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March 16, 2018

VIA ELECTRONIC MAIL

British Columbia Utilities Commission
6th Floor, 900 Howe Street
Vancouver, B.C.
V6Z 2N3

Attention: Patrick Wruck, Commission Secretary and Manager, Regulatory Support

Dear Sirs/Mesdames:

Re: British Columbia Utilities Commission Inquiry into the Regulation of Electric Vehicle Charging Service ~ Project No. 1598941

We are counsel to the Commercial Energy Consumers Association of British Columbia (the "CEC"). Attached please find the CEC's Written Evidence with respect to the above-noted proceeding.

If you have any questions regarding the foregoing, please do not hesitate to contact the undersigned.

Yours truly,

OWEN BIRD LAW CORPORATION

Christopher P. Weafer

CPW/jj
cc: CEC
cc: Registered Interveners

COMMERCIAL ENERGY CONSUMERS ASSOCIATION OF BRITISH COLUMBIA

<u>WRITTEN EVIDENCE</u>

British Columbia Utilities Commission Inquiry into the Regulation of Electric Vehicle Charging Service
Project No. 1598941

March 16, 2018

Commercial Energy Consumers Association of British Columbia
Written Evidence

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COMMERCIAL ENERGY CONSUMERS ASSOCIATION OF BRITISH COLUMBIA

British Columbia Utilities Commission Inquiry into the Regulation of Electric Vehicle Charging Service ~ Project No. 1598941

March 16, 2018

The Commercial Energy Consumers Association of BC (the "CEC") represents the interests of ratepayers receiving energy under commercial tariffs in applications before the BC Utilities Commission ("BCUC" or "Commission").

By Order G-10-18 the Commission has established an inquiry to review the regulation of electric vehicle ("EV") charging service (the "Inquiry") pursuant to Section 82 of the *Utilities Commission Act* ("UCA").

The Commission identified a list of potential regulatory issues that may form the scope of the Inquiry which includes the following:

Scope A: Basis for Regulation

1. Do EV charging stations operate in a competitive environment in BC or are they a natural monopoly service?
2. Are the customers of EV charging stations captive or do they have a choice?
3. Should the Commission regulate the services provided by EV charging stations? What are benefits and detriments to such regulation?

Scope B: Rate Design and Rate Setting

4. Should the rate design of EV charging stations be established under a public utility's traditional cost of service model or some other model? And within that context, what are the customer pricing options (eg. Energy based rate vs. time-based rate)?
5. Should the EV charging station service rate be based on a public utility's existing wholesale or commercial or some other rate?
6. Should public utilities include EV charging stations in their regulated rate base or through a separate non-regulated entity?
7. If public utilities provide EV charging services within their regulated business, is there a risk of cross-subsidization from other rate classes to support this new service and if so, is the proposed rate design potentially unduly discriminatory?

Other Matters

8. Any other matters that may assist in the effective and efficient review of the Inquiry.

The CEC provides the following evidence for the Commission's consideration.

A. SUMMARY

(1) Electric Vehicle (EV) charging stations are not a natural monopoly and could largely operate in a competitive environment with an exemption from the UCA.

(2) Customers of charging stations are not captive and have several options for charging.

(3) The Commission does regulate distribution of electricity and should continue to do so by exempting EV charging stations from regulation except for a simple annual reporting requirement.

(4) The Commission's utility rate design for electricity supply should be based on the existing customer call tariffs and the underlying cost of service. The tariffs should move toward Time of Use pricing for residential and commercial customers, including any EV charging that occurs under these tariffs. EV charging station rates should be established by the market providers in a market exempted from regulation related to the sale of electricity and lightly regulated in regard to a simple annual reporting enabling the Commission to oversee the exempted market.

(5) The EV charging station rates should be lightly regulated overall and be unregulated as to rate design and pricing. The electricity supplied by the utility should be provided at residential or commercial rates as the case may be.

(6) Utilities should not include EV charging stations in their regulated rates. If they are to provide such service they should do so through a separate non-regulated utility. Utility participation in providing fast charging stations on long-distance highway corridors may be useful to temporarily fill a gap in the market until the market develops further.

(7) The inclusion of EV charging in utility rate bases would have limited risk of cross-subsidization initially due to the size of the market. Cost of service ratemaking in the future could enable proper cost allocation and eliminate cross-subsidization.

(8) The long-term development of the electrification of light vehicle transportation is likely to evolve as a competition between the current electric vehicle (EV) model, being individually owned vehicles charging mainly at home augmented by public charging and workplace charging, and future autonomous self-driving vehicles (AV) fleets model, being fleet owned with charging at temporary street parking locations and with significant potential for increased ride sharing. As the competition between these models evolves and as they compete with the current internal combustion engine (ICE) individually owned vehicles, there is a significant potential for disruption of the market and displacement of use for the supporting infrastructure for each model. Such disruptions are better handled in competitive markets than in monopoly utilities.

The CEC's perspectives based on its modelling of the long-term future are in part shaped by the evidence that the overwhelming costs associated with electrification of light vehicle transportation is the cost of electricity. This cost will likely substantially outweigh all the other supporting infrastructure costs. The CEC's conclusion from this fact is that it will be appropriate for the utilities to concentrate on these costs and the related rate class tariffs and not try to bring what is likely a downstream competitive market service related to vehicle charging into the regulated utility rate base.

B. INTRODUCTION

Electric vehicles are a new and rapidly growing market worldwide and in Canada. There are currently 41 electric vehicle (EV) models on Canadian roads including 26 plug-in hybrids (PHEVs) and 15 battery electric vehicles. EV sales topped 1% of total motor vehicle sales in the third quarter of 2017.[1] 4,000 EVS in BC[2] or more.

Battery limitations for range and significant charge times have restricted long distance travel. In BC, 95% of all car trips in BC urban areas are less than 30 km.[3] Most EV owners today do the bulk of their charging at home at relatively low cost. Access to a robust public nation-wide or province-wide charging station network for long-distance travel is still under development which limits the value of electric vehicles. This situation can inhibit uptake of purely electric vehicles and confine their use to local driving.

Many people consider public charging availability to be the key to a growing electric vehicle market. The public charging station infrastructure in Canada has been largely developed as a consequence of federal, provincial and local programs aimed at offsetting the cost and encouraging deployment[4] and remains in a state of continual change and rapid development. In addition to the governmental impetus, manufacturers of charging equipment, automobile manufacturers, network service providers and other stakeholders are rapidly working to advance the market and establish a foothold in an industry in which technology is not yet established and the key players have not yet been determined.

There are different levels of charging stations including both AC charging and DC charging, as illustrated below.

[1] https://www.fleetcarma.com/electric-vehicle-sales-in-canada-q3-2017/
[2] Exhibit B-1, FortisBC DCFC Service Application Appendix F EV Tech Overview page iv
[3] https://pluginbc.ca/charging-stations/public-charging/
[4] tps://www.theicct.org/sites/default/files/publications/EV-charging-best-practices_ICCT-white-paper_04102017_vF.pdf

AC Charging Systems	DC Charging Systems
AC Level 1: 120 volt single phase AC up to 16 amps, for up to 1.9 kiloWatt charge rate. Typically this is limited to 12 amps.	**DC Level 1**: 200-450 volts DC up to 36 kiloWatts (80A)
AC Level 2: 240 volt single phase AC up to 80 amps, for up to 19.2 kiloWatt charge rate. Typically this is 32 amps.	**DC Level 2**: 200-450 volts DC up to 90 kiloWatts (200A)
AC Level 3: More than Level 2. A couple of car makers make cars supporting three phase AC charging at rates up to 43 kiloWatts.	**DC Level 3**: 200-600 volts DC up to 240 kiloWatts (400A)

[5]

Level 1 and Level 2 charging can both be provided at home or in public places at relatively low cost but require significant time to charge.

Level 3 DC Fast Chargers (DCFC) bypass the onboard charger and provide DC electricity to the vehicle battery via a special charging port and provide a charge much more rapidly. They are more expensive to install. DCFC charging is not useful for topping up as the charge can slow down significantly if the battery state of charge (SOC) is not below 80%.[6]

Most, but not all vehicles can charge in a DCFC port. Plug-in Hybrid Electric Vehicles (PHEVs) are not able to use DC fast chargers. Tesla maintains its own proprietary fast charging technology which is limited to Tesla vehicles.

Some consider that 'fast charging' could potentially overtake Level 2 as the most prominent method of charging. The new releases of 200+ mile electric vehicles will create significant demand for fast charging for longer distance travel.[7] Most modern fully-electric vehicles can be equipped with DC quick charge capability and there are were nearly 2,200 DC high speed fast chargers in the US.[8]

The CEC considers that it is important for the Commission to consider the long-term objectives and the rapidly occurring contextual changes as regulation can have a significant effect on the development of the EV market in its eventual determination surrounding the regulation of EV charging. There is no universal benchmark for the number of electric vehicles per public charge Point. Improvements in distance range, new car options, declining vehicle prices, rising gasoline prices, and the development of future technologies such as wireless charging and battery swapping will all contribute to the development of the EV market. This EV market can potentially have a significant impact on the electric grid and load requirements. However smart

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[5] https://greentransportation.info/ev-charging/range-confidence/chap4-charging/4-charging-levels.html
[6] https://chargehub.com/en/electric-car-charging-guide.html#publiccharging
[7] https://longtailpipe.com/2015/06/23/chargepoint-preparing-the-dc-fast-charging-future-two-dcfcs-announced-network-expansion-coming-soon/
[8] https://www.fleetcarma.com/dc-fast-charging-guide/

grid technologies are also being developed to minimize the impact on the electricity infrastructure.

Appendix A provides background information for the Commission's consideration.

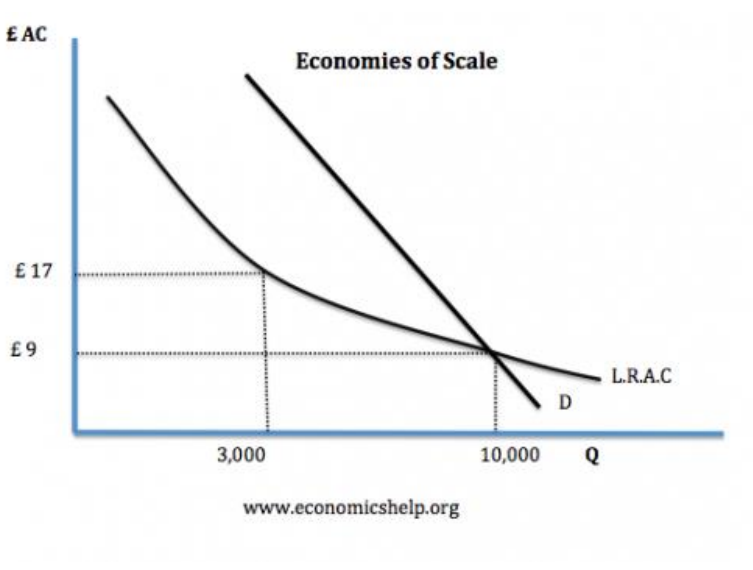
An average charge for 30 km trip takes approximately one hour at a level 2 public charging station.

1. Do EV charging stations operate in a competitive environment in BC or are they a natural monopoly service?

1.1 Natural monopolies arise when extremely high infrastructure costs or other significant barriers to entry exist relative to the size of the market such as technical superiority, patents, access to suppliers, government regulation or others. Sometimes the first-in supplier can saturate the market and become a natural monopoly. Natural monopolies provide the largest supplier with an overwhelming market advantage over potential competitors.

1.2 A formal definition of a natural monopoly is

> 'an industry in which multi-firm production is more costly than production by a monopoly'[9]



[10]

[9] William Baumol (1977) https://www.economicshelp.org/blog/glossary/natural-monopoly/
[10] https://www.economicshelp.org/blog/glossary/natural-monopoly/ AC = Averge cost, Q = units

1.3 Monopolies can also occur as a result of regulation that confers a distinct advantage to one supplier over potential competitors. The monopoly can typically meet the market's entire demand, controls the method of production and is the only entity authorized to produce a given product.

1.4 Natural monopolies can use an industry's limited resources to greatest efficiency and have the ability to offer the lowest unit price to consumers. However, the lack of competition reduces motivation towards economic efficiency, and can result in higher prices.

1.5 Since substitute products or services usually exist, certain jurisdictions define a market as a monopoly if there is a firm possessing over 25% market share and facing no significant competition.[11]

1.6 The CEC submits that the issue of "natural monopoly" might best be considered in light of the different types of charging stations and their functionality.

A. Resale of electricity
B. Charging Station Infrastructure Cost
   a. Home Charging Level 1
   b. Home Charging Level 2
   c. Public Charging Level 2
   d. Public DC Fast Charging Level 3
C. Other Barriers to Entry
D. Summary and Conclusions

A. Resale of electricity commodity

1.7 The CEC notes that the generation of electricity by the utility may be considered a 'natural monopoly' due to the very high costs associated with generation costs and transmission and distribution networks. The CEC notes that there are other generators of electricity such as Independent Power Producers and net metering customers which do also supply electricity.

1.8 The CEC does not consider the 'resale' of electricity to be 'natural monopoly'. There is a vast distribution network already established in BC and existing tariffs which facilitate broad access to industrial, commercial or residential ratepayers. They are no major costs associated with the resale of electricity and no evidence to suggest that resale can be most cost effectively undertaken by a single provider, or even by the utility.

[11] https://www.ukessays.com/essays/economics/the-advantages-and-disadvantages-of-monopoly.php

B. Charging Station Infrastructure Costs

Home Charging Level 1

1.9 Level 1 charging stations provide about 8 km of range for one hour of charge and consist of cord-sets that plug into a regular 120V outlet.

1.10 Level 1 equipment necessary for this charging is not expensive and is included in the cost of the vehicle.[12]

1.11 Regular 120V outlets are ubiquitous and readily accessible at no or little cost to the vehicle owner being already established. The cost of electricity is incremental, typically provided at the residential rate and dependent on usage. Customers are limited to the public electric utility for the supply of electricity.

1.12 The CEC submits that there is a no evidence of a natural monopoly for home charging. The equipment is produced at minor expense by multiple car manufacturers and passed onto the customer through the sale of the electric vehicle.

Home Charging Level 2

1.13 Level 2 charging stations provide for faster charging and may include additional features. The most common level 2 charging stations have similar electrical requirements to a stove or clothes drier.[13] One hour of charge provides a range of approximately 30 km.[14]

1.14 The hardware for Level 2 charging stations is not expensive. Retail prices are low and declining and today EV owners or others can typically install a Level 2 charging station for under $2000, including the hardware (under $1000) plus installation by an electrician. There are several manufacturer and suppliers of charging stations including Elmec, JuiceBox, Sun-Country-Highway, FLO and others. Units are sold online or through big box retailers such as Home Depot and compete on price and functionality.[15] Installation costs require the installation of a 240V circuit, but this is readily accessible through the use of a qualified electrician.

1.15 Information on suppliers of Level 2 charging stations is provided in Appendix C.

[12] https://www.greenbiz.com/blog/2014/05/07/rmi-whats-true-cost-ev-charging-stations
[13] https://www.plugndrive.ca/guide-ev-charging/
[14] https://www.plugndrive.ca/guide-ev-charging/
[15] https://www.plugndrive.ca/charging-station-store/

1.16 Customers have access to electricity at residential (or commercial rates) and there is no requirement for changes to utility regulation in order to facilitate the sale of electricity for home charging.

1.17 The CEC submits that there is a no evidence that a natural monopoly exists or that equipment may be supplied more cost effectively from one participant rather than many. Rather, the CEC considers that a that wide and competitive market for Level 2 home charging equipment and installation already exists.

Public Charging Level 2 AC 240V

1.18 Level 2 public charging stations use a 240V plug. They are more robust and include features such as quad pedestals, LCD screens, advance payment and data tracking communication, and dual port power routing capabilities. They may be found in parking garages, curbside or other public locations.

1.19 Public charging stations are more expensive than home chargers, but are also readily available from multiple manufacturers such as GE and Schneider Electric. They can be purchased online at a variety of online distributors or big box retailers such as Home Depot Costs vary but typically do not exceed $10,000 including installation. Retail equipment prices are in the order of $1000-$7000[16] and installation costs may be more significant depending on location. Certain charging companies such as FLO offer charging station packages which include equipment, installation and charging for a monthly fee.[17]

1.20 Level 2 charging stations are proliferating across North America. BC Hydro[18] states that there are close to 1,000 public charging stations in BC. These are continuing to be deployed and deployment may be expected to continue for some period of time resulting in a much larger collection of public charging stations.

1.21 The evidence is that there is no natural monopoly in the provision of EV Level 2 home charging or Public AC charging stations as evidenced by rapid growth, multiple participants in the market and relatively easy customer access to alternatives.

1.22 Owners and network management of public AC charging stations are not required to make a significant investment, and may be installed as a convenience, attraction or other

[16] https://www.homedepot.com/p/AeroVironment-Quad-Pedestal-30-Amp-Level-2-EV-Charging-Stations-with-25-ft-Cable-19130/205852631 and https://cleantechnica.com/2014/05/03/ev-charging-station-infrastructure-costs/
[17] https://flo.ca/business/plans
[18] https://www.bchydro.com/powersmart/electric-vehicles/charging.html

purpose at limited cost to the supplier as demonstrated by the approximate 250 stations in the City of Vancouver alone.

1.23 The CEC recognizes that municipal and other governmental support have kept charging rates free or low for end customers to date with subsidies, and as such is likely to be temporary and not indicative of free market dynamics.

1.24 The CEC submits that, in addition to government policy supporting electric vehicles, a significant reason making this support necessary is the existing regulatory burden on resellers of electricity under the UCA rather than any condition of natural monopoly.

Level 3 – Public DC Charging/Fast Charging (DCFC)

1.25 Level 3 DC Fast Chargers allow much faster charging than Level 2 charging and can provide a similar average charge (for 30 km range) in a few minutes. They can provide up to 80% of a vehicle charge in 20 minutes or less. One hour of charge provides approximately 250 km of range. The charging range for a Long-Distance vehicle, such as the Chevrolet Bolt is about 90 miles in about 30 minutes.[19]

1.26 There are significantly fewer DC Fast Charging stations available in BC though they are also actively being deployed throughout the province.

1.27 The Province of BC and the federal government are supporting 30 DC fast chargers through a Pilot managed by BC Hydro. The British Columbia Electric Vehicle Infrastructure Project is led by BC Hydro and supported by the Province of BC, the federal government, municipalities and the private sector. Greenlots provides the EV network managing the stations as a private partner.[20] The FortisBC Electric Vehicle DCFC service application identified [20] DCFC stations operating or planned as of October 2016.[21] As of October 2017 there were over 30 fast-charge locations in BC, excluding Tesla's Superchargers.[22] On its website Tesla identifies 18 superchargers installed or coming soon in the Province.[23] There is currently 1 DC charger supported by the City of Vancouver[24] and the City is considering the installation of 5 additional stations.[25]

[19] https://www.chevyevlife.com/bolt-ev-charging-guide
[20] https://pluginbc.ca/wp/wp-content/uploads/2014/08/FAQ-EV-DCFC-pilot-2Oct2014.pdf
[21] FortisBC Electric Vehicle DCFC Service Application, Powertech Background Report EV Technology and Market Overview page 21
[22] https://pluginbc.ca/charging-stations/public-charging/
[23] https://www.tesla.com/en_CA/findus/list/superchargers/Canada
[24] Located at Empire Fields on Hastings Street next to Hwy 1
[25] City of Vancouver Electric Vehicle Ecosystem Program Update

1.28 The cost of a Level 3 DC charging station can range between $50,000 and $100,000 at present for the equipment[26] and installation.[27] Additionally, there are variable costs of energy and transaction fees; plus annual fixed costs of approximately $1500 related to electricity demand charges, network management systems and others. Additionally, the site of a public charging station could require an additional outlay depending upon the location.

1.29 Information on suppliers of public Level 3 charging stations is included in Appendix D.

1.30 These costs do not represent a significant cost barrier for a competitive market.

1.31 The installation of a DC charging station for commercial purposes can most likely be economically justified with the resale of electricity with a small profit margin per unit, or as the basis for some other motivation, such as the sale of Electric Vehicles using proprietary charging technology. (see 'Tesla' discussion below)

1.32 Most DC Fast Charging stations throughout North America have user fees. For the purpose of the BC Hydro Pilot, hosts have agreed to implement a $0.35/kWh charge with a minimum $2.00 sales per charge session, which equates to a typical fill.

1.33 A natural monopoly does not exist in the Level 3 fast charging stations because the infrastructure costs of $100,000 or so do not represent a significant barrier to entry. Rather, the main barrier to entry is through the restrictions imposed by the UCA discussed under **Barriers to Entry** below.

1.34 Additionally, there is no evidence that one company is significantly able to create a price advantage or that a single company can more cost effectively supply DC chargers than other companies, and there is no pre-existing single DC supplier that prevents entry. The Tesla supercharging technology and network is limited to Tesla vehicles, this is discussed below.

Tesla Superchargers

1.35 Tesla has developed a propriety Super charger which provides a charge faster than any other chargers on the market. A 'long-range' battery with supercharging is able to charge

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[26] https://pluginbc.ca/wp/wp-content/uploads/2014/08/FAQ-EV-DCFC-pilot-2Oct2014.pdf
[27] FortisBC Electric Vehicle DCFC Service Application, Powertech Background Report EV Technology and Market Overview page 46

170 miles of range in about 30 minutes or nearly double the 90 miles at Level 3 DC charging for the Chevrolet Bolt.[28]

1.36 Tesla superchargers have a maximum power output of 120 kW. By contrast, non-Tesla charges are in the 7kW – 8 kW max capacity. Only Tesla cars can use the Tesla Supercharger.

Tesla Network

1.37 The BC Tesla network (18 stations) is part of the most extensive, and quickly growing fast-charging network around the world. Tesla had an established goal of reaching 10,000 Superchargers online by the end of 2017 but fell short with an existing 8,250.[29] Tesla recently built a giant 50-Supercharger station in China[30], and several other very large stations elsewhere.[31] Tesla plans to have bigger charging stations with more amenities such as Lounges for popular long-distance routes where Tesla drivers would need to charge in order to complete them.[32] Tesla is also releasing Tesla buses and Tesla semi-trailers.

1.38 Tesla is currently moving away from its previous allocation of free unlimited access to its supercharger network to a new pay per use for Tesla Model 3. Tesla is also attempting to deter the commercial use of its charging stations, and to focus on the use of electric vehicles for long-distance journeys.

1.39 The CEC considers that Tesla has established a monopoly-like moat around its super-chargers, based on its proprietary technology.

1.40 However the CEC does not consider this to be a natural or other monopoly for the following reasons.

1. The Tesla charging stations are limited to Tesla vehicles, and there are many companies existing in the EV market.
2. The market for Long-Distance EV, which Tesla has dominated, is rapidly changing and new longer-distance EV's such as the Chevrolet Bolt offer a reasonable substitute.
3. There are many cost-effective and acceptable alternatives to Supercharging.
4. There is competition underway.

[28] https://www.chevyevlife.com/bolt-ev-charging-guide
[29] https://electrek.co/2017/12/26/tesla-supercharger-record-year-goal/
[30] https://electrek.co/2017/11/16/tesla-giant-50-supercharger-station-china/
[31] https://electrek.co/guides/tesla-supercharger/ October 28, 2017
[32] https://electrek.co/guides/tesla-supercharger/ November 15, 2017

1.41 The CEC considers that there are no significant cost barriers to entry in the Level 1 and Level 2 charging markets which is demonstrated by the inexpensive price and proliferation of Level 2 charging stations, and the ubiquitous availability of home charging.

1.42 While there are some cost barriers at the Level 3 Fast Charging stations, (between $50,000 and $100,000) they are not significant.

C. C. Other Barriers to Entry

Utility Regulation

1.43 Electricity in BC will presumably continue to be provided by the BC Hydro and FortisBC utilities and regulated by the Commission

1.44 Section 1 of the UCA defines a seller of electricity as a Public Utility, and subject to regulation by the BCUC.

> "public utility" means a person, or the person's lessee, trustee, receiver or liquidator, who owns or operates in British Columbia, equipment or facilities for
>
> (a) the production, generation, storage, transmission, sale, delivery or provision of electricity, natural gas, steam or any other agent for the production of light, heat, cold or power to or for the public or a corporation for compensation, or
>
> (b) the conveyance or transmission of information, messages or communications by guided or unguided electromagnetic waves, including systems of cable, microwave, optical fiber or radio communications if that service is offered to the public for compensation,
>
> but does not include
>
> (c) a municipality or regional district in respect of services provided by the municipality or regional district within its own boundaries,
>
> (d) a person not otherwise a public utility who provides the service or commodity only to the person or the person's employees or tenants, if the service or commodity is not resold to or used by others,
>
> (e) a person not otherwise a public utility who is engaged in the petroleum industry or in the wellhead production of oil, natural gas or other natural petroleum substances,

(f) a person not otherwise a public utility who is engaged in the production of a geothermal resource, as defined in the Geothermal Resources Act, or

(g) a person, other than the authority, who enters into or is created by, under or in furtherance of an agreement designated under section 12 (9) of the Hydro and Power Authority Act, in respect of anything done, owned or operated under or in relation to that agreement;

1.45 Under this UCA the sale or resale of electricity deems the purveyor to be a utility (unless it is a municipality or otherwise exempted) and subject to considerable regulation. This regulatory burden creates a significant barrier to entry and provides a monopoly to the utility if left in place. Additionally, to the extent that the monopoly utility or municipality resells electricity at subsidized prices, the market opportunity is considerably diminished.

1.46 Additionally, BC Hydro's Electric Tariff Section 9.1 'Resale of Electricity' does not contemplate the resale of electricity for Electric Vehicles or generally allow for a profit to be generated. It states:

9.1 Resale of Electricity

If a Customer wishes to resell to a tenant of the Customer at the same Premises and on a metered basis Electricity provided by BC Hydro to the Customer, the price for such Electricity will not exceed the price that BC Hydro would have charged had such tenant been a Customer of BC Hydro. This requirement will be included in an agreement for resale between BC Hydro and the Customer.

1.47 The CEC submits that for electric vehicle charging existing regulation is an artificial barrier, and unless the Commission actively confers a monopoly on one or more EV station supplier such as a utility, there is no natural monopoly.

1.48 The CEC submits that to the extent that the regulatory burden was removed to allow for the resale of electricity at rational prices there is an opportunity for a competitive market to exist and expand with the sale of Electric Vehicles.

1.49 The Commission has broad jurisdiction to facilitate the opportunity for the resale of electricity for electric vehicle purposes. Alternatively, the Commission could confer a monopoly if it so determined by limiting the opportunity for electricity resale to utilities and maintaining the regulatory requirements for all sellers/resellers.

1.50 The CEC does not support the creation/maintenance of a monopoly for the provision of DC Fast Charging stations. The market appears to be developing rapidly and it would be reasonable to expect that there are several potential competitors who could enter the market absent regulatory restrictions. As an example Tesla is doing so independently with its own business model.

Technology and Patents

1.51 Standardized technologies are utilized at the Level 1 or Level 2 charging level, and there is no technological barrier to entry due to the ubiquitous existence of the electricity infrastructure which is readily accessed through these charging technologies.

1.52 It is common, however, in new technology markets for different technologies to compete for dominance, and this is occurring in the Electric Vehicle fast charging market.

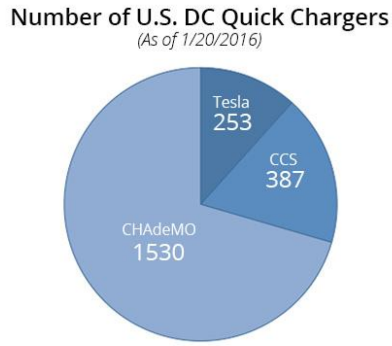
1.53 Fast charging, including Level 3 DC Fast Charging and Tesla supercharging is unfolding according to various manufacturer developments. It is available in 3 primary forms, which each service different vehicle types. These include: CHAdeMO, Combined Charging System (CCS) and the Tesla Superchargers.

1.54 CHAdeMO is a DC charging standard for electric vehicles and is developed by the CHAdeMO Association, which is also tasked with certification and ensuring compatibility between the car and the charger. There are 230 certified chargers and 50 charger manufacturers.[33]

1.55 The Combined Charging System (CCS) is an open and universal charging system for electric vehicles. The CCES technology and architecture has been enshrined in international standards. Drivers of any type of electric vehicle can choose between normal and fast charging.[34]

1.56 Tesla's proprietary supercharging technology has significant benefits in charging time but is limited to Tesla vehicles. Tesla vehicles can add 170 miles in 30 minutes, and 210 miles in 40 mins, compared to about 90 miles in 30 minutes for the other DC Fast Chargers.

[33] https://www.chademo.com/about-us/what-is-chademo/
[34] http://charinev.org/about-us/benefits/



[35]

1.57 It is reasonable to expect that over time the Level 3 DC Fast charging technology race will continue to evolve and could potentially become standardized or one technology will become predominant.

1.58 At this point technology or patents do not provide a barrier to entry sufficient to create a natural monopoly, however it remains to be seen if one technology will prevail.

1.59 To the extent that multiple manufacturers will be able to cost-effectively manufacture and provide DC charging regardless of whether it is CHAdeMO or CCS there is no natural monopoly.

1.60 Where Tesla is able to provide a superior product it is likely that this will provide a competitive edge as far as EV purchase decision goes and could serve as a protective moat. However, given the restriction of Supercharging to Tesla vehicles, the significant assortment of alternative vehicles and vehicle manufacturers, and the ongoing push in technology for improved charging, the CEC does not consider it likely that there is a form of monopoly available to Tesla to control the sales and pricing in the EV market overall.

1.61 The CEC notes that other criteria factor into purchase decisions and Tesla vehicles have price point, vehicle availability, corporate financial security and other concerns which could serve to limit their position vis- a- vis other larger car manufacturers.

First-In/Product Availability Dominance

1.62 There is no first-in/product availability dominance in the Level 1 or Level 2 charging markets which is established with significant mixed availability.

[35] https://www.fleetcarma.com/dc-fast-charging-guide/

1.63 There does appear to be significant contention for first in/availability dominance with regard to Fast Charging.

1.64 The CEC notes that the CHAdeMO charging stations were the most readily available as of early 2016. As of January 2016 it was believed that CHAdeMO accounted for about 1530 of the 2170 US DC quick chargers; Tesla accounted for 253 and CCS accounted for 387.[36] However, Tesla has committed to creating a Supercharging network of significant proportions.

1.65 To the extent that DC Fast charging stations (either CHAdeMo or CCS) do not proliferate as quickly as the Tesla Super Charging stations, there could be some preliminary market dominance in the fast-charging market if customers believe their only option is to purchase a Tesla in order to travel long-distances in a timely manner. In this scenario, customers committed to electric vehicle long-distance driving could develop the Tesla market further, which would further contribute to a position of dominance for the Tesla vehicles and supercharging stations.

1.66 However, at best this situation is prospective and there is no evidence to suggest that the generic DC Fast Charging stations could or would not be deployed in a competitive environment given the opportunity for profit. There are many suppliers of other DC Fast Charging stations and manufacturers of vehicles able to charge at DC Fast Charging stations and to the extent the alternative DC charging stations become standardized and improved there is the opportunity for significant competition for Tesla supercharging.

1.67 Additionally, while Supercharging stations could proliferate, it is unlikely they could reach market saturation.

1.68 The CEC notes that customers retain the option of purchasing a Plug In Hybrid Electric Vehicle (PHEV) vehicle which offers a reasonable alternative to the extent that gasoline and diesel remain readily available. Accordingly, there is a clear substitute for long-distance road travel, although this is not nearly as cost-effective as EV only travel. As the majority of passenger vehicle travel is local, PHEVs remain a viable option with charging available at Level 1 and Level 2 chargers.

1.69 The CEC submits that increasing deployment of Fast Charging stations will contribute to a more robust EV market.

[36] https://www.fleetcarma.com/dc-fast-charging-guide/

D. Summary and Conclusion

1.70 Overall the CEC does not consider there to be a natural monopoly for charging stations or the resale of electricity.

1.71 There is no evidence that one manufacturer or supplier can produce charging stations more cost-effectively than others, and no significant barriers to entry from a cost, technological, patent, first-in domination or other standpoint.

1.72 The UCA and BC Hydro's Terms and Conditions do create barriers to entry and confer monopolies on 'utilities' as defined by the UCA. The CEC submits that the Commission has the jurisdiction to exempt resellers of electricity from this regulation and could allow for a competitive marketplace.

2. Are the customers of EV charging stations captive or do they have a choice?

2.1 The CEC defines the question of customer captivity vs. choice as whether or not customers have access to reasonable alternatives to efficiently achieve their objectives.

2.2 The CEC considers that, as a result of battery capability status and charging requirements there is a distinct difference between the choices available to customers for local travel and for long-distance travel at this time.

A. Local Travel
- Level 1 Home Charging
- Level 2 Private
- Level 2 Public
- Networked stations

B. Longer Distance Travel

C. Summary and Conclusions

A. Local Travel

2.3 The vast majority of electric car charging occurs either at home or at work. In BC, 95% of all car trips in BC urban areas are less than 30 km.[37] Customer choice in local travel is therefore an important indicator of customer 'captivity'

2.4 As discussed below customers generally have significant choice for charging for local travel at the Level 1 and Level 2 charging levels at very low cost.

[37] https://pluginbc.ca/charging-stations/public-charging/

Level 1 Home Charging

2.5 Level 1 home charging is ubiquitously available for single residential family properties and home charging can frequently be secured for drivers living in condominiums or strata. Level 1 charging is also frequently available in office garages or other longer-term parking locations.

2.6 For this level of charging, customer choice is determined by vehicle choice and there are a significant number of competitive options in both EV and PHEVs. All EVs can utilize the standard outlet for home charging ensuring there is no captivity.

2.7 The CEC therefore considers there to be significant customer choice for Level 1 charging.

Level 2 – Private Charging

2.8 Level 2 Fast charging is also fairly ubiquitous and is accessible to most EV car types with adaptors. As part of the Clean Energy Vehicle program (Community Charging Infrastructure Fund) British Columbia invested $2.7 million towards supporting deployment of Level 2 charging infrastructure.

2.9 Level 2 charging is available for private home or office charging and may either be plugged in or hardwired. As noted in Section 1 there are many manufacturers and purveyors of Level 2 charging station equipment creating customer choice for this equipment.[38] Equipment may be purchased and installed for less than $2000[39] which provides reasonably affordable access for most electric vehicle owners.

2.10 The CEC notes that Flo and Chargepoint offer their own equipment options along with several other manufacturers such as Sun Country Highway, Elmec and Siemens.

2.11 The CEC considers there to be significant affordable choice in the availability of private Level 2 Fast charging.

Level 2 - Public Charging

Proliferance

2.12 Public Level 2 charging is available in parkades, curbside and other charging stations and is also becoming increasingly ubiquitous. Although most charging can be completed at home, public charging is required to 'top up' and relieve range anxiety during daily activities.

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38 http://pluginbc.ca/charging-program/manuf_list/

39 https://cleantechnica.com/2014/05/03/ev-charging-station-infrastructure-costs/

2.13 There are currently believed to be up to 1000 public charging stations in BC.[40]

2.14 Level 2 charging may be classified as either non-networked or part of a networked system. Additionally, many stations are free to use while others require payment. There is no industry standard and pay-per-use varies from location to location.[41] Typical costs are in the order of $2.50 flat rate or $1.00 per hour.[42]

2.15 The City of Vancouver manages 75 Level 2 public charging stations. No payment is required at the vast majority of these stations however fees will be introduced at 9 locations in order to promote turnover. Fees are being kept as low as possible to support access and promote sharing. The City estimates that there are an additional 175 charging points available to EV driving that are managed by parking garages, hotels, shopping malls, and other services.[43]

City of Vancouver Charging Rates

Electric Vehicle User Fees
What rates are being introduced?

The EV charging station user fees, along with any parking fees, will be paid as a blended rate at the charging station, unless otherwise noted. As well, unless otherwise noted, EV user fees will initially be in effect only for daytimes (9am-6pm) with evening and overnight rates left at $0.

Blended rate of parking and EV charging station range from $2 per hour to $8.50 per hour. The higher rates are due to high parking-per-hour rates, as the initial EV charging rates per hour are not higher than $2 per hour.

Site	Parking Rate ($/hr)	EV Rate ($/hr)	Blended rate (paid at EV station, $/hr)	Network Provider	# plugs
Aquarium	$2.50	$1.00	$3.50	Chargepoint	2
Britannia Community Centre	$0	$2.00	$2.00	Chargepoint	2
City Hall* City business only during daytime	$3.00 from 6pm - 6am weekdays and all day weekends and holidays.	$2.00 weekdays	$3.00 evenings and weekends	Chargepoint	4
	$0 from 6am - 6pm weekdays.	$0 evenings and weekends.	$2.00 weekdays.		
Coal Harbour Community Centre*	Daytime: 6, to a maximum of 16.00	Daytime (6am-7pm): $2.00	Daytime: $8.50 for first 2.5 hours, then $2.00 per hour	Chargepoint	2
	Evenings: $7.00 flat rate (7pm - 6am)	Evenings (7pm-6am): $0	Evening: $7.00 flat rate		
Hastings Park / PNE*	N/A	$1.00	$1.00	Chargepoint	2
Hillcrest Community Centre	$0	$2.00	$2.00	Flo	2
Mainland	$4.00 daytime. Free overnight	$2.00 daytime. Free overnight	$6.00 daytime and evening Free overnight	Chargepoint	2

40 https://pluginbc.ca/charging-stations/
41 https://www.plugndrive.ca/guide-ev-charging/
42 https://www.plugndrive.ca/guide-ev-charging/
43 http://vancouver.ca/streets-transportation/electric-vehicles.aspx

Site	Parking Rate ($/hr)	EV Rate ($/hr)	Blended rate (paid at EV station, $/hr)	Network Provider	# plugs
Mt Pleasant Community Centre	$4.00	$0.00	$4.00	Chargepoint	3
Vancouver Main Library*	N/A	$2.00	$2.00	Chargepoint	3

*Pay at booth or pay at parking meter as applicable.

[44]

2.16 Non-networked stations are not able to communicate with other stations and offer few benefits beyond charging capability.[45] There are many non-networked locations already operating throughout BC, Canada and other parts of the world. They are relatively easy to install and their reasonable costs[46] mean that there is little restriction on their deployment. PlugIn BC provides a webpage devoted to Planning and Hosting a Charging Station with 7 clear steps, and a list of resources for prospective hosters. The CEC submits that level 2 public charging stations the can be expected to continue to grow in availability as the market for EVs grows.

2.17 The CEC submits that the availability of non-networked charging stations offer customer choice to home charging or to network based charging.

Networked Stations

2.18 Networked charging stations are connected to other stations and/or to a server. Some of the benefits include data tracking, remote monitoring and updating, charge station reports, user access controls, mobile app integration, payment collection and online reservation systems.[47]

2.19 There are 3 main charging service networks in BC, including ChargePoint, VERNetwork/Flo and GreenLots (Level 3 DCFC chargers). The majority of B.C.'s Level 2 networked stations are free to use, however drivers may be required to join a service network to access the stations. Members are offered various ways to authorize the use of a charging station, such as scanning a member card at the desired charging station. EV owners can obtain a member card by registering online with the charging service networks.

2.20 ChargePoint and Flo dominate the Level 2 network stations in BC. However are an additional 7 network operators active in other provinces. In the US, five of the nine charging networks in the AFDC data base provide 75.8% of the public charging

[44] Electric Vehicle User Fees, http://vancouver.ca/files/cov/Electric-vehicle-user-fees-november.pdf
[45] https://pluginbc.ca/charging-stations/
[46] https://cleantechnica.com/2014/05/03/ev-charging-station-infrastructure-costs/ Note: $6000 US converted to CAD
[47] https://pluginbc.ca/charging-stations/

locations. Chargepoint is the world's leading electric vehicle charging network and commands 39.3% of the market share.[48]

Customer Access

2.21 There are several websites that identify charging stations by geographic region which provides easy access for customers to select a nearby public charging station. These typically reference two major station locator websites including ChargeHub and Plugshare.[49]

2.22 PlugShare and ChargeHub provide location services enabling drivers to identify charging sites and the operator of and kinds of Plugs and charging rates. For instance, PlugShare identifies three kinds of plugs at a particular hotel in Vancouver. This includes Tesla (6), EV Plug Chargepoint (1) and NEMA Non-networked (1). At a public parking lot PlugShare identifies 10 stations of non-networked EV Plugs. Although it is not possible to have the live status of non-networked charging stations, ChargeHub facilitates check-ins to alert other drivers to its occupation.[50]

2.23 The CEC submits that networked charging service is already a competitive business and does not have captive customers, particularly considering the private charging options available. Given the ongoing proliferation of Level 2 charging sites, and the opportunity for customers to identify locations and types of plug-ins available the CEC considers that customers have reasonable choice for this type of charging.

2.24 The CEC submits that the low prices and ubiquitous charging opportunities provide significant customer choice as customers do not need to search far for low cost charging. The CEC recognizes this pricing is frequently a result of subsidization.

2.25 The CEC recognizes that the Chargepoint, Flo and Tesla networked stations may initially command market share based on benefits available. But potential competition from other network providers from the US, declining costs and improving battery technologies should provide significant market discipline.

2.26 The CEC has developed a model for projecting the number of charging stations required for future years. It shows that a very large number of charging stations will be required in the future and will ensure that there is no customer captivity. (Details provided in Section 8)

2.27 There are currently relatively few DC Fast chargers and Superchargers available for customers in BC for local travel which reduces customer choice for this type of charging.

[48] http://evadoption.com/statistics-of-the-week-us-electric-vehicle-charging-stations-chargers-and-networks/
[49] Chargehub.com and Plugshare.com
[50] https://chargehub.com/en/networks.html

However customers only requiring local travel have the option of Level 1 and Level 2 charging.

B. Longer Distance Travel

2.28 Longer distance travel[51] for 'all-electric' vehicles generally requires access to Fast Charging, either through DC Fast chargers or the Tesla Superchargers to complete a trip with acceptable charging times. Drivers with PHEV's can travel longer distances using a combination of gasoline and electricity, albeit at significantly higher cost.

2.29 As discussed above, different Fast Charging technologies are currently required for different vehicle types, and there is contention for dominance of the Fast Charging market.

2.30 Charges are in the order of about $15.00/hour.[52]

2.31 At present, there is limited deployment of DC Fast charging stations and Tesla Supercharging stations throughout BC. PlugInbc states that there are over 30 DCFC stations in BC (excluding Tesla superchargers)[53] and there are several more stations expected to be added in 2018.[54]

2.32 Greenlots is the currently the only network used for BC's DC Fast Charging Stations and has established itself further as BC Hydro's partner in its DCFC charging stations. FortisBC is planning to partner with FLO to establish 5 DCFC utility-based stations as part of the Accelerate Kootenays project.[55]

2.33 The CEC submits that non-Tesla customers have limited choice in DC Fast Charging at present. The CEC expects that with reduction in utility regulation and restrictions on electricity resale there could be a significantly greater number of market participants in the provision of DC Fast Charging.

2.34 Tesla customers have a small network of about 10 superchargers in BC with several more planned for installation by the end of 2018. Tesla has also installed multiple 'Destination' Level 2 Charging stations (Wall connectors) at restaurants and hotels to in the lower part of the province as well as in a few locations farther north, such as Fort St. John.

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[51] Longer-Distance travel refers to travel in excess of 30 kms.
[52] https://www.plugndrive.ca/guide-ev-charging/
[53] https://pluginbc.ca/charging-stations/public-charging/
[54] Acceleratekootenays.ca
[55] FortisBC EV DCFC Service Application Exec. Summary page 1

2.35 Tesla owners are able to charge in a DC Fast charging stations with a special adapter and Tesla owners therefore have more choice than other EV owners for fast charging. Certain Fast Charging stations are beginning to include technology that permits charging of Teslas, similar to Tesla Supercharger stations, although this is not supported by Tesla.

2.36 For context there are approximately 12,000 gasoline stations in Canada (or approximately 3 stations for every 10,000 people) owned and operated by at least 4 major suppliers (Chevron, Esso, Shell, Petro Canada) and several smaller corporations such as Mohawk, Domo, and others.[56] This array serves approximately 3.6 million vehicles registered in BC[57] (plus travellers) compared to approximately 3,700 EV's and 1,750 PHEVs.[58] The CEC notes that gasoline stations do not need to differentiate themselves on the basis of local or long distance travel, and do not compete with home refuelling. Additionally, several gasoline stations are closing in certain areas of the province, particularly in the lower mainland where rising property values have changed the economics of the stations. This reduction in gasoline availability is creating additional contention for refueling for vehicles with combustion engines and will over time serve to diminish the differential in convenience afforded by the existing network of refueling stations.

2.37 The CEC submits that overall, customers have reasonable choice in EV charging given the limited number of EVs in the province, and can be expected to have more as charging stations continue to proliferate.

C. Summary and Conclusion

2.38 The CEC submits that there is significant to reasonable customer choice available for EV charging at Level 1 and Level 2 which facilitates local travel and customers are therefore not captive to a single supplier.

2.39 To the extent that customers require DCFC there is limited customer choice at present however it is expected that these charging stations will increase in number. Greenlots has established itself as a major network manager, however the cost of DCFC service stations are not high and competition could enter with the financial incentive.

2.40 The CEC notes that for long-distance travel, customers have the choice of selecting a hybrid vehicle and utilizing the existing petroleum fuel network.

2.41 Overall the CEC considers that customers of charging stations are not captive and have several options for charging, which will continue to increase.

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[56] https://globalnews.ca/news/3454305/number-of-gas-stations-in-canada-grew-in-2016/
[57] 2016 data Motor Vehicle Registration by Province and Territory www.statscan.gc.ca
[58] https://pluginbc.ca/2016-stellar-year-evs-bc/

3. Should the Commission regulate the service provided by EV charging stations? What are benefits and detriments to such regulation?

3.1 The CEC addresses this issue in the following manner:

A. Should the Commission regulate the service provided by EV Charging Stations
B. General Advantages and Disadvantages of regulation
C. Types of Regulation
D. Regulation of Utility Supply to EV Charging Stations
E. Other Jurisdictions
F. Summary and Conclusions

A. Should the Commission regulate the Services provided by EV Charging Stations?

3.2 As noted above, the UCA assigns a broad definition of public utility and includes

> (a) the production, generation, storage, transmission, sale, delivery or provision of electricity, natural gas, steam or any other agent for the production of light, heat, cold or power to or for the public or a corporation for compensation[59]

3.3 Under Section 88(1)(2)and (3) of the UCA, the Commission is provided with discretion to apply its orders as it deems appropriate.

3.4 Regulation of services provided by EV charging stations for compensation are within the Commission's jurisdiction to regulate.

3.5 The CEC does not believe that it is necessary for the Commission to exert a level of regulation normally applied to utilities for purveyors of electricity for electric vehicle charging.

3.6 The CEC has provided information above that indicates many entities are already actively participating in the electric vehicle charging market, and the EV market is growing rapidly with significant change. There is no natural monopoly. The CEC provides evidence below that there is significant capacity for a robust competitive marketplace to develop in the future.

3.7 The CEC submits that ultimately the electric vehicle market could develop to the point that EV charging can be managed competitively.

Charging Station Competitive Landscape in the Future

3.8 The CEC has modeled the future growth of EV and AV charging stations and has analyzed the current geographic distribution of charging station capacity.

[59] *Utilities Commission Act*, Definitions

3.9 The current distribution of charging stations was taken from the ChargeHub publicly available data on their website and has been captured at approximately March 1, 2018. BC Hydro says that the number of charging stations is closer to 1000 so at this time the data below should be considered a subset, albeit a very large sample. The current distribution of charging stations is showing substantial geographic distribution and evidence of an active competitive market with many competitors providing the service for business marketing reasons.

Current Public Charging Stations by Region						
	Level 2			**DCFC**		**Totals**
Region	**Non-Tesla**	**Tesla**	**Tesla Compatible**	**Non-Tesla**	**Tesla**	
Vancouver Island	118	13	4	4	1	140
Greater Vancouver	218	0	0	0	0	218
Fraser Valley	37	0	0	0	0	37
Sea to Sky	10	5	1	2	2	20
South Interior	17	12	4	0	0	45
Okanagan	27	25	11	2	2	69
Cariboo	6	9	2	3	3	21
North Interior	32	4	5	1	1	47
Totals	**465**	**68**	**27**	**28**	**9**	**597**

3.10 Currently BC has approximately 10 EV's per charging station, which would be in the mid-range of the jurisdictional review data.

3.11 The CEC model projections for numbers of charging stations is based on an NREL study estimating the number of charging stations that should be required per electric vehicle. The data the CEC used for its projections showed approximately 25 EVs per station. Other studies have shown a substantial range of electric charging stations per unit of penetration of electric vehicle into a population.

3.12 The figure below was produced by The International Council on Clean Transportation (ICCT). This data shows a potentially wide range for adoption of electric vehicles charging stations in multiple jurisdictions around the world with significantly different levels of charging stations. This data shows that the current charging station projections the CEC is using are toward the high end of the jurisdictional comparison.

3.13 Consequently, the CEC submits that its model projections are likely appropriate for the purposes of planning and decision making regarding the appropriate regulatory structure for this market. Also, the CEC can produce scenario models for any range of parameters used in its modeling if the Commission would like alternative views.

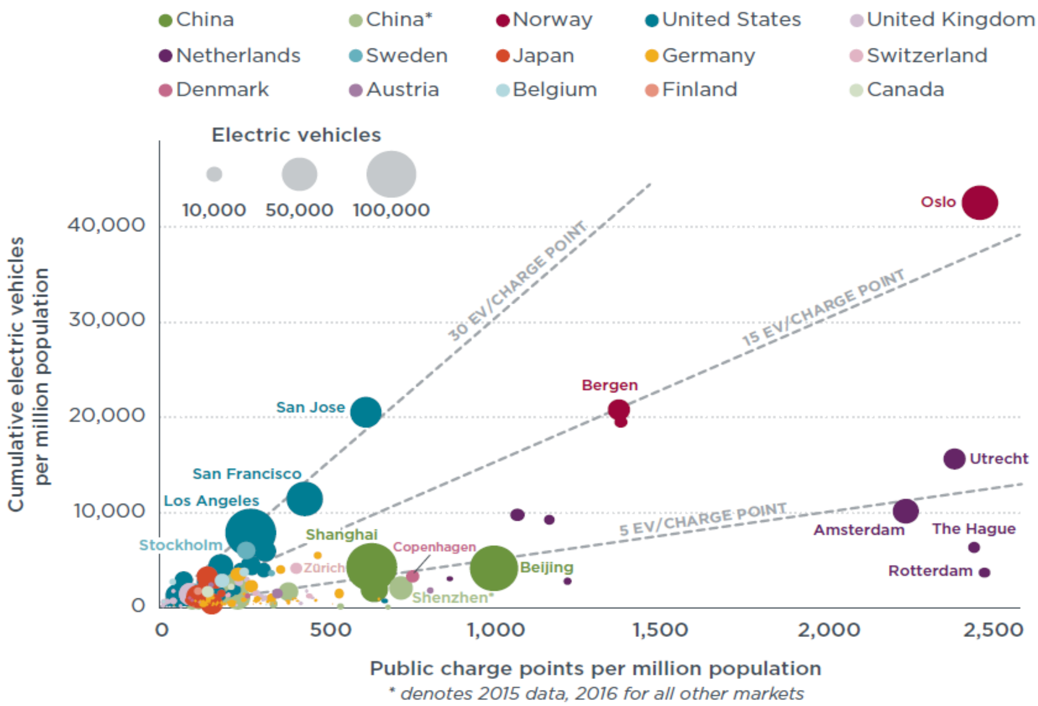


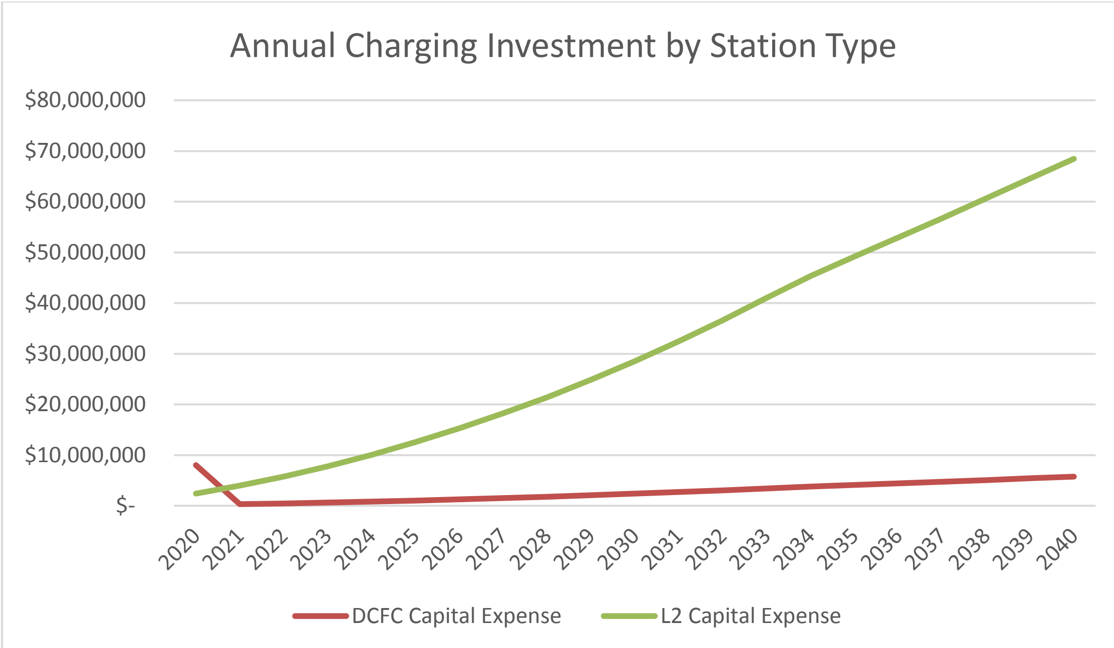
Figure 2. Public charging infrastructure and electric vehicle registrations per million population by metropolitan area, with size of circles indicating total electric vehicles.

3.14 The CEC's projection of charging stations for EV charging in BC are shown in the table below distinguishing between Level 2 charging and DC Fast Charging. From this projection it can be seen that the number of charging stations required will be very large. For a transformation of the light vehicle transportation market to EV's and AV's the charging station requirements could be 3 time the CEC projection shown below.

CEC EV Charging Station Projections

Year	Capacity L2	Capacity DCFC	Coverage (highway) DCFC
2020	603	8	112
2021	959	13	112
2022	1475	20	112
2023	2172	29	112
2024	3070	41	112
2025	4191	56	112
2026	5555	75	112
2027	7183	97	112
2028	9097	123	112
2029	11316	153	112
2030	13863	187	112
2031	16760	226	112
2032	20028	270	112
2033	23690	319	112
2034	27736	374	112
2035	32123	433	112
2036	36847	497	112
2037	41914	565	112
2038	47325	638	112
2039	53086	715	112
2040	59200	798	112

3.15 The investment in the future required for BC-based EV charging stations could reasonably be expected to grow to over $100 million with a full transformation of the market to electric vehicles requiring closer to $500 million. The CEC's estimate of charging station costs is shown below but is limited to the costs for the equipment and does not cover other capital costs or ongoing operating costs for which the CEC has made other estimates.



3.16 The CEC concludes from this analysis that the charging station market will grow into a completely robust competitive market driven by technological changes at a number of levels.

3.17 Consequently, the CEC recommends that the Commission give significant weight to this potential future environment and establish the regulatory regime for this market now under an anticipated competitive market scenario. The CEC recommends that the Commission establish utility participation in the EV charging market in unregulated competitive corporate structures separate from inclusion in the utility's rate base. To the extent that the Commission would like to facilitate EV charging, or particularly the DCFC versions of EV charging, this could be accommodated from the utility with the presumption of transfer at a future time to the unregulated competitive corporate structure.

Obstacles to Competition

3.18 The CEC submits that government policies enabling subsidization and the regulatory burden imposed by the UCA have the potential to limit competition from developing.

3.19 Municipalities, such as the City of Vancouver, and commercial entities are often not seeking compensation for the electricity provided for EV charging which results in free or very low charging costs for electric vehicle owners but little profit potential or incentive for competitors to enter the market, particularly in DCFC where the costs of infrastructure are higher. Since municipalities and other tax funded entities purchase electricity from BC Hydro at commercial rates the free distribution of electricity to EV owners creates a taxpayer subsidy to owners of electric vehicles. Charging infrastructure costs are also being subsidized by several government programs[60] at a variety of government levels. Commercial entities providing charging may rely on subsidization or may simply absorb the relatively low cost into their own business model for their own commercial purposes, and distribute it as a service to those customers with electric vehicles.

3.20 In addition to policy and other governmental reasons and influences the CEC expects that the zero to low charging rates situation has at least partially developed for commercial enterprises in order to avoid the regulatory burden that would apply as a reseller deemed to be a 'public utility.' The standard regulatory burden is onerous.

3.21 The Commission, with ministerial approval, has the power to exempt entities from regulation pursuant to Section 88 (3) of the UCA.

> Application of orders
>
> 88 (1) In making an order, rule or regulation, the commission may make it apply to all cases, or to a particular case or class of cases, or to a particular person.
>
> (2) The commission may exempt a person from the operation of an order, rule or regulation made under this Act for a time the commission considers advisable.
>
> (3) The commission may, on conditions it considers advisable, with the advance approval of the minister responsible for the administration of the *Hydro and Power Authority Act*, exempt a person, equipment or facilities from the application of all or any of the provisions of this Act or may limit or vary the application of this Act.

3.22 The CEC submits that it would be appropriate for the Commission to provide some form of exemption for the provision of electricity for electric vehicles to allow costs to be recovered and a reasonable profit to be generated.

3.23 The CEC submits that a model similar to that of the Class Exemption for BC Hydro Customers that Resell Electricity Under Certain Lease Agreements could be appropriate, or a more open model which allowed for light regulation with limited reporting.

B. General Advantages and Disadvantages of Regulation

3.24 The CEC submits that in general, regulation has significant advantages in controlling pricing to ensure fairness, allowing broad access and preventing price gouging, especially where the market is limited to one or a very limited number competitive suppliers and the

[60] https://pluginbc.ca/charging-program/charging-solutions-incentives/

product or service represents a basic requirement, such as the ability to have lights, heat, run equipment etc. Ensuring broad access to BC's electricity resources and preventing price gouging is one of the benefits of BC Hydro's restriction on the resale of electricity.[61]

3.25 As noted above BC Hydro's Electric Tariff Section 9.1 'Resale of Electricity' does not generally allow for a profit to be generated from the resale of electricity to tenants.

> 9.1 Resale of Electricity
>
> If a Customer wishes to resell to a tenant of the Customer at the same Premises and on a metered basis Electricity provided by BC Hydro to the Customer, the price for such Electricity will not exceed the price that BC Hydro would have charged had such tenant been a Customer of BC Hydro. This requirement will be included in an agreement for resale between BC Hydro and the Customer.

3.26 The CEC submits that the principle behind this tariff section is that a profit should not be generated on the resale of electricity. The CEC submits that under competitive market conditions it is reasonable for the Commission to permit a profit to be made on the resale of electricity. To a theoretical degree this occurs in any business using large quantities of electricity in the production of goods and services for sale to other markets. The CEC submits that under competitive market conditions, where access to electricity is largely unrestricted the energy may be considered as a ratepayer commodity resource appropriately used for economic or other objectives as it is under other commercial uses.

3.27 Additionally, regulation can ensure that scarce public resources, such as electricity can be managed cost effectively and distributed fairly. For example, regulation to cost-causation principles enables energy to be provided to a customer group at its average cost of service.

3.28 Regulation also has the ability to facilitate the cost-effective deployment of important products and services by creating a market scenario that supports this function when it might not otherwise be supportable in a competitive environment. Demand side management (DSM) regulation ensures that programs and activities are available to support behaviours deemed to be in the public good.

3.29 On the negative side, regulation can inhibit competition, reduce differentiation and limit the development of multiple options by preferentially selecting a single or a few suppliers. Regulation can be a very expensive addition to the cost of service creating higher costs and is inconvenient and difficult for stakeholders. Regulation that acts as an obstacle to market participation can be used by businesses to create moat-like advantages

[61] BC Hydro Electric Tariff 9.1 Resale of Electricity

where none would normally exist and create excess profit opportunities. Similarly, it could allow survival of businesses that full competition might otherwise reject as overly costly.

3.30 The CEC submits that the Commission should consider both the public interest in the development of the electric vehicle market and the impacts that will likely accrue to BC Hydro and other stakeholder interests from such development if left to market forces or if regulated to some varying degree.

3.31 Development of the infrastructure and accessibility to affordable fast charging stations in a reasonably ubiquitous network can be expected to be key in the penetration and use of electric vehicles and particularly 'all electric' vehicles for long-distance travel.

3.32 The CEC submits that the Commission's approach to regulation will likely be significant in the timeliness, extent and affordability of the EV charging infrastructure development in BC. However, the CEC also considers that the determination of the value of expanding the electric vehicle market is primarily the purview of government policy at the federal, provincial and municipal levels. Ultimately the CEC believes that the EV market development will be heavily influenced by the course of developments worldwide, in North America, the United States and the rest of Canada.

3.33 The CEC submits that a long-term view of the market supports the facilitation of a competitive marketplace and the regulatory obstacle to such competition should be removed to the greatest extent possible.

C. Types of Regulation

3.34 The CEC considers that there are several types of regulation available to the Commission related to electric vehicle charging stations, such as:

- Price regulation of charging station rates
- Rate design
- Equipment standards
- Customer Access and Services provided
- Safety
- Utility supply

Price Regulation

3.35 The CEC submits that one of the kay considerations with regard to charging station regulation is the potential for price gouging. To the extent that the Commission facilitates the resale of electricity with prohibitions on mark-ups customers are protected from price gouging on the explicit delivery of energy. However, it is not unreasonable to expect that indirect price gouging could occur through the use of service or other fees and requirements affiliated with the electricity charging where one or a few suppliers dominate the industry.

3.36 At Level 1 and Level 2 charging there are several consumer options and low barriers to entry. At present, many of the public EV charging stations provide free charging, due to subsidization, because of the nominal cost or because of the attraction it provides for other services being offered, such as parking or accommodation. The CEC would therefore not expect price gouging to occur at this level.

3.37 At Level 3 charging there are, at present, significantly fewer customer options and the risk of potential price gouging is greater. Nevertheless, the CEC considers that the cost barriers to entry are not excessive, and there remains significant opportunity for the industry to develop with multiple suppliers absent the regulatory obstacle or cost subsidization for certain providers The CEC submits that once the market is developed there will be no requirement for specific price regulation.

3.38 The CEC submits that during the market development phase it could be reasonable to require simple reporting to ensure reasonable limits on the mark-up of electricity if necessary.

Rate Design

3.39 The CEC discusses Rate Design under Section 4

Equipment Standards

3.40 The CEC notes that equipment for charging stations is currently in a state of flux as equipment manufacturers at all levels of the electric vehicle market (ie. charger manufacturers, battery manufacturers, vehicle manufacturers etc) race to secure position.

3.41 The CEC submits that there is no advantage to establishing specific equipment standards during the present market development beyond that required to fulfill safety and other pertinent code requirements.

Customer Access and Services Provided

3.42 The CEC submits that to the extent that the market for all charging Levels is competitive the market will typically ensure customer access and the appropriateness of services provided.

3.43 Where the market is not competitive and a single or limited set of charging station suppliers are authorized it could be necessary for regulation to stipulate the availability and services required to meet the public interest.

3.44 The CEC does not believe that such regulation is necessary at this time, and will not be unless it becomes apparent that problems have arisen.

3.45 The CEC submits that it would be reasonable for the Commission to provide a process under which customer complaints could be examined by the Commission if market barriers develop.

Safety

3.46 The CEC is not aware of significant safety concerns arising from EV charging as electrical safety and other such concerns regarding charging stations are addressed under federal or provincial regulation.

D. Regulation of Utility Supply to Charging Stations

Price and Rate Design of EV Rates

3.47 Price regulation and rate design at the utility level could regulate the price that electric vehicle charging stations would pay to receive electricity for that use. This could include the development of an EV rate either on a separate tariff or within the existing tariff structures.

3.48 For instance, electric vehicle charging at home could be priced to reflect the incremental demand placed on the electric system from multiple households plugging in and charging overnight. Time of Use rates could be utilized to manage demand and optimize the use of the transmission and distribution systems.

3.49 Commercial charging stations could be assessed a special rate that reflected the price of future distribution network upgrades and build-outs that might potentially be needed to accommodate the fast charging stations.

3.50 The CEC recognizes that the electric grid and Load Resource Balance could be significantly affected by the uptake of electric vehicles. As the electric vehicle population increases, it is expected that there could be a significant increase in BC Hydro's overall load.

3.51 Additionally, there is likely to be a significant impact on peak demand at both a local and regional level as drivers begin to charge when they arrive at home after the workday.

3.52 Further, fast DC charging stations utilize a great amount of power for short periods of time, potentially meaning that additional upgrades will be required to the distribution network.[62]

3.53 The CEC does not believe that a special tariff for electric vehicle charging is necessary or appropriate. As discussed below in Section 5, it is anticipated that EV charging stations can purchase electricity at commercial or residential rates which already recover their cost of service.

3.54 The CEC considers that the electric vehicle charging will continue to proliferate and act as one of the many end-uses for electricity such as lighting, equipment operation, space heating etc that is employed now and will be in the future. The CEC notes that electric vehicle charging applies to both commercial and residential customers, and as such, the costs are appropriately included in the rate class cost of service analysis.

3.55 The CEC notes that the Commission does not typically regulate electric utilities by end-use. The CEC does not support electric regulation by end-use or end-user type as it will ultimately become complex and potentially unduly discriminatory.

E. Other Jurisdictions

3.56 At present there is no clear and consistent approach to the regulation of EV charging, and there is a wide variety of complicating factors as a result of the various regulatory frameworks in existence.[63]

3.57 Most states have yet to determine an approach and are awaiting information as to the outcomes of various alternatives.[64] There has been a recent trend in the US towards the exemption of EV service providers from statutes governing public utilities with California Public Utility Commission leading the way in 2010.

3.58 Affirmatively enabling public utility investment in EV charging stations is also happening and this has been undertaken in Oregon which permits non-regulated, non-rate base participation.[65]

3.59 The outcomes of these approaches are not yet known.

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[62] https://www.theicct.org/sites/default/files/publications/EV-charging-best-practices_ICCT-white-paper_04102017_vF.pdf

[63] http://www.pepperlaw.com/publications/electric-vehicle-charging-station-regulation-why-your-local-electric-vehicle-charging-station-doesnt-and-shouldnt-look-like-your-local-gas-station-2016-06-23/

[64] http://www.pepperlaw.com/publications/electric-vehicle-charging-station-regulation-why-your-local-electric-vehicle-charging-station-doesnt-and-shouldnt-look-like-your-local-gas-station-2016-06-23/

[65] http://www.pepperlaw.com/publications/electric-vehicle-charging-station-regulation-why-your-local-electric-vehicle-charging-station-doesnt-and-shouldnt-look-like-your-local-gas-station-2016-06-23/

F. Summary and Conclusion

3.60 The CEC considers that it is appropriate for the Commission to exempt EV charging stations from standard utility regulation. The CEC considers that it could be reasonable for the Commission to provide high level regulation of the pricing and service access during the transition period until a competitive marketplace has the opportunity develop. However, if the Commission chooses to regulate end-use charging, even temporarily, the CEC recommends that a clear transition to a competitive market be established.

3.61 Overall, the CEC finds that the Commission does regulate distribution of electricity and should continue to do so by exempting EV charging stations from regulation except for a simple annual reporting requirement.

4. Should the rate design of EV charging stations be established under a public utility's traditional cost of service model or some other model. And, within that context, what are the customer pricing options (Eg. Energy rate vs. time-based rate)?

4.1 The CEC notes that there are two service station rates that can apply a) between the electric utility (BC Hydro or FortisBC Inc.) and the charging station provider, and b) between the charging station provider and the end consumer. The Commission typically regulates the utility to customer rates based on customer class and not on the end use. A commercial or other customer is free to use the energy as it requires. The Commission has regulated the price to the consumer when electricity is resold as a commodity, as in this case.

4.2 The CEC provides the following structure in addressing this issue.

A. Electric Utility Rates to Service Station Providers
B. Electric Vehicle Charging Service to End Customers
C. Utility Operated Fast Charging Stations
D. Customer Pricing Options
E. Time of Use Rates
F. Summary and Conclusions

A. Electric Utility Rates to Service Station Providers

4.3 The rates charged between the electric utility and the service station provider are currently covered under the existing residential and commercial tariffs. These tariffs generally provide for each rate class to recover its cost of service.

4.4 At present, electric vehicle charging is so minimal that it does not materially impact the cost of service of any rate class. Additionally, electric vehicle charging is also used by both commercial and residential end-users. At this time therefore, the CEC does not believe that a separate Electric Vehicle tariff is required between the utility and the station owner.

4.5 The CEC notes that electric vehicle charging is anticipated to become significantly greater in the future and could influence the Load Resource Balance (LRB) as well as requiring upgrades for the local distribution network as a result of the high-power requirements for DC Fast Charging. The CEC submits that a Cost of Service based model can appropriately attribute costs to the relevant rate class based on cost causation.

4.6 The CEC considers that the existing commercial rates to charging station service providers, based on the cost of service model are the most appropriate way for the utilities to collect their revenue requirements.

B. Electric Vehicle Charging Service to End Customers

4.7 The CEC does not support the establishment of a separate, regulated rate for EV charging stations to end customer.

4.8 The primary model options for regulating and establishing charging station rates include the traditional cost of service model, a formula-based model, a market-based model, or a subsidized model.

4.9 A cost of service model establishes rates based on a reviewed cost to provide service, plus a regulated profit. The advantages of a traditional cost of service model are that costs are clearly identified and customers can be charged at the costs that they cause for the utility with a pre-determined rate of return. Utilities are unable to use their position of control to extract better than fair profits and customers receive value for their payments. Cost of service regulation is typically used for large utilities and it can be cumbersome and costly to regulate.

4.10 A formula-based regulatory model establishes pricing based on a formula oft-times established with a cost of service foundation. Formula based models (such as Performance Based Ratemaking) are intended to adjust the incentives of utilities to promote cost containment while at the same time reducing the cost of regulation. Formula-based models, particularly those paired with intermittent Cost of Service regulation, have the disadvantage of creating incentives for inappropriate cost reductions combined with the opportunity to increase costs during the cost of service regulation periods, paving the way for future cost reductions in formula-based regulation periods.

4.11 Market based models allow charging stations to seek compensation based on what the market will bear. Market based models are the hallmark of competitive markets where vendors are free to maximize profits, but profits are kept in check by purchasers who are free to choose alternatives.

4.12 Subsidized models provide subsidization by a government, utility or other entity to a purveyor where the market will not support the growth of product/service, but the service is deemed to be in the public interest.

4.13 Overall the CEC considers that a market-based model is the appropriate model for charging service station rates in the long term for all charging stations and in the near term for Level 1 and Level 2 types of charging, while fast charging may need some short term assistance for long-distance highway travel

Level 1 Home Charging

4.14 Level 1 home charging customers typically utilize their own electricity provided under the residential (or potentially commercial) tariff. The cost of home charging will increase BC Hydro charges by about $15-$35 per month depending on vehicle and usage.[66]

4.15 The CEC recommends that electricity for residential charging be provided to the end customer by the utility under utility residential rates derived from cost of service analysis.

Level 2 Public Charging

4.16 Level 2 charging stations are relatively inexpensive to install, appear to be accommodated in the business model of the reseller and there are few barriers to competition beyond subsidization and utility regulation. Additionally, they are proliferating in such a manner that customers have a wide range of options for charging. Customers also have the option of Level 1 home charging.

4.17 The CEC notes that the charging stations will (presumably) be purchasing electricity from the utility at a rate that already recovers its cost of service. Price signal considerations are already embedded into the price of energy.

4.18 The CEC therefore submits that it is reasonable to allow market forces to determine the appropriate rates for Level 2 charging. The CEC considers that it would be appropriate for the Commission to permit the resale of electricity for compensation at Level 2 charging and exempt the purveyors from the relevant sections of the UCA, using a complaint driven process to assess issues as they arise. The CEC believes this would

[66] https://www.bchydro.com/powersmart/electric-vehicles/owning-an-electric-vehicle/ev-and-your-bill.html

preserve the option for the Commission to regulate if a necessity arose but would not interfere in the development of the competitive market.

4.19 The CEC believes that competition and alternative charging options will ensure low rates for EV end use customers. Electric vehicles will not be restricted to a single group but will instead cut across all ratepayers. The CEC expects that the cost of electricity and the cost of charging service will be combined into a single electric vehicle charge rate and would not be readily distinguishable in any event.

4.20 To the extent that the Commission is willing to remove the restriction on electricity commodity resale for profit but not willing to allow an entirely free market at present, the CEC submits it could be appropriate for the Commission to temporarily allow for a rate based on a cost of service plus maximum return on investment mark-up model through light regulation and minimal reporting for suppliers of multiple networked charging stations. This model would protect consumers from price gouging and ratepayers from paying for infrastructure used to earn a profit for a small number of resellers.

4.21 The CEC recommends light regulation and adoption of a competitive market-based service.

Competitive Level 3 DC Fast Charging (DCFC)

4.22 Level 3 charging stations are more expensive to install (up to $100,000) and are generally required to provide charging service for long-distance/intercity travel. There are fewer existing charging stations and the cost of the infrastructure is not as readily justified by customer attraction to another business model.

4.23 With regard to Level 3 DCFC charging, the CEC believes that a competitive market is also the preferred option and will ultimately result in the fairest pricing. The CEC considers this to be achievable in the future given the relatively low cost of infrastructure and limited barriers to entry, and the long-term forecasts for electric vehicles. The CEC believes it is important that the Commission consider the long-term marketplace when establishing its current regulation so as to facilitate development and avoid unnecessary and artificial constraints

4.24 The CEC recognizes that at present ‘competition’ for fast charging is limited or does not exist creating a potential for price gouging if only one or a few suppliers enter, or are authorized to enter the market. Nevertheless, the CEC does not believe it is appropriate for the Commission to establish a specific rate for the resale of electricity for EV charging. The CEC does not agree with the pricing of electricity by end-use, which results in a myriad of overlaps by rate class, has significant cost of service analysis complications and paves the way for other segregation by end-use.

4.25 Additionally, the CEC considers that there is no clear, enforceable delineation between the resale of the electricity commodity and the sale of services surrounding the sale of electricity. That is, resellers have the option for charging parking fees, facility use fees or other service fees which can equally result in price gouging as a result of the public's requirement for fast charging.

4.26 The CEC submits that a single EV charging rate could also be unfair as charging stations can be expected to have significantly different cost structures based on their location or other factors relevant to the establishment of a charging station.

4.27 The CEC submits that light regulation would be appropriate for DCFC until a robust competitive market is established. The CEC considers it would be appropriate for the Commission to permit the resale of electricity with a conditional exemption from the standard public utility requirements under the UCA. Resellers could be required to provide annual reporting of costs and income enabling the Commission to ensure that price gouging did not occur. Such a method would allow the Commission to retain oversight and oversee rates while the infrastructure and competition is building.

4.28 The CEC notes that DC Fast Charging services have the potential to cause increases in the costs of local distribution network. Fast charging stations use very high amounts of power for short periods of time, such that more expensive upgrades may be required with relatively low usage.[67] Cost of service analysis can appropriately be used to ensure these costs are included in the price of the commercial rates being charged to the station, and ultimately would likely be passed into the rates passed on to the Fast Charging consumers. The CEC submits that this is a reasonable outcome.

Regulation as a Means to Promote Deployment

4.29 The CEC recognizes the 'chicken and egg' situation concerning DCFC charging station deployment. Significant market motivation for the widespread installation of DCFC fast chargers does not yet exist due to the minimal population of EV long-distance travellers and the restrictions on resale of electricity for profit; at the same time, a network of charging stations will be necessary to advance the adoption of EVs for long-distance travel.

4.30 However, the CEC notes the federal and provincial support for EV charging infrastructure which contribute to the development of the charging networks. The CEC submits that profitable resale of the electricity commodity could facilitate the establishment of a DCFC charging network throughout the province for the benefit of all and may well be the appropriate means to achieve the necessary infrastructure.

[67] Emerging Best Practices for Electric Vehicle Charging Infrastructure page 24

4.31 The CEC submits that a provisional reduction in the current public utility reporting requirements for the resale of electricity for compensation would be adequate to remove the barrier to the deployment of DCFC charging stations and allow DCFC charging stations to proliferate according to market demands. The CEC notes that DCFC charging stations are being deployed throughout the United States and that electric vehicle sales are continuing to increase. The CEC submits that these forces can ultimately result in the deployment of a competitive network of charging stations in BC given some reasonable profit potential.

4.32 Under market-based rates the rate structure would be established by the reseller and enable them to meet their cost structures as necessary. The CEC submits that over time this will result in a fair market price for customers.

C. Utility Operated Fast Charging Stations

4.33 BC Hydro operates a number of DC Fast Charging stations[68] and FortisBC is intending to install 5 DC Fast charging stations in its service area.

4.34 FortisBC has requested a specific EV charging rate which it has developed based on a levelized cost of service rate. The rate would remain flat over a 10 year analysis period and would collect the incremental cost of service over that period.[69] Cost of service includes power purchase expense, operations and maintenance expense, property taxes, depreciation, amortization of CIAC, income taxes and earned return.[70] The CEC notes that the rate would reflect the utility's cost structure and the cost of capital would be included in the utility rate base.

4.35 The CEC submits that there is no requirement for the Commission to establish an electric vehicle charging service as part of the FortisBC utility or to provide a separate rate for such a program. The CEC does not agree that the utility should provide added infrastructure to its rate base when the service can be provided in a competitive marketplace. The CEC submits that participation by the utility could potentially serve to restrict competitive participation, particularly where cost subsidies exist and significantly diminish profit potential.

4.36 The CEC considers that to the extent FortisBC wishes to participate in the electric vehicle market it could do so from the position of an unregulated entity purchasing energy from FortisBC at commercial rates as discussed under Section 6.

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[68] FortisBC Electric Vehicle DCFC Service Application page 19
[69] FortisBC Electric Vehicle DCFC Service Application page 19
[70] FortisBC Electric Vehicle DCFC Service Application page 13 and Appendix C

4.37 To the extent that the Commission determines that it would be appropriate for a utility to provide a EV charging service and rate, the CEC submits that it is reasonable to base the rates on its cost of service rather than a formula or subsidized rate.

D. Customer Pricing Options

4.38 Pricing options to the customer include:

- Energy level-based charge by kWh or other measure
- A periodic time-based charge (monthly, annually or other)
- Charging time based – fixed and energy blended charge
- Per charge based
- No charge subsidy
- Low charge subscription subsidies
- Charges embedded in GHG tax; tax credit applied (provincial subsidy)
- Charges embedded in price of vehicle as tax on others, or in price of car from purchase

4.39 FBC proposes a time-based rate of $9.00 per half hour pro-rated to the second of time spent plugged in at the station plus a 15 percent transaction fee for global management payable to FLO.[71] They assume 20kWh per charge event based on reviewing 2 BC Hydro owned DCFC charging stations, a City of Vancouver estimate of use (25kWh) and a PlugInBC website.

4.40 Other BC charging hosts are based on a price per kWh ($0.35). The FBC rate equates to approximately $0.38/kWh.

4.41 FBC states in its application that energy-based rates hamper efficient use of charging stations as users may not be incented to vacate the parking space. Additionally they point out that energy meters internal to the EV DCFC stations are not currently accredited by Measurement Canada and as such they are only considering time-based rate options.

4.42 The CEC acknowledges that at present the Measurement Canada accreditation represents a significant restriction, but submits that the concern surrounding parking can readily be managed with regulation, and further that this concept applies to charging stations that are also used as parking spaces, and would not necessarily apply to charging stations used for recharging by long-distance travellers as is similar to gas-stations.

4.43 The CEC is concerned that a time-based rate does not necessarily reflect the consumption of electricity, but instead the charging rate of the vehicle. The CEC notes that charging rates vary significantly with the level of existing charge.

[71] FBC EV DCFC Service Application page 18

E. Time of Use Rates

4.44 TOU electricity rates have different prices for different times of use.

4.45 Typically, when an electric utility is constrained by the capacity it has to deliver electrical energy and periodically the demand for electrical energy exceeds the capacity to supply that electrical energy at a point in time. At that time the utility can become more efficient if it is able to encourage customers to switch their demand for the electricity to another point in time when the utility is not capacity constrained.

4.46 One way to encourage electric utility customers to switch their demand for electricity to a different point in time is to provide a higher price signal for the potentially capacity constrained time periods and a lower price signal for the periods of time that are highly likely to not be capacity constrained. This is effectively time of use pricing.

4.47 Capacity constraints for electric utilities are limits to the generating capacity and the transmission capacity to deliver power. The utility can run into these constraints at peak demand time periods which will occur both seasonally and at particular times of the day and the week.

4.48 Accurately providing TOU pricing will depend on the capabilities of smart meters, which can be used to measure the electricity delivered by time periods, which can be measured to a level of resolution at 5 minutes increments. The charging of time of use rates may more typically be hourly.

4.49 TOU pricing typically will be established for high load hours (6:00 am to 10:00 pm) and low load hours (10:00 pm to 6:00 am). For BC Hydro the peak demands are cold weather related and occur in the winter months from November to February.

4.50 BC Hydro's integrated resource plans indicate that the utility is likely to become more capacity constrained in the future, whereas in the past this was not as significant a problem. BC Hydro also is approaching the point at which it will has developed all of the inexpensive capacity it had available and is now having to consider planning for much more expensive capacity options. Consequently, it will become increasingly valuable for BC Hydro to consider implementing TOU pricing.

4.51 Electric Vehicle (EV) requirements if they become ubiquitous could have the potential of requiring significant upgrading of the electric distribution systems, making TOU pricing to encourage EV charging to be done overnight a very valuable option for avoiding the potentially significant costs of electric system upgrades. Conversely, TOU pricing for EV's, encouraging overnight charging, can be considered as increasing the efficiency of the capital already invested in the electricity generation, transmission and distribution systems.

4.52 The CEC submits that TOU pricing should continue to be piloted by BC Hydro and should eventually be adopted by the utility on a mandatory basis for all residential and commercial customers because of the cost-effectiveness of the efficiency improvements it offers in better utilization of BC Hydro's entire electricity delivery system.

4.53 The CEC does not support subsidization models where a competitive model can provide service.

4.54 Overall the CEC considers that prices which reflect the cost of service in terms of energy use and demand are the most rational and likely to have the best outcome in delivering an appropriately competitive market.

4.55 The CEC submits that a combined demand and energy- based charge such as exists in utility commercial rates is preferable as it most accurately reflects the combination of fixed and variable costs of the electric grid and the consumption by the customer.

4.56 The CEC recommends that the Commission establish with the utilities timeframes for implementation of TOU pricing with appropriate decision milestones.

F. Summary

4.57 The CEC submits that it is appropriate for the market participants to develop their own pricing structure for electric vehicle charging as an end-use, but that to the extent the Commission establishes an end-use rate it should reflect cost of service characteristics.

4.58 The Commission's utility rate design for electricity distribution should be based on cost of service and move toward Time of Use pricing for residential and commercial customers, including any EV charging that occurs under these tariffs.

4.59 EV charging station rates should be established by the market providers.

5. Should the EV charging station service rate be based on a public utility's existing wholesale or commercial or some other rate?

5.1 The CEC does not support the introduction of a separate EV rate for electricity either between the utility and an EV charging station provider, or between an EV charging station provider and the public consumer.

5.2 The CEC does not consider EV charging to represent a distinct rate class as it does not have significantly differing costs of service characteristics from other rate classes, which are large and defined by the group of consumers rather than by end use.

5.3 The CEC notes that there is wide variation in the use of electricity sold under both the commercial and residential tariffs which accommodates differences in amount, load factor, demand characteristics, value to the subscriber and many other conditions. The CEC submits that electric vehicle charging is appropriately considered one of those uses and can readily be accommodated under the existing residential and commercial tariffs.

5.4 The CEC addresses the issue in the following manner:

A. Rates from the Utility to the Charging Station
B. Rates from the Charging Station to the Public
C. Other Considerations
D. Summary and Conclusions

A. Rates from the Utility to the Charging Station

5.5 For commercial purposes, the CEC submits that BC utilities should sell electricity to a charging station at the utility's standard commercial rates which properly recover their cost of service.

5.6 For residential purposes, the CEC submits that BC utilities should sell electricity to a resident with a need for charging at the utility's standard residential rates which also recover their cost of service.

B. Rates from a Charging Station to the Public

5.7 The CEC submits that market-based rates are the preferred long-term rates for EV charging and should not be defined by the Commission but established by each provider in an unregulated competitive environment

5.8 Market rates would likely reflect the commercial rates in the electricity sold to the reseller and incorporate additional expenditures or other profit requirements. The CEC submits it should be up to the reseller to determine the appropriate model for their unique circumstances.

5.9 The CEC submits that to the extent the Commission disagrees and undertakes to select a rate design for the Utility (ie. from the Utility to the EV station provider or user) it should be based on a cost-of-service (COS) model which reflects the existing end cost of build-out and delivery costs required to service the Electric Vehicle market. Such a model would ensure fairness in the principle of cost-causation because those customers necessitating the development would pay for the infrastructure developed.

C. Other Considerations

5.10 To the extent that the Commission wishes to establish rates for EV charging stations to the consumer, there are several additional options open to the Commission.

5.11 The CEC submits that one consideration in setting rates would be the optimal management of the electric grid. Time of Use and Non-firm service off-peak energy rates would permit the Commission to passively manage the demand on the electric grid particularly at the residential level, and encourage charging overnight, or when the demand for electricity is generally lower.

5.12 The CEC does not consider that wholesale rates or subsidized rates have any particular rationale to establish their merit and does not support the use of these rates as a basis for EV charging.

D. Summary and Conclusions

5.13 The CEC submits that the EV charging station rates should be lightly regulated overall and be unregulated as to rate design and pricing. The electricity supplied by the utility should be provided at residential or commercial rates as the case may be.

6. Should Public Utilities include EV charging stations in their regulated rate base or through a separate non-regulated utility?

6.1 The CEC addresses this issue in the following manner:

A. Regulated Rate Base or Non-Regulated Utility?
B. Summary and Conclusions

A. Regulated Rate Base or Non-Regulated Utility?

6.2 The CEC does not consider it necessary for the electric utility (Ie. BC Hydro or FortisBC) to establish charging stations independently of the market.

6.3 The CEC is of the view that the primary value of utility participation in the charging market is the opportunity to develop the initial DCFC charging station network throughout BC. However, there is a significant market-based push throughout the world to establish the DCFC charging infrastructure and this should be encouraged to develop in BC in the private sector competitive market.

6.4 Long-term participation by utilities could have the effect of dampening participation by other prospective competitors by entrenching themselves in primary locations and pre-establishing rates based on utility cost-structures.

6.5 The CEC submits that it might be reasonable for the Commission to facilitate temporary participation in the DCFC market in order to encourage the development of the EV market overall which is clearly an objective of government at several levels. Utility based DCFC charging stations along highway corridors could be provided on a temporary basis before moving to a competitive market-based model.

6.6 To the extent that BC utilities do participate in the market, the CEC submits that it would be preferential for them to participate through a separate non-regulated utility purchasing electricity from the regulated utility at standard commercial rates. Capital costs and risks could be absorbed by the non-regulated company and the Commission may oversee the relationship to ensure there is no cross-subsidy from the regulated utility to the unregulated utility.

6.7 A non-regulated utility would more accurately reflect the cost-structure of a market-based charging service enterprise and facilitate competition. Under such a scenario, the utility would be free to establish rates based on market demand and competition could be expected to enter where pricing was excessive. To the extent that the Commission wished to manage pricing during the infrastructure development period it could do so with annual reporting to oversee reasonable prices if necessary.

Other Jurisdictions

6.8 According to recent US information a small number of US states have affirmatively permitted utilities to own and operate EV charging stations. The Public Utility Commission of Oregon permits electric utilities to invest in EV charging stations as a non-regulated non-rate base venture. In Texas utilities own and operate EV charging stations successfully.[72] However Texas also allows for competition in the sale of electricity in parts of the state not served by a municipal owned power company or cooperative.[73]

B. Summary and Conclusions

6.9 The CEC submits that utilities should not include EV charging stations in their regulated rates. If they are to provide such service they should do so through a separate non-regulated utility. Utility participation in providing fast charging stations on long-distance

[72] Why Your Local Electric Vehicle Charging Station Doesn't (And Shouldn't) Look Like Your Local Gas Station
[73] State Utilities Law and Electric Vehicle Charging Stations

highway corridors may be useful to temporarily fill a gap in the market until the market develops further.

7. If public utilities provide EV charging services within their regulated business, is there a risk of cross subsidization to support this new service and if so, is the proposed rate design potentially unduly discriminatory?

7.1 The CEC addresses this issue in the following manner:

A. Cross Subsidization Risk
B. Summary and Conclusions

A. Cross Subsidization Risk

7.2 The CEC considers that as a new service with both fixed and variable costs there is a theoretical risk of cross-subsidization between non-EV utility ratepayers and EV utility ratepayers in either direction if the EV charging service is established within the regulated business.

7.3 To the extent that the EV charging service under-recovers its cost of service over a reasonable period of time non-EV ratepayers could be responsible for the recovery of the capital expenditures, rate of return, operating expenses and all other fixed and variable charges. To the extent that the utility acquires electricity it is unable to sell at least at its incremental cost, the additional costs would also be to the account of the non-EV ratepayer. Conversely, if the EV charging service over-recovered its cost of service over a significant period of time there is the potential for cross-subsidization to occur in the other direction.

7.4 The CEC notes that cost recovery for an EV utility-based service would include appropriate allocation of all the transmission, distribution, customer costs etc. which are caused as a result of the provision of the service. Energy sold to commercial customers may include a basic charge and demand charge as well as an energy charge and these are potentially valid considerations in assessing the EV cost of service recovery as well.

7.5 The CEC finds that the service proposed by FBC has very limited risk of cross-subsidization from non-EV ratepayers to EV ratepayers.

7.6 The CEC finds the expenditures to be relatively low and FBC's assumptions regarding sales and prospective revenues to be conservative.

7.7 The Present Value of the Annual Revenue requirement is $278,000 over 10 years. Capital expenditures are expected to be approximately $500,000 gross, and only $160,000 net of a Contribution in Aid of Construction from the Community Energy Association.[74] Additional capital of $55,000 is anticipated for communications and consultation. Earned return is estimated at $10,000 in year 1, and declining to $4,000 by year 10.

7.8 Operating costs are also generally low.

Cost of Service											
Power Purchase Expense		2	2	3	4	4	6	7	9	11	14
Operation & Maintenance	Line 39	6	6	6	7	7	7	7	7	7	7
Property Taxes	Line 44	-	-	0	0.3	0.3	0.4	0.4	0.4	0.4	0.4
Depreciation Expense	Line 70	32	32	32	32	32	32	32	32	32	32
Amortization Expense on CIAC	Line 84	(22)	(22)	(22)	(22)	(22)	(22)	(22)	(22)	(22)	(22)
Income Taxes	Line 127	2	(2)	0	2	3	4	4	4	5	5
Amortization		4	5	5	5	5	5	5	5	4	4
Earned Return	Line 109	10	10	9	8	8	7	6	5	5	4
Incremental Annual Revenue Requirement	Sum of Line 2 to Line 9	**35**	**32**	**34**	**36**	**37**	**39**	**40**	**41**	**43**	**45**
PV of Revenue Requirement (After-tax WACC of 5.88%)	Line 10 / (1 + Line 111)^Yr	33	28	29	29	28	27	27	26	26	25
Total PV of Annual Revenue Requirement	Sum of Line 11	***278***									

7.9 The annual revenue requirement is approximately $30,000, with a PV of $278,000 over 10 years and FBC's proposal is expected to recover the full $278,000.

7.10 However, the CEC does not have the inputs of the Power Purchase expense, and is therefore unable to determine if the rate properly recovers its cost of service in power purchase, transmission, distribution etc. To the extent that the Power Purchase expense rate does not recover these costs, there is a risk of cross-subsidization to the non-EV ratepayers.

Undue Discrimination

7.11 The CEC does not consider there to be undue discrimination at present as a result of the small market size, although this is expected to grow significantly. In the future cost of service analysis can allow for proper cost allocation to ensure there is no cross-subsidization.

B. Summary and Conclusions

7.12 The CEC finds that the inclusion of EV charging in utility rate bases would have limited risk of cross-subsidization initially due to the size of the market. Cost of service ratemaking in the future could enable proper cost allocation and eliminate cross-subsidization.

8. Other Matters

A. Long Term Scenarios for Electrification of Transportation

[74] Exhibit B-1, FortisBC Electric Vehicle DCFC Service Application

8.1 The CEC has examined three important model scenarios for disruption in the light vehicle transportation markets, being the following.

1) Internal Combustion Engine Vehicles Only with No EV or AV Development (Individual vehicle ownership with gasoline engines and private sector fueling)

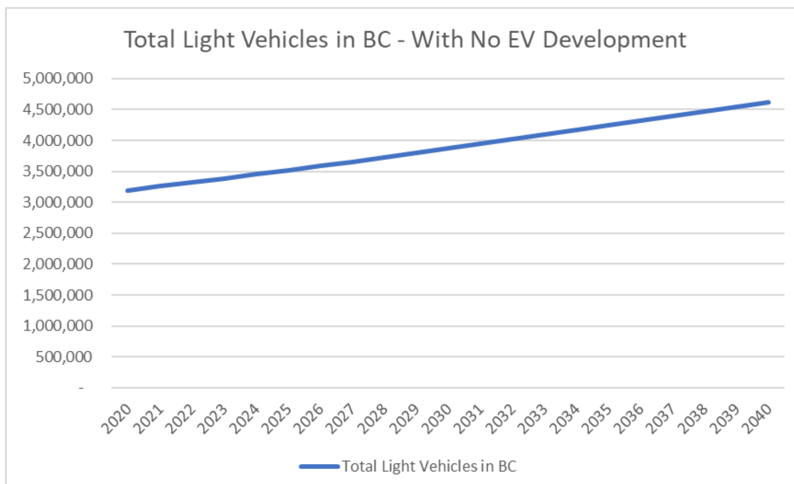
2) Electric Vehicle Displacement of Internal Combustion Engine Vehicles (Individual vehicle ownership with private sector self-service charging)

3) Autonomous Vehicle Displacement of Internal Combustion Engine Vehicles (fleet ownership of autonomous vehicles with ride sharing & automated charging)

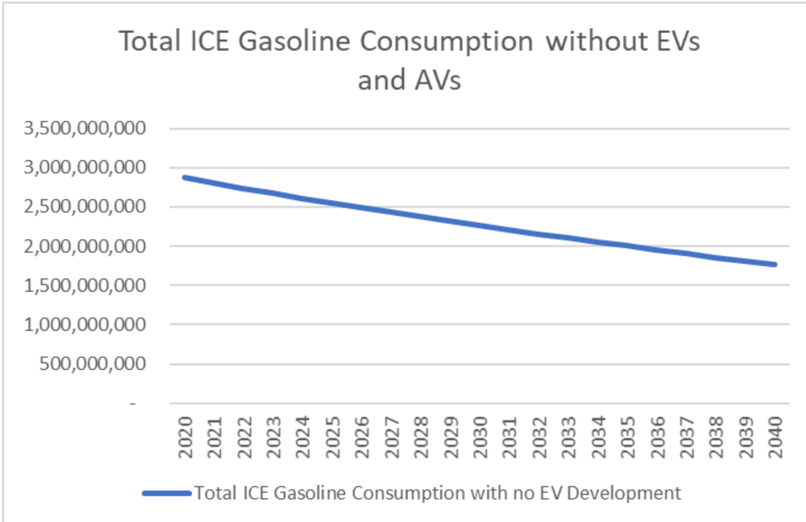
8.2 Each of these scenarios is examined below to assess what sort of issues may arise for the Commission's regulation of the vehicle charging and electricity rate setting.

1) Internal Combustion Engine Vehicles Only with No EV or AV Development (Individual vehicle ownership with gasoline engines and private sector fueling)

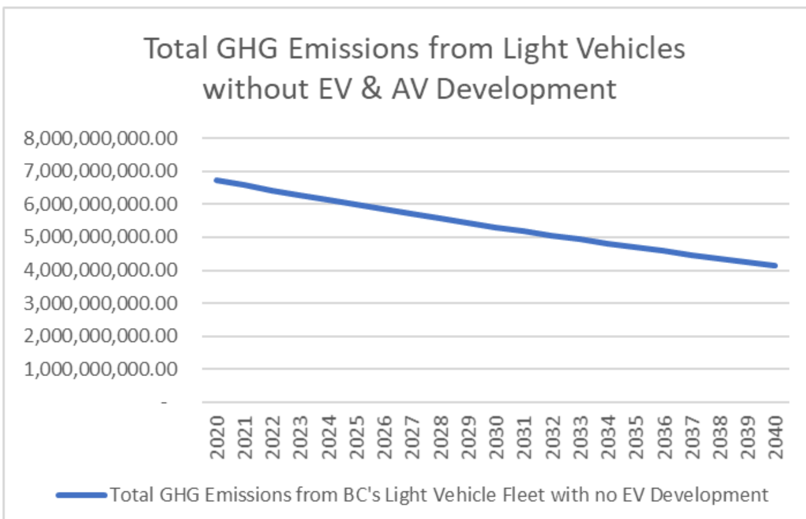
8.3 This scenario assumes individual vehicle ownership of vehicles with gasoline engines and private sector fueling at gasoline stations. The scenario projects existing patterns of vehicle ownership across the growing population demographics recognizing the eligible driver population ages. The BC light vehicle fleet grows from just over 3 million vehicles in 2018 to over 4.6 million for the 20 years planning horizon adopted for the analysis.



8.4 This vehicle fleet is projected to become significantly more efficient in the use of the petroleum-based energy, gasoline used to power the fleet. Fleet fuel efficiency is expected to improve from about 6 litres per 100 km to around 3 litres per 100 km. The consequence of such changes should they occur as forecast would be a significant drop in annual gasoline consumption from over 3 billion litres to just under 2 billion litres over 20 years.

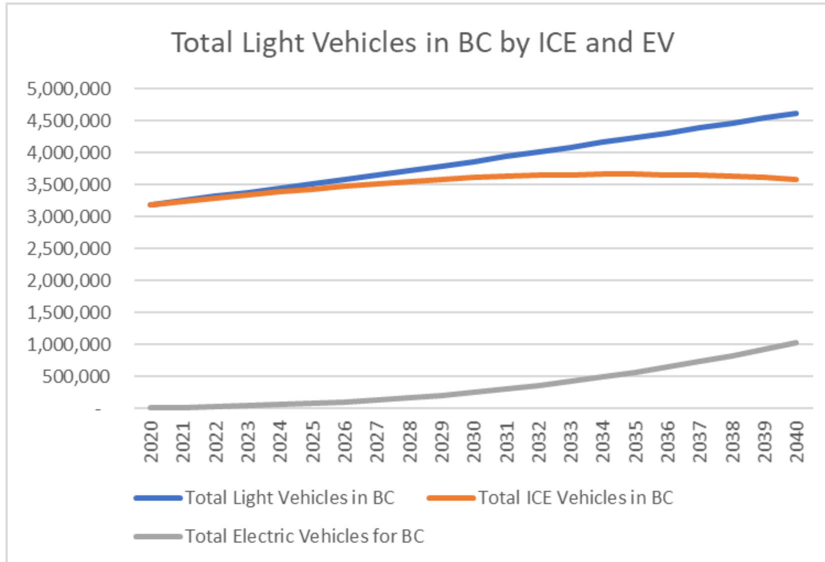


8.5 The vehicle fleet background base assumptions for greenhouse gas emissions are declining because all of the vehicle fleet growth is more than offset by fuel efficiency improvements. The GHG emissions from BC's light vehicle fleet would reduce from over 7 million tonnes of CO_2e emissions to just over 4 million tonnes of CO_2e. Consequently, the vehicle fleet contribution to BC's GHG emissions reductions would be significant without electrification of the fleet.

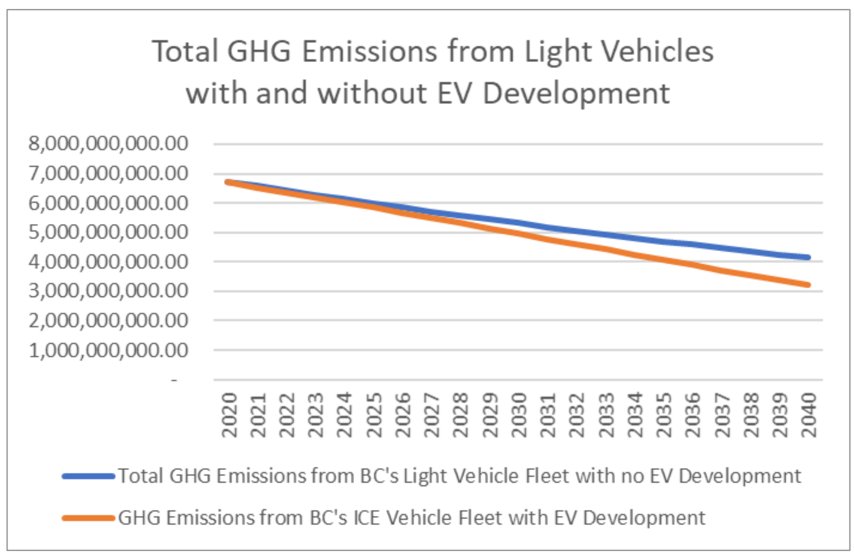


2) Electric Vehicle (EV) Displacement of Internal Combustion Engine Vehicles (Individual vehicle ownership with private sector self-service charging)

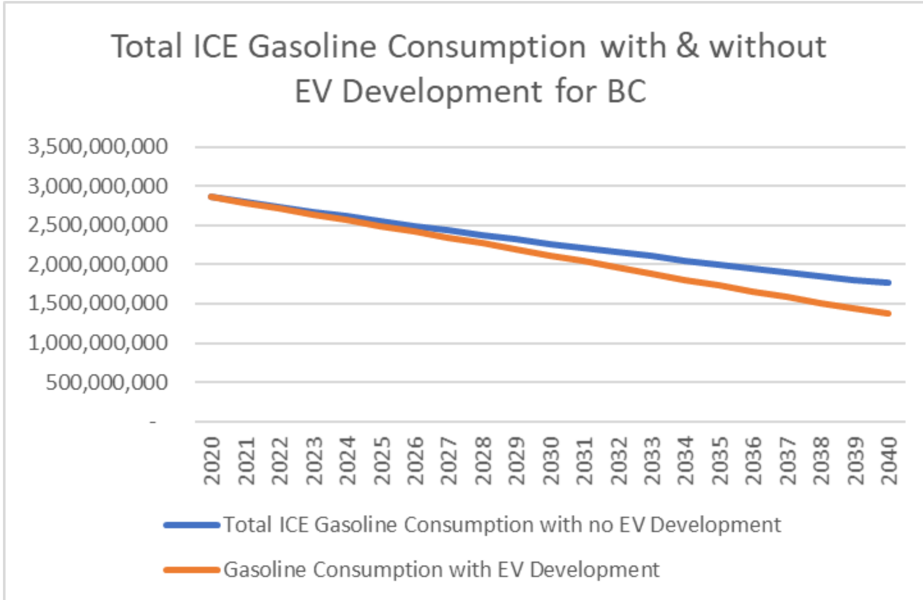
8.6 Electric light vehicles have been developing slowly in BC for some years, currently reaching approximately 6000 vehicles out of a total of about 3 million vehicles or .2% of the BC vehicle fleet. The EV fleet is expected to grow substantially in the coming 20 years as various of the barriers to uptake of the EVs are overcome. As the EV fleet in BC grows toward 1 million vehicles, approaching 25% of the BC light vehicle fleet, the ICE vehicle fleet is reduced significantly and its growth flattens out before it starts declining.



8.7 The gasoline fuel consumption of the BC light vehicle fleet declines further than the efficiency gains for ICE vehicles, which results in a drop of over 38%, increasing the drop to about 45%, because of the EV fleet. The impacts of the combined effects of these light vehicle initiatives, occurring in multiple jurisdictions around the world, will likely have a dramatic effect on the gasoline fuelling station business, the gasoline fuel production refinery business and the crude oil exploration and production businesses.

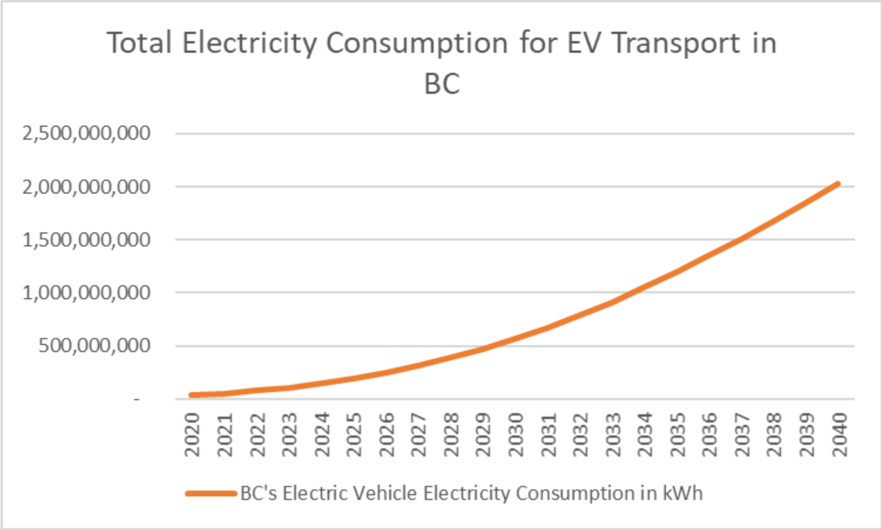


8.8 The consequence of adding electric vehicles to the BC fleet at the levels projected also increases the BC reduction of greenhouse gas emissions from light vehicles. The GHG reductions parallel the reductions projected for gasoline consumption

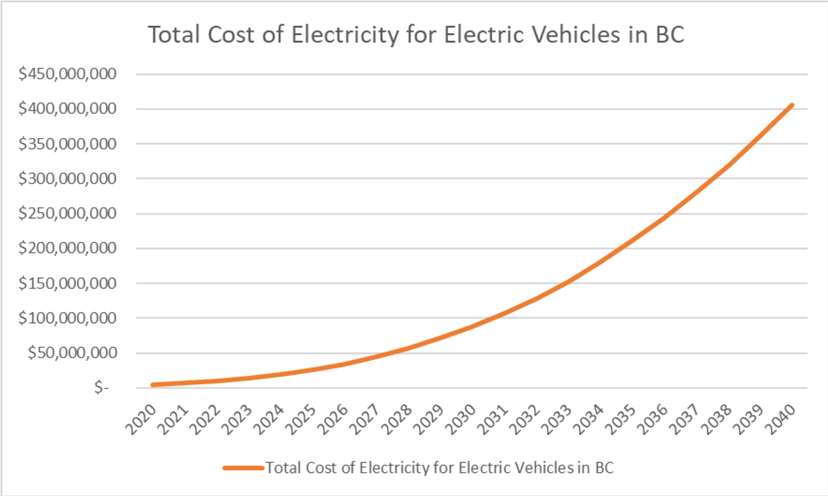


dropping the emission by about 45% over 20 years based on the ICE vehicle fuel efficiency assumptions and the expansion of the EV fleet.

8.9 The expansion of the EV fleet in BC requires the supply of electricity to increase significantly. Over the 20 years period the EV fleet electricity requirements would grow from near zero now to over 2000 GWh of electrical energy consumption.

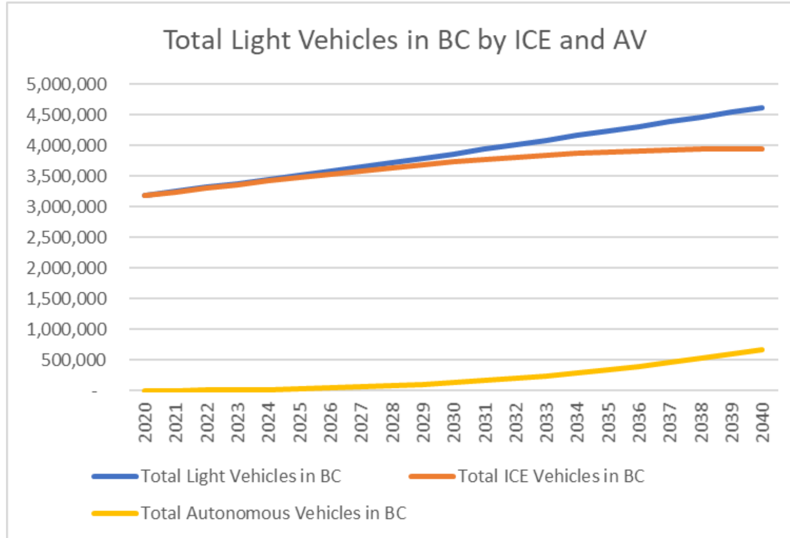


8.10 The cost of electricity for electric vehicles in BC would be a substantial new revenue for BC Hydro growing to over $400 million per year over 20 years. At the residential cost of the electricity to fuel vehicle transportation would be approximately $.04/km driven or about ½ the price of fuel for an ICE vehicle. The electric vehicle would be expected to have additional costs related to battery replacement over the life of the vehicle which could be on the order of $.12/km driven, potentially making the electric vehicle more expensive than gasoline fueling at the present time.

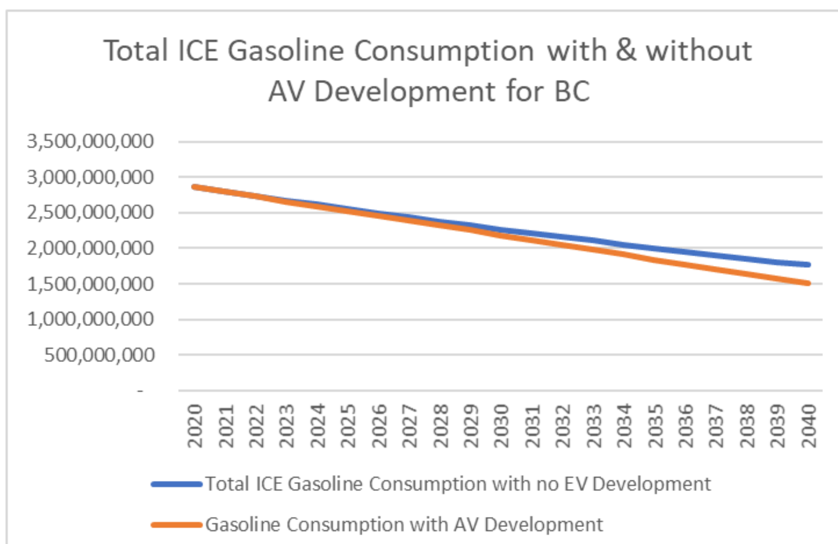


3) Autonomous Vehicle (AV) Displacement of Internal Combustion Engine Vehicles (Autonomous vehicle fleet ownership with ride sharing automated charging)

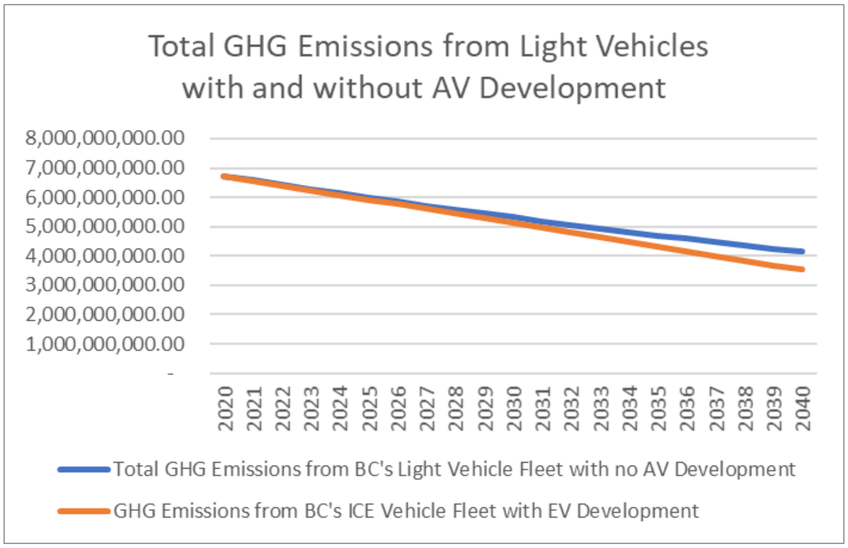
8.11 With the advent of technological changes enabling the potential for autonomous vehicle transportation it becomes possible to assess that the introduction of electric vehicles owned by individuals may be followed by fleets of autonomous electric vehicles owned by the fleet service provider, offering rides for individuals on an as needed basis. It can be anticipated that the autonomous electric vehicle fleets will be a considerably more efficient and less expensive model for transportation giving rise to the potential that the economic drivers for this model for transportation may well dominate in the longer-term future.



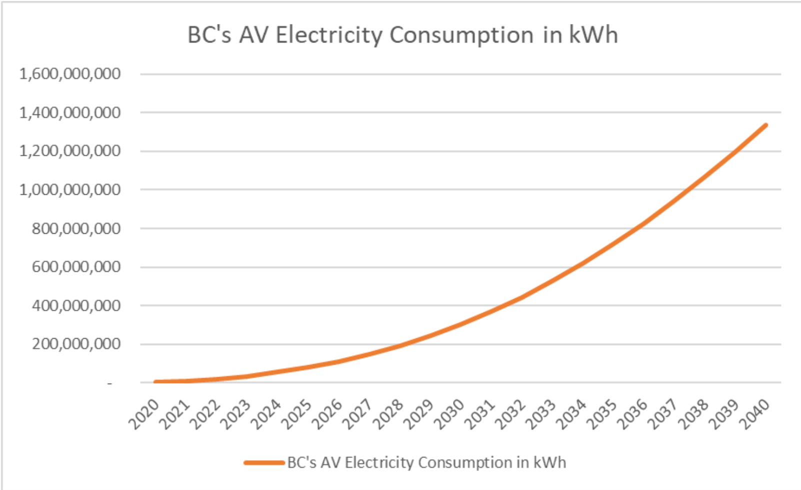
8.12 The total gasoline consumption of ICE vehicles is further displaced by the potential for autonomous vehicle transportation. The slower development of the autonomous electric vehicle service results in a slower displacement of ICE fuel use but could be expected to grow to a level out pacing EV development.



8.13 The greenhouse gas emissions from an AV fleet in BC would be in line with the reduction in gasoline consumption precipitated by the growth of the AV fleets. The impact on transportation emissions reduction would likely grow more slowly than reductions from individually owned electric vehicles.



8.14 The electricity consumption for AV transportation in BC would be expected to grow more slowly than for EV adoption, at least initially, because AV adoption is expected to trail the adoption of individually owned electric vehicles. However, eventually AV adoption may be expected to require substantially less electricity than EV adoption because of the greater potential that AV adoption would have for ridesharing than the individually owned electric vehicle model.



B. Scenario for Future Development of the EV and AV Markets & Their Charging

Adoption Scenarios

8.15 The CEC model currently includes scenarios for differing EV and shared AV adoption rates and reflects the impact that these differences will have on other aspects of the model, which are detailed below.

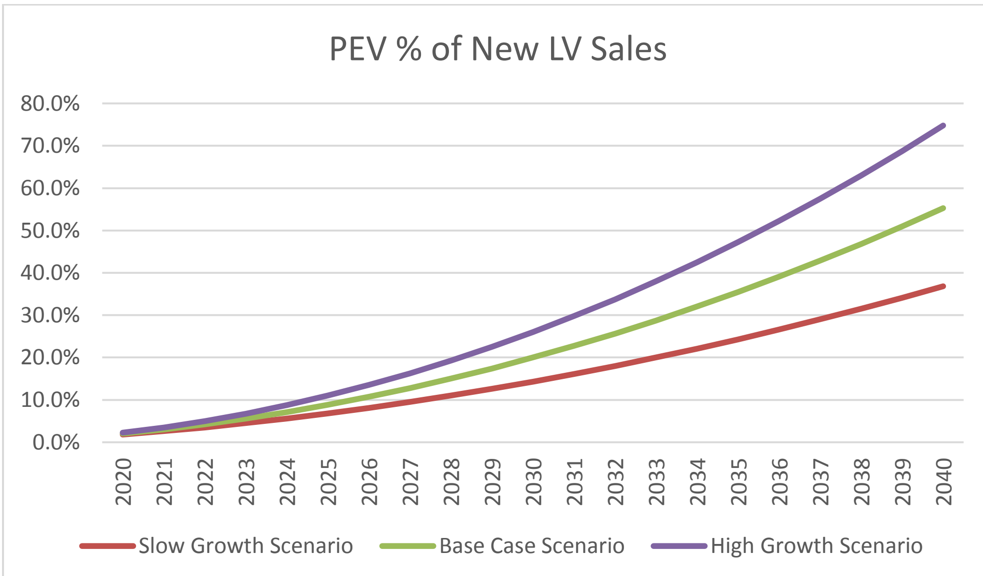
8.16 PEV Adoption Scenarios: The low-, base-, and high- growth scenarios all assume that shared AV grows at the base rate.

8.17 AV Adoption Scenarios: The low-, base-, and high- growth scenarios all assume that PEV grows at the base rate.

8.18 Combined Adoption Scenarios: PEV and AV are evaluated at the same level (low/low, base/base, high/high).

8.19 The graphs display the different growth scenarios, while the tables provide raw numerical data as well as the different scenarios' impact on key outcomes in the models.

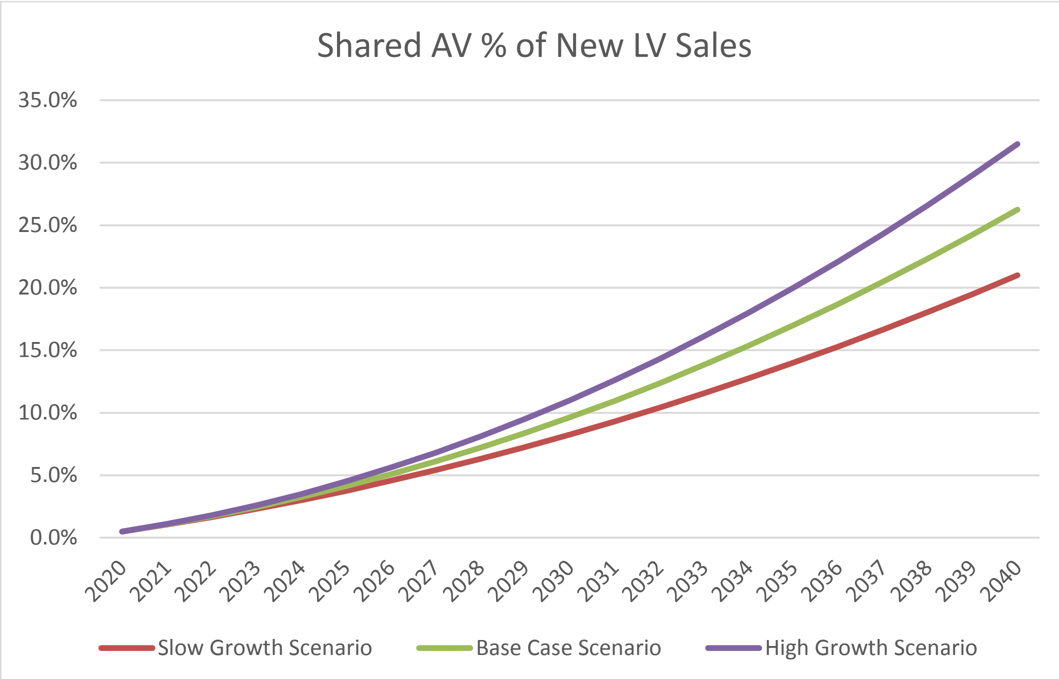
PEV Adoption Scenarios, % of New LV Sales



Year	Slow Growth Scenario	Base Case Scenario	High Growth Scenario
2020	1.8%	2.0%	2.3%
2021	2.6%	3.0%	3.5%
2022	3.5%	4.2%	5.0%
2023	4.5%	5.6%	6.8%
2024	5.6%	7.1%	8.8%
2025	6.8%	8.8%	11.0%
2026	8.1%	10.7%	13.5%
2027	9.5%	12.8%	16.3%
2028	11.0%	15.0%	19.3%
2029	12.6%	17.4%	22.5%
2030	14.3%	20.0%	26.0%
2031	16.1%	22.7%	29.8%
2032	18.0%	25.7%	33.8%
2033	20.0%	28.8%	38.0%
2034	22.1%	32.0%	42.5%
2035	24.3%	35.5%	47.3%
2036	26.6%	39.1%	52.3%
2037	29.0%	42.9%	57.5%
2038	31.5%	46.8%	63.0%
2039	34.1%	51.0%	68.8%
2040	36.8%	55.3%	74.8%

	GHG Emissions (kg CO2e)	Capital Expenses	Energy Costs (PEV + AV)
Slow Growth			
2020	6,699,034,992	$8,397,496	$4,253,059
2030	4,860,434,793	$24,701,679	$97,149,920
2040	2,895,431,003	$67,228,077	$458,546,542
Base Case			
2020	6,697,515,687	$8,615,077	$4,466,992
2030	4,774,776,013	$31,078,179	$118,526,432
2040	2,610,534,945	$88,038,920	$584,550,711
High Growth			
2020	6,695,913,132	$8,844,581	$4,692,646
2030	4,684,423,602	$37,804,077	$141,074,260
2040	2,310,028,145	$109,990,083	$717,459,218

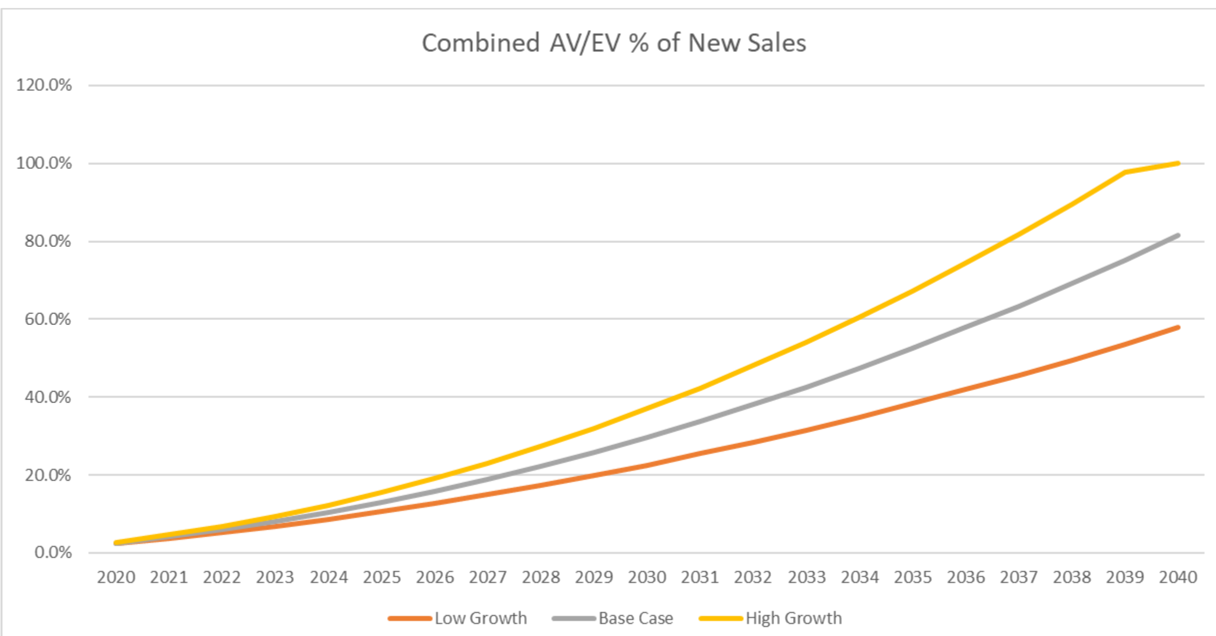
Shared AV Adoption Scenarios



Year	Slow Growth Scenario	Base Case Scenario	High Growth Scenario
2020	0.5%	0.5%	0.5%
2021	1.1%	1.1%	1.1%
2022	1.7%	1.7%	1.8%
2023	2.3%	2.5%	2.6%
2024	3.0%	3.3%	3.5%
2025	3.8%	4.1%	4.5%
2026	4.6%	5.1%	5.6%
2027	5.4%	6.1%	6.8%
2028	6.3%	7.2%	8.1%
2029	7.3%	8.4%	9.5%
2030	8.3%	9.6%	11.0%
2031	9.3%	11.0%	12.6%
2032	10.4%	12.4%	14.3%
2033	11.6%	13.8%	16.1%
2034	12.8%	15.4%	18.0%
2035	14.0%	17.0%	20.0%
2036	15.3%	18.7%	22.1%
2037	16.7%	20.5%	24.3%
2038	18.1%	22.3%	26.6%
2039	19.5%	24.3%	29.0%
2040	21.0%	26.3%	31.5%

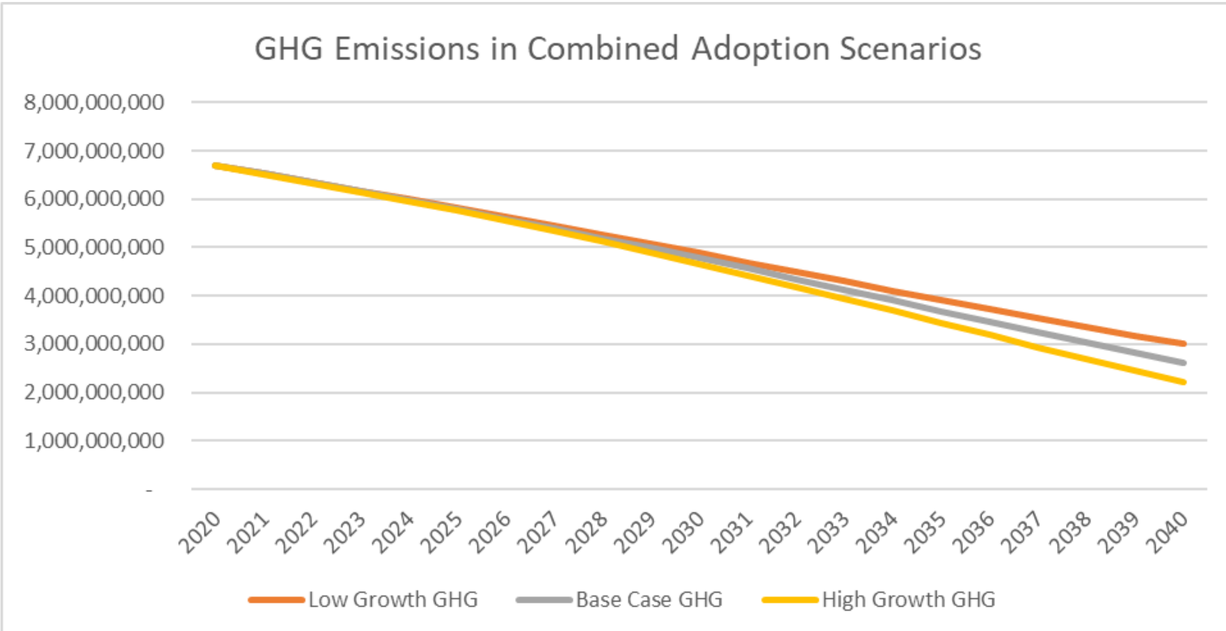
	GHG Emissions (kg CO2e)	Capital Expenses	Energy Costs (PEV + AV)
Slow Growth			
2020	6,697,515,687	$8,615,077	$4,466,992
2030	4,795,793,367	$29,788,838	$115,029,786
2040	2,715,815,119	$81,681,074	$553,508,417
Base Case			
2020	6,697,515,687	$8,615,077	$4,466,992
2030	4,774,776,013	$31,078,179	$118,526,432
2040	2,610,534,945	$88,038,920	$584,550,711
High Growth			
2020	6,697,515,687	$8,615,077	$4,466,992
2030	4,753,758,660	$32,367,520	$122,023,079
2040	2,505,254,772	$94,396,766	$615,593,005

Combined Adoption Scenarios



Year	Slow Growth Scenario	Base Case Scenario	High Growth Scenario
2020	2.3%	2.5%	2.8%
2021	3.7%	4.1%	4.6%
2022	5.2%	6.0%	6.8%
2023	6.8%	8.0%	9.4%
2024	8.6%	10.4%	12.3%
2025	10.6%	13.0%	15.5%
2026	12.7%	15.8%	19.1%
2027	14.9%	18.9%	23.1%
2028	17.3%	22.2%	27.4%
2029	19.9%	25.8%	32.0%
2030	22.6%	29.6%	37.0%
2031	25.4%	33.7%	42.4%
2032	28.4%	38.0%	48.1%
2033	31.6%	42.6%	54.1%
2034	34.9%	47.4%	60.5%
2035	38.3%	52.5%	67.3%
2036	41.9%	57.8%	74.4%
2037	45.7%	63.3%	81.8%
2038	49.6%	69.2%	89.6%
2039	53.6%	75.2%	97.8%
2040	57.8%	81.5%	100.0%

	GHG Emissions (kg CO2e)	Capital Expenses	Energy Costs (PEV + AV)
Slow Growth			
2020	6,699,034,992	$8,397,496	$4,253,059
2030	4,881,452,147	$23,412,337	$93,653,273
2040	3,000,711,177	$60,870,231	$427,504,248
Base Case			
2020	6,697,515,687	$8,615,077	$4,466,992
2030	4,774,776,013	$31,078,179	$118,526,432
2040	2,610,534,945	$88,038,920	$584,550,711
High Growth			
2020	6,695,913,132	$8,844,581	$4,692,646
2030	4,663,406,248	$39,093,418	$144,570,907
2040	2,204,747,971	$116,347,929	$748,501,512



Year	Low Growth GHG (kg CO2e)	Base Case GHG	High Growth GHG
2020	6,699,034,992	6,697,515,687	6,695,913,132
2021	6,527,724,122	6,523,950,017	6,519,976,069
2022	6,351,865,016	6,344,399,498	6,336,551,871
2023	6,176,135,655	6,163,303,864	6,149,834,267
2024	5,997,386,476	5,977,335,567	5,956,312,522
2025	5,816,278,116	5,787,028,482	5,756,390,687
2026	5,632,948,446	5,592,437,212	5,550,038,802
2027	5,447,703,945	5,393,821,836	5,337,470,692
2028	5,260,375,906	5,190,998,390	5,118,488,478
2029	5,072,084,594	4,985,098,098	4,894,236,648
2030	4,881,452,147	4,774,776,013	4,663,406,248
2031	4,688,792,414	4,560,397,168	4,426,417,178
2032	4,495,838,947	4,343,761,367	4,185,139,657
2033	4,302,274,316	4,124,629,734	3,939,417,875
2034	4,107,973,615	3,902,965,816	3,689,308,599
2035	3,916,095,352	3,682,221,977	3,438,573,814
2036	3,727,002,025	3,463,102,755	3,188,274,618
2037	3,540,625,761	3,245,839,197	2,938,953,379
2038	3,357,284,353	3,031,009,472	2,691,459,174
2039	3,177,239,041	2,819,101,701	2,446,515,934
2040	3,000,711,177	2,610,534,945	2,204,747,971

9. Appendices

Appendix A – Background Information

Appendix B – Model

Appendix C – Suppliers of Level 2 Charging Stations

Appendix D – Suppliers of DCFC-Charging Stations

Appendix E – Connector Types for EV Charging

Appendix F - CEC Research Document List

Appendix A
Background Information

1) Introduction[75]

An **electric vehicle**, also called an **electric drive vehicle**, uses one or more electric motors or traction motors for propulsion. An electric vehicle may be powered through a collector system by electricity from off-vehicle sources, or may be self-contained with a battery, solar panels or an electric generator to convert fuel to electricity.[1] EVs include road and rail vehicles, surface and underwater vessels, electric aircraft and electric spacecraft.

EVs first came into existence in the mid-19th century, when electricity was among the preferred methods for motor vehicle propulsion, providing a level of comfort and ease of operation that could not be achieved by the gasoline cars of the time. Modern internal combustion engines have been the dominant propulsion method for motor vehicles for almost 100 years, but electric power has remained commonplace in other vehicle types, such as trains and smaller vehicles of all types.

In the 21st century, EVs saw a resurgence due to technological developments and an increased focus on renewable energy. Government incentives to increase adoptions were introduced, including in the United States and the European Union.[2][3]

2) Batteries[76]

An **electric-vehicle battery** (EVB) or **traction battery** is a battery used to power the propulsion of battery electric vehicles (BEVs). Vehicle batteries are usually a secondary (rechargeable) battery. Traction batteries are used in forklifts, electric Golf carts, riding floor scrubbers, electric motorcycles, full-size electric cars, trucks, vans, and other electric vehicles.

Electric-vehicle batteries differ from starting, lighting, and ignition (SLI) batteries because they are designed to give power over sustained periods of time. Deep-cycle batteries are used instead of SLI batteries for these applications. Traction batteries must be designed with a high ampere-hour capacity. Batteries for electric vehicles are characterized by their relatively high power-to-weight ratio, energy-to-weight ratio and energy density; smaller, lighter batteries reduce the weight of the vehicle and improve its performance. Compared to liquid fuels, most current battery technologies have much lower specific energy, and this often impacts the maximal all-electric range of the vehicles. However, metal-air batteries have high specific energy because the cathode is provided by the surrounding oxygen in the air. Rechargeable batteries used in electric vehicles include lead–acid ("flooded", deep-cycle, and VRLA), NiCd, nickel–metal hydride, lithium-ion, Li-ion polymer, and, less commonly, zinc–air and molten-salt batteries. The amount of electricity (i.e. electric charge) stored in batteries is

[75] Wikipedia. (2018, March 14). Electