of SFU's 2014 Plug-in Vehicle Owners' Survey (PEVOS)

EV sales forecasts

In order to determine the number of DC fast charging locations that will be required in the next decade, it was necessary to estimate the number of EVs that will be circulating on Canadian roads.

Forecasting EV sales (an emerging industry with a limited history) is challenging. Future sales depend on a large number of factors, including the price of conventional fuels relative to the price of electricity, the range and performance of EVs, the price of EVs relative to the price of comparable ICE vehicles, the availability of a greater number and variety of EV makes and models, the availability of government incentives (for the purchase of EVs and for the installation of charging infrastructure) and the availability of other incentives to encourage EV ownership.

Five (5) EV sales forecast scenarios have been developed ranging from the “worst case” scenario (#1) to the “optimistic” scenario (#5). Scenarios #2, #3 and #4 are based on a “realistic” projection of sales that reflect information available today (examples: significantly greater expected range of EVs from 2016 on, variety of EV models to be introduced in the short term).

Scenario #4 presents the realistic scenario that was used as the basis for the financial projections. Representatives of the auto manufacturers vetted this scenario. A total of 750 DC fast charging locations hosting 1,600 DCFCs are foreseen by this scenario by 2025 (950 urban and 650 en route). This realistic scenario forecasts 500,000 EV sales in 2025, representing approximately 20% of total light-duty vehicle sales in Canada in that year.

Business model calculations

The calculations, based on Scenario #4, distinguish between urban and en route DCFCs. Pricing forecasts assume an increase in pricing over time and higher pricing for en route stations compared to their urban counterparts.

With a breakeven in the sixth year of operation, the anticipated payback for the urban DCFC is just under 8 years. With a breakeven in the fourth year of operation, the anticipated payback of the en route is just under 7 years.

In both cases, there is a very attractive return on investment for a station owner willing to take the risk and be patient. However, the risks are at least commensurate with the expected ROI: sales of BEVs may be slower than expected for a number of reasons. Consequently, few investors are currently willing to deploy large numbers of DC fast charging stations, especially with no government support or guarantees.

Considerations for DC fast charging deployment

With sales of less than one percent of new vehicle sales, EVs currently represent a niche market in Canada. As battery technology improves and range increases, as prices of EVs decline (through economies of scale) and as Canadians become more familiar with the benefits of owning an EV, this market will grow significantly. The deployment of a network of DC fast charging stations must therefore take into consideration the changes that will occur as we move towards mass-market adoption of EVs. Some of these concerns include:

- Deploying for the EV range of the early adopter or of the mass market (i.e. what range will dictate spacing of DCFC locations);
- Equitable pricing, given that some models draw more power than others;

- Developing charging solutions for urbanites who have no home charging options;
- Significant growth of shared mobility and growing trend of urbanites avoiding vehicle ownership;
- Carbon credits associated with DC fast charging;
- Developing strategies for recouping loss of revenues from fuel taxes (potentially through the use of a road tax);
- Interoperability to facilitate usage of DC fast charging, regardless of network;
- Common signage identifying DC fast charging stations across the country;
- Power level requirements of future EV models with more powerful batteries;
- Automation of transportation and the implications on the type of charging requirements of autonomous EVs.

Recommendations regarding additional research

It would be beneficial to undertake quantitative market research to identify the factors contributing to the EV purchase decision (purchase drivers) and their relative importance in Canada¹⁵. This research would allow for an understanding of the impact that availability of DC fast charging has on the decision to purchase an EV. It should be noted that a study done in British Columbia did investigate the potential market for plug-in electric vehicles in Canada and investigates how consumer interests may guide such shifts¹⁶.

The issue of road tax must also be examined closely in order for the best possible advice on this topic to be provided to Canadian lawmakers. In order to do so, a closer examination of indirect costs (also called externalities) to Canadians must be considered. The reduction of air pollutants will reduce cases of pulmonary diseases, for example. This will in turn reduce the cost of health care for our governments. Such cost reductions can offset a share of the lost revenues from the fuel taxes and should be weighted in the determination of a fair amount of tax. The type of tax should also be examined. An increase in the purchase cost of an automobile may have a greater negative impact than an equal amount being spread over several years using car registration fees as the carrier of this new tax.

¹⁵ This can be undertaken using regression analyses.

¹⁶ Axsen, J., S. Goldberg, J. Bailey, G. Kamiya, B. Langman, J. Cairns, M. Wolinetz, and A. Miele (2015) Electrifying Vehicles: Insights from the Canadian Plug-in Electric Vehicle Study. Simon Fraser University, Vancouver, Canada

Résumé

Les transports contribuent pour une part importante aux émissions de gaz à effet de serre (GES), représentant 24 % de l'ensemble des émissions au Canada (de ce nombre, 52 % sont générées par des véhicules légers ou de petits camions)¹⁷. L'électrification des transports est une solution de choix pour réduire les polluants atmosphériques et les GES. Considérant qu'environ les deux tiers de la production d'électricité¹⁸ au Canada viennent de sources d'énergies renouvelables, l'électrification des transports est une excellente façon de contribuer aux efforts de réduction des émissions de GES et d'autres polluants pour améliorer la qualité de l'air et la santé.

Le Conseil canadien des ministres de l'environnement (CCME) est un forum intergouvernemental composé des ministres de l'environnement des 14 gouvernements du Canada. Formé en 2011, le Groupe de travail sur les sources mobiles (GTSM) du CCME a reçu le mandat d'élaborer des approches de collaboration intégrées pour lutter contre les émissions provenant de sources mobiles. Le GTSM travaille à des initiatives destinées à réduire les polluants atmosphériques et les GES provenant de sources mobiles dans le cadre du Système de gestion de la qualité de l'air. Vu l'intérêt que suscitent les véhicules électriques (VÉ) chez la population canadienne et les réductions d'émissions que permettra éventuellement de réaliser le déploiement accru de ces véhicules dans le secteur des transports, le GTSM a désigné l'utilisation des VÉ appartenant à la flotte des véhicules légers comme un domaine d'intérêt, centré sur l'élaboration d'approches pour les infrastructures.

Même si les ventes de VÉ augmentent beaucoup d'année en année au Canada, seulement 12 500 VÉ¹⁹ environ roulaient sur les routes canadiennes en mars 2015. Ce chiffre représente moins d'un dixième pour cent du nombre total de véhicules à passagers au Canada.

Les ventes de VÉ sont limitées par plusieurs facteurs, incluant le prix de ces véhicules par rapport au prix des véhicules à moteur à combustion interne (MCI) équivalents, l'autonomie limitée des VÉ, la lenteur de la recharge, le manque d'infrastructures de recharge et le nombre restreint de modèles offerts par les constructeurs et les concessionnaires.

Bien que la recharge des VÉ se fasse dans plus de 90 % des cas à la maison ou au travail, la disponibilité de bornes de recharge publiques est essentielle, car les propriétaires de VÉ craignent de manquer d'électricité avant d'atteindre leur destination (un phénomène connu sous le nom d'« angoisse de la panne »). L'angoisse de la panne peut en effet se révéler un important obstacle à l'achat d'un VÉ²⁰.

Les infrastructures publiques de recharge appartiennent généralement à l'une des deux catégories suivantes : les bornes de recharge de niveau 2 ou les bornes de recharge rapide en courant continu (RRCC). Les bornes de RRCC (généralement alimentées à 208/480 V CA en triphasé) permettent une recharge rapide. Les VÉ dotés d'un socle de recharge rapide en CC de type CHAdeMO ou SAE²¹ peuvent gagner de 80 à 110 km d'autonomie (plus dans le cas d'un véhicule Tesla) en

¹⁷ *Tendances en matière d'émissions au Canada*, Environnement Canada, octobre 2013, https://www.ec.gc.ca/ges-ghg/985F05FB-4744-4269-8C1A-D443F8A86814/1001-Canada's%20Emissions%20Trends%202013_f.pdf.

¹⁸ Association canadienne de l'électricité, <http://lelectricitedelavenir.ca/la-valeur-de-lelectricite/prix-de-lelectricite/facteurs-de-tarification/combinaison-des-technologies-de-production/>.

¹⁹ À la fin de mars 2015.

²⁰ Cette question a été abordée à l'occasion de la Conférence EVE2015, où un équipementier automobile a indiqué que l'angoisse de la panne était la première raison invoquée pour ne pas acheter un VÉ. Selon un représentant de Ford présent à cette conférence, les clients disent qu'ils n'achèteront pas de VÉ à moins de savoir que l'infrastructure de recharge est disponible.

²¹ Également appelé connecteur combo SAE J1772 CA/CC.

20 minutes environ.

Grâce aux bornes de RRCC, les automobilistes peuvent :

- parcourir de longues distances – certaines bornes de RRCC étant situées dans des corridors de transport, les automobilistes peuvent recharger la batterie de leurs VÉ entre les grandes régions métropolitaines²²;
- recharger leurs VÉ à ces bornes s'ils ne peuvent pas le faire à la maison ou au travail²³ (voir la section 4.1);
- recharger leurs VÉ en régions métropolitaines plus rapidement qu'à l'aide d'une borne de niveau 2;
- tolérer un niveau de charge plus bas dans leur véhicule, montrant ainsi que l'angoisse de la panne – obstacle courant à l'achat d'un VÉ – est en baisse.

Infrastructure de recharge rapide en CC au Canada

Environ la moitié des VÉ en usage sur les routes canadiennes sont compatibles avec les bornes de RRCC.

Au moment d'écrire le présent rapport (mai 2015), il existe au total 48 stations de RRCC au Canada (dont 15 abritent des bornes « Supercharger » de Tesla), stations qui regroupent 139 bornes. Les bornes de RRCC se concentrent dans les trois provinces les plus peuplées du pays – en effet, 90 % des bornes de RRCC se trouvent en Colombie-Britannique (42 %), en Ontario (19 %) et au Québec (29 %).

Pour qu'un conducteur de VÉ puisse traverser le pays, le Canada, vu sa taille, a besoin d'un beaucoup plus grand nombre de stations de RRCC que le Royaume-Uni ou la Norvège. Néanmoins, les stations de RRCC sont beaucoup moins nombreuses au Canada que dans ces nations européennes. Comme le montre le tableau 7 (p. 26 du rapport, en anglais seulement), en termes de population par station de RRCC, le Canada (et plus particulièrement l'Ontario) se classe au dernier rang des instances à l'étude.

De nombreux acteurs, notamment des services publics d'électricité, des constructeurs automobiles et diverses entités privées, disent souhaiter installer des bornes de RRCC supplémentaires au Canada.

Financement de l'infrastructure pour les bornes de recharge rapide en CC au Canada

Le déploiement de l'infrastructure requise pour les bornes de RRCC en est encore à ses balbutiements au Canada. Sauf dans le cas de Tesla et d'AZRA, ce sont les gouvernements, les organismes publics ou les sociétés d'État qui s'occupent du déploiement des réseaux au Canada. Cette situation est attribuable au risque élevé que semble présenter ce secteur (malgré un rendement élevé du capital investi) et à la période de récupération, beaucoup plus longue que ce que les investisseurs privés sont généralement prêts à accepter. En raison de l'investissement requis, du nombre relativement restreint de VÉ et de la faible fréquence des recharges, le financement conventionnel des bornes de RRCC (financement par actions, par emprunt ou par une combinaison des deux) s'est avéré pratiquement impossible, une situation qui a peu de chances de changer dans un avenir rapproché.

Les projets de déploiement d'infrastructures de RRCC qui ont réussi ont été financés de l'une ou l'autre des façons suivantes :

²² <http://www.theevproject.com/cms-assets/documents/127233-901153.q2-2013-rpt.pdf>.

²³ Souvent le cas lorsque le propriétaire du VÉ n'a pas accès à un espace de stationnement désigné.

4. de généreuses subventions du gouvernement provincial, du gouvernement fédéral ou des deux ordres de gouvernement;
5. un investissement privé de la part de constructeurs automobiles désireux d'atténuer l'angoisse de la panne et d'accroître les ventes de VÉ;
6. un modèle d'investissement novateur, inspiré du marché immobilier commercial et de ses sources dérivées de revenus.

Dans la plupart des cas, le montant total disponible pour investissement est relativement peu élevé et la procédure à suivre pour obtenir de l'aide financière du gouvernement (si une telle aide existe) peut s'avérer assez compliquée, onéreuse et difficile d'accès. Ces facteurs sont les principales raisons pour lesquelles les infrastructures de RRCC se déploient relativement lentement au Canada.

Coût des bornes de recharge rapide en CC : achat et installation

Le coût des bornes de RRCC installées varie beaucoup selon divers facteurs. Le coût est composé de trois éléments, soit le matériel (ou la borne proprement dite), l'installation et les biens réels (terrain et commodités).

Pour ce qui est de l'achat du matériel de RRCC, le coût varie selon le constructeur, les caractéristiques de l'unité et le nombre d'unités commandées. Bien que le prix des bornes soit à la baisse, la plupart des acteurs²⁴ qui ont contribué à la présente étude ont mentionné des prix d'environ 30 000 \$ par unité pour 2015²⁵.

De son côté, le coût d'installation varie selon les facteurs suivants :

- l'existence d'une source d'alimentation électrique en triphasé adéquate à proximité;
- les travaux de génie civil à effectuer sur les lieux;
- l'importance de la dimension esthétique pour l'exploitant;
- la période de l'année à laquelle est fait le travail d'installation (un point à considérer dans toutes les provinces sauf la Colombie-Britannique);
- l'organisation qui assure la gestion du projet.

Selon les renseignements recueillis auprès d'intervenants canadiens qui jouent un rôle dans l'installation des bornes de RRCC, le coût d'installation varie énormément, allant de 15 000 \$ à 60 000 \$. Ces montants n'incluent pas le coût ni l'installation de matériel périphérique tel que des abris d'autos à panneaux solaires et des plateformes chauffantes pour garantir en tout temps l'accès aux bornes aux propriétaires de VÉ.

Le coût des biens réels varie également beaucoup, allant de zéro²⁶ à plusieurs milliers de dollars le mètre carré dans les grands centres urbains.

Critères utilisés pour déterminer l'emplacement des bornes de RRCC

Les critères utilisés pour déterminer l'emplacement des bornes de RRCC varient d'un réseau à l'autre. Vu la rareté actuelle des bornes et les motivations diversifiées des propriétaires de réseaux, ces critères ne sont pas nécessairement représentatifs du mode de sélection de tous les emplacements futurs.

Règle générale, les critères de sélection des emplacements reflètent les réalités de chaque territoire

²⁴ Les services publics d'électricité et les exploitants des réseaux de RRCC.

²⁵ Les prix cités varient de 25 000 \$ à 40 000 \$ l'unité.

²⁶ Exemple : lorsqu'une tierce partie cède les biens réels sans frais.

en termes de dispersion de la population et d'habitudes de déplacement des automobilistes²⁷. À la base, un critère de première importance est le type d'emplacement, à savoir le choix d'un emplacement en milieu urbain ou d'un emplacement dans le réseau autoroutier. Si ce dernier est stratégique et nécessaire aux déplacements sur de longues distances, le premier jouit d'une plus grande visibilité et peut jouer un rôle important dans l'éducation et la sensibilisation du public.

Utilisation présente et future des bornes de RRCC

Les bornes de RRCC sont peu utilisées pour deux grandes raisons :

- le nombre relativement restreint de VÉ au Canada;
- dans la grande majorité des cas, les propriétaires de VÉ rechargent leurs véhicules à la maison ou, dans une moindre mesure, au travail.

Si les bornes de RRCC situées en milieu urbain ou à proximité risquent d'être utilisées plus fréquemment que celles situées le long des autoroutes²⁸, ces dernières contribuent cependant beaucoup à l'adoption des VÉ, car en réduisant l'angoisse de la panne, elles offrent aux propriétaires de VÉ le filet de sécurité dont ils ont besoin pour se déplacer sur de longues distances.

À mesure qu'apparaîtront des modèles de VÉ dotés d'une plus grande autonomie²⁹, il serait normal de s'attendre à une augmentation du nombre de VÉ. Plus de VÉ sur les routes se traduira par une plus grande utilisation de l'infrastructure de RRCC disponible. Un rapport de l'Electrical Power Research Institute (EPRI) indique cependant que plus l'autonomie des VÉ augmente, plus le pourcentage de véhicules utilisant les bornes de RRCC diminue.

L'analyse de l'EPRI a d'importantes conséquences sur l'utilisation future des bornes de RRCC et met en cause la capacité des exploitants à tirer suffisamment de revenus des recharges seules pour couvrir le coût de l'achat, de l'installation, de l'exploitation et de l'entretien des bornes.

Avantages connexes mesurés et non mesurés

Le déploiement d'un réseau de RRCC comporte de nombreux avantages connexes éventuels; certains sont plus faciles à mesurer que d'autres. Voici une liste de certains de ces avantages.

- Aux revenus générés par les bornes de recharge s'ajoutent les revenus « périphériques » provenant de la vente de produits dans les points de vente avoisinants.
- L'installation d'une borne de RRCC (ainsi que des constructions et de l'équipement connexes) sur le terrain d'une station-service est une option attrayante pour les exploitants de stations-service qui louent ces emplacements. Selon un sondage effectué par l'Association des véhicules électriques du Québec (AVÉQ), un conducteur de VÉ qui s'arrête pour recharger son véhicule achètera entre 3 et 14 \$ de produits (nourriture, boissons ou autres) pendant la recharge de son véhicule.
- Des promotions croisées qui ciblent les propriétaires de VÉ sont une source éventuelle de revenus supplémentaires. Ainsi, l'exploitant du réseau de RRCC auquel appartient la station peut générer des revenus supplémentaires en s'associant avec des entreprises qui souhaitent offrir leurs produits et services à un segment de la population qui est relativement

²⁷ Pendant la répartition de la population ne sont pas identiques d'une province à l'autre. De plus, la circulation varie considérablement selon les activités des résidents (exemple : en Colombie-Britannique, les déplacements des résidents du Grand Vancouver vers les attractions et les activités à l'intérieur des terres ou sur la côte).

²⁸ Source : Présentation de AddÉnergie, donnée lors de la Conférence EV2015VÉ. Selon AddÉnergie, la borne de RRCC la plus fréquemment utilisée au Québec est située à Montréal (5 charges par jour).

²⁹ Selon les annonces faites par les équipementiers automobiles, au moins quatre modèles de VÉ dotés d'une autonomie minimale de 300 kilomètres seront offerts en 2017 au prix approximatif de 40 000 \$.

plus éduqué et relativement mieux nanti que la moyenne³⁰.

Pour les propriétaires de VÉ, ces promotions rendent l'appartenance au réseau et la conduite d'un VÉ encore plus attrayantes.

Pour beaucoup, les bornes de RRCC sont un signe visible de la politique pro-environnement d'une organisation. Outre les avantages susmentionnés, les bornes de RRCC contribuent à réduire les émissions de gaz à effet de serre et d'autres polluants atmosphériques en incitant les consommateurs à acheter et à conduire des VÉ au lieu de véhicules à MCI équivalents. Ces avantages environnementaux sont également associés à des avantages pour la santé.

Enfin, les bornes de RRCC accroissent les revenus des services publics d'électricité canadiens, qui produisent l'électricité au Canada et fournissent des emplois à la population canadienne.

Évaluation de l'analyse de rentabilité

Pour préparer l'analyse de rentabilité, nous avons pris en considération les points suivants :

- les habitudes de déplacement des automobilistes canadiens (distances parcourues);
- les progrès technologiques qui permettent de produire des véhicules à l'autonomie considérablement accrue à des prix raisonnables;
- les coûts actuels et projetés associés à l'achat et à l'installation d'une borne de RRCC;
- les coûts variables associés à l'entretien et à l'exploitation d'une borne;
- le nombre projeté de VÉ au Canada (cinq scénarios);
- le nombre projeté de bornes de RRCC.

Prévision des ventes de VÉ

Pour déterminer le nombre de bornes de RRCC dont nous aurons besoin dans les dix prochaines années, il faut estimer le nombre de VÉ qui rouleront alors sur les routes canadiennes.

Prévoir les ventes de VÉ (une industrie émergente à l'histoire limitée) n'est pas chose facile. Les ventes futures dépendent d'un large éventail de facteurs, incluant le prix des carburants conventionnels par rapport au prix de l'électricité; l'autonomie et la performance des VÉ; le prix des VÉ par rapport au prix des véhicules à MCI comparables; l'existence d'un plus grand nombre de marques et de modèles de VÉ; l'existence d'incitatifs gouvernementaux (pour l'achat d'un VÉ et pour l'installation d'infrastructures de recharge); et l'existence d'autres incitatifs pour encourager les consommateurs à devenir propriétaires d'un VÉ.

Cinq (5) scénarios prévisionnels ont été développés pour les ventes de VÉ, qui vont du pire scénario (n° 1) au scénario le plus optimiste (n° 5). Les scénarios n°s 2, 3 et 4 présentent une prévision « réaliste » des ventes basée sur les données actuellement disponibles (exemples : un accroissement considérable de l'autonomie des VÉ prévu à partir de 2016, l'apparition d'une variété de modèles de VÉ prévue à court terme sur le marché).

Le scénario réaliste no 4 est celui qui a été utilisé comme base pour les prévisions financières. Des représentants de constructeurs automobiles ont examiné soigneusement ce scénario, qui prévoit que le pays comptera au total 750 stations de RRCC abritant 1 600 bornes de RRCC d'ici 2025 (950 bornes en milieu urbain et 650 sur les routes). Ce scénario réaliste prévoit également la vente de 500 000 VÉ en 2025, ce qui représentera environ 20 % du total des ventes de véhicules légers au Canada cette année-là.

³⁰ Présentation de Suzanne Goldberg lors de la Conférence EV2015VÉ : What BC's Electric Vehicle Owners Tell Us About Driving and Charging. Preliminary analysis of SFU's 2014 Plug-in Vehicle Owners' Survey (PEVOS).

Modèle d'affaires : calculs

Les calculs, fondés sur le scénario n° 4, font une distinction entre les bornes de RRCC situées en milieu urbain et celles sur les routes. Les prix projetés supposent une hausse des prix dans le temps ainsi que des prix plus élevés pour les bornes sur les routes que pour celles en milieu urbain.

Avec un seuil de rentabilité dans la sixième année d'exploitation, le délai de récupération du capital investi pour une borne de RRCC en milieu urbain est estimé à un peu moins de huit ans. Avec un seuil de rentabilité dans la quatrième année d'exploitation, le délai de récupération du capital investi pour une borne de RRCC sur les routes est estimé à un peu moins de sept ans.

Dans les deux cas, le rendement du capital investi est prometteur pour un propriétaire de bornes prêt à prendre le risque et à faire preuve de patience. Cependant, le risque est à tout le moins proportionnel au rendement du capital investi, car les ventes de VÉ à batterie pourraient se révéler plus lentes que prévu pour de multiples raisons. Par conséquent, peu d'investisseurs sont actuellement prêts à déployer de grandes quantités de bornes de RRCC, particulièrement s'ils ne disposent d'aucune garantie ou aide financière du gouvernement.

Points à considérer pour le déploiement de bornes de RRCC

Comme les ventes de VÉ représentent moins de 1 % des ventes de véhicules neufs, les VÉ constituent un marché à créneaux au Canada. À mesure que les batteries s'amélioreront sur le plan technologique, que l'autonomie des VÉ s'accroîtra, que leur prix diminuera (grâce à des économies d'échelle) et que les Canadiennes et les Canadiens découvriront les avantages de posséder un VÉ, ce marché connaîtra cependant un essor considérable. Le déploiement d'un réseau de bornes de RRCC doit donc tenir compte des changements qui se produiront lorsque les VÉ deviendront un produit de grande diffusion. Parmi les points qu'il faudra alors prendre en considération, mentionnons :

- la question de savoir si le déploiement des bornes doit se faire en fonction des premiers propriétaires de VÉ ou en fonction du marché grand public (en d'autres mots, quelle distance (autonomie) dictera l'espacement entre les stations de RRCC);
- l'établissement d'un prix équitable, considérant que certains modèles consomment plus d'électricité que d'autres;
- l'élaboration de solutions de recharge pour les citoyens qui ne peuvent pas recharger leurs véhicules à la maison;
- l'importante croissance des transports en commun et une tendance grandissante chez les citoyens à ne pas acheter de véhicule;
- les crédits carbone associés à la RRCC;
- l'élaboration de stratégies pour compenser la perte des revenus tirés des taxes sur l'essence (possiblement par l'imposition d'une taxe routière);
- l'interopérabilité, pour faciliter l'usage des bornes de RRCC, peu importe le réseau;
- une signalisation commune pour identifier les stations de RRCC à la grandeur du pays;
- les besoins en alimentation électrique des futurs modèles de VÉ dotés de batteries plus puissantes;
- l'automatisation des transports et ses conséquences sur les besoins des VÉ autonomes en matière de recharge.

Recommandations concernant des travaux de recherche supplémentaires

Il serait bon d'effectuer une étude de marché pour déterminer les facteurs qui poussent un consommateur à acheter un VÉ (stimulateurs d'achat) et l'importance relative de ces facteurs au Canada³¹. Cette étude permettrait de comprendre l'impact qu'a la disponibilité des bornes de RRCC sur la décision d'acheter un VÉ. Il convient de mentionner qu'une étude effectuée en Colombie-Britannique s'est penchée sur les débouchés possibles pour les VÉ rechargeables au Canada et s'interroge justement sur l'influence que peuvent avoir les intérêts des consommateurs sur de tels changements³².

Il convient également d'étudier de près la question de la taxe routière afin de donner le meilleur avis possible aux législateurs canadiens à ce sujet. Pour ce faire, un examen étroit des coûts indirects (aussi appelés « coûts externes ») s'impose. À titre d'exemple, mentionnons que la réduction de la pollution atmosphérique diminuera les cas de maladies pulmonaires, ce qui entraînera une réduction du coût des soins de santé pour les gouvernements. Ces réductions de coûts, qui peuvent compenser une partie de la perte des revenus tirés des taxes sur l'essence, doivent être prises en compte au moment de déterminer un montant de taxe équitable. Le type de taxe est un autre point à examiner. L'augmentation du prix d'achat d'une automobile est susceptible d'avoir un impact plus négatif que le fait de percevoir un montant égal, étalé sur plusieurs années, à même les frais d'immatriculation automobile.

³¹ Cette étude peut être réalisée à l'aide d'analyses de régression.

³² Axsen, J., S. Goldberg, J. Bailey, G. Kamiya, B. Langman, J. Cairns, M. Wolinetz et A. Miele (2015). *Electrifying Vehicles: Insights from the Canadian Plug-in Electric Vehicle Study*, Simon Fraser University, Vancouver, Canada.

1. Introduction

Transportation is an important contributor to GHG emissions, accounting for 24% of all emissions in Canada (of which 52% is generated by light-duty vehicles and small trucks)³³. The electrification of transportation offers an important option for reducing air pollutants and GHGs. Given that clean, renewable electricity represents approximately two-thirds of Canada's generation mix³⁴, moving to electric mobility is an excellent means of contributing positively to environmental efforts of reducing GHG emissions and other pollutants to improve air quality and health outcomes.

The Canadian Council of Ministers of the Environment (CCME) is an intergovernmental forum, made up of the 14 member governments. The CCME Mobile Sources Working Group (MSWG) was established in 2011 to develop integrated and collaborative approaches to address mobile source emissions. The MSWG works on initiatives to address air pollutants and GHGs from mobile sources as part of the Air Quality Management System. With the growing interest in EVs by Canadians and the potential emission benefits that can be achieved through their increased deployment in the transportation sector, the MSWG has identified EV use within the light-duty fleet as an area of interest, with a focus on approaches for infrastructure.

An electric vehicle (EV) is one that is propelled by one or more electric motors, using electrical energy stored in rechargeable batteries or another energy storage device.

Two types of EVs can be recharged using a charging station: Battery Electric Vehicle (BEV) and Plugin Hybrid Electric Vehicle (PHEV).

*"A **battery electric vehicle (BEV)** runs entirely using an electric motor and battery, without the support of a traditional internal combustion engine, and must be plugged into an external source of electricity to recharge its battery. Like all EVs, BEVs can also recharge their batteries through a process known as regenerative braking, which uses the vehicle's electric motor to assist in slowing the vehicle, and to recover some of the energy normally converted to heat by the brakes."³⁵*

*A **plug-in hybrid (PHEV)** uses an "electric motor and battery that can be plugged into the power grid to charge the battery, but also has the support of an internal combustion engine that may be used to recharge the vehicle's battery and/or to replace the electric motor when the battery is low"³⁶.*

Figure 1 presents the monthly Canadian EV plug-in sales for the period covering January 2013 to December 2014 inclusively. Despite strong year-over-year sales increases of EVs in Canada, approximately 12,500 EVs³⁷ are being used on Canadian roads as of March 2015. This represents less than one-tenth of one percent of the total number of passenger vehicles in Canada.

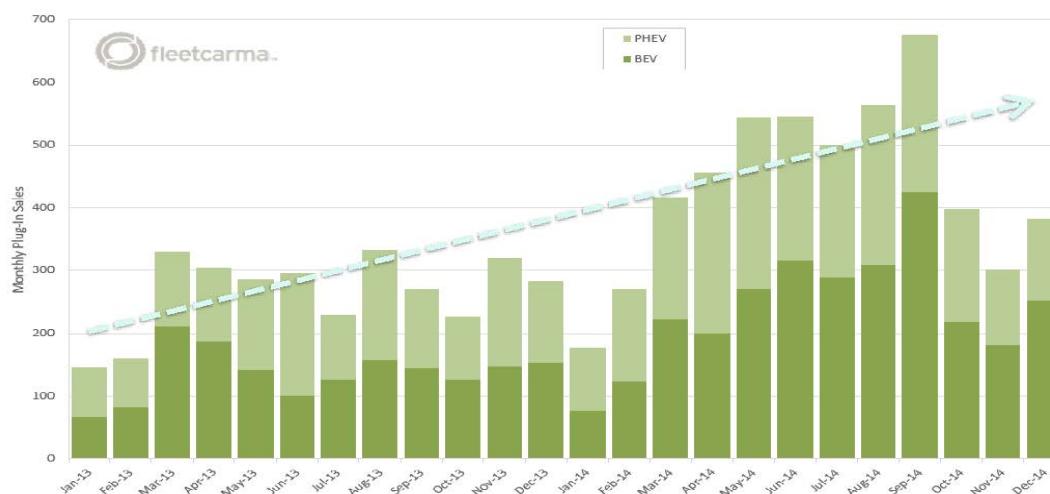
³³ Canada's Emissions Trends, Environment Canada, Oct 2013, http://www.ec.gc.ca/ges-ghg/985F05FB-4744-4269-8C1A-D443F8A86814/1001-Canada%27s%20Emissions%20Trends%202013_e.pdf

³⁴ Canadian Electricity Association, <http://powerforthefuture.ca/the-value-of-electricity/electricity-pricing/pricing-factors/the-generation-mix/>

³⁵ Plug In BC: The Beginners Guide Electric Vehicles (EV), http://pluginbc.ca/wp/wp-content/uploads/2014/07/EV-Beginners-Guide_Final_Sept2_2014.pdf

³⁶ Idem

³⁷ End of March 2015

Figure 1. Canadian Monthly Plug-In Vehicle Sales, January 2015

Source: FleetCarma, compiled from Polk data and other sources

The sale of EVs is limited by several factors, including the price of EVs relative to their internal combustion engine (ICE) counterparts, limited driving range per charge, long charging time, lack of charging infrastructure and the limited choice of models offered by manufacturers and at dealerships.

The importance of the price of EVs relative to their ICE counterparts is underlined by the fact that 96% of EVs in Canada have been sold in the three provinces that offer a financial incentive that helps to reduce the price of the vehicle (Ontario: \$8,500, Québec: \$8,000, British Columbia (BC): \$5,000 or more). Table 1 presents the total cumulative number of new EVs sold in Canada by province.

Table 1. Number of new EVs sold in Canada by Province, up to March 2015

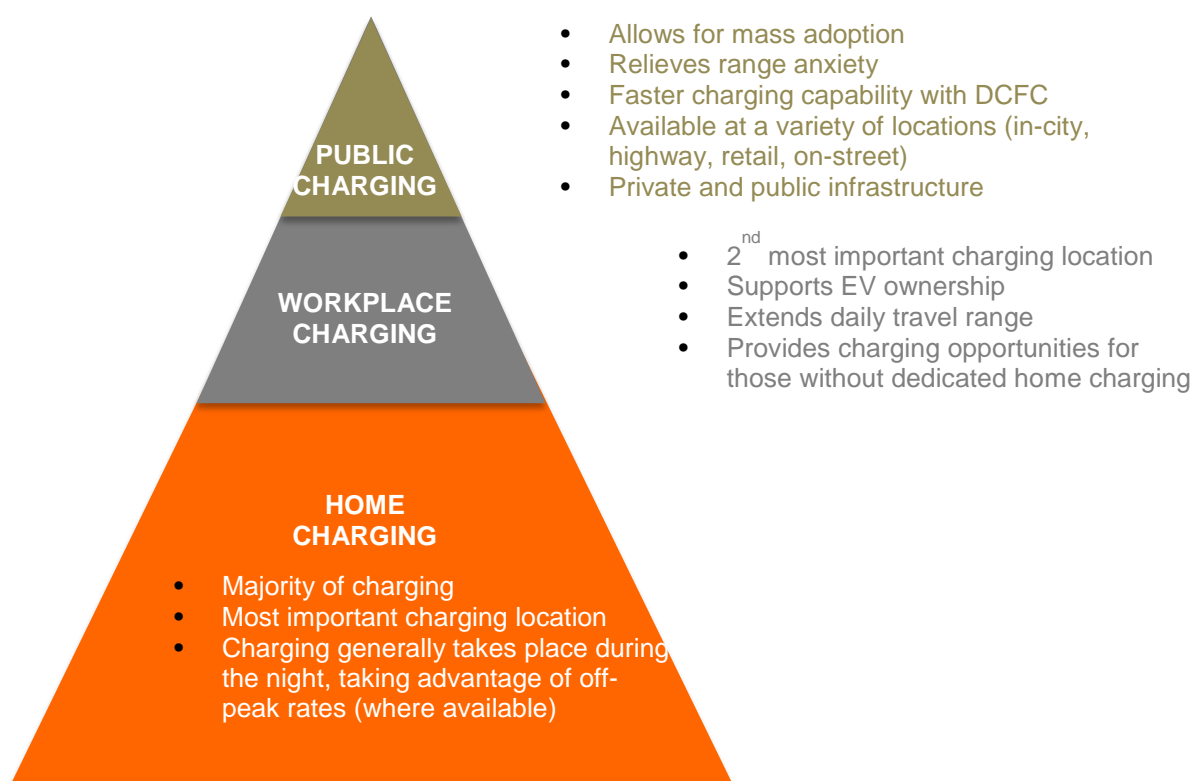
	# of EVs	% of CDN total
Québec	5,710	46%
Ontario	4,311	35%
BC	1,931	15%
Alberta	297	2%
Manitoba	83	1%
Nova Scotia	53	<1%
Saskatchewan	42	<1%
New Brunswick	38	<1%
Nfld & Labrador	10	<1%
PEI	9	<1%
NWT	2	<1%
Yukon	1	<1%

Source: Electric Mobility Canada

Charging infrastructure

As depicted in Figure 2, the home is the primary charging location for EVs while workplace charging provides the second most important charging opportunity. It is estimated that over 90% of charging³⁸ takes place at home or at work³⁹.

Figure 2. EV charging today



Despite this concentration of charging at home and work, availability of public charging is essential as EV owners worry about running out of electricity before reaching their destinations (known as range anxiety). In fact, range anxiety can act as a significant barrier to an EV purchase⁴⁰. In a study undertaken in June 2014 among EV owners in BC, the majority (over 60%) of EV owners stated that it is important to know about potential charging opportunities other than their home. This was particularly true of pure BEV owners, specifically Nissan Leaf and Tesla Model S owners. Public charging provides peace of mind to

³⁸ Charging refers to energy.

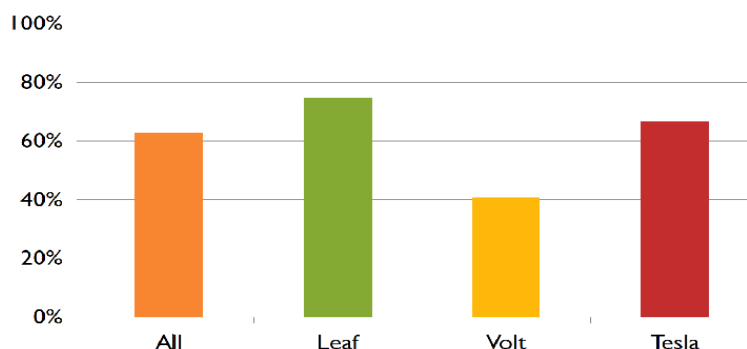
³⁹ <http://pluginbc.ca/charging-stations/charging-at-home/>,
<http://avt.inl.gov/pdf/EVProj/NissanLeafDrivingChargingSlides.pdf>

A 2015 research study undertaken by S. Goldberg and SFU of BC EV owners (Axsen, J., S. Goldberg, J. Bailey, G. Kamiya, B. Langman, J. Cairns, M. Wolinetz, and A. Miele (2015). Electrifying Vehicles: Insights from the Canadian Plug-in Electric Vehicle Study. Simon Fraser University, Vancouver, Canada) concluded that 18% of **charging sessions** (not energy or charge time) were public, 19% were at work and the remainder (63%) were at home. A charging session is a plug in event. This indicates that public charging sessions generally draw less energy and last longer than those at home or at work.

⁴⁰ The issue of range anxiety was discussed at the EVE2015 conference where one OEM indicated that range anxiety is the most important reason for not buying an EV. According to a Ford representative at this conference, customers are saying that if they do not know the charging infrastructure is available, they will not buy an EV.

EV owners. These results are presented in Figure 3.

Figure 3. “It is important to know about potential charging opportunities other than my home”⁴¹



Source: Suzanne Goldberg, Simon Fraser University and Navius Research (June 2014), n=126⁴²

Another study undertaken in BC in 2015 concluded that respondents who expressed a greater interest in EVs are those who have been more exposed to charging infrastructure. The results are presented in Figure 4. While the authors of the above-noted study did find a significant bivariate relationship between public charger awareness and EV interest, “when controlling for multiple explanatory variables in regression analyses, the relationship is weak or non-existent”⁴³. However, it should be noted the results were obtained primarily from customers interested in plug-in hybrid vehicles (where public charging is less of a concern), and did not specifically explore whether or not public charging helped prospective customers overcome the initial barrier of range anxiety.

Figure 4. Relationship between public charger awareness and EV interest



Source: Axsen, J., S. Goldberg, J. Bailey, G. Kamiya, B. Langman, J. Cairns, M. Wolinetz, and A. Miele (2015). Electrifying Vehicles: Insights from the Canadian Plug-in Electric Vehicle Study. Simon Fraser University, Vancouver, Canada

⁴¹ X-axis: Vehicle model owned, Y-axis: % of respondents

⁴² Small sample size. At a 95% confidence level, margin of error of ± 8.4 .

⁴³ Suzanne Goldberg: “While perceived existence of at least one charger exhibits no significant relationship with PEV interest, perceived existence of multiple chargers can have a weak but significant relationship. Thus, public charger awareness is not a strong predictor of PEV interest; other variables are more important, such as the availability of level 1 (110/120-volt) charging at home.”

Public charging

Public charging infrastructure generally falls into two categories:

- Level 2 chargers⁴⁴
 - 220/240 Volts of Alternating Current (VAC) charging
 - Requires several hours to achieve full charge from a fully depleted state (actual time depends on vehicle)
 - Charging time varies on the power supply:
 - Charging time for 100 km of BEV range with 230 VAC voltage & power supply=3.3 KW is 6 to 8 hours
 - Charging time for 100 km of BEV range with 230 VAC voltage & power supply=7 KW is 3 to 4 hours
- DC fast chargers
 - Typically 480 Volts of Direct Current (VDC) charging
 - Charging of 80% of the battery capacity from a depleted state within minutes (typically, 20 to 30 minutes depending on vehicle and state of charge)

Public charging can also be classified as follows:

- Destination charging (hotels, restaurants, shopping centres, etc. where EV owners can recharge their vehicle on an opportunistic basis);
- Curb-side charging (stations located in urban areas where residents and visitors can recharge their EVs);
- Inter-city or en route charging (stations located on well-travelled highways, normally in rest areas or service centres).

DC fast charging

Direct-current (DC) fast charging (typically 208/480 VAC three-phase input) enables rapid charging. EVs equipped with a CHAdeMO, or an SAE DC⁴⁵ fast charge receptacle can add 80 to 110 km of range (more for a Tesla) in approximately 20 minutes.



⁴⁴ Level 2 charging is also the most frequently used at home. According to research undertaken by SFU (Suzanne Goldberg) among BC EV owners, 75% had a Level 2 charger, 23% had Level 1 while the remainder had no home charging access. These statistics are slightly higher than those reported by the California Centre for Sustainable Energy which indicates that 64% of California EV owners have installed a Level 2 charger at home.

⁴⁵ Also called an SAE J1772 AC/DC combo connector

While the vast majority of charging is performed at home overnight with low or modest rate AC charging, much higher charge rate DC-fast charging enables ... the very fastest rate charging. DC fast charging is typically thought most useful for battery electric vehicles (BEVs) that have no gasoline engine backup for inter-city travel, BEVs that drive an unusually large number of around-town miles every day, or to support any kind of electric vehicle driver who does not have the ability to charge at home (e.g. multifamily housing residents or those who park on the street). DC fast charging is most often associated with the fastest charging rates possible in an attempt to approach the rapid energy transfer rate of gasoline refueling.

While DC fast charging still delivers slower than the energy transfer at the gas pump, DC fast charging can get the electric vehicle driver back on the road conveniently with a battery replenished to provide a substantial amount of range. For an inter-city trip, a rough estimate is that a large battery BEV (such as an 85kWh Tesla Model S) can acquire enough charge for about 2.5 hours of highway driving in 30 minutes at the fastest Tesla Supercharger DCFC station. This net refueling time is only modestly longer than a conventional vehicle on a long highway trip when considering a realistic long trip gas station stop is likely to include stretching one's legs, a bathroom break, or perhaps grabbing a bite to eat or a snack (and not just the 5 minutes for the actual fuel pumping).

There are several unique Fast-Charge implementations or standards for the fastest charging: CHAdeMO, the SAE J1772 Combined Coupler Standard (called CCS or "Combo") and Tesla.

Source: <http://electricvehicle.ieee.org/2015/01/08/plug-hybrid-electric-vehicle-dc-fast-charging-future-just-got-interesting/>

Figure 5. DC fast charging connector standards and compatibility



DCFC connector standard	SAE J1772 Level-1 and Level-2 Coupler & DC charging	CHAdeMO DCFC Coupler	Tesla SuperCharger (proprietary specifications)
Compatible vehicles	US & European (BMW i3, Smart Fortwo)	Nissan Leaf, Mitsubishi i-MiEV, Tesla (with adapter)	Tesla

DCFCs enable EV motorists to ...

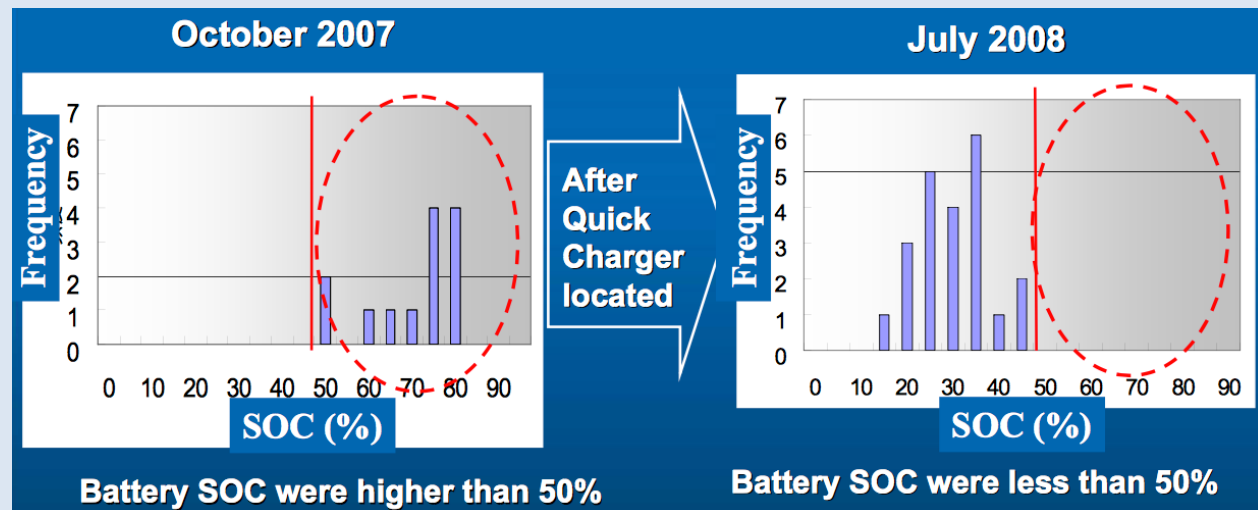
- Travel longer distances: Some DCFCs are located in travel corridors, where they provide range extension to vehicles between major metropolitan areas⁴⁶;
- Charge their EVs in metropolitan areas more quickly than using a Level 2 charger;
- Charge their EVs when home/at work charging is not available or possible⁴⁷ (discussed in section 4.1);
- Tolerate a lower state of charge (SOC) in their vehicle, thereby demonstrating a decrease in range anxiety.

⁴⁶ <http://www.theevproject.com/cms-assets/documents/127233-901153.q2-2013-rpt.pdf>

⁴⁷ Often the case when the EV owner does not have access to a dedicated parking space.

Public charging availability and its connection to increased EV adoption⁴⁸

In 2008, the Tokyo Electric Power Company (TEPCO) evaluated that the presence of public charging acted as a safety net for EV owners, allowing them to travel longer distances and to return the vehicle with a lower state of charge.



Source: TEPCO, 2008

In 2015, the range anxiety of the EV owner has not changed much. Charging infrastructure is much like an insurance policy that one would like to have, in case it is required.

Determining the impact of the presence of charging infrastructure, and more specifically DC fast charging, on the decision to purchase an EV is rather difficult given the need to isolate the presence of this infrastructure on the decision process among all other parameters taken into consideration by a consumer considering the purchase of an EV. A document prepared by Li, Tong, Xing and Zhou of the University of Cornell, estimates that a "10% increase in the number of public charging stations would increase EV sales by 10.8%".^{49,50}

EV compatibility

At the end of 2014, there were almost eleven thousand EVs on Canadian roads. Half of this EV fleet was compatible with DC fast charging, as detailed in Table 2.

⁴⁸ One of the auto manufacturers selling vehicles in Canada has indicated that a proprietary study was undertaken demonstrating the link between the presence of DC fast charging and number of electric vehicles sold. Unfortunately, this company is unwilling to share the results of this study for inclusion in this report.

⁴⁹ Shangun Li, Lang Tong, Jianwei Xing, Yityi Zhou, The Market for Electric Vehicles: Indirect Network Effects and Policy Impacts, March 2015

⁵⁰ Public charging stations encompass both Level 2 and DC fast charging. The latter is not isolated in this analysis.

Table 2. DC fast charging compatibility of Canadian EV fleet, February 2015

	Avg range on Electric (km)	# of vehicles in Canada	DCFC compatibility
BEV		5400	
BMW i3	160	100	SAE
Chevrolet Spark	131	29	SAE
Ford Focus EV	122	202	SAE
Kia Soul EV	149	39	CHAdEMO
Mitsubishi i-Miev	100	494	CHAdEMO
Nissan Leaf	121	2,101	CHAdEMO
Smart fortwo	109	799	SAE
Tesla Model S	335 (60 KWH) 426 (85 KWH)	1,580	Tesla SuperCharger CHAdEMO (via optional external adapter)
Tesla Roadster	394	53	Tesla SuperCharger CHAdEMO (via optional external adapter)
Toyota Rav4	166	3	CHAdEMO
PHEV		5543	
BMW i3 REX	116-240	98	SAE (optional)
BMW i8	35	28	no DCFC compatibility
Cadillac ELR	59	58	no DCFC compatibility
Chevy Volt	61	4,232	no DCFC compatibility
Fisker Karma	83	100	no DCFC compatibility
Ford C-Max Energi	34	425	no DCFC compatibility
Ford Fusion Energi	34	303	no DCFC compatibility
McLaren P1	31	3	no DCFC compatibility
Porsche Panamera SE Hybrid	36	7	no DCFC compatibility
Toyota Prius Plug-in	18	289	no DCFC compatibility
TOTAL		10,943	
Total SAE compatible		1,228	
Total CHAdEMO compatible		4,270	
Total Tesla compatible		1,633	
% of CDN EV fleet compatible with DCFC		50%	

Source: Polk data with CrossChasm manipulation, Plug'nDrive, auto manufacturer website (February 2015)

2. Today's DC Fast Charging Infrastructure

2.1 Inventory of existing DC fast charging stations in Canada, USA and Europe

Determining the total inventory of existing DC fast charging stations in Canada, the US and Europe is challenging as no repository is complete. A combination of Internet research and one-on-one interviews allowed for a more complete inventory of DCFCs in Canada.

2.1.1 Canadian inventory

The inventory of Canadian DCFCs was completed thanks to contributions from PlugShare, Mogile Technologies, the Tesla SuperCharger website as well as input from Hydro-Québec, BC Hydro, AddEnergie and AZRA.

As detailed in Table 3, in total, at the writing of this report (May 2015), there are 48* DCFC locations in Canada (including 15 Tesla SuperCharger locations) hosting 139 ports. The DCFCs are concentrated in the country's three most populous provinces: 90% of the DC fast charging locations are in BC (42% of locations), Ontario (19% of locations) and Québec (29% of locations).

Table 3. DCFC locations in Canada, May 2015

Province	Locations within province	Ports		
		CHAdEMO	SAE	Tesla
Alberta	2			8
British Columbia	20*	15*		24
Manitoba	1	1	1	
Nova Scotia	2	2	1	
Ontario	9	5	5	44
Québec	14**	12**	12**	9
Total	48	35	19	85

*Plus an additional 10 to be installed by Q12016. Under BC's Clean Energy Vehicle (CEV) Program Phase 2, the intention is to add an additional 20 locations between April 1, 2016 and March 31, 2018 for a total of 50 locations in BC by 2018.

** According to Circuit électrique management, 4 new DCFC locations will be added before the end of Q3 2015. These 4 locations will offer both CHAdEMO and SAE ports. These DC fast charging locations are not however presented in the detailed listing on the following page, nor on the map in Figure 6 as location details have not been provided. In section 2.2, the Circuit Électrique's intentions to create a total of 50 DCFC sites in Québec.

A listing of Canadian DCFCs is provided on the following page (yellow: to be installed in 2015).

Table 4. DCFCs in Canada

Prov	Location	Address	Ports / # of Type (CHAdeMO, SAE)	Station Owner	Cost	Hours	Level 2
AB	Canmore	1719 Bow Valley Trail, Canmore, AB T1W 1J7	4 Tesla SuperCharger	Tesla	Free for Tesla owners	24x7	1
AB	Red Deer	3310 50 Avenue, Red Deer, AB T4N 3A9	4 Tesla SuperCharger	Tesla	Free for Tesla owners	24x7	1
BC	Abbotsford	1256 Surra Way, Abbotsford, BC V2S 8R2	1 CHAdeMO	Greenlots	Free	24x7	1
BC	Duncan	2687 James St. Duncan, BC V9L 2X5	1 C-AceMO	Greenlots	Free	24x7	1
BC	Golden	1200 12th Street North, Golden, BC V0A 1H0	4 Tesla SuperCharger	Tesla	Free for Tesla owners	24x7	1
BC	Hope	412 Wallace St., Hope, BC V0X 1L0	1 C-AceMO	Greenlots	Free	24x7	1
BC	Hope	830-840 Fraser Ave., Hope, BC V0X 1L0	6 Tesla SuperCharger	Tesla	Free for Tesla owners	24x7	1
BC	Kamloops	910 McGill Rd, Kamloops, BC V2C 6N6	1 C-AceMO	Greenlots	Free	24x7	1
BC	Kamloops	1290 Trans-Canada Hwy., Kamloops, BC V2C 6B3	4 Tesla SuperCharger	Tesla	Free for Tesla owners	24x7	1
BC	Langley	7666 202 Street, Langley, BC V2Y 3J4	1 C-AceMO	Greenlots	Free	24x7	1
BC	Meritt	2202 Voght, Meritt, BC V1K 1B8	1 CHAdeMO	Greenlots	Free	24x7	1
BC	Nanaimo	51 Gordon St., Nanaimo, BC V9T 6Z4	1 C-AceMO	Greenlots	Free	24x7	1
BC	North Vancouver	1401st St E, North Vancouver, BC V7L 1B3	1 CHAdeMO	Greenlots	\$0.35 per kWh with \$2.00 minimum	24x7	1
BC	Revelstoke	301 Victoria Road W, Revelstoke, BC V0E 2R0	1 C-AceMO	Greenlots	Free	24x7	1
BC	Revelstoke	1925 Laforne Blvd, Revelstoke, BC V0E 2R0	4 Tesla SuperCharger	Tesla	Free for Tesla owners	24x7	1
BC	Sechelt	Tra 307 Mall, 5755 Cowie Street, Sechelt, BC V0N 3A0	1 C-AceMO	Greenlots	Free	24x7	1
BC	Squamish	37955 2nd Ave., Squamish, BC V8B 0A3	1 CHAdeMO	Greenlots	Free	24x7	1
BC	Squamish	40167 Glendale P., Squamish, BC V8B 0G2	6 Tesla SuperCharger	Tesla	Free for Tesla owners	24x7	1
BC	Surrey	17710 56A Ave., Surrey, BC V3S 1G4	1 CHAdeMO	Greenlots	Free	24x7	1
BC	Surrey	17710 56A Ave., Surrey, BC V3S 5-6	1 C-AceMO	Greenlots	Free	24x7	1
BC	Vancouver	3351 East Hastings Street, Vancouver, BC V5K 2A5	1 CHAdeMO	Greenlots	Free	24x7	1
BC	Vancouver	3440 Seachon, Road Victoria, BC V6Z 039	1 C-AceMO	Greenlots	\$0.35 per kWh with \$2.00 minimum	24x7	1
MB	Winnipeg	Skinner Rd, Winnipeg, MB R3J 3Y9	2 1 SAE, 1 CHAdeMO	Red River College	Free	8:00 am - 8:00 pm	1
NS	Halifax	1075 Barrington Street, Halifax, NS B3H 2T8	2 1 SAE, 1 CHAdeMO	VER-network	VER-network \$2.50 per 15 minutes	24x7	1
NS	Turton	75 Treaty Trail, Turton, NS B2N 5A9	1 CHAdeMO	Millbrook Band	Free	24x7	1
ON	Barrs	100 Mapleview Drive East, Barrs, ON L4V 9H6	6 Tesla SuperCharger	Tesla	Free for Tesla owners	24x7	1
ON	Comber	7018 Industrial Drive, Comber, ON N0P 1J0	8 Tesla SuperCharger	Tesla	Free for Tesla owners	24x7	1
ON	Cornwall	635 Brookdale Avenue, Cornwall, ON K6J 4P3	6 Tesla SuperCharger	Tesla	Free for Tesla owners	24x7	1
ON	Kingston	97 Dalton Ave., Kingston, ON K7K 0C4	6 Tesla SuperCharger	Tesla	Free for Tesla owners	24x7	1
ON	Mississauga	2100 Matheson Blvd E., Mississauga, ON L4W 5S6	2 1 SAE, 1 CHAdeMO	Windsor Carcoba	Free	Mon - Fri, 7:30 a.m. - 6:30 p.m.	1
ON	Mississauga	5290 Orlator Drive, Mississauga, ON L4W 4Z5	2 1 SAE, 1 CHAdeMO	Nissan Canada	Free - available for Leaf owners	24x7	1
ON	Oronto	1325 Lawrence Ave E, Toronto, ON M3A 1C6	6 Tesla SuperCharger	Tesla	Free for Tesla owners	24x7	1
ON	Vaughan	161 Cityview Blvd, Vaughan, ON L4H 0A9	6 3 SAE, 3 CHAdeMO	PowerStream	Free	24x7	1
ON	Woodstock	580 Brun Blvd., Woodstock, ON N4V 1E5	6 Tesla SuperCharger	Tesla	Free for Tesla owners	24x7	1
QC	Boucherville	500 rue Alouet, Boucherville, QC J4B 2Z6	2 1 SAE, 1 CHAdeMO	Circuit Electrique	\$2.5/session for Level 2, \$10/h for 50kW DC	24x7	1
QC	Deschambault	11 Rue des Pins, Deschambault, QC G0A 1S0	2 1 SAE, 1 CHAdeMO	Circuit Electrique	\$2.5/session for Level 2, \$10/h for 50kW DC	24x7	1
QC	Deschambault-Grandme	150 route Dusault, Deschambault, QC G0A 1S0	2 1 SAE, 1 CHAdeMO	Réseau Aéro	4.99\$/30min	24x7	1
QC	Grand-Ville	1141 2e Avenue, Grand-Ville, QC G9T 2Y9	2 1 SAE, 1 CHAdeMO	Emtec	Free	24x7	1
QC	Lavaltrie	250, autoroute 40, Lavaltrie, QC J0X 2Z0	2 1 SAE, 1 CHAdeMO	Circuit Electrique	\$2.5/session for Level 2, \$10/h for 50kW DC	24x7	1
QC	Maskinongé	161 autoroute 40 Est., Maskinongé, QC	2 1 SAE, 1 CHAdeMO	Circuit Electrique	\$2.5/session for Level 2, \$10/h for 50kW DC	24x7	1
QC	Mirabel	18275 boulevard de Verdilles, Mirabel, QC J7J 0R6	2 1 SAE, 1 CHAdeMO	Réseau Aéro	4.99\$/30 min facturé à la minute	24x7	1
QC	Montreal	4451 rue Bern, Montréal, QC H2J 1W5	2 1 SAE, 1 CHAdeMO	Circuit Electrique	\$2.5/session for Level 2, \$10/h for 50kW DC	24x7	1
QC	Saint-Raymond	247 Côte Joyeuse, Saint-Raymond, QC G0A 4G0	2 1 SAE, 1 CHAdeMO	Réseau Aéro	4.99\$/30min	24x7	1
QC	Tecumseh	475 rue Vachon, Tecumseh, QC G6T 6V2	2 1 SAE, 1 CHAdeMO	Circuit Electrique	\$2.5/session for Level 2, \$10/h for 50kW DC	24x7	1
QC	Victoriaville	125 rue De Bigré, Victoriaville, QC G8P 4Z2	2 1 SAE, 1 CHAdeMO	Circuit Electrique	\$10/h for 50kW DC	24x7	1
QC	Yamachiche	4 rue Sainte-Anne, Yamachiche, QC G0X 3J0	2 1 SAE, 1 CHAdeMO	Circuit Electrique	\$2.5/session for Level 2, \$10/h for 50kW DC	24x7	1

Sources: PlugShare, Mogile Technologies, Hydro-Québec, BC Hydro, AddEnergie, AZRA, <http://www.teslamotors.com/supercharger>

A review of the preceding table reveals some important DC fast charging differences across the country:

- **Charging cost:** in Québec, DCFC users pay a fee (exception: the use of Tesla SuperChargers is free to Tesla owners) while in the rest of the country, the use of DCFCs is free (exceptions: two BC locations)⁵¹.

When there is a cost charged to the customer, in Québec, the price is based on time (\$10 per hour, fractioned and charged by the minute) whereas the model that is being applied in BC is a price per kWh⁵².

- **Type of station:** In Québec and Ontario, all DCFC sites (with the exception of Tesla SuperCharger locations) offer both SAE and CHAdeMO ports to maximize utilization regardless of the vehicle DC charging requirements. In BC, however, the DCFC locations offer CHAdeMO type chargers⁵³. Under the BC CEV Program Phase 2, these DCFCs (installed before SAE was available) will be retrofitted to include SAE stations.
- **Station ownership:** In BC, with the exception of Tesla, all DC fast chargers are owned by BC Hydro⁵⁴ but operated by the municipalities⁵⁵. In Québec, again with the exception of Tesla, the utility (through Circuit électrique) is the owner of most of the DC fast chargers. AZRA Network⁵⁶ owns and operates three DCFCs in Québec while Elmec⁵⁷ owns and operates one.

In Ontario, with the exception of Tesla, the owners of DCFCs are Nissan, Mitsubishi and PowerStream⁵⁸. In Alberta, the DCFCs currently deployed are owned by Tesla while in Manitoba, it is owned by Red River College.

In Nova Scotia, there are two DC fast chargers:

- one in Truro that is owned by Millbrook Native Band, and
- one in Halifax that is owned by Nova Scotia Power.

⁵¹ Note: Only two DC fast charging stations owned by BC Hydro require payment for usage: \$0.35/kWh with a minimum charge of \$2.00 per session. Important to note that this rate applies to only two DC fast charging locations (May 2015) but that it will apply to all other BC DC fast charging stations in coming months (exception: Tesla SuperChargers). While BC Hydro has encouraged all municipalities to charge a fee for usage of DC fast chargers, to date two municipalities have proceeded with this change. The minimum sales amount ensures the recovery of the \$0.91 payment transaction fee and any electricity dispensed before reaching the \$2.00 mark.

⁵² For the two locations that currently charge a fee.

⁵³ BC Hydro is considering adding an SAE DC fast charger next to the CHAdeMO ones. These stations can be interlocked, sharing supply.

⁵⁴ All 30 stations currently planned are financed by the governments of BC and Canada. Site hosts provide nominal financing for the stations.

⁵⁵ Greenlots, a network administrator, undertakes remote station monitoring, payment processing and offers call centre for customer support.

⁵⁶ Information on AZRA provided further in this section as well as in section 2.6.

⁵⁷ Elmec (<http://www.elmec.ca/language/en/>) is an electro-mechanical customized product supplier. According to the company's website, Elmec aims to become an important manufacturer of residential, commercial and industrial charging stations.

⁵⁸ PowerStream is a power company.

AZRA Corp. (http://www.azracorp.com/en#page_title) is a privately held, Canadian company that has deployed DC fast charging stations in three of the five service stations planned for this year, without any government assistance. Its objective: 300 DC fast charging stations installed in Canada before 2020, without any government assistance.

In fact, AZRA is a real estate developer specialized in developing rest areas combined with service stations and quick service restaurants and sites for office towers, hotels and destination businesses. AZRA “anticipates the needs of travellers in order to improve their lives and those of their children”. The company delivers on that promise by equipping its sites with a DCFC. The occupant(s) lease(s) the site from AZRA with the equipment installed, and according to the company’s Vice President, “they love it when a DCFC is on the premises”.

The DC fast charging equipment cost represents, on average, little more than 1% of the total project.

The payment solution developed by AZRA is both simple and universal, being entirely based on its unique smart phone app. The company plans on innovating again by issuing rebate coupons for EV drivers to use in nearby businesses. See <http://azranetwork.co/azra/> for more details.

- **Availability of Level 2 charger⁵⁹:** In Québec, at all the Circuit électrique DC fast charging locations, there is a Level 2 charger available. Outside Québec, this does not appear to be common practice.

There is no consensus in the industry regarding the importance of having a Level 2 charger available next to the DCFC as the experiences vary. Research undertaken with BC EV owners indicates that Level 2 backup at DCFC locations is a priority. Under the BC CEV Program Phase 2, the installation of Level 2 chargers at DCFC locations will form part of the BC policy for funding DCFCs.

Supporters of L2 charger next to DCFC	Opponents of L2 charger next to DCFC
<p>Availability of L2 is essential in case of ...</p> <ul style="list-style-type: none"> • DCFC failure (L2 is a fall back) • Usage of DCFC by another EV driver • The EV motorist wants a top off from 80% to 100% 	<p>Availability of L2 is unimportant as ...</p> <ul style="list-style-type: none"> • Utilization is weak, if any, as ... <ul style="list-style-type: none"> ◦ DCFC usage is almost always available ◦ Even if the DCFC is being utilized, the average connection time (generally, less than 20 minutes) results in an EV driver preferring to wait for the availability of the DCFC, instead of using the L2 charger, particularly in the case of a highway recharge • Its installation adds to the costs of the site (different type of connection than the DCFC)

The above-listed charging stations are presented in Figure 6.

⁵⁹ A total of 2,308 public Level 2 chargers are available in Canada (source: ChargeHub, Mogile Technologies).

Figure 6. Map of Canada with DCFC locations, Spring 2015



The map can be accessed at the following address: <https://www.google.com/maps/d/edit?mid=z3wamWyN1MRQ.kMaoM6eCoweU>

2.1.2 US inventory

According to the Alternative Fuels Data Center of the US Department of Energy (US DOE), there are a total of 1,196 DCFC locations hosting 2,562 charging ports across the country. The details are provided in Table 5.

Table 5. DCFC locations in the United States, September 2015⁶⁰

	J1772 (SAE)	CHAdMO	Tesla	Total ⁶¹
Number of locations	266	914	202	1,196
Number of charging ports	469	1,228	1,234	2,562

Source: http://www.afdc.energy.gov/fuels/electricity_locations.html

The location of DCFCs in the United States is visually presented in Figure 7.

Figure 7. Map of DCFC locations in the United States, September 2015⁶²



Source: http://www.afdc.energy.gov/fuels/electricity_locations.html

⁶⁰ September 2015, including private DCFC

⁶¹ Given that one location may have both J1772 (SAE) and CHAdMO DC fast chargers, the numbers in the table cannot be summed.

⁶² DCFCs in Hawaii are not presented in this map. Mapping software on DOE site does not permit these Hawaii locations to be presented with the remainder of the continental US.

2.1.3 European inventory

With the help of AVERE (the European Association for Battery, Hybrid and Fuel Cell Electric Vehicles) as well as through information obtained from three websites (<http://ccs-map.eu>, <http://www.chademo.com>, <http://www.teslamotors.com/supercharger>), it has been determined that there are more than 3,200 DCFC stations in Europe. Details of the DC fast charging stations in Europe are presented in Table 6.

Table 6. DCFC stations in Europe, May 2015

	J1772 (SAE)	CHAdE MO	Tesla	Total
Number of chargers	841	1,659	756	3,256

Sources: <http://ccs-map.eu>, <http://www.chademo.com>, <http://www.teslamotors.com/supercharger>

2.1.4 Comparison of population, # of EVs per DCFC location

Table 7 presents a summary comparison of the number of EVs per DC fast charging location as well as the overall jurisdiction population by DC fast charging location. These statistics present only part of the picture in each jurisdiction. For example, the size of each jurisdiction (square km) is an important aspect that is not reflected in this table and analysis. Given the size of Canada, a significantly larger number of DC fast charging locations are required to allow an EV driver to travel across the country than would be the case in the United Kingdom or Norway. Despite this fact, the number of DC fast charging locations in Canada is significantly lower than in these two European nations.

Assessing the population served by the number of DC fast charging locations permits us to determine the completeness of a DC fast charging network. In terms of population that can be served by each DC fast charging location, Canada (and particularly, Ontario) ranks lower than all the other jurisdictions presented.

Table 7. Comparison of population, # of EVs per DC fast charging location⁶³

Jurisdiction	Population	# of EVs	# of DCFC locations	Population per DCFC location	# of EV per DCFC location
Canada	35.16M	12,487 (a)	48	732,500	260
BC	4.61M	1,931 (a)	20	230,500	97
Ontario	13.6M	4,311 (a)	9	1,511,111	479
Québec	8.18M	5,710 (a)	14	584,286	408
United States	318.9M	329,395 (g)	1196	266,639	275
California	38.8M	110,185 (b)	219	177,169	503
Oregon	3.97M	4,116 (c)	75	529,333	55
Washington	7.06M	22,351 (d)	44	160,455	508
Georgia	10.1M	12,000 (e)	34	297,059	353
Europe	507.4M				
Norway	5.1M	50,000 (f)	200	25,500	250
UK	64.1M	32,400 (f)	781	82,074	41

Source: US DC fast charging locations: http://www.afdc.energy.gov/fuels/electricity_locations.html, European fast charging locations: <http://www.plugshare.com/>, number of EVs in Canada: EMC, number of EVs in the US: <http://energycenter.org/clean-vehicle-rebate-project/cvrp-rebate-map>, <http://www.wsdot.wa.gov/NR/rdonlyres/28559EF4-CD9D-4CFA-9886-105A30FD58C4/0/WAEVActionPlan2014.pdf>, <http://www.bizjournals.com/atlanta/print-edition/2014/08/08/atlanta-eyeing-incentives-to-install-vehicle.html?page=all>

Column 3 titled #of EVs: The letters in parentheses refer to the dates of the statistics.

(a) March 31 2015, (b) June 2015, (c) 2014, (d) Feb. 2015, (e) July 2014, (f) May 2015, (g) Sept. 2015

The last column of Table 7 presents the average number of EVs per DC fast charging location. This statistic indicates that Canada's DC fast charging locations serve a comparable or, in some cases, lower number of EVs than DC fast charging locations in other jurisdictions. This reflects the relatively low number of EVs in this country. However, as the number of EVs increases, new DC fast charging locations will be required to maintain this number of EVs per location.

2.2 Planned Canadian locations

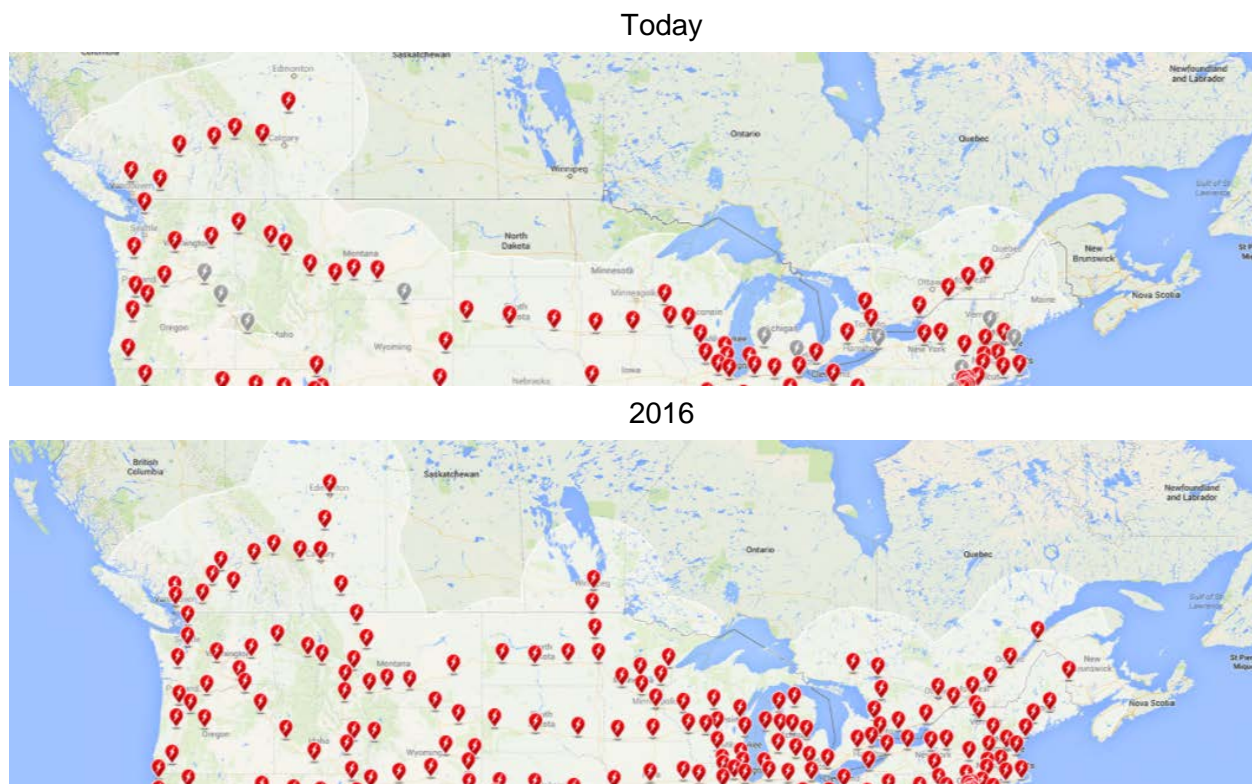
Numerous organizations have made announcements and others have shared their plans with the authors of this report regarding the deployment of additional DCFCs in Canada. These organizations include electric utilities, auto manufacturers and network administrators. As of the end of April 2015, the following DCFC plans have been made public:

- On its website (http://www.teslamotors.com/en_CA/supercharger), **Tesla** presents the SuperChargers to be deployed in 2015 as well as 2016 (Figure 8). According to this

⁶³ Various dates. Please see column 3 letter references explained below table.

website⁶⁴, an additional eight locations will be added to the existing 15 in Canada (for a total of 23 at the end of 2015). An additional nine locations are planned for 2016. A comparison of the current and future (2016) maps indicates that additional SuperCharger sites are planned for British Columbia, Alberta, Manitoba, Ontario and Québec. Typically, each site will offer several ports.

Figure 8. Tesla SuperCharger Locations in Canada: May 2015 and in 2016



- In January of this year, **Nissan** announced it will support the expansion of the public charging network the Electric Circuit with a significant investment in 25 DC Fast Charging sites⁶⁵: twenty in 2015 and five in 2016. The **Circuit électrique** intends to create a total of 50 DCFC sites in Québec (including the 25 that Nissan will be supporting) in high traffic areas, both on principal corridors as well as in large urban centers⁶⁶.

Figure 9 presents the Circuit électrique's current and targeted DCFC locations.

⁶⁴ Our requests to Tesla (both to Canadian and US representatives of the organization) to supply more detailed information did not yield any results.

⁶⁵ Source: Nissan Press release, January 15, 2015.

⁶⁶ <http://nouvelles.hydroquebec.com/communiqués-de-presse/706/nissan-hydro-quebec-reseau-recharge-public-vehicules-electriques-quebec/>



Bornes en service: DCFCs currently in service; Bornes visées: targeted DCFCs

- **BC Hydro** intends to have 30 DCFC deployed by March 2016 (in case of unforeseen events, the timetable may be extended to September 2016). As part of the BC CEV Program Phase 2, 20 more DCFC locations will be added (for a total of 50 by March 2018). In addition, the first 15 DCFC locations will be retrofitted to include SAE standard.
- **Sun Country Highway** has stated the intent to deploy an undisclosed number of DCFC stations in 2015⁶⁸.
- With respect to Canada's most populous province, Ontario, neither the provincial government nor any of its agencies has made any official announcements regarding DC fast charging plans. Unofficially, at least two auto manufacturers have indicated an interest to partner with the Government of Ontario to deploy DCFC along Highway 401 as well as around the Golden Horseshoe. Such a deployment would allow for the most heavily travelled corridor in the country (between Québec City and Toronto) to be electrified⁶⁹.

⁶⁷ Bornes en service: DCFCs currently in service; Bornes visées: targeted DCFCs

68 At the EV2014VÉ Conference (October 2014), Kent Rathwell, CEO of Sun Country Highway, revealed that his organization would be deploying an additional 1,000 charging stations in 2015. (<http://cleantechnica.com/2014/11/14/sun-country-highway-announces-massive-infrastructure-rollout/>). While the majority of these stations will be Level 2, according to representatives of the organization, several DCFC will also be deployed in BC, Québec and Ontario. The exact numbers and locations are confidential.

69 The Circuit électrique management team has been interested in collaborating on the electrification of this corridor for several years. Collaboration between stakeholders in both Québec and Ontario would be beneficial to ensure common signage and ease of use by EV owners from both provinces.

- **AZRA** plans to deploy DCFCs in 300 locations across Canada over the next three to five years⁷⁰. A map of the targeted locations is provided in Figure 10. No funding has been confirmed or committed for the deployment of these units.

Figure 10. AZRA's targeted DCFC sites, May 2015⁷¹



2.3 Examples of DCFC incentive programs

To date, in Canada, governments and EV manufacturers have generally provided the investment for DCFC installation.

Government incentives are generally in the form of a financial rebate to decrease the cost of purchase and installation of the charging station.

In the US, the Federal Alternative Fuel Infrastructure tax credit was implemented to cover 30% of installation costs, up to a maximum of \$30,000⁷².

In Canada, government contributions to the installation of DC fast charging stations have been evident in two provinces: Québec and BC. In the case of Québec, the provincial government mandated its state corporation, Hydro-Québec, to develop a network of charging stations, including DC fast charging stations. In this case, Circuit électrique (owned by Hydro-Québec), has paid in whole⁷³ or in part for the deployment of DC fast chargers. In BC, both the Government of Canada⁷⁴ and the provincial government contributed to the DC fast charging infrastructure that has been deployed. These initiatives are not incentive programs.

One **auto manufacturer, Nissan**, has, to date, provided financial contributions to encourage the deployment of 25 DC fast charging stations in Québec. While Nissan's EV Advantage program offers up to \$15,000 to businesses or other groups that deploy CHAdeMO-compatible public charging stations⁷⁵, it is currently available only in the US⁷⁶.

⁷⁰ Information shared with the authors of this report.

⁷¹ Source: AZRA. Precise locations were not disclosed by AZRA. It is important to note that this map reflects intentions expressed by members of the senior management team. No commitments exist.

⁷² <http://chargedevs.com/newswire/nissan-get-a-fast-charger-installed-fast-get-some-fast-cash/>

⁷³ Initial DC fast chargers deployed in Québec were paid entirely by the government in Québec as part of a pilot.

⁷⁴ The federal government of Canada does not specifically provide incentives for the installation of DCFCs. Its contribution to the financing of EV charging stations in BC was incidental to the NRCan ecoENERGY program, which supports a market transformation towards the efficient use of clean energy in the transportation sector at large.

⁷⁵ <http://chargedevs.com/newswire/nissan-get-a-fast-charger-installed-fast-get-some-fast-cash/>

2.4 Typical sources of DC fast charging infrastructure funding

Three important stakeholders generally provide the funding for DC fast charging:

- **Governments** (municipal, provincial/territorial/state and federal governments);
- **Electric utilities** (often, on behalf of government);
- **Private funders** (auto manufacturers, real estate developers and other businesses).

While much of the charging infrastructure initially deployed in the US⁷⁷ and Europe was funded largely by government, increasingly, governments are looking to partner with private business for the deployment of charging infrastructure, including DCFCs.

The planned deployment of DCFCs in Québec by Circuit électrique (funded by the Government of Québec) and Nissan in collaboration with local businesses (hotels, restaurants, attractions) is a good example of public-private shared investments in DC fast charging. In this way, the procurement and installation costs of the DCFCs are shared between three stakeholders.

In the case of the DC fast charging infrastructure in British Columbia, the contribution of the ecoENERGY Innovation Initiative for demonstration projects of Natural Resources Canada was matched by in-kind and financial contributions from the Province of British Columbia as well as private and municipal partners.

In Europe as well, public-private funding is the predominant charging infrastructure model. For example, in France, Bolloré, a French investment and industrial holding group that's behind Paris' hugely successful Autolib electric car sharing program, is partnering with the government of France to deploy 16,000 charging stations across the country, including both DCFCs and Level 2 chargers⁷⁸.

The ELECTRIC (European Long-distance Electric Clean Transport Road Infrastructure Corridor) project is a consortium of five partners (ABB, the Dutch e-mobility operator and retailer Fastned B.V., the Danish e-mobility operator CLEVER A/S, the Swedish Public utility and e-mobility operator Öresundskraft AB and the German Testing and Certification Institute VDE Prüf-und Zertifizierungsinstitut GmbH) that will result in the installation of 155 ABB Terra Series DCFC in Northern Europe: Germany (67 chargers), Sweden (35 chargers), the Netherlands (up to 30 chargers) and Denmark (23 chargers). It is a \$10.5 million (USD) project that is co-funded by the European Union's Trans-European Transport Networks (TEN-T Initiative) and local partners⁷⁹.

Table 8 summarizes the reasons why vehicle manufacturers and other commercial organisations are funding the deployment of the DC fast charging stations.

⁷⁶ Source: Nissan interview, Spring 2015

⁷⁷ The EV project, the largest deployment of electric vehicle charge infrastructure in history, was an investment of \$115 million by the US DOE. Partner contributions amounting to \$115 million brought the total project to \$230 million. 87 DCFC were installed in the context of this project.

⁷⁸ <http://www.france24.com/en/20141208-paris-electric-car-infrastructure-go-nationwide/>

No information available regarding the specific number of DCFCs.

⁷⁹ <http://www.prnewswire.co.uk/news-releases/launch-of-the-ten-t-co-funded-project-european-long-distance-electric-clean-transport-road-infrastructure-corridor-electric-285937151.html>

Table 8. Private business motivations in the deployment of DC fast charging projects⁸⁰

Private sector partner	Benefits
EV manufacturers	<ul style="list-style-type: none"> • Promotes additional EV sales • More EV sales in jurisdictions with ZEV regulations, allow the auto manufacturer to meet its quotas and avoid financial penalties • Provides brand exposure in a positive light
Retailers (service station owners, fast food chains, big box retailers, etc.)	<ul style="list-style-type: none"> • Attracts EV customers located farther away from store location • Fits with sustainability initiatives of some of these companies • Unlike many sustainability initiatives, a DCFC is a very visible sustainability measure • The EV owner profile is an attractive one (generally home owners with relatively higher annual incomes⁸¹)
Investor-owned utilities, private power generators	<ul style="list-style-type: none"> • Generates revenues • Fits with sustainability initiatives
Restaurants, hotels, etc.	<ul style="list-style-type: none"> • Differentiation strategy to attract EV owners, the EV owner profile is an attractive one (generally home owners with relatively higher annual incomes) • Fits with sustainability initiatives of some of these companies
Real estate developer	<ul style="list-style-type: none"> • Differentiation strategy to attract EV owners • Adds value to properties for lease or sale (condos) • Fits with sustainability initiatives

AZRA is a rare, entirely privately funded initiative that is investing in the deployment of DCFCs. A description of this business model is provided in section 2.6.

⁸⁰ Source of information: interviews undertaken in the context of this mandate with a variety of stakeholders, including but not limited to electric utilities, auto manufacturers, retailers, network operators, charging station manufacturers and a real estate developer.

⁸¹ Suzanne Goldberg presentation at the EV2015VÉ Conference: What BC's Electric Vehicle Owners Tell Us About Driving and Charging. Preliminary analysis of SFU's 2014 Plus-in Vehicle Owners' Survey (PEVOS)

2.5 Cost of purchase and installation of DC fast charging stations⁸²

The price for the purchase and installation of DC fast charging stations varies widely depending on a number of factors. The three main cost components are the equipment (or charger), the installation and the real estate (land and amenities).

In the case of the **purchase** of the DC fast charging equipment, the cost varies depending on the manufacturer, the unit specifications as well as the number of units ordered. While the price of chargers has been declining, most stakeholders⁸³ contributing to this research cite 2015 prices of approximately \$30,000 per unit⁸⁴.

The **installation** cost varies depending on ...

- The availability of a suitable source of 3-phase electricity in close proximity;
- The civil work required on site;
- The importance of the aesthetics to the operator;
- The time of the year at which the installation work is performed (a consideration in all provinces except BC);
- The organization managing the project.

Based on the information gathered from Canadian stakeholders involved in the installation of DCFCs, the installation cost can vary from \$15,000 to over \$60,000. This does not include the cost or installation of peripheral equipment, such as solar carports and heating pads, to ensure the space is accessible at all times to EV owners.

The cost of **real estate** can also vary widely, ranging from zero⁸⁵ to several hundreds of dollars per square meter in major urban centers.

2.6 Key stakeholders and their importance in the installation

The stakeholders involved in a DCFC deployment vary by jurisdiction and by business model. The following describes three business models: BC Hydro, Circuit électrique and AZRA Network.

Although the regulatory environment is similar, a key difference between the BC Hydro and Circuit électrique models is the degree to which the electric utilities have been involved in network development. In Québec, Hydro-Québec was identified by the provincial government as the ideal stakeholder to oversee the deployment of a network of charging infrastructure across the province. In contrast, in BC, although BC Hydro led the development of the first 30 DC fast charging stations, it did so in a partnership approach with site hosts to share in the costs and risks of deploying the network.

In the case of BC Hydro, four key stakeholders are identified and illustrated in Figure 11. The utility maintains ownership of the DCFCs and contracts a local installer to perform the installation work. This installer is generally the one called upon if the station requires repairs. In the case of BC, this work is performed by Greenlots, a network administrator.

BC Hydro has created leases for participating municipalities. Under the terms of the lease, the municipality is the DCFC operator and host⁸⁶. In exchange for providing a service, the municipality

⁸² A breakdown of US DCFC equipment and installation costs is available upon request.

⁸³ Public electric utilities and DC fast charging network operators.

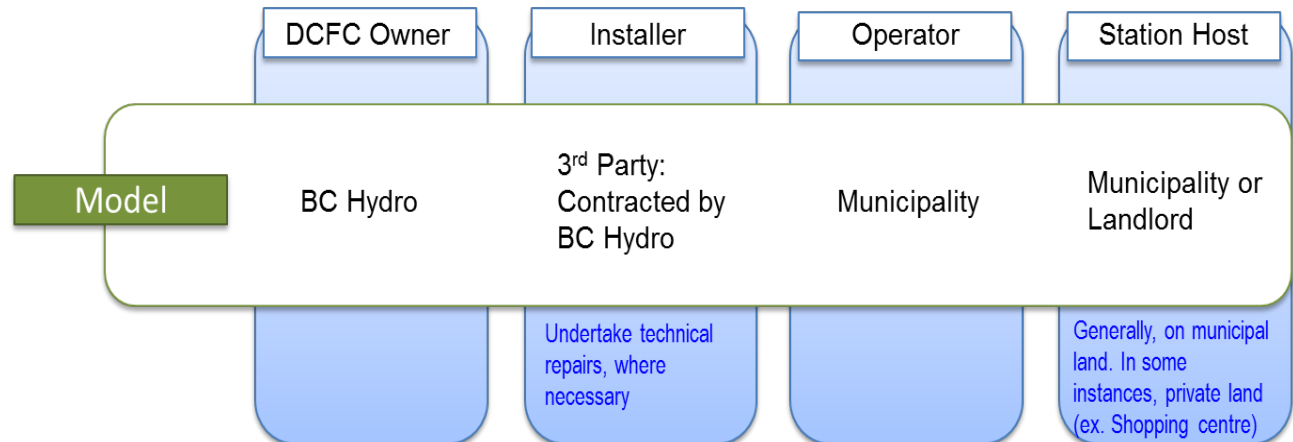
⁸⁴ Prices cited range from \$25,000 to \$40,000 per unit.

⁸⁵ Example: in the case where the real estate is granted by a third party without charge.

⁸⁶ The host can also be another stakeholder, example a shopping mall.

collects the revenues generated by the use of the DC fast charging station⁸⁷. Greenlots receives an annual fee of \$260 per station to cover payment processing, station monitoring⁸⁸ and handle call centre issues.

Figure 11. BC Hydro DCFC project business model



Source: BC Hydro, modified by MARCON (text in blue)

Circuit électrique is the owner and operator of the largest DC fast charging network in Québec. Its business model is different from that in BC. For Circuit électrique, the key stakeholders include Hydro-Québec (and therefore the government of Québec), a financial partner (ex. Nissan⁸⁹) and ideally, a third party able to host the DCFC station. The installation of a DCFC also involves the local municipality.

⁸⁷ Only two municipalities in BC currently charge a fee for usage of the DC fast charging station. Others are expected to do the same in coming months.

⁸⁸ If fault is detected with the DCFC, Greenlots personnel can reboot remotely or contact the municipality to undertake necessary maintenance on site.

⁸⁹ Please see section 2.2 for information regarding Nissan's financial contributions to the deployment of DCFCs in Québec.

Figure 12. AZRA Network business model



AZRA Network's business model, summarized in Figure 12, differs considerably from the previous two and involves different stakeholders. Its stakeholders are those holding a lease on AZRA's properties. They include the conventional fuel supplier (pleased not to lose a customer that moves from ICE to EV) and the tenants of the complex who happily serve the needs of the driver that will be on the property, generally for approximately 20 minutes, purchasing products available at the location (food, drink, etc.), spending between \$3 and \$14 per charging session⁹⁰. AZRA assumes the cost of installation and maintenance of the DCFC.

2.7 Criteria used to determine location for DCFC installation

The criteria used to determine the location for the installation of a DCFC vary by network. Given the current scarcity of stations and the varied motivations of network owners, these are not necessarily indicative of how all future locations will be selected.

Generally speaking, the siting criteria reflect the realities of the population dispersion and motorist travel patterns within each jurisdiction⁹¹. At a very basic level, a key criterion is urban versus highway location. While the latter is strategic and necessary to permit longer-distance travel, the former provides greater visibility and can play an important role in public education and awareness⁹².

As depicted in Figure 13, the criteria for identifying optimal sites evolve over time as EV adoption improves. Initially, charging station visibility and convenience are considered key objectives in site selection.

According to UBC's TIPS Lab

The framework for deploying EV Fast Charging Stations consists of a series of time prioritized objectives and a series of station types. Starting from the left [Figure 13], the foremost concerns upon immediate deployment are Visibility, Convenience, Cultural Branding and Reliability.

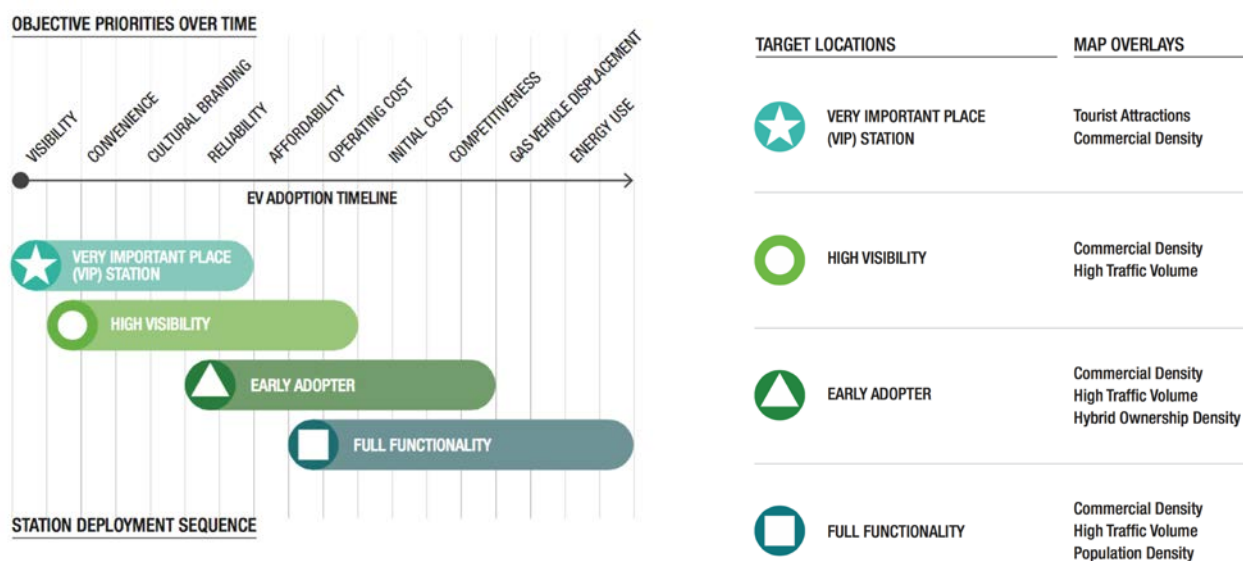
All Fast Charging Station network deployments should start with Very Important Place (VIP) and High Visibility Stations. Appropriate locations for these stations will be determined through the mapping processes undertaken in Step 2. Again, please see the Guide to the Station Location Process for descriptions of the station typologies.

⁹⁰ Source: AVÉQ member survey.

⁹¹ During the EV2015VÉ Conference breakout session on charging infrastructure, it became clear that not all provinces have the same realities with respect to population concentration and distribution. Further, traffic patterns vary considerably, depending on the activities of residents (example: in BC, travel of residents of the greater Vancouver area to attractions and activities inland or up the coast).

⁹² In addition, DCFCs located in more urban areas tend to be used more frequently (source: AddEnergie).

Figure 13. BC site selection objective priorities

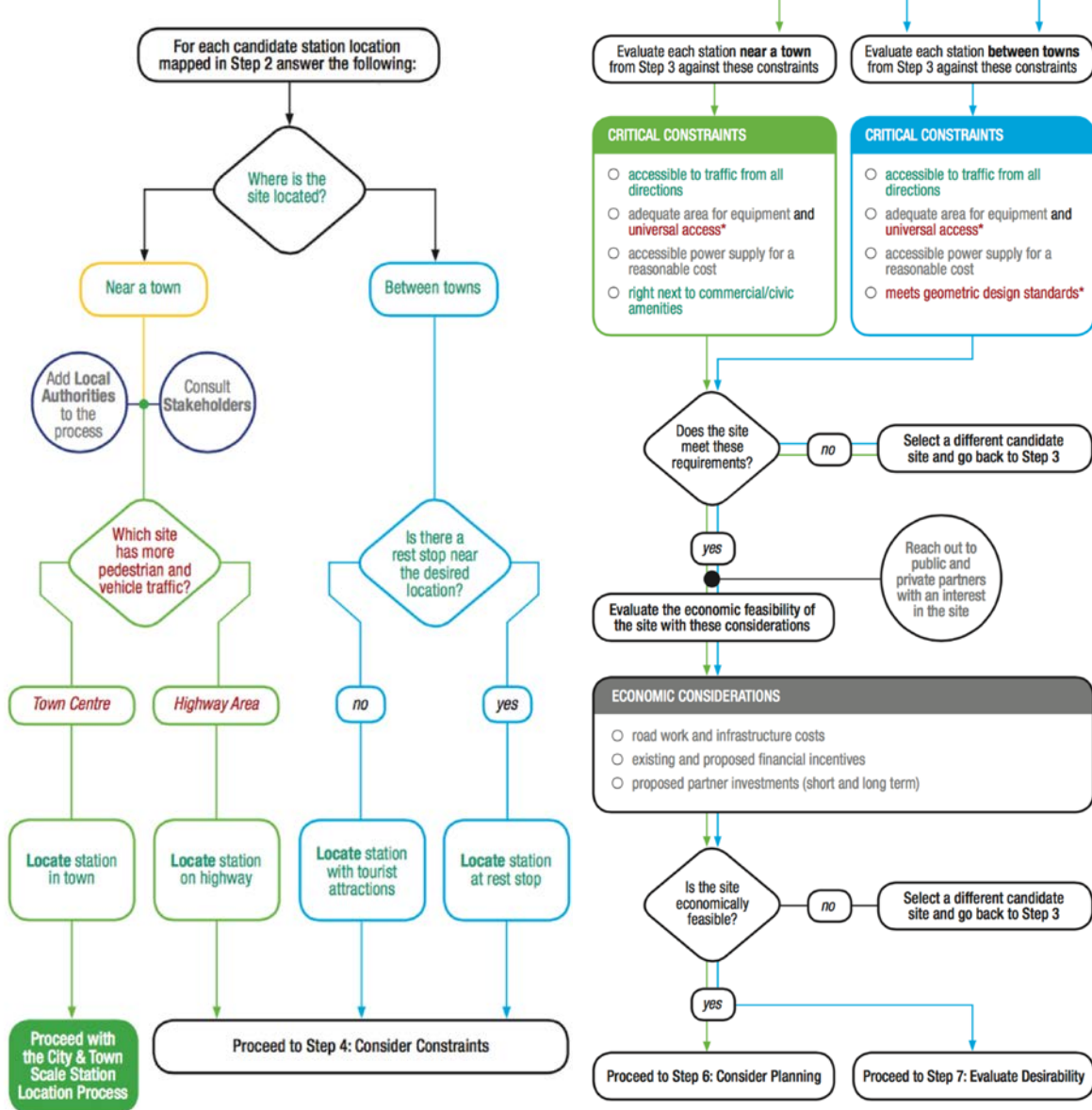


Source: TIPS Lab, University of British Columbia

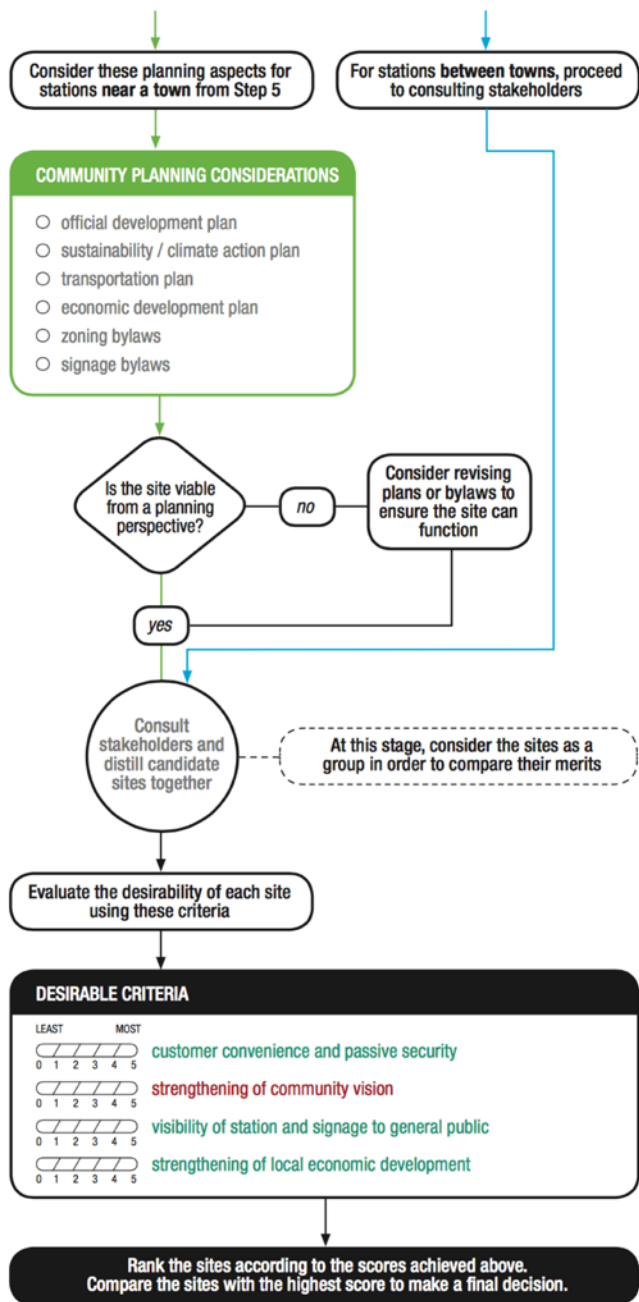
A description of some of the most important site selection criteria used by BC Hydro, Circuit électrique and AZRA Network is provided following.

In BC, site selection followed a 2-stage approach. In the first phase, travel patterns, existing and expected EV adoption areas, and strategic corridors were reviewed to identify the top strategic locations or communities for DC Fast Charging. Then, a detailed sited evaluation process was followed that, for the early network, prioritized accessibility, visibility, access to neighbouring conveniences while charging (e.g. coffee shops, downtown cores, etc.), education, and ease of access to electrical requirements. BC also encouraged communities to identify their interest through a “hand-raiser” process. In BC, the TIPS Lab of the University of British Columbia developed an outline of the site-specific criteria to be considered for site selection, once strategic locations had been identified. Figures 14A, B and C detail the considerations⁹³. Following is a more complete picture of the process.

⁹³ Please note that Figures 14 B and C are a continuation of Figure 14 A.

Figure 14A, B, C. BC site selection framework⁹⁴

Source: Tips Lab, University of British Columbia

Figure 14A, B, C. BC site selection framework (cont'd)⁹⁵

Source: Tips Lab, University of British Columbia

In the case of Circuit électrique, while visibility and public education are important, the site selection criteria are much more focused on situating the stations in strategic locations, considering road travel patterns of Québécois. The site selection process includes the following list of criteria:

- Installation along a route that benefits from significant passenger car traffic and connects urban centers;
- 3-phase current availability, as this will limit installation costs;
- Interest of the host site to financially share the costs associated with the installation of a DCFC;
- Ease of access to the site for the installation, for use by the EV driver and for ease of maintenance;
- Right-of-way to access the station and to bring in electric current;
- Preferably, availability of washroom facilities and a café in close proximity.

In the case of AZRA, the decision is strictly real estate related. Therefore, the company requires a location that will be attractive to potential renters (as this will attract motorists who will spend money purchasing products while they wait for their vehicle to charge⁹⁶) and where the property will gain value over time and be relatively easy to sell.

Increasingly, DC fast charging network operators are recognizing the importance of locating the chargers in close proximity to services (washroom facilities, restaurants, cafés) that can be used by the EV driver during charging.

2.8 DC fast charging deployment challenges

A few but rather important challenges were encountered during the deployment of the existing DC fast charging infrastructure in Canada. Some were easily avoidable, others not as much.

This section deals with challenges, best practices and lessons learned.

2.8.1 Funding

DC fast charging infrastructure deployment within Canada is in its infancy. With the exception of Tesla and AZRA, network scale deployment has been the work of governments, their agencies or Crown Corporations in Canada. This results from the perceived lack of acceptable financial returns on investment and significantly longer paybacks than private investors are willing to accept. Given the investment required, the relatively small number of EVs and the low incidence of charging, conventional financing of DC fast charging stations (equity, debt or a mixture of both) has been nearly impossible, and is unlikely to change in the foreseeable future.

The successful DC fast charging infrastructure network deployments have been financed in one of the following ways:

- Highly subsidized by provincial and/or federal government;
- Private investment made by auto manufacturers aimed at reducing range anxiety and increasing EV sales; and,
- One innovative investment model inspired by the commercial real estate market and derivative sources of income.

⁹⁶ As indicated elsewhere in this report, based on AVÉQ's member survey, an EV driver spends between \$3 and \$14 buying products from peripheral businesses while waiting for the vehicle to charge.

In most cases, the total amount of investment available is relatively small and the process to obtain government funding (if and when it is available) can be rather complicated, onerous and rare. This explains, in large part, the relatively slow rate at which DC fast charging infrastructure is deploying in Canada.

2.8.2 Utility regulations, codes and standards

There are very few regulations, codes and standards that specifically impact the deployment of DC fast charging stations.

A utility will only provide power to installations meeting the electrical code, a subset of the National Building Code (NBC) of Canada (and its provincial versions, where applicable). It applies to any electrical installation, regardless of its purpose. In some provinces, additional guidelines are provided by either utilities (example, Hydro-Québec's EV Charging Stations Technical Installation Guideline) or safety related agencies (example: the Electrical Safety Authority of Ontario). These are meant to help installers apply the NBC properly.

In some Canadian jurisdictions⁹⁷, the law forbids the resale of electricity by a third party, for example this is the case in Québec. Charging station operators in this province cannot sell energy to EV owners. Despite the fact that alternative pricing solutions⁹⁸ have been designed to avoid this encumbrance, this continues to be an impediment to greater DCFC market development.

2.8.3 Considerations of electricity grid

The main challenge related to the deployment of a DC fast charging station network with consideration to the electricity grid is the availability of 3-phase current where the station is required. This is generally not a major technical impediment, but it can be a source of considerable cost if the station is located far from the source (along highways, for example) or in a building complex not equipped with the adequate power supply.

Destination charging locations are usually less problematic as most of these are located where the grid is readily available. Nevertheless, most operators choose to have a separate meter for their charging station. In this way, they can monitor the power factor of the installation closely and avoid exceeding a demand level that could prove costly for all future charging at the site⁹⁹.

With respect to the availability of energy, the low incidence rate and the few DCFCs installed have not proven to cause problems to electrical utilities to date. In the future, however, some utilities may experience limited energy supply during certain periods of the day / week / year that may result in utilities imposing limitations on the availability of the charging service on those relatively rare occasions¹⁰⁰.

⁹⁷ The situation in BC is discussed in section 2.9.

⁹⁸ This means that the users cannot be charged for the kilowatt-hours (kWh) they consume. But any bundling of services that includes these same kWh can be invoiced to the user as long as the basis for invoicing is not a kWh. To the best of our knowledge, no pricing scheme has ever been challenged in a Canadian court of law.

⁹⁹ Most utilities have a dual base electricity tariff. Their customers are therefore charged for their energy consumption (per kWh) and for the highest power demand (in kW) incurred in the course of the year. It becomes important for operators to minimize their use of power in order to maintain their cost of electricity as low as possible.

¹⁰⁰ Consultations with a reliable number of electrical utilities on this issue were beyond the scope of the current study but Hydro-Québec and BC Hydro have already stated that meeting the demands of EVs will not be a problematic in the foreseeable future, if ever. Hydro-Québec representatives claim that even a million EVs on Québec's roads would not be problematic for the utility.

2.8.4 Permit issuance

No significant problems or important challenges associated with permitting for DC fast charging stations have been identified in the context of this research. In the case of BC Hydro, the stations are generally “treated as a utility installation, avoiding any building or development permits”¹⁰¹. In most cases, the only permit required is an electrical one.

2.8.5 Other challenges¹⁰²

The multiplicity of design standards for DC fast charging stations does not promote fast deployment by independent third parties and it reduces the potential market for individual stations. This situation therefore impacts the eventual profitability of the stations. At present, all commercially available charging stations are conductive. In Canada, most DC fast charging stations use equipment built according to SAE Standard J1772-2009 (IEC 62196-2) or CHAdeMO¹⁰³. Although slightly more expensive¹⁰⁴, dual technology stations J1772 Combined Coupler Standard (called CCS or “Combo”) are also available on the market.

As not all vehicles are compatible with all DC fast charging technologies, dual stations are increasingly being installed, with Tesla Superchargers being altogether different and so far inaccessible to any other car make/model¹⁰⁵.

In the past, the business models contemplated by station owners were essentially based on obtaining government support for one facet or another in the deployment of stations. This was required because the small fleet of EVs in Canada could not possibly sustain a purely mercantile model.

At an average rate of \$5 per charge session, 12,000 sessions are required to recover the fixed costs, averaging \$60,000¹⁰⁶. This calculation excludes the variable costs (including operation and maintenance as well electricity¹⁰⁷). For a two-year payback, an average of 116 sessions per charger per week would be required to cover only the fixed costs of purchase and installation (excluding cost of capital). None of the DC fast charging stations presented in Table 8 demonstrate this level of usage¹⁰⁸.

There are no tangible examples of profitable DC fast charging stations in Canada to date. Our research did not identify any profitable¹⁰⁹ public DCFC stations in the US or Europe. The lesson learned therefore is that at least in the short term, a more innovative, less station-centric business model must be developed in order to generate enough revenue to cover the station fixed and variable costs.

¹⁰¹ Source: BC Hydro

¹⁰² Battery usage associated with air conditioning and heating is addressed in section 3.1.

¹⁰³ Please see Table 1 for additional information on what models use which technology.

¹⁰⁴ A dual technology station adds 10% more to the total cost (purchase and installation) of a DC fast charging installation (source: AddEnergie).

¹⁰⁵ Elon Musk, Tesla's CEO, stated he'd be willing to open up the designs (of the Tesla Supercharger) in order to build a standard that can be used interchangeably across the industry. This would allow competing electric car models to charge up at the Supercharger network that already dots the U.S. and beyond. Source: <http://techcrunch.com/2014/06/09/tesla-wants-to-open-its-supercharger-standard-to-other-electric-car-makers/>

¹⁰⁶ Cost of financing is not taken into consideration.

¹⁰⁷ Electricity charges can be considerable, sometimes upwards of \$5/kWh.

¹⁰⁸ According to AddEnergie, the DCFC most utilized in Québec is one located in Montréal (on average, 5 charge sessions per day or 35 per week).

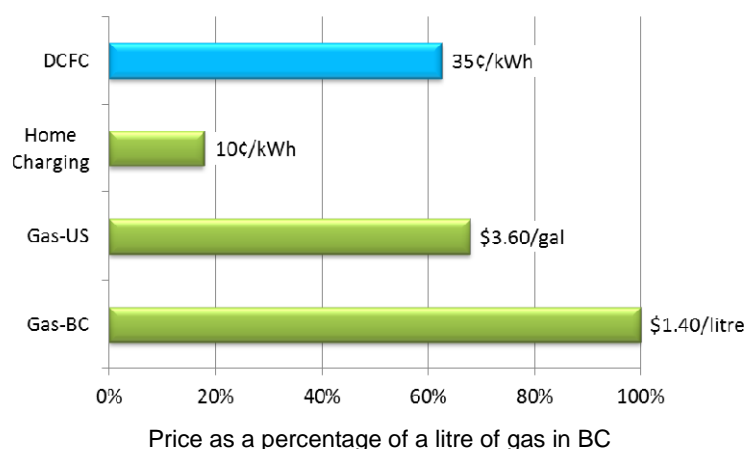
¹⁰⁹ A “profitable DCFC station” would be one that generates a financial benefit, one where direct, tangible monetary revenues exceed total costs (capital and operations).

2.9 Cost to customers and use of current DC fast charging stations¹¹⁰

Currently, three pricing models are in place in Canada for the current use of DC fast charging:

- **Free of charge:** With the exception of the Circuit électrique and AZRA Network DCFCs in Québec and two DCFCs in BC¹¹¹, use of all other DCFCs in Canada is provided free of charge.
- **Time based:** In Québec, the price charged is based the number of minutes of charging. Currently, EV owners using a DCFC in Québec pay \$5.00 per 30 minutes. Users are charged per minute of charging (no minimum charge).
- **kWh based:** In BC, the rate is \$0.35 per kWh, with a minimum charge of \$2.00. As presented in Figure 15, the DCFC price remains competitive with the price of gasoline¹¹². At a price of \$1.40 per litre of gas, the DCFC recharge price of \$0.35 per kWh is slightly more than 60% (fuel equivalent).

Figure 15. BC Hydro DCFC Price Comparison



Source: BC Hydro (based on cost per distance travelled)

A key difference between the pricing structure of the Circuit électrique and BC Hydro models is the regulatory environment allowing or preventing other parties in each province to resell electricity. In the case of Québec, only Hydro-Québec can sell electricity. No other party in the province can resell electricity.

¹¹⁰ The cost per location is presented in the detailed DCFC list in section 2.1.1.

¹¹¹ Currently, only two DCFCs in BC require payment of \$0.35/kWh with a minimum of \$2.00 per charge session. The intent of BC Hydro and Greenlots is to introduce this pricing structure to all the DCFCs in the province (excluding Tesla SuperChargers).

¹¹² The cost competitiveness of the price charged to EV owners for DC fast charging, will vary depending on the price of fuel.

Consequently, in Québec, all parties wishing to operate charging stations and collect revenue are required to *get creative*: charge a fee by the minute or a fixed amount for a service (example, parking and charging combined). In BC, the situation is different. Third parties in this province, that are municipalities, can sell to anyone. Landlords and employers have the right to resell electricity to their own tenants or employees¹¹³. Therefore, the municipality, acting as operator and station host, charges a fee of \$0.35/kWh with a minimum charge of \$2.00 per session¹¹⁴. However, with the exception of these exclusions in B.C., other entities wishing to operate charging stations and collect revenue from the sale of electricity are, similar to Québec, required to get creative or be regulated as a utility.

Access to the DC fast charging stations in Canada requires the driver to have an account/membership. In Québec, Circuit électrique charges \$10 to create an account and obtain a membership. This \$10 card provides free access to four Level 2 charge sessions¹¹⁵. In BC, to create a Greenlots account, there is no cost to the user unless he/she does not have an iPhone or Android phone¹¹⁶.

Providing charging at no cost to consumers has been used in many jurisdictions to encourage EV adoption. However, many of the stakeholders consulted in the context of this research emphasized the importance of avoiding providing charging at no cost, as there is a real value to the charge. Further, those who support requesting payment for the charge indicate that moving from “free” to a price sometimes creates dissatisfaction.

Despite the DC fast charging stations being free to use or being charged a cost competitive price (compared to gas)¹¹⁷, the utilization of these stations is low for two principal reasons:

- Relatively limited number of EVs in Canada;
- The large majority of recharging is being completed at home, and to a lesser extent, at work.

Table 9 presents the usage of seven DC fast charging stations in BC (three in suburban areas, three in corridor towns and one in an isolated town) and two in Québec (one in an urban location and one in a highway location). Drawing conclusions based on the average weekly charges of these stations is challenging for the following reasons:

- Limited number of months of operation;
- A variety of locations that are not necessarily comparable between Québec and BC;
- A combination of free to use and fee based stations.

In fact, the average number of weekly charges per station varies considerably, even among stations that have approximately the same location profiles. For example, the first three stations in Table 9 are located in suburban areas. The average weekly charges at these “free” stations vary from 2.6 to 24.7. Among the BC DC fast charging stations located in corridor towns, the average number of charging sessions per week ranges from 3.2 to 13.4. Of the three, the one with the greatest weekly utilization is the one that charges a fee for usage.

¹¹³ In BC, “if a Customer wishes to sell Electricity which the Customer has purchased from BC Hydro to a tenant of that Customer on the same Premises on a metered basis, then the Customer shall agree that the selling price for such Electricity shall not exceed the price which BC Hydro would have charged had that tenant been a Customer of BC Hydro. This requirement shall be included in an agreement for resale between BC Hydro and the Customer” (General provisions of the British Columbia Hydro and Power Authority, tariffs, April 2008, article 9,2 page 34).

¹¹⁴ As already mentioned, currently only two municipalities are charging this fee. Others are expected to begin charging a fee in coming months.

¹¹⁵ Given that a Level 2 charge costs \$2.50, the four free Level 2 sessions means that the membership and account are free of charge.

¹¹⁶ Those without an iPhone or Android phone, can order an RFID. A fee of \$5 is charged for shipping and handling.

¹¹⁷ The cost competitiveness of the price charged to EV owners for DC fast charging, will vary depending on the price of fuel.

Table 9. Usage of select DC fast charging stations in Canada

	Station location	Charge events	Dates of charge events		Energy dispensed (kWh)	Average charge	Charges / week	Usage fee
			From	To				
British Columbia	Suburban	76	14/05/2014	30/11/2014	603	9.0 kWh, 23.9 min	2.6	None
	Suburban	252	02/06/2014	30/11/2014	2064	7.9 kWh, 18.3 min	9.8	None
	Suburban	42	19/11/2014	30/11/2014	270	9.0 kWh, 24.6 min	24.7	None
	Corridor Town	128	04/06/2014	30/11/2014	1153	8.2 kWh, 19.1 min	5.1	None
	Corridor Town	342	06/06/2014	30/11/2014	3127	9.1 kWh, 24.0 min	13.4	\$0.35/kWh, min. charge: \$2.00/session
	Corridor Town	37	31/08/2014	30/11/2014	309	8.8 kWh, 23.8 min	3.2	None
	Isolated Town	62	20/06/2014	30/11/2014	539	9.6 kWh, 27.1 min	2.6	None
QC	Urban	490	End of 2014	May 2015	4116	6.7 kWh, 20.3 min	12.2	\$4.99 / 30 minutes, priced per minute
	Highway	317	10/01/2015	May 2015	3346	10.8 kWh, 23.0 min	19.0	\$4.99 / 30 minutes, priced per minute

Source: Hydro-Québec, BC Hydro, Powertech

While no clear conclusions can be drawn with respect to average number of weekly charge sessions, there is more consistency surrounding the average charge. The average charge time ranges from 18.3 minutes to 27.1 minutes¹¹⁸.

There are important reasons for locating DC fast charging stations in both urban areas as well as corridors. Location decisions will often reflect the realities of each jurisdiction¹¹⁹.

While DC fast charging stations located closer to, or in, urban areas may be used more frequently than those located on highways¹²⁰, chargers located on highways play an important role in EV adoption by providing EV owners with the safety net required to make longer distance travel (limiting range anxiety).

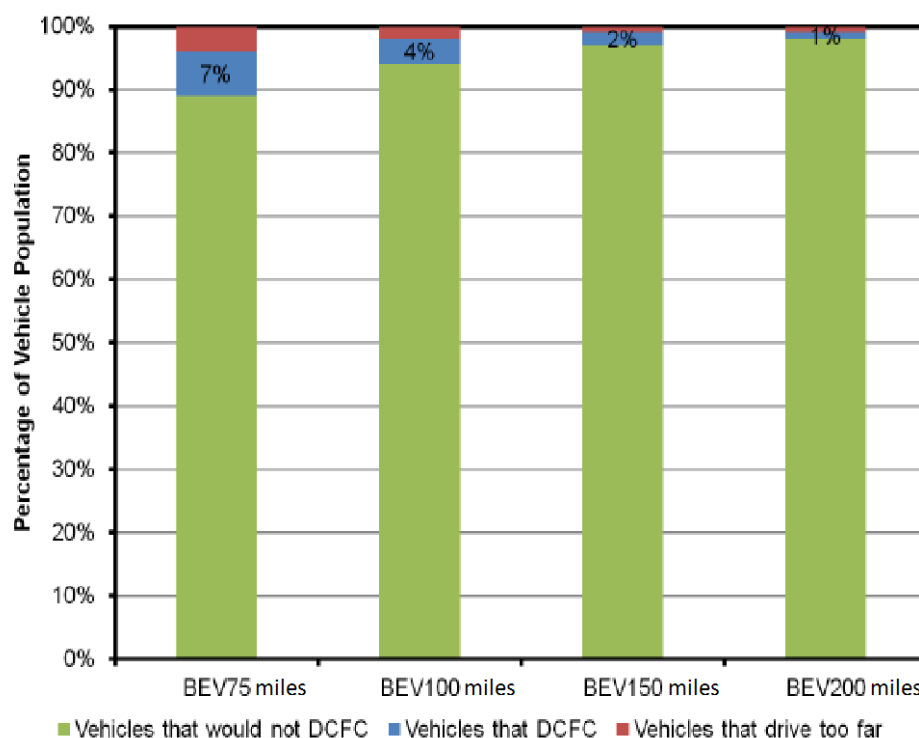
¹¹⁸ The experience is similar in the United States: <http://www.theevproject.com/cms-assets/documents/126447-30174.dcf-initexp.pdf>

¹¹⁹ During the consultation on charging infrastructure at the EV2015VÉ Conference, it became clear that each province's population dispersion, location of major urban centers and travel patterns of residents were different. These differences will likely play a role in decisions regarding where to optimally locate DC fast charging stations.

¹²⁰ Source: AddEnergie presentation at the EV2015VÉ Conference. According to AddEnergie, the DC fast charger used most frequently in Québec is one situated in Montréal (on average, 5 charge sessions per day).

As more EV models are introduced with longer range¹²¹, it would be reasonable to expect that EV adoption will increase. More EVs will result in greater use of the DC fast charging infrastructure available. However, a report from the Electrical Power Research Institute (EPRI) indicates that as the range of EVs increases, the percentage of the vehicle population using DC fast charging decreases. Figure 16 graphically presents this analysis.

Figure 16. Estimated demand for DC fast charging on an average day^{122,123}



Source: A Review of Initial Analysis and Early Market Data on DC Fast Charging, EPRI, December 2013

EPRI's analysis has important implications on the future use of DCFCs and their ability to generate enough revenue from charging alone to cover the cost of purchase, installation, operation and maintenance of the stations.

2.10 Payment methods

There are several payment approaches currently used in North America and Europe.

Initially, the most popular method was the membership card or apparatus containing a radio frequency identification (RFID) chip identifying each user as a member of the network entitled to the service, providing access to the equipment and making the link between the member and his/her

¹²¹ Based on OEM announcements, at least four (4) EV models with a range of at least 300 km, priced at approximately \$40,000, will be available in 2017.

¹²² In its analysis, EPRI assumed that DC fast charging will be used for trips between 80% and 160% of the range of a BEV. Trips of shorter duration will not require DC fast charging, and trips longer than 1.6 times the range of the vehicle would require multiple fast charges, which is assumed to push most drivers to use a different vehicle or create an alternate plan for the trip.

¹²³ BEV75= BEV with 75 miles of range, etc.

account for payment purposes. Using this approach, each network operates a unique system using proprietary protocols distinctive to its network. Each network also has custom, proprietary credentials for user authentication, such as RFID cards.

Not surprisingly, this method has resulted in important compatibility issues, as members of one network cannot access the equipment of others. EV owners wishing to use multiple networks must maintain credentials for each network.

Using an RFID identifier, the invoicing/payment process can take place in one or several ways:

- Added to the electrical utility invoice;
- Produced on a separate invoice dedicated exclusively to the charging service;
- Added to a credit card preselected by the member;
- Deducted from a prepaid card unique to the network.

EV owners maintaining credentials with several networks therefore receive multiple invoices and may even have to use a variety of payment methods.

In order to resolve this issue, in the US, two of the largest networks of charging stations launched a project called “Collaboratev”. Collaboratev was set up as a not-for-profit entity that would manage a data exchange interface and clearing house for transactional data from various networks.

Collaboratev was meant to allow various networks to process transactions from other networks, effectively allowing a consumer to “roam” across networks. It is unclear whether this roaming would still require maintaining unique access means for each network. Unfortunately, one of the two networks behind Collaboratev declared bankruptcy (ECotality), and the project was abandoned.

A similar organization has been formed in Europe under the name Hubeject and seeks to provide a similar inter-network clearinghouse for charging across Europe¹²⁴.

A second, more recent approach also exists. A smart phone application, developed by AZRA Network, is used to perform all the functions of the RFID card/apparatus: client identification, charging equipment access and invoicing interface. The application is available for all smart phones from their respective app stores, free of charge.

Payment is made easy as a credit card linked to the smart phone is used to preload the currency to the app for payment. When the EV owner reaches a DC fast charging station, he/she unlocks it using the app and starts charging. The cost of the charge is deducted from the e-wallet built into the application.¹²⁵

Another initiative worthy of mention is EVite¹²⁶, whose objective is to make fast charging non-discriminatory throughout Switzerland. It has published standards for fee-based fast charging stations. At every EVite station, payment via credit card must be possible, while prices shall be visible at every location.

Network interoperability is therefore a challenge the industry has not resolved yet. As with any new technology, convenience and ease of use for the user is key to adoption. The lack of interoperability is often characterized as an “annoyance” for current and prospective EV owners that should be resolved to improve ease of use.

¹²⁴ Hubeject website: <http://www.hubeject.com/pages/en/index.html#1-1-home.html>

¹²⁵ The application also boasts a map that locates all AZRA charging stations as well as those of other networks. AZRA is open to the use of its application by all networks, which would simply require a change in relatively small programming and a fee for processing payments and sharing income.

¹²⁶ <http://www.swiss-emobility.ch/fr/EVite/Technik/Commen-puis-je-payer.php>

2.11 Other challenges

There are various other challenges related to the operation of DC fast charging stations.

For example, the Nordic climate that prevails in most provinces requires snow removal to ensure the accessibility of charging stations at all times. Installations such as canopies and heated charging spaces (under the pavement or pads¹²⁷) are technically feasible, but add to capital and operating costs.

Most DCFCs have the capability to communicate their real-time status to network operators (available, in use or out-of-order). Each charging station status is reported back to the network members using an application that is proprietary to each network. Increasingly, these networks accept to share that information with organisations such as Mogile Technologies¹²⁸ (<http://www.mogiletech.com>). The successful distribution of this information is a key success factor in the deployment of a Canada-wide network of DC fast charging stations.

Another challenge relates to consumer education. DC fast charging stations are relatively easy to use on account of their design. Yet, consumers are not familiar with them and, as a consequence, harbour a certain fear with regards to their use. Although not essential, an online customer support service appears effective at helping potential users get acquainted with the charging station. The CAA offers this service 24/7 to members of the Circuit électrique in Québec.

2.12 Consumer willingness to pay

Typical costs to the EV owner for the use of a DCFC commonly range between \$5 and \$7 per charge¹²⁹. While this may seem like a high cost relative to residential charging, EPRI research indicates that this has very little impact on the total cost of ownership for most EV owners. If access to DC fast charging enables a driver to use his/her BEV instead of a gasoline vehicle, the driver should be willing to pay \$10 or more for this service¹³⁰. This is driven by two factors:

- Infrequent use of DC fast charging: almost all BEV owners need fast charging less than once per week¹³¹
- Fuel costs for the replacement vehicle for a trip of more than 75 miles (120 km) are significant.

¹²⁷ Heating elements under the pavement.

¹²⁸ The owner of the EV ChargeHub website (<http://www.evchargehub.com>) and the corresponding mobile application Charging station information is incorporated into a larger map of all charging stations and their current status.

¹²⁹ US & Canadian charge rates

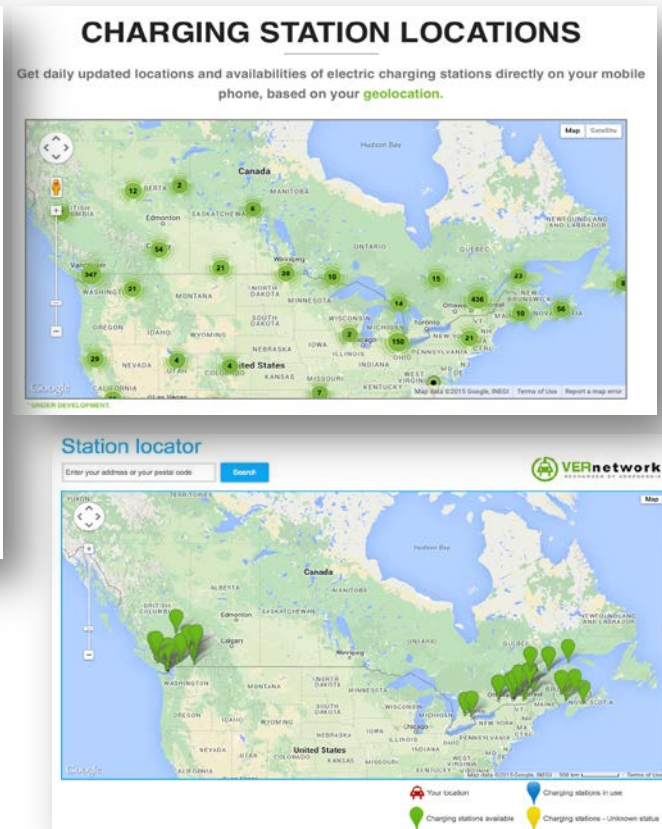
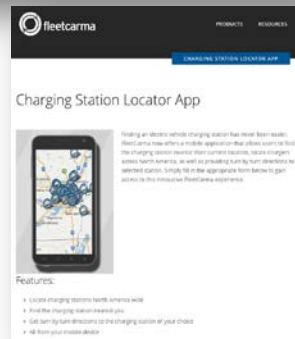
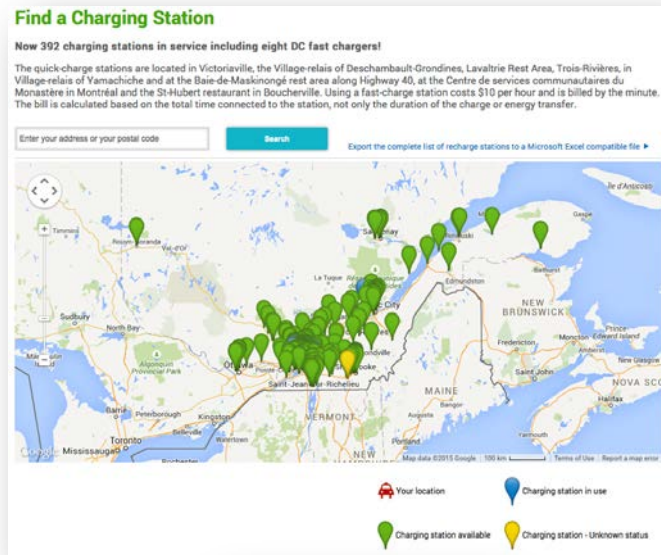
¹³⁰ Electric Transportation Technology Update Newsletter, EPRI, September 2013

¹³¹ In the future, as more urbanites (without access to dedicated parking) adopt EVs, usage of DC fast charging in urban environments will likely happen more frequently. This is addressed in more detail in section 4.1. For urbanites that use urban DC fast charging regularly, the price elasticity of demand is likely to be different from that of the EV motorist who has access to home charging and uses DC fast charging infrequently.

2.13 Method used to communicate DC fast charging station locations

Several apps and websites indicate the presence of DC fast charging and Level 2 station locations in Canada. Given that new charging stations are being deployed at an increasing frequency, the apps and websites are often not up-to-date and therefore incomplete.

Some of these apps / websites are provided by Circuit électrique, Plug Share, VERnetwork, AZRA network, Electric Mobility Canada, Fleet Carma, Plug'n Drive and the Canadian Automobile Association (CAA).



2.14

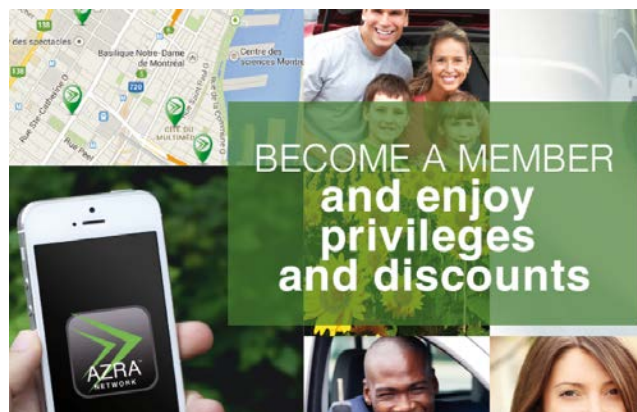
Measured and unmeasured co-benefits

Numerous potential benefits are associated with the deployment of a DC fast charging network; some are more easily measured than others. Following is a list of some of these benefits.

- In addition to the revenue generated from the charging session, there is an opportunity to generate “peripheral” revenues from the sale of products in retail establishments that are located near (or not so near) the charging station.

As mentioned earlier in this report, AZRA’s current model is to install a DC fast charging station along with the other building and equipment at the service station. In a survey of its members, the Quebec association of EV owners (AVÉQ) has measured that an EV driver who stops for a charge will spend between \$3 and \$14 on food, drink or other products while the vehicle is charging.

- By targeting EV owners with cross-promotions (coupons and special promotions for products and services that are not necessarily offered in the periphery of the DCFC), there is an opportunity to generate additional revenues according to AZRA's Vice President. The network operator can therefore generate additional revenues by partnering with businesses that wish to target their products and services to a segment of the population that is relatively more educated and relatively more affluent than the average



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For the EV owner, this increases the value of being a member of the network and being an EV driver.

- Section 2.4 describes the benefits to specific stakeholders involved in DC fast charging. For many, DC fast charging is a visible message of the organization's pro-environment stance.
- Beyond the above-noted benefits, DC fast charging contributes to reducing GHG emissions and air pollutants by encouraging consumers to purchase and use EVs instead of their ICE counterparts. These environmental benefits are also associated with health benefits.
- Finally, DCFCs can increase the revenues of Canadian electric utilities that generate electricity in Canada and provide jobs for Canadians. Some of Canada's leading electric utilities have stated that meeting the electricity demands of a significant increase in the number of electric vehicle does not pose a problem. Smaller electric utilities may feel the impacts more than larger utilities however the pace of EV growth should allow utilities to prepare accordingly with measures encouraging charging to be undertaken outside of peak hours.

In addition to potential job creation resulting from additional revenues, the co-benefits by stakeholder category are summarized in Table 10.

¹³² Suzanne Goldberg presentation at the EV2015VÉ Conference: What BC's Electric Vehicle Owners Tell Us About Driving and Charging. Preliminary analysis of SFU's 2014 Plus-in Vehicle Owners' Survey (PEVOS)

Table 10. Stakeholder co-benefits from the deployment of DC fast charging projects

Stakeholder	Co-benefits
Governments	<ul style="list-style-type: none"> • Environmental benefits • Health benefits • Positive for citizens (lower noise & air pollution) • Generates revenues for government-owned utilities • Use of domestic kWh results may contribute to lowering fossil fuel import requirements and improving trade balance¹³³ • Increased adoption of EVs helps jurisdictions meet their GHG emissions reductions obligations • Visible example of government's pro-environmental stance
Electric utilities	<ul style="list-style-type: none"> • Fits with sustainability initiatives • Positions for future V2G (vehicle to grid) opportunities
EV auto manufacturers	<ul style="list-style-type: none"> • Positive brand exposure • Gaining access to charging data provides valuable insights to manufacturers about vehicle usage and charging behaviours of customers • Increased sales of EVs would improve compliance of auto manufacturers with federal regulations limiting GHG emissions from passenger automobiles and light trucks
Retailers (service station owners, fast food chains, big box retailers, etc.)	<ul style="list-style-type: none"> • Fits with sustainability initiatives of some of these companies • Unlike many sustainability initiatives, a DCFC is a very visible sustainability measure
Restaurants, hotels, etc.	<ul style="list-style-type: none"> • Fits with sustainability initiatives
Real estate developer	<ul style="list-style-type: none"> • Adds value to properties for lease • Fits with sustainability initiatives

¹³³ Canada is a net importer of fossil fuel. Canadian electricity is generated domestically. Using domestic kWh hours to power vehicles (EVs) instead of fossil fuel to power ICE vehicles helps lower the fossil fuel requirements and improves the country's trade balance.

3. Business case evaluation

To develop the business case, we took into consideration:

- Canadian motorist travel behaviours (distances driven);
- Technology improvements leading to significantly improved range at reasonable vehicle prices;
- Current and projected costs associated with the purchase and installation of the DC fast charging station;
- Variable costs for maintenance and operation of the station;
- Projected number of EVs in Canada (five scenarios);
- Projected number of DCFCs.

3.1 Canadian motorist travel distances

The analysis undertaken assumes that travel behaviours portrayed by Canadians today will remain similar until 2025. Transport Canada undertook an analysis of the latest statistics collected (2014) and provided two key pieces of information:

- The distribution of individual trips undertaken by Canadian motorists (Table 11), and
- The distribution of daily travel undertaken by Canadian motorists (Figure 18).

Based on the statistics provided, only 1% of individual trips undertaken by Canadian motorists are over 100 km.

Table 11. Canadian motorist individual trip distribution (km), 2014¹³⁴

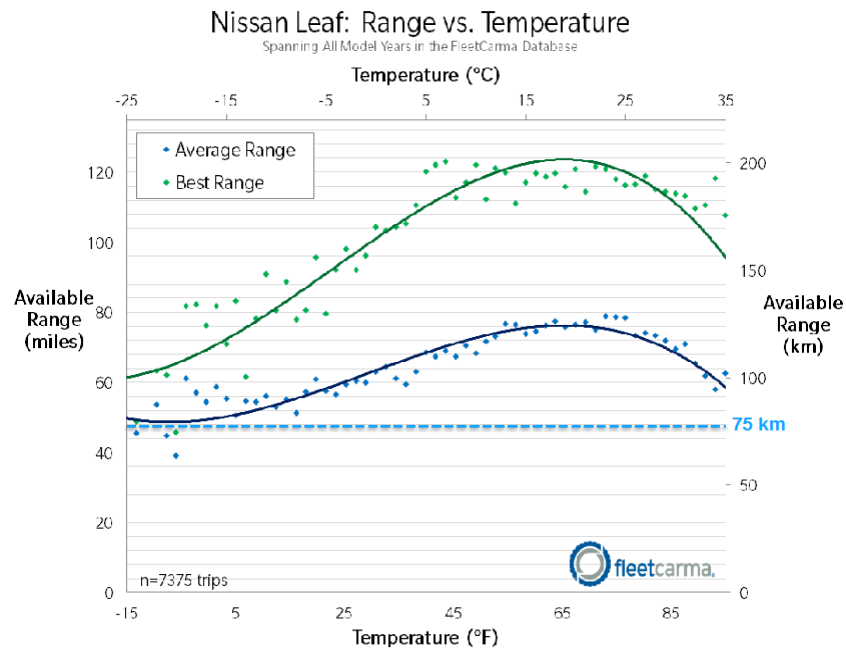
Trip distribution	% of trips
Less than 1 km	25.2%
1 - 5 km	36.9%
6 - 10 km	15.4%
11 - 15 km	7.3%
16 - 20 km	4.1%
21 - 30 km	4.4%
31 - 50 km	3.5%
51 - 100 km	2.1%
100+ km	1.0%

Source: Transport Canada, 2015

¹³⁴ Based on weighted sampling to represent vehicles in Québec, Ontario, Manitoba and Saskatchewan. Distribution based on 350,627 trips and 3,665 vehicles. Only active vehicles were considered in the calculations.

The majority of EVs in the Canadian market today compatible with DC fast charging are capable of undertaking 99% of the individual trips completed by the average Canadian driver of a light-duty vehicle. However, as demonstrated in Figure 17, the use of heating and air conditioning¹³⁵ decreases the range of the vehicle significantly. In winter conditions, a Nissan Leaf may have difficulty undertaking up to 7% of the trips completed by Canadian motorists without recharging along the route¹³⁶. Without the use of DC fast charging, longer distance travel would be extremely difficult for drivers of the majority of DC fast charging-compatible vehicles in Canada today.

Figure 17. Nissan Leaf range



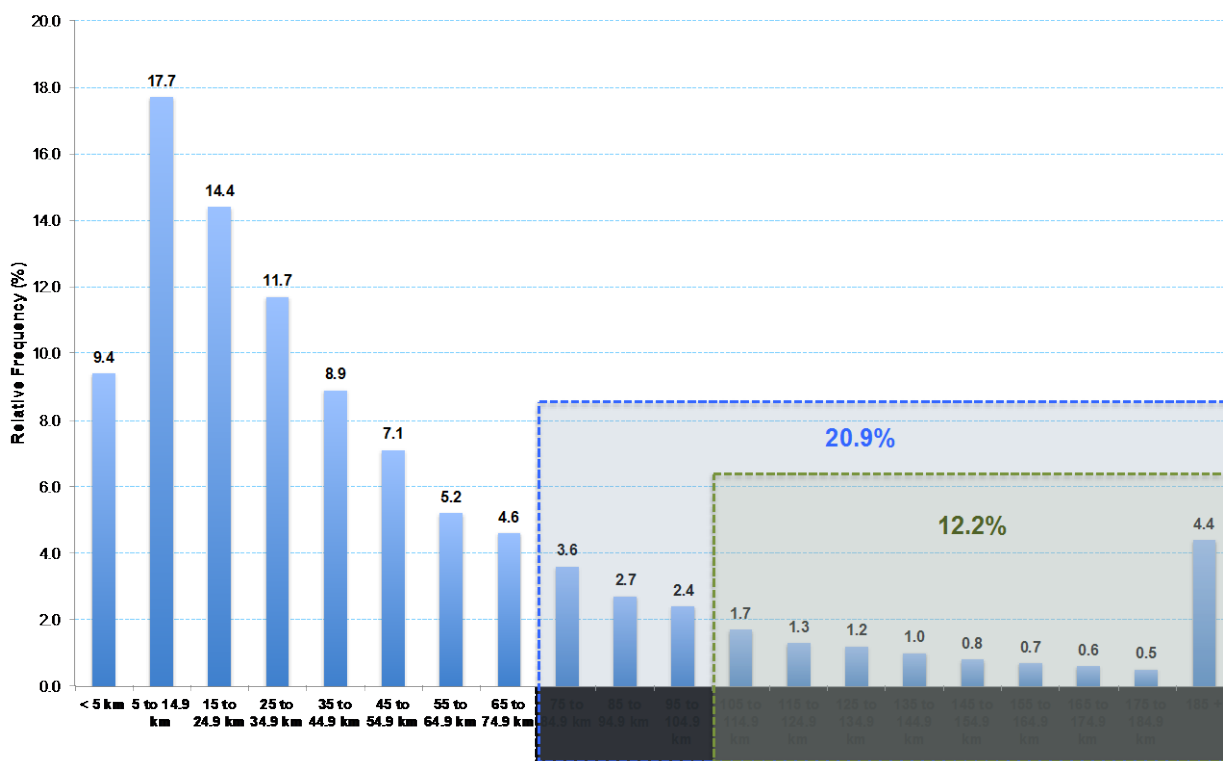
According to Transport Canada, active vehicles make, on average, 5.7 trips per day. The distribution of the total distance traveled per day by Canadian motorists is presented in Figure 18.

With the range available in today's DC fast charging-compatible EVs, more than 20% of daily Canadian motorist travel in winter conditions would be challenging without a recharge.

¹³⁵ To address ambient temperature.

¹³⁶ The use of HVAC can reduce range by up to 60%.

Figure 18. Canadian motorist daily travel distribution (km), 2014¹³⁷



Source: MARCON, data provided by Transport Canada, 2015

3.2 Improved vehicle range

At least four EV models with a minimum range of 300 km are expected to be commercially available in 2017. Based on auto manufacturer announcements, these models will be priced around \$40,000.



The availability of EVs of significantly greater range at considerably more affordable prices than longer-range EVs that are currently available will be a game changer¹³⁸ in EV adoption. With at least 300 km of range, these EV models would be able to meet the large majority of the daily travel requirements of Canadian motorists¹³⁹.

Chevy Bolt: 300 km of range, 2016 availability

¹³⁷ Based on weighted sampling to represent vehicles in Québec, Ontario, Manitoba and Saskatchewan. Distribution based on 350,627 trips and 3,665 vehicles. Only active vehicles were considered in the calculations.

¹³⁸ "The message from consumers about the Bolt EV concept was clear and unequivocal: build it," said Batey [Executive VP and President, North America, GM]. "We are moving quickly because of its potential to completely shake up the status quo for electric vehicles as the first affordable long-range EV in the market." (<http://www.chevrolet.com/culture/article/bolt-ev-concept-car.html>)

¹³⁹ Assumption: that trips in the 185 km+ category are almost all 300 km or less.

3.3 Acquisition and operation costs of DC fast chargers

Currently, charging station networks are comprised of stations owned by one or several parties (Station Owners), and operated by another (Network Operator). For example, Hydro-Québec's Circuit électrique is operated by VERnetwork (réseauVER)^{140,141}. In the case of Tesla's charging network, it is composed of Tesla owned SuperChargers and Tesla subsidized Level 2 destination chargers¹⁴².

3.3.1 Station owners

Typically, the space for the installation of a DCFC is provided by a sponsoring station owner at a location such as a service station (called *en route* location) or an urban (often public) space.

The owner also purchases the equipment and pays, in whole or in part¹⁴³, for its installation. The capital costs for the station owner are therefore limited to:

- The cost of the DCFC itself;
- The cost of the electrical installation;
- The cost of any civil work required to accommodate the station.

The price of stations (discussed in section 2.5) most often cited for recent purchases of DCFCs is \$30,000. Due to economies of scale, the price of a DC fast charger is expected to drop by 10 to 15% before the end of the decade¹⁴⁴.

Aside from the cost of the charger itself, the balance of the cost can vary significantly depending on the location and the pre-existing conditions¹⁴⁵ of the location where it is installed. The particular requirements and practices of the organization that owns the station can also have a significant impact on the cost of installation.

The cost of the electrical installation is dependent on the availability of an appropriate electrical feed at the location. An *en route* type station located in a green-field location with no other facilities to share the expense burden can cost upwards of \$100,000 if a power line and a power line transformer must accommodate that new station. Conversely, installing a DCFC on the wall of a garage in close proximity to a distribution panel that can accommodate the additional load of 3-phase current can cost as little as \$12,000.

The cost of civil work is also subject to wide variations. Civil work related to indoor installations is limited to a sign on the wall, some paint on the floor and possibly minor repairs after the electric conduits have been installed. On the other hand, the potential cost of an outdoor station can be very high if the owner wants to light it, heat it, cover it, add amenities (such as washrooms), equip it (with Wi-Fi capabilities for example) and decorate it.

The cost of installation varies considerably depending, in large part, on location, availability of three-phase power and who undertakes the installation¹⁴⁶. According to AddEnergie, manufacturer and distributor of charging stations and operator of a charging network called VERNetwork, the cost of installation can be as low as \$18,000 but can exceed \$100,000 in certain situations. The ideal

¹⁴⁰ The network is not branded VERnetwork.

¹⁴¹ Circuit électrique and VERnetwork will soon be interoperable for EV owners.

¹⁴² Tesla declined to provide specific costs for their Superchargers.

¹⁴³ Contributions from partners can be used to lower the price of purchase and installation (example, Nissan's contribution to deployment of 25 DCFCs in Québec).

¹⁴⁴ Source: interviews undertaken with electric utilities, charging station manufacturers and network operators.

¹⁴⁵ For example, if trees need to be cut and the area cleared.

¹⁴⁶ Installation by a private company tends to cost less than installation by a government body.

situation would involve using a transformer that has the potential for additional load and where no trenching in pavement is required. In this situation, the total installation cost could be less than \$20,000¹⁴⁷.

For the purposes of analysis and development of the business case, an average capital cost of \$60,000 has been used to cover both the purchase price and installation of the DCFC. Table 12 presents typical costs associated with the cost and installation of a DCFC in an indoor urban environment and an outdoor en-route location.

Table 12. Average cost of purchase and installation of DCFC by location¹⁴⁸

	LOCATION OF STATION	
	Indoor Urban	Outdoor <i>en route</i>
DCFC	\$30,000	\$30,000
Electrical Installation	\$8,000	\$15,000
Civil Work	\$7,000	\$15,000
TOTAL	\$45,000	\$60,000

Our calculations assume that the owners already own or had the space for the DC fast charging stations and no costs have been associated with the cost of acquiring space.

Station owners also must assume the costs related to the operation if DC fast charging stations (OPEX). These are mostly variable costs:

- Electricity
 - In BC: \$2 for a typical fill (about 20kWh)¹⁴⁹
 - In Quebec, the price would be the same (tariff G is applicable¹⁵⁰)
 - Elsewhere in Canada (except in Manitoba), the price would be higher and may vary according to the time of day and period of the year (time-of-use tariffs)
- Station Management
 - In Québec, RéseauVER charges \$750 per station per year
 - In BC, Greenlots (the Network Operator) receives \$260 per station per year¹⁵¹
- Equipment maintenance
 - RéseauVER offers a yearly contract that includes monitoring and parts for a \$750 fee per year
- Network (Transaction) Handling
 - RéseauVER: 15%
 - In BC: \$0.91 transaction fee¹⁵²

¹⁴⁷ Source: BC Hydro

¹⁴⁸ Does not take into consideration such costs as opportunity cost, property taxes and inspection costs.

¹⁴⁹ Source: <http://pluginbc.ca/wp/wp-content/uploads/2014/08/FAQ-EV-DCFC-pilot-2Oct2014.pdf>

¹⁵⁰ Comprises a monthly fixed charge (\$12.33), the price of power and energy at \$0,0965/kWh. Source: <http://www.hydroquebec.com/business/rates-and-billing/rates/electricity-rates-business-customers/rate-g/>

¹⁵¹ Source: <http://pluginbc.ca/wp/wp-content/uploads/2014/08/FAQ-EV-DCFC-pilot-2Oct2014.pdf>

¹⁵² Source: <http://pluginbc.ca/wp/wp-content/uploads/2014/08/FAQ-EV-DCFC-pilot-2Oct2014.pdf>

Table 13 presents the costs used in the evaluation¹⁵³.

Table 13. DCFC operating and maintenance costs by station location

	LOCATION OF STATION	
	Indoor Urban	Outdoor <i>en route</i>
Electricity (per charge)*	\$2.40	\$2.40
Management fee (annual)	\$750.00	\$750.00
Equipment maintenance contract (annual)	\$750.00	\$750.00
Network (transaction) fees (per charge, 15% of revenues**)	\$1.05	\$1.50
Site maintenance*** (annual)	n.a.	\$1,000
Miscellaneous (annual)	\$500.00	\$500.00

* Based on a 20kWh per charge and a total price (power and energy) of \$0.12/kWh

** Assumes a \$10 flat fee per 20 kWh charge at *en route* charging stations, and \$7 at urban stations

*** Snow removal, garbage removal and similar tasks

An independent station owner wishing to install its equipment on a property they do not own would have to make an arrangement with the site owner. If the latter operates a commercial concern of interest to motorists, they might well forgo rent in favour of the added patronage from EV owners. Otherwise, rent would have to be paid for the site where the station is installed. The same would apply to snow removal and ancillary services at the site if the fast charging equipment is simply complementing an array of other services¹⁵⁴.

3.3.2 Network operators

Although network operators can own the DC fast chargers they network, they are generally not the owners. Instead, they offer an integrated station management service to their customers. Some, as in the case of Sun Country, also offer the equipment for sale to station owners and sometimes provide installation services. In other cases, such as VERnetwork, a sister organisation (in this case, AddEnergie¹⁵⁵) sells the equipment.

The main purpose of network operators is to bring management tools and expertise to the industry. Therefore, they assume operation and maintenance responsibilities on behalf of station owners and add an additional component to the marketing mix: a brand. Table 14 summarizes the services generally provided by network operators.

¹⁵³ BC Hydro estimates that \$1,200 per station per year for maintenance, operation and demand peak charges, including \$260 per station per year paid to Greenlots.

¹⁵⁴ We have conservatively chosen to retain these costs in our model.

¹⁵⁵ AddEnergie also manufactures level 2 and DC fast charging stations in Canada for public, at work and private organizations.

Table 14. Typical services provided by network operators

Service Categories	Typical Services
Management	<ul style="list-style-type: none"> • Membership development • Membership management • Provision of membership cards • Monetization and revenue management • 24/7 customer service¹⁵⁶ • Collection and storage of operational statistics for larger clients such as Circuit électrique
Equipment repair & maintenance	<ul style="list-style-type: none"> • Annual inspection of DCFC stations • Emergency and routine repairs • 24/7 monitoring of working order
Network administration & promotion (also called Transaction handling)	<ul style="list-style-type: none"> • Collection of payments • Payment of station owners • Advertising • Membership development
Cross-marketing and miscellaneous	<ul style="list-style-type: none"> • Promotion of station owner services • Cross promotion of stations within the network • Other promotional activities

The management (\$750.00/year), equipment maintenance contract (\$750.00/year) and network fees (15% of station usage fee) cover all these services. In some cases, EV owners must pay a small membership fee but in most cases, such membership fees are offset by “free” charging services as it is important for networks to gain the largest possible membership early in the lifecycle of this industry.

3.3.3 Incentives

At this time, and as stated in section 2.3, there are no incentives offered by the federal, provincial or municipal governments for the purchase of DC fast charging stations in Canada. No DCFC infrastructure incentive has been taken into account in our model.

3.3.4 Regional variations

Most of the suppliers in the industry are providing equipment worldwide and their price does not vary by province/territory. It may well vary as a function of volume, existing or potential.

Installation costs, based on the hourly rate of electricians, will vary from one province to another. BC's, Alberta's and Ontario's rates are higher than those present in Manitoba, Saskatchewan and Atlantic Canada. In fact, electrician compensations vary slightly more than 100% across the country. We have therefore chosen an average cost of installation of \$15,000 for our model, which may be on the low side for Alberta and on the high side for New Brunswick.

¹⁵⁶ Circuit électrique chose to not to work with its Network Operator for this service and contracted the CAA to provide 24/7 customer service at what we are told is a very low fee per call.

Experience with the installation of existing DC fast charging stations indicates that there is a wider variance attributable to the customer organisation policies and practices than any other factor.

3.4 EV sales forecasts

A key input into determining the number of DC fast charging locations that will be required in the next decade is the number of EVs that will be circulating on Canadian roads.

Forecasting EV sales ten years into the future is challenging given that ...

- This is an emerging industry with limited history
- Future sales are dependent on a large number of factors, including ...
 - The price of fuel relative to the price of electricity;
 - The range and performance of EVs;
 - The price of EVs relative to the price of comparable ICE vehicles;
 - The availability of a greater number and variety of EV makes and models;
 - The availability of government financial rebates for the purchase of EVs and for the installation of charging stations (Level 2, DC fast charging);
 - The availability of other incentives to encourage EV ownership (examples: access to HOV lanes, preferential parking, and workplace charging programs).

Five (5) EV sales forecast scenarios have been developed ranging from the “worst case” scenario (#1) to the “optimistic” scenario (#5). Scenarios #2, #3 and #4 are based on a “realistic” projection of sales that reflect information available today (examples: significantly greater expected range of EVs from 2016 on, variety of EV models to be introduced in the short term).

The difference between Scenarios #2, #3 and #4 is the number of DC fast charging locations available across the country. Varying this “realistic” scenario assuming all things remain equal with the exception of the number of DC fast charging locations is extremely challenging as no empirical studies demonstrating the quantitative link between the presence of DC fast charging and EV sales exist. Despite this lack of quantitative data, it is generally agreed that the presence of DC fast charging has and will continue to have a positive impact on EV deployment. As discussed in section 4.3, EV uptake by urban dwellers with no dedicated parking will, in large part, be facilitated by the presence of inner city DC fast charging.

All scenarios assume a ten-year vehicle life^{157,158}. After ten years, the vehicle is assumed to be withdrawn from the market.

A road tax on EVs has not been taken into consideration in any of the scenarios. It is addressed in section 4.6.

3.4.1 Worst-case scenario

The worst-case scenario essentially assumes that “*everything that can go wrong, will*”. This scenario makes the following assumptions:

- Low price of fossil fuel relative to price of electricity;

¹⁵⁷ This includes vehicles that are sold as used but continue to be used.

¹⁵⁸ According to auto manufacturing representatives consulted, ten years is a reasonable assumption given the quality of the vehicles and the relatively few parts that may fail. As far as the battery is concerned, if a replacement is required to ensure the vehicle continues to function properly, replacing the battery on a Chevy Volt costs approximately \$2,500 (approximately \$5,000 for a Nissan Leaf). In the future, battery replacement is expected to cost even less and upgrades to longer-range batteries possible.

- High price of EVs relative to ICE counterparts;
- No improvement in battery performance, range compared to 2015 models;
- Number of EV makes and models available remains unchanged compared to 2015;
- Financial incentives for EV purchase:
 - Québec does not renew its purchase rebate after having reached the 10,200 EV (representing the amount currently allocated for EV purchase incentives)
 - BC does not offer additional purchase rebates beyond the \$10.5 million budget currently invested
 - Ontario eliminates EV purchase rebates;
- No other incentives introduced by governments to encourage EV adoption;
- No education efforts undertaken to expose the Canadian public to EVs;
- No additional investments in public charging infrastructure (DC fast charging stations announced but not deployed will not be installed) due to government cutbacks.

This scenario assumes that the number of DCFCs installed at the time of writing of this report are the only ones to be installed; i.e., that no further investments in DC fast charging deployment will be made. Obviously, this level of DCFC deployment, in combination with the assumptions presented above, would be insufficient to ensure significant EV adoption by Canadian motorists.

Additional assumptions are presented in the column to the right (events impacting scenario) of Table 15.

Table 15. Scenario #1 EV projections

SCENARIO 1. WORST CASE SCENARIO: NO MORE DCFC INSTALLED							
Year ending ...	Annual sales	Withdrawal of EVs from market**	EV ADOPTION			% of EV compatible with DCFC	Events impacting scenario
			Total	BEV	PHEV		
2014*	5,231		10,943	5,400	5,543	50%	
2015	7,847		13,559	6,779	6,779	50%	Increase by 50% compared to 2014 sales thanks to purchase rebate programs in BC, ON, QC
2016	2,354		15,912	8,662	7,250	54%	QC, ON purchase rebates eliminated. Only BC rebates in place.
2017	1,600		17,512	10,102	7,410	58%	BC rebates no longer available. Sales equivalent to approximately 20% of 2015 sales
2018	1,600		19,112	11,542	7,570	60%	90% of EV sales are BEVs reflecting the fact that those who purchase the vehicles are making the most pro-environment choice possible.
2019	1,600		20,712	12,982	7,730	63%	
2020	1,600		22,312	14,422	7,890	65%	
2021	1,600		23,912	15,862	8,050	66%	
2022	1,600	2,000	23,512	16,302	7,210	69%	In 2022, many of the EVs sold in 2011& 2012 are at least 10 years old. These vehicles are being withdrawn from the market
2023	1,600	3,000	21,395	16,242	5,870	76%	
2024	1,600	4,800	18,195	15,182	3,730	83%	
2025	1,600	6,000	13,795	13,122	390	95%	

* Rounding

** Assuming approximately 10-year vehicle life

At the end of this ten-year period, EVs continue to remain a niche market in Canada, with approximately the same number of EVs on the road than exist at the time of writing of this report.

3.4.2 Realistic scenarios

Three realistic scenarios have been developed (Scenarios #2, #3 and #4). The assumptions for all three are the same, with one exception: the number of DC fast charging locations in Canada. Despite the lack of empirical evidence making the link between the presence of DC fast charging and EV sales, we understand that the presence of DC fast charging on corridors and outside city limits will provide the safety net required by EV drivers, enabling them to make longer distance travel. The two assumptions underlying the evolution between the three realistic scenarios:

- The greater the number of locations, the more important the safety net, the greater the impact on EV sales;
- The greater the presence of DC fast charging in urban areas, the greater the uptake of EVs by urbanites with no dedicated parking that can be used for the installation of residential charging units.

The assumptions underpinning Scenarios #2, #3 and #4 are:

- Power train electrification is essential to meeting fuel economy regulations;
- Difference between EV and ICE vehicle ownership will continue to be favourable for EVs¹⁵⁹;
- Declining price of EVs due to economies of scale;
- Battery efficiency improves and battery prices decline (economies of scale);
- Significant battery range improvements thanks to significant investments by auto OEMs, Silicon Valley stakeholders as well as research institutions;
- Availability of at least four more BEV models with a range of at least 300 km and a maximum price of \$40,000¹⁶⁰;
- Increasing number of EV makes and models available to Canadian motorists, as indicated in Table 16.

¹⁵⁹ According to the US Department of Energy's Energy Outlook 2015, the price per barrel of oil is expected to increase to \$99 USD in 2020 and to \$148 USD in 2030.

¹⁶⁰ <http://www.technologyreview.com/news/536336/inexpensive-electric-cars-may-arrive-sooner-than-you-think/>

Table 16. EV makes and models to be introduced by 2019

Make	Model	Type	Body Style	Battery	AER	Launch
Hyundai	Sonata	PHEV	Sedan	9.8	22	Q1 2015
Chevrolet	Volt	PHEV	Hatchback	18.4	50	Q3 2015
BMW	X5	PHEV	SUV	9	20	Q3 2015
Audi	A3 etron	PHEV	Wagon	8.8	30	Q3 2015
Mercedes	C350	PHEV	Luxury sedan	6.2	20	Q4 2015
Tesla	Model X	BEV	Crossover	TBD	250	Q4 2015
Mercedes	S-Class	PHEV	Luxury sedan	TBD	TBD	Q4 2015
Volvo	XC90 T8	PHEV	SUV	9.2	20	Q4 2015
BMW	328e	PHEV	Luxury sedan	TBD	22	Q1 2016
Mitsubishi	Outlander	PHEV	Crossover	TBD	TBD	Q2 2016
Audi	Q7 etron	PHEV	SUV	17.3	25	Q4 2016
Chrysler	Town & Ctry	PHEV	Minivan	TBD	TBD	Q4 2016
Volvo	V60	PHEV	Wagon	TBD	TBD	Q4 2016
Nissan	Leaf	BEV	Hatchback	TBD	TBD	Q4 2016
Chevrolet	Bolt	BEV	Hatchback	TBD	200	Q4 2017
VW	Cross Coupe	PHEV	SUV	14.1	20	Q4 2017
Subaru	TBD	PHEV	Crossover	TBD	TBD	Q4 2017
Porsche	Pajun	BEV	Luxury sedan	TBD	TBD	Q4 2018
Jaguar	F-Pace	BEV	Crossover	TBD	300	Q2 2019

Source: EPRI

- The cost of home charging a 450 km range BEV remains less than \$20;
- Attempts at introducing hydrogen and CNG fuelled cars will be unsuccessful due to the high cost of infrastructure required for gaseous fuel distribution;
- Continued availability of purchase rebates:
 - Québec likely to renew purchase rebate beyond 10,200 EVs sold¹⁶¹
 - BC purchase rebates of \$10.5 million (covering between 1500 and 2000 EVs, depending on whether older ICE vehicles are replaced with electrics)
 - Ontario likely to continue offering its purchase rebate¹⁶²;
- Municipal and provincial governments to introduce additional measures to encourage EV adoption^{163, 164};

¹⁶¹ Based on an interview undertaken with a representative of the Ministry of Transportation of Québec, this Ministry is already working on such a program.

¹⁶² Given the decision of the Government of Ontario to join Québec and California in a cap and trade system as well as the continued pro-environmental stance of the Ontario government, it would be reasonable to assume that the purchase rebates will be maintained until the market reaches a tipping point, where enough EVs are on Ontario's roads and where the purchase price of an EV is in line with its ICE counterparts, no longer requiring a purchase rebate.

¹⁶³ Examples: access to HOV lanes, preferential parking

¹⁶⁴ Example of municipal government action encouraging EV adoption: Montréal's Mayor, Denis Coderre, announced on April 14th 2015 that his government intends to make Montréal the leader in electrification of transportation. One project to lead in that direction: 1000 BEVs in car sharing by 2020 (250 vehicles in spring of 2016, 200-250 vehicles per year thereafter).

- Private stakeholder investments in electrification of transportation¹⁶⁵;
- Municipal, provincial and federal governments undertake increasingly important actions to fight climate change and EVs are an important part of the solution;
- As the number of EVs increase in Canada¹⁶⁶ (including private passenger vehicles, car sharing vehicles and taxis), a greater percentage of Canadians will be exposed to them, contributing to much improved consumer education and interest.

If we were to inflate total industry vehicle sales by 2-3% per annum, we would expect approximately 2.5 million light-duty vehicle sales in Canada in 2025¹⁶⁷. The realistic scenario of 460,000 (scenario #2), 480,000 (scenario #3) and 500,000 (scenario #4) EVs sold in 2025 would represent 18.4%, 19.2% and 20% respectively of total light-duty vehicle sales in Canada.

As illustrated in Figure 19, these percentages are well within the range of EV forecasts as a percentage of global total light-duty vehicle sales estimated by twelve organizations. Goldman Sachs¹⁶⁸, not presented in this graph, estimates that in 2025, gasoline and diesel vehicles will make up 75% of vehicle sales.

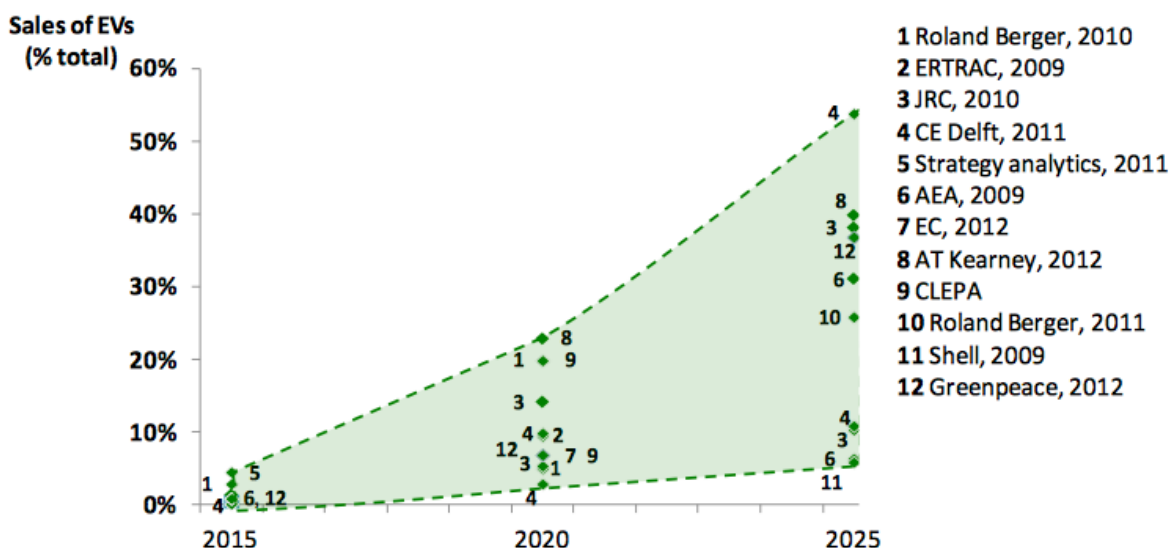
¹⁶⁵ Private capital being injected in a project to electrify Montréal's taxi fleet. This project would require the deployment of 125 DC fast charging stations scattered throughout the city of Montréal. <http://affaires.lapresse.ca/portfolio/transport-electrique/201506/18/01-4879044-objectif-1000-taxis-electriques-a-montreal.php>

¹⁶⁶ Mobility, particularly urban mobility, is changing rapidly as more transportation options (including various forms of car sharing, ride sharing, taxis and transit) are available to urbanites. As more affordably priced EVs with greater range become available, EVs will likely be used to meet the needs of many of these urban mobility options.

¹⁶⁷ While an analysis of the impact of transit, car sharing, ride sharing and other forms of mobility on passenger vehicle sales in Canada is of interest, it is beyond the scope of this mandate.

¹⁶⁸ <http://www.businessinsider.com/is-goldman-sachs-right-that-7-megatrends-will-dominate-the-global-auto-industrys-future-2015-5>

Figure 19. EVs as a percentage of total light-duty vehicle sales, an international perspective¹⁶⁹



Notes: where literature sources provide figures in terms of percentages, we have converted them to absolute figures using the new fleet volumes estimated based on extrapolation from 2010 sales provided in ICCT (2011). Estimates from Greenpeace (2012) are based on the weighted average of projections for the small, medium and large market segments.

Source: Ricardo-AEA/ED58334/Issue Number

2 http://www.transportenvironment.org/sites/te/files/publications/Ricardo%20AEA_2025%20targets_Report_Jan_2013_0.pdf

¹⁶⁹ From the report: The figure compares predicted annual sales of electric vehicles in Europe from several studies, which include both market forecasts and scenarios. Market forecasts are produced by industry analysts and are used by companies to help them plan and manage their product portfolio and predict the market sales principally rely on projecting existing trends into the future in combination with some expertise or detailed understanding of the existing market place. Scenarios are generally based on various more specific assumptions on future technical development (e.g. battery cost and performance improvements) and other key influencing factors (e.g. future oil prices). In some cases back-casting approaches are also used: i.e. starting from a desired future position and working backwards towards the current situation in order to establish what would need to happen in order for this to be achieved – these are most commonly used by governments and policy makers. ... The highest estimates in 2020 are from Roland Berger (2010) in “the future drives electric” scenario, which see the market share for EVs and PHEVs reaching 20% in Western Europe by 2020, and from AT Kearney (2012) with a corresponding share of 23%. The estimate from Roland Berger (2010) is an optimistic scenario where uptake of EVs is driven by higher oil prices, accelerated battery cost reduction, stronger government support and a broader EV product range in the next five to ten years. The results from AT Kearney (2012) are based on interviews with Original Equipment Manufacturers (OEMs), suppliers and governments, supported by calculations of the Total Cost of Ownership (TCO). These come from their “moderate” scenario, which represents their estimate of the most likely development. The highest estimate in 2025 is from CE Delft (2011) in the “EV Breakthrough” scenario. This assumes that from 2015 onwards R&D leads to a rapid reduction of battery cost and increase in battery lifetime, whereas ICE development is roughly in line with expectations from the car CO₂ regulations (i.e. based on expectations resulting from the cost-curves developed in TNO, 2011). The total cost of ownership for advanced EVs is assumed to become competitive with conventional vehicles in certain market segments. Government incentives are assumed to be high at first but rapidly reduce from 2015 onward. The second-highest estimate in 2025 (40%) is from AT Kearney (2012), which is based on their “most likely” predictions.

3.4.2.1 Realistic scenario #2

To ensure travel across the country, a DC fast charger would need to be located at 60 km intervals. As indicated in Figure 17, this distance would allow for a Nissan Leaf to make the trip in winter conditions, even with charging providing 80% of battery capacity. As illustrated in Figure 20, a total distance of 7,568 km would need to be covered:

- 5,945 km from Vancouver to Halifax;
- 300 km from Calgary to Edmonton;
- 260 km from Regina to Saskatoon;
- 803 km from Ottawa, through Toronto to Windsor.

Scenario 2 assumes the deployment of the DCFCs at 127 strategically positioned locations hosting four to eight chargers at each location, much along the same model Tesla is currently using. The positioning of DCFCs along such a corridor necessitates cooperation and coordination between relevant authorities across provinces. This coordination will ensure that the DCFCs are located across provincial borders at intervals enabling safe EV travel, thereby maximizing range confidence.

Figure 20. Map of Canada allowing travel with an EV coast-to-coast (Pacific-Atlantic) and along important travel corridors



Key travel corridors to accomplish coast-to-coast travel (Pacific- Atlantic) include the Trans-Canada highway and some major highways linking major cities to the Trans-Canada highway (excluding highway 1A in Saskatchewan and the short leg going to PEI), namely:

- In Nova Scotia: NS-102
- In New Brunswick, NB-101
- In Québec, highway 40
- In Ontario, highway 401
- In Saskatchewan, highway 11
- In Alberta, highway 2

Collaboration between the relevant stakeholders to strategically position DCFC locations at intervals of 60 km will be key to maximizing geographic coverage with 127 locations. Current deployment plans do not necessarily have coast-to-coast coverage in mind. For example, two DCFC locations in B.C. (one situated at 17710 56A Avenue in Surrey and the other at 7888 200 Street in Langley) are less than 9 kilometers apart. These locations are important to ensure exposure to and utilization by Vancouver's urbanites. However, they are not positioned to maximize coast-to-coast EV travel.

Table 17. Scenario #2 EV projections

SCENARIO 2. REALISTIC SCENARIO: 127 LOCATIONS, 4 TO 8 CHARGERS PER LOCATION***						
Year ending ...	Annual sales	Withdrawal of EVs from market**	EV ADOPTION			Events impacting scenario
			Total	BEV	PHEV	
2014*	5 200		11 000	5 500	5 500	50%
2015	7 800		18 800	9 400	9 400	50%
2016	11 700		30 500	15 250	15 250	50%
2017	19 305		49 805	29 729	20 076	60%
2018	31 853		81 658	53 619	28 040	66%
2019	52 558		134 216	95 665	38 551	71%
2020	86 720		220 937	165 041	55 895	75%
2021	130 000		350 937	269 041	81 895	77%
2022	200 000	2 000	548 937	438 041	110 895	80%
2023	275 000	4 000	819 937	669 791	150 145	82%
2024	375 000	6 000	1 188 937	1 004 291	184 645	84%
2025	460 000	8 000	1 640 937	1 437 291	203 645	88%

* Rounding

** Assuming approximately 10-year vehicle life

*** Excluding Tesla SuperChargers

Events impacting scenario:

- Increase by 50% compared to 2014 sales due to purchase rebate programs in BC, ON, QC
- 65% increase in sales compared to 2016: Availability of at least 4 "affordable" (approx. \$40K) BEV models with autonomy of 300 km+. From this point, BEVs become an increasingly important proportion of overall EV sales: 75% of 2017 sales
- 65% Y/Y increase in sales: Availability of affordable longer-range EV models & greater visibility of EVs contributing to improved consumer awareness. Lack of additional investments in DCFC results in relatively greater interest in PHEV compared to scenarios 3, 4
- Increasing in number of EV models
Battery performance continues to improve
Economies of scale contribute to lowering price of batteries & vehicles to the point where purchase rebates are no longer required
Lifecycle cost of a BEV is less expensive than an ICE vehicle all over Canada,

In addition to the assumptions listed in 3.4.2, the right hand column of Table 17 presents additional explanations for the projections between 2015 and 2025.

This scenario forecasts 1.64 million EVs on Canadian roads in 2025. Given the greater autonomy of affordable EV models to be introduced starting in 2016, this scenario assumes greater consumer interest for BEVs. Consequently, the latter represent 88% of EVs¹⁷⁰ in Canada in 2025.

¹⁷⁰ DCFC compatible EVs

3.4.2.2 Realistic scenario #3

This scenario foresees 300 DC fast charging locations hosting a total of 1,000 DCFCs. This scenario envisages urban DC fast charging locations in addition to the inter-city locations aimed at facilitating coast-to-coast EV travel.

The presence of additional DC fast charging locations will increase the range confidence of EV drivers and contribute to increasing EV sales.

The EV projections associated with this scenario are presented in Table 18.

Table 18. Scenario #3 EV projections

SCENARIO 3. REALISTIC SCENARIO: 300 DC FAST CHARGING LOCATIONS HOSTING 1000 DCFC***						
Year ending ...	Annual sales	Withdrawal of EVs from market**	EV ADOPTION			% of EV compatible with DCFC
			Total	BEV	PHEV	
2014*	5,200		11,000	5,500	5,500	50%
2015	7,800		18,800	9,400	9,400	50%
2016	11,700		30,500	15,250	15,250	50%
2017	19,890		50,390	30,168	20,223	60%
2018	33,813		84,203	55,527	28,676	66%
2019	57,482		141,685	101,513	40,172	72%
2020	97,720		239,405	179,689	59,716	75%
2021	140,000		379,405	298,689	80,716	79%
2022	215,000	2,000	592,405	480,439	111,966	81%
2023	285,000	4,000	873,405	734,939	138,466	84%
2024	390,000	6,000	1,257,405	1,102,439	154,966	88%
2025	480,000	8,000	1,729,405	1,554,439	174,966	90%

* Rounding

** Assuming approximately 10-year vehicle life

*** Excluding Tesla SuperChargers

Increase by 50% compared to 2014 sales thanks to purchase rebate programs in BC, ON, QC

70% increase in sales compared to 2016: Availability of at least 4 "affordable" (max \$40K) BEV models with autonomy of 300 km+. From this point, BEVs become an increasingly important proportion of overall EV sales: 75% of 2017 sales. Slightly slower progression to 95% of all EV sales than Scenario 4 as fewer DCFC sites results in slightly more range anxiety.

70% Y/Y increase in sales: Availability of affordable longer range EV models & greater visibility of electrics contributing to improved consumer awareness.

Increasing number of EV models
Battery performance continues to improve
Economies of scale contribute to lowering price of batteries & vehicles to the point where purchase rebates are no longer required
Lifecycle cost of a BEV is less expensive than an ICE vehicle all over Canada,
Increase in # of DCFC sites compared to Scenario 2 results in greater EV sales

In addition to the assumptions listed in 3.4.2, the right hand column of Table 18 presents additional explanations for the projections between 2015 and 2025.

This scenario forecasts 1.73 million EVs on Canadian roads in 2025. As with scenario #2, given the greater autonomy of affordable EV models to be introduced starting in 2016, this scenario assumes greater consumer interest for BEVs. Consequently, the latter represent 90% of EVs in Canada in 2025.

3.4.2.3 Realistic scenario #4

Scenario #4 assumes a greater deployment of DC fast chargers compared to Scenario #3. This scenario foresees a total of 750 DC fast charging locations hosting 1,600 DCFCs by 2025. The details of this scenario, including the number of DC fast charging locations per year, are presented as the basis for the financial projections in section 3.5.

The EV sales projections associated with this scenario are presented in Table 19.

Table 19. Scenario #4 EV projections

SCENARIO 4. REALISTIC SCENARIO: 750 DC FAST CHARGING LOCATIONS HOSTING 1600 DCFC***						
Year ending ...	Annual sales	Withdrawal of EVs from market**	EV ADOPTION			Events impacting scenario
			Total	BEV	PHEV	
2014*	5,200		11,000	5,500	5,500	50%
2015	7,800		18,800	9,400	9,400	50%
2016	11,700		30,500	15,250	15,250	50%
2017	20,475		50,975	30,606	20,369	60%
2018	35,831		86,806	64,646	22,160	74%
2019	62,705		149,511	124,215	25,296	83%
2020	109,733		259,244	228,462	30,782	88%
2021	150,000		409,244	370,962	38,282	91%
2022	225,000	2,000	632,244	583,712	48,532	92%
2023	300,000	4,000	928,244	866,712	61,532	93%
2024	400,000	6,000	1,322,244	1,243,712	78,532	94%
2025	500,000	8,000	1,814,244	1,714,712	99,532	95%

* Rounding

** Assuming approximately 10-year vehicle life

*** Excluding Tesla SuperChargers

Events impacting scenario:

- Increase by 50% compared to 2014 sales thanks to purchase rebate programs in BC, ON, QC
- 75% increase in sales compared to 2016: Availability of at least 4 "affordable" (max \$40K) BEV models with autonomy of 300 km+. From this point, BEVs become an increasingly important proportion of overall EV sales: 75% of 2017 sales & 95% thereafter
- 75% Y/Y increase in sales: Availability of affordable longer range EV models & greater visibility of electrics contributing to improved consumer awareness. The objective of the Government of Québec is to have 100,000 EVs by 2020 (this represents just under 40% of the total number of EV forecasted: consistent with the fact that QC has traditionally led the CDN market in EV sales)
- Increasing number of EV models
- Battery performance continues to improve
- Economies of scale contribute to lowering price of batteries & vehicles to the point where purchase rebates are no longer required
- Lifecycle cost of a BEV is less expensive than an ICE vehicle all over Canada
- Increase in # of DCFC stns compared to Scenario 3 results in greater EV sales

In addition to the assumptions listed in 3.4.2, the right hand column of Table 19 presents additional explanations for the projections between 2015 and 2025.

Assuming 2.5 million total light-duty vehicle sales in Canada in 2025¹⁷¹, 20% of these sales would be EVs. This is well within the range of forecasts presented in Figure 19.

This scenario forecasts 1.81 million EVs on Canadian roads in 2025. As with scenarios 2 and 3, given the greater autonomy of affordable EV models to be introduced starting in 2016, this scenario assumes greater consumer interest for BEVs. Consequently, the latter represent 95% of EVs in Canada in 2025.

Table 20 presents the number of urban and en route DC fast charging locations and stations associated with the sales forecasts provided in scenario #4.

¹⁷¹ Changes in mobility discussed in section 4.4, including greater use of car sharing, may result in lowering the total light-duty vehicles sales in Canada. Even under such circumstances, EV sales as a percentage of overall light-duty vehicles sales would fall well within the range of forecasts presented in Figure 19.

Table 20. Urban and en route DC fast charging locations and stations associated with Scenario #4

Chargers and locations	2016	2019	2022	2025
Total number of locations	83	195	300	750
Urban station	18	70	125	500
En route station	65	125	175	250
Number of chargers	83	275	625	1600
Urban charger	18	150	340	950
En route charger	65	125	285	650

3.4.3 Optimistic scenario

The optimistic scenario assumes:

- A very high price of fuel relative to the price of electricity (well above \$100/barrel);
- Technology improvements in batteries and economies of scale leading to important decreases in the price of EVs (EV price equivalent to ICE counterpart price);
- Wide range of makes and models of EVs available in Canada;
- Provincial purchase rebates available in BC, Manitoba, Ontario, Québec and Nova Scotia;
- Federal purchase rebate of \$3,000 per vehicle in 2016 and 2017;
- Additional measures introduced by government to encourage EV adoption, including access to HOV lanes, preferential parking, workplace charging programs, change in building codes;
- Significant investment in education to expose the Canadian public to EVs (2015-2018);
- Presence of DC fast charging in cities as well as between cities;
- Attempts at introducing hydrogen and CNG fuelled cars will be unsuccessful due to the high cost of infrastructure required for gaseous fuel distribution.

In addition to the 750 DC fast charging locations projected in scenario #4 (in 2025), this scenario envisages additional urban and en route DCFCs ensuring access to a DCFC in all Canadian cities with a population of at least 25,000.

The EV sales projections associated with this scenario are presented in Table 21.

Table 21. Scenario #5 projections

SCENARIO 5. OPTIMISTIC SCENARIO: DOUBLE SCENARIO 4 DC FAST CHARGING						
Year ending ...	Annual sales	Withdrawal of EVs from market**	EV ADOPTION			Events impacting scenario
			Total	BEV	PHEV	
2014*	5,200		11,000	5,500	5,500	50%
2015	7,800		18,800	9,400	9,400	50%
2016	15,600		34,400	17,200	17,200	50%
2017	50,000		84,400	50,640	33,760	60%
2018	150,000		234,400	170,640	63,760	73%
2019	250,000		484,400	370,640	113,760	77%
2020	350,000		834,400	670,640	163,760	80%
2021	450,000		1,284,400	1,110,640	173,760	86%
2022	500,000	2,000	1,782,400	1,610,640	171,760	90%
2023	600,000	4,000	2,378,400	2,210,640	167,760	93%
2024	650,000	6,000	3,022,400	2,860,640	161,760	95%
2025	700,000	8,000	3,714,400	3,560,640	153,760	96%

* Rounding

** Assuming approximately 10-year vehicle life

In addition to the assumptions listed in 3.4.2, the right hand column of Table 21 presents additional explanations for the projections between 2015 and 2025.

This scenario forecasts 3.71 million EVs on Canadian roads in 2025. As with scenarios #2, #3 and #4, given the greater autonomy of affordable EV models to be introduced starting in 2016, this scenario assumes greater consumer interest for BEVs. Consequently, the latter represent 96% of EVs in Canada in 2025.

Assuming 2.5 million total light-duty vehicle sales in Canada in 2025, 28% of these sales would be EVs. This is well within the range of forecasts presented in Figure 19 but considered as highly optimistic by the auto-manufacturing representatives consulted in the context of this research.

3.5 Business model calculations

The business model is based on the “realistic” scenario as this scenario is based on the most likely outcome of the parameters and factors considered.

To develop the business model, a series of hypotheses were formulated. These are presented in section 3.5.1. The resulting financial forecasts are presented in section 3.5.2.

Table 22 establishes the DC fast charger requirements for the number of EVs forecasted in scenario #4. Scenario 4 forecasts of the number of BEVs on Canadian roads are presented in line (a) of the following table. The model is based on the premises that there are significant differences between urban and *en route* stations and therefore, specific hypotheses are formulated for each type of station.

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	
a	Number of BEVs on Canadian roads	9,400	15,250	30,606	64,646	124,215	228,462	370,962	583,712	866,712	1,243,712	1,714,712
	Number of charges per annum country wide											
	Urban stations											
b	Percentage of fleet requiring DCFC services	0.5%	0.5%	0.5%	1.0%	2.0%	4.0%	8.0%	10.0%	10.0%	10.0%	10.0%
c	Number of charges per week	2	2	2	2	1	1	1	1	1	1	
	Annual number of recharges in urban settings in Canada	4,888	7,930	15,915	67,232	129,184	475,201	1,543,202	3,035,302	4,506,902	6,467,302	8,916,502
	<i>En route</i> stations											
						82,570	1,309,087	2,897,213	5,165,851	7,670,401	11,006,851	15,175,201

It would be reasonable to assume that, by 2025, 10% of the BEVs sold in Canada will be owned by **urbanites** with no access to private parking or charging facilities at work¹⁷³. It is anticipated that the range of these vehicles will reach 480 km over the period. We therefore foresee that the number of charges required by urban EV owners will drop to a single event per week in the vast majority of cases (reflected in line “c” of the preceding table).

¹⁷² Please note that the table presents the number of CHARGES required per year, not the charging stations required.



forecast period. We foresee that the relatively small number of long-range trips undertaken by BEV owners will change as a result of two factors:

- Current EVs are often the household's second car; the other (ICE) car continues to be used for longer distance trips. This will change as the range improves.
- With BEVs able to reach the 480 km mark before the end of the forecast period, EPRI expects the use of DCFCs dropping to 1% of the vehicles on any given day (the line indicated by the letter "e" in the preceding table).

Despite these above noted statistics, the number of DC fast charges will exceed 15 million events per year by 2025.

Pricing assumptions were also made to anticipate market behaviour. These are presented in Table 23.

Table 23. Pricing forecasts by station location

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Average price of charging (80% of battery capacity)											
Urban station	\$ 7.00	\$ 7.50	\$ 8.00	\$ 10.00	\$ 11.00	\$ 15.00	\$ 17.50	\$ 20.00	\$ 22.50	\$ 25.00	\$ 30.00
En route station	\$ 10.00	\$ 11.00	\$ 12.00	\$ 15.00	\$ 20.00	\$ 25.00	\$ 30.00	\$ 35.00	\$ 40.00	\$ 45.00	\$ 50.00

Currently, charging a Nissan Leaf at a public DCFC can cost as much as \$10¹⁷⁴. Given the range of the vehicle, this price is not unreasonable and was used as a starting point. Future improvement in range will not be coming from an enhancement in the efficiency of the motor drive. Rather, the improved range will result from an increase in battery capacity by as much as four times the current 24 kWh on board a Nissan Leaf. The cost of recharging a vehicle is therefore expected to increase to reflect this added capacity as well as a modest 5% increase in rates in the first few years of the forecast period.

As it is the case for conventional fuels, the price of *en route* charging will also be considerably higher than the cost of urban charging. This *en route* service being used rarely (two or three times a year), we feel a much higher price per charge is justifiable and acceptable when compared with urban charging provided to EV urbanites with no other option but to charge at public stations.

¹⁷⁴ See <http://www.aveq.ca/actualiteacutes/puissance-nergie-pointe-et-le-cot-rel-dune-recharge-au-qubec>

Other working hypotheses include the costs presented in section 3.3 and the following cost of financing based on a 10% interest rate¹⁷⁵ calculated as follows:

Urban Charger		
Loan	Interest	Payment
Year 1	\$4,500	\$13,500
Year 2	\$3,600	\$12,600
Year 3	\$2,700	\$11,700
Year 4	\$1,800	\$10,800
Year 5	\$900	\$9,900

En route Charger		
Loan	Interest	Payment
Year 1	\$6,000	\$18,000
Year 2	\$4,800	\$16,800
Year 3	\$3,600	\$15,600
Year 4	\$2,400	\$14,400
Year 5	\$1,200	\$13,200

3.5.2 Financial forecast

Table 24 presents the results for an average urban DCFC based on the number of stations described in scenario #4.

Table 24. Urban DCFC financial forecasts

URBAN CHARGER BUSINESS CASE	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	CUMULATIVE
REVENUES from charging events (Yearly)	\$ 4,277	\$ 3,304	\$ 5,093	\$ 14,940	\$ 9,473	\$ 75,032	\$ 163,673	\$ 178,547	\$ 202,811	\$ 230,975	\$ 281,574	\$ 1,169,699
EXPENSES												
CAPEX												
CAPEX Depreciation / 10 year linear	\$ 4,500	\$ 4,500	\$ 4,500	\$ 4,500	\$ 4,500	\$ 4,500	\$ 4,500	\$ 4,500	\$ 4,500	\$ 4,500	\$ 4,500	\$ 49,500
Cost of capital (5 year loan)	\$ 4,500	\$ 3,600	\$ 2,700	\$ 1,800	\$ 900	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 13,500
OPEX												
Electricity	\$ 1,100	\$ 833	\$ 1,263	\$ 6,226	\$ 5,025	\$ 34,474	\$ 67,681	\$ 82,907	\$ 103,876	\$ 120,395	\$ 128,423	\$ 552,204
Management fee (variable)	\$ 642	\$ 496	\$ 764	\$ 2,241	\$ 1,421	\$ 11,255	\$ 24,551	\$ 26,782	\$ 30,422	\$ 34,646	\$ 42,236	\$ 175,455
Management fee (fix)	\$ 750	\$ 788	\$ 827	\$ 868	\$ 912	\$ 957	\$ 1,005	\$ 1,055	\$ 1,108	\$ 1,163	\$ 1,222	\$ 10,655
Equipment maintenance contract	\$ 750	\$ 788	\$ 827	\$ 868	\$ 912	\$ 957	\$ 1,005	\$ 1,055	\$ 1,108	\$ 1,163	\$ 1,222	\$ 10,655
Site maintenance												\$ -
Miscellaneous & unforeseen	\$ 500	\$ 525	\$ 551	\$ 579	\$ 608	\$ 638	\$ 670	\$ 704	\$ 739	\$ 776	\$ 814	\$ 7,103
TOTAL COST	\$ 12,741	\$ 11,528	\$ 11,432	\$ 17,083	\$ 14,277	\$ 52,781	\$ 99,412	\$ 117,003	\$ 141,753	\$ 162,644	\$ 178,417	\$ 819,072
NET PROFIT (LOSS)	-\$ 8,464	-\$ 8,224	-\$ 6,339	-\$ 2,142	-\$ 4,803	\$ 22,250	\$ 64,261	\$ 61,544	\$ 61,058	\$ 68,331	\$ 103,157	\$ 350,627
ROI	-19%	-18%	-14%	-5%	-11%	49%	143%	137%	136%	152%	229%	78%

With a breakeven in the sixth year of operation, the anticipated payback is just under 8 years.

¹⁷⁵ Dow Jones average annual compound return: 11.12%. The rate of 10% is a round number reflecting the opportunity cost of investing the money in the market.

As indicated in Table 25, with a breakeven in the fourth year of operation, the anticipated payback period for the average case DCFC *en route* charger is slightly better at just under 7 years.

Table 25. *En route* DCFC financial forecasts

EN ROUTE CHARGER BUSINESS CASE	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	CUMULATIVE
REVENUES from charging events (Yearly)	\$ 2,745	\$ 1,884	\$ 3,575	\$ 35,394	\$ 72,542	\$ 115,818	\$ 142,527	\$ 261,646	\$ 361,543	\$ 408,559	\$ 481,438	\$ 1,887,671
EXPENSES												
CAPEX												
CAPEX Depreciation / 10 year linear	\$ 6,000	\$ 6,000	\$ 6,000	\$ 6,000	\$ 6,000	\$ 6,000	\$ 6,000	\$ 6,000	\$ 6,000	\$ 6,000	\$ 6,000	\$ 66,000
Cost of capital (5 year loan)	\$ 6,000	\$ 4,800	\$ 3,600	\$ 2,400	\$ 1,200							\$ 18,000
OPEX												
Electricity	\$ 494	\$ 324	\$ 591	\$ 9,833	\$ 21,162	\$ 31,928	\$ 34,380	\$ 69,425	\$ 104,162	\$ 118,311	\$ 131,748	\$ 522,358
Management fee (variable)	\$ 412	\$ 283	\$ 536	\$ 5,309	\$ 10,881	\$ 17,373	\$ 21,379	\$ 39,247	\$ 54,231	\$ 61,284	\$ 72,216	\$ 283,151
Management fee (fix)	\$ 750	\$ 788	\$ 827	\$ 868	\$ 912	\$ 957	\$ 1,005	\$ 1,055	\$ 1,108	\$ 1,163	\$ 1,222	\$ 10,655
Equipment maintenance contract	\$ 750	\$ 788	\$ 827	\$ 868	\$ 912	\$ 957	\$ 1,005	\$ 1,055	\$ 1,108	\$ 1,163	\$ 1,222	\$ 10,655
Site maintenance	\$ 1,000	\$ 1,050	\$ 1,103	\$ 1,158	\$ 1,216	\$ 1,276	\$ 1,340	\$ 1,407	\$ 1,477	\$ 1,551	\$ 1,629	\$ 14,207
Miscellaneous & unforeseen	\$ 500	\$ 525	\$ 551	\$ 579	\$ 608	\$ 638	\$ 670	\$ 704	\$ 739	\$ 776	\$ 814	\$ 7,103
TOTAL COST	\$ 15,906	\$ 14,556	\$ 14,035	\$ 27,015	\$ 42,890	\$ 59,130	\$ 65,779	\$ 118,893	\$ 168,826	\$ 190,249	\$ 214,850	\$ 932,129
NET PROFIT (LOSS)	-\$ 13,161	-\$ 12,672	-\$ 10,460	\$ 8,378	\$ 29,652	\$ 56,688	\$ 76,748	\$ 142,753	\$ 192,717	\$ 218,310	\$ 266,588	\$ 955,542
ROI	-22%	-21%	-17%	14%	49%	94%	128%	238%	321%	364%	444%	159%

In both cases, there is a very attractive return on investment for a station owner willing to take the risk and be patient. However, the risks are at least commensurate with the expected ROI: sales of BEVs may be slower than expected for a number of reasons. Consequently, few investors are currently willing to deploy large numbers of DC fast charging stations, especially with no government support or guarantees.

4. Considerations for DC fast charging deployment

With sales of less than one percent of new vehicle sales, EVs currently represent a niche market in Canada. As battery technology improves and range increases, as prices of EVs decline (through economies of scale) and as Canadians become more familiar with the benefits of owning an EV, this market should grow significantly. The deployment of a network of DC fast charging stations must therefore take into consideration the changes that will occur as we move towards mass-market adoption of EVs. Some of these concerns are presented in this section.

4.1 Deploying for the EV range of the early adopter or of the mass market

As already mentioned, the 2016 arrival of the Chevy Bolt and other affordable BEV models with at least 300 km of range is anticipated will act as a tipping point in the EV market. Scenarios 2, 3, 4 and 5 presented in section 3 reflect an important increase in sales beyond 2017. The number of DC fast-charging compatible EVs with the limited range of today will represent a small minority of all EVs on Canadian roads beyond the 2017 date. Given this reality, should we be deploying DC fast charging taking into consideration the relatively limited range of the few BEVs¹⁷⁶ in the Canadian market today or should we be deploying for the needs of BEVs with a greater range? This issue was discussed at a breakout session on infrastructure at EV2015VÉ Conference (May 2015). The group in attendance generally felt that given limited resources available for charging infrastructure, the deployment of DC fast charging infrastructure should reflect the EVs with greater range. This solution, however, means that the early adopters may not be well served.

4.2 Equitable pricing

Where charging is based on a price per minute fee, regardless of the power being drawn by the vehicle, the price paid per km is lower for greater range EVs (such as a Tesla) than their counterparts with relatively limited range (example, a Nissan Leaf)¹⁷⁷. As the number of makes and models increases, it will become important to develop a more equitable way of pricing depending on the energy drawn per minute.

4.3 Charging solutions for the urban dweller

Research undertaken in both Canada¹⁷⁸ and the United States¹⁷⁹ draws a portrait of the average EV owner:

- Is relatively better educated than the average;
- Earns a higher annual income;

¹⁷⁶ Nissan Leaf is the BEV with the most sales in Canada.

¹⁷⁷ Electric vehicles draw power at different rates.

¹⁷⁸ Suzanne Goldberg, Simon Fraser University and Navius Research (June 2014), n=126

¹⁷⁹ California Plug-In Electric Vehicle Owner Survey (Feb 2014), n=3,881

- Lives in a single detached home (83% of BC EV owners¹⁸⁰, 88% of California EV owners¹⁸¹).

Living in a single family home facilitates EV ownership, as installation of a charging station¹⁸² is the sole decision of the homeowner.

Despite the fact that home ownership stands at a strong 69% in Canada¹⁸³, multi-unit structures are very present in the country's metropolitan areas as are older single-family homes with no parking amenities. In fact, one-third¹⁸⁴ of Canadian households reside in apartment buildings of two or more stories. In some urban areas, like Montréal, home ownership is significantly lower (55%¹⁸⁵). Many Montrealers, like urban dwellers in many of Canada's cities, live in apartments or older homes without garages or parking facilities.



Plateau Mont-Royal, Montréal



Little Italy, Toronto

If Canadians living in homes without a garage or other dedicated parking area are to adopt EVs, charging solutions will need to be available. Such solutions include, but are not limited to, workplace charging, Level 2 on-street charging and inner city DC fast charging.

4.4 Mobility trends

The mobility industry is experiencing and will continue to experience significant change. Technology has enabled new forms of mobility to emerge, including ride sharing (provided by Transportation Network Companies) and various forms of car sharing. The availability of these alternative forms of mobility combined with relatively high cost of vehicle ownership and low average utilization¹⁸⁶ are resulting in urbanites looking increasingly at giving up their personal vehicle. Car sharing, provided by 21 fleets in Canada, is experiencing important growth and currently serves over 300,000 Canadians¹⁸⁷.

¹⁸⁰ Suzanne Goldberg, Simon Fraser University and Navius Research (June 2014), n=126

¹⁸¹ California Plug-In Electric Vehicle Owner Survey (Feb 2014), n=3,881, <https://cleanvehiclerebate.org/eng/vehicle-owner-survey/feb-2014-survey>

¹⁸² 80% of BC EV owners have a Level 2 charger at home. Suzanne Goldberg, Simon Fraser University and Navius Research (June 2014), n=126

¹⁸³ http://www.cmhc.ca/en/corp/about/cahoob/data/data_003.cfm

¹⁸⁴ idem

¹⁸⁵ idem

¹⁸⁶ Average utilization of personal passenger vehicle: 4%

¹⁸⁷ Source: MARCON research in car sharing market

As municipalities tackle issues of congestion¹⁸⁸, many are encouraging public transit and shared forms of mobility, including car sharing. Consequently, this latter form of mobility is expected to progress at a rapid pace over the next decade.

As vehicle sharing grows in popularity, ensuring a strong penetration of EVs in car sharing fleets will become important to minimizing urban pollution. A key obstacle to EV adoption by car sharing fleets in Canada¹⁸⁹ and around the world is the availability of urban charging. Moving forward, it will be important to consider if Level 2 or DC fast charging solutions should be prioritized for the car sharing fleets.

4.5 Carbon market

Use of EVs could help jurisdictions and other entities to meet their GHG emissions reduction targets. These vehicles could be associated with carbon credits. To the extent that DC fast charging stations contribute to increasing EV sales deployment and usage, they too could be associated with carbon credits. Clarity and monetization of the carbon market could generate additional interest and investment in DC fast charging in the private sector.

4.6 Road tax

The more optimistic scenarios developed for the purposes of this study imply the loss of substantial revenues from fuel taxes for our provincial and federal governments. These taxes are intended to provide the necessary funds to build and maintain our road infrastructure. Currently, electricity used as a replacement fuel is only subject to standard sales taxes (GST, HST and/or PST). The imposition of any kind of road tax on EVs could negatively affect the growth of the EV market. This topic has not been addressed in this study and was not taken into account in any of the five scenarios developed, thereby indirectly assuming that no road tax will come into effect in the next ten years. Consequently, the lack of road tax imposed on EVs is an incentive that encourages the purchase of such vehicles.

EVs do however use the road infrastructure, as do their ICE counterparts. As EVs become a larger proportion of the total light-duty vehicles using Canadian roads, it should be expected that governments, seeing their gas tax revenues stagnate or decline, will introduce road taxes to cover road infrastructure costs.

The state of Oregon¹⁹⁰, for example, will apply a \$0.0156 per-mile fee to EVs¹⁹¹. This suggested fee is considered to be the equivalent to what the average ICE vehicle owner would pay in gas taxes.

Given a fully functioning carbon market, it is reasonable to expect that a carbon credit will at least offset the road tax.

4.7 Interoperability

As the number of EVs and DC fast charging stations increase, it is also possible that new charging networks and stakeholders enter the market. Ease of use of charging stations and convenience are two key factors that will contribute to converting a motorist from an ICE vehicle to an EV. It would

¹⁸⁸ The Mayor of Montréal recently announced a plan to have 1,000 electric car sharing vehicles in the city.

¹⁸⁹ Source: EV car sharing study undertaken by MIRATECH on behalf of Electric Mobility Canada, 2015.

¹⁹⁰ http://www.greencarreports.com/news/1082608_oregon-too-wants-to-tax-electric-cars-and-55-mpg-plus-cars-too

¹⁹¹ For more information about the program, please visit: <http://www.myorego.org>.

be unreasonable to expect future EV drivers to be members of numerous charging networks, using several accounts and payment methods as is currently the case.

If the intent is to facilitate travel between provinces, interoperability will be imperative not only within each province but across provincial borders. A pan-Canadian interoperability standard or protocol should be established. The Circuit électrique and the VERnetwork¹⁹² are already collaborating on creating interoperability in their respective networks.

4.8 Common signage

While the symbol for charging stations is normalized in British Columbia and Québec, common signage identifying DC fast charging stations does not yet exist nationally and would be useful in helping EV motorists easily identify the location of the stations as they are driving.



4.9 Power levels with future EV models with more powerful batteries

The expected increase in EV range will result from equipping cars with more powerful batteries. These will necessarily require more energy. A Nissan Leaf battery pack can store 24 kWh that provides it with a 120 km range. Future improvements¹⁹³ will require a four to five fold increase in battery capacity with future EVs carrying 85 to 100 kWh on board in order to increase their range to that of a conventional fuel car.

4.10 Automation of transportation

Vehicular automation is the focus of significant R&D effort around the world. While the timelines for full automation vary by stakeholder¹⁹⁴, it would be reasonable to expect fully autonomous

¹⁹² VERnetwork / RéseauVER (<http://www.reseauver.com/index.en.html>) is affiliated with AddEnergie, manufacturer and distributor of charging stations.

¹⁹³ Source: <http://www.technologyreview.com/news/536336/inexpensive-electric-cars-may-arrive-sooner-than-you-think/>

¹⁹⁴ According to the Transportation Evolution Institute, national organization studying the impacts of changes in mobility, Silicon Valley developers of the technology, like Google, tend to be more aggressive. The latter forecast commercial availability of fully autonomous vehicles by the end of the decade. Some of the auto manufacturers are promoting a slower evolution towards full automation.

passenger vehicles will make the commercial debut within the next decade. If such vehicles are to be electric, charging solutions that do not require human intervention will be required. Tesla, for example, is reportedly working on an automatic charger¹⁹⁵ while other manufacturers are contemplating induction charging. Induction charging will likely be an important charging solution for autonomous EVs.

4.11 Recommendations regarding additional research

A good understanding of the relative importance of the factors that contribute to the EV purchase decision is important. While we understand that availability of DC fast charging contributes to increasing EV sales, we have not discovered any research that makes this link in a quantifiable manner. This was the key challenge in being able to distinguish between scenarios 2, 3 and 4 presented in Section 3.

It would be beneficial to undertake quantitative market research to determine the factors contributing to the EV purchase decision (purchase drivers) and their relative importance¹⁹⁶. This research would allow for an understanding of the impact that availability of DC fast charging has on the decision to purchase an EV.

The issue of road tax must also be examined closely in order for the best possible advice on this topic to be provided to Canadian lawmakers. In order to do so, a closer examination of indirect benefits to Canadians must be considered. The reduction of air pollutants will reduce cases of pulmonary diseases, for example. This will in turn reduce the cost of health care for our governments. Such cost reductions can offset a share of the lost revenues from the fuel taxes and should be weighted in the determination of a fair amount of tax. The type of tax should also be examined. An increase in the purchase cost of an automobile may have a greater negative impact than an equal amount being spread over several years using car registration fees as the carrier of this new tax.

¹⁹⁵ <http://www.theverge.com/2014/12/31/7474057/elon-musk-says-tesla-automatic-car-charger-solid-metal-snake>

¹⁹⁶ This can be undertaken using regression analyses.

5. Conclusions and Recommendations

The transportation sector accounts for 24% of Canada's GHG emissions. It therefore represents much potential for GHG emissions reductions in Canada. Increasing the share of zero-emission vehicles (therefore EVs) in the country's fleet could be a central element of a national strategy to meet our GHG emissions reductions objectives.

Despite the lack of empirical evidence, the industry recognizes that one of the most critical success factors in increasing the adoption of EVs is the availability of DC fast charging infrastructure. To date, however, the deployment of such infrastructure in Canada has been limited. With the exception of the investments made by Tesla in developing its SuperCharger network, the large majority of DCFCs currently available across the country have been deployed using government funding.

Using reasonable assumptions and hypotheses¹⁹⁷ based on extensive research and industry consultations, the authors of this report developed a realistic scenario of EV sales forecasts (referred to as Scenario #4, section 3.4.2.3). This scenario forecasts a steady progression of EV sales resulting in a total of 1.8 million EVs on Canada's roads by 2025.

This number of EVs will require 750 DC fast charging locations (500 urban and 250 en route) hosting 1,600 DCFCs (950 urban and 650 en route) to meet charging needs¹⁹⁸.

As indicated in the business case calculations presented in section 3.5, the payback period of just under 8 years for the urban DCFC and just under 7 years for the en route DCFC suggests that government funding will be necessary to ensure the deployment of DC fast charging required both in cities and along key travel corridors between cities. This deployment will be important to achieving the EV sales forecast presented in Scenario #4.

It is therefore recommended that government (municipal, provincial, territorial and federal) collaborate with electric utilities and private enterprise to deploy additional DCFCs. To ensure that travel across the country is facilitated, it is recommended that government authorities coordinate with their counterparts in adjoining provinces to ensure optimal location of DCFCs.

¹⁹⁷ Reasonable given information available at the time of writing of this report.

¹⁹⁸ These estimates reflect a reasonable expectation that over the course of the coming decade, battery performance will improve, resulting in longer distances covered between charges. <http://betanews.com/2015/09/29/elon-musk-expects-evs-will-have-1000km-range-by-2017/>

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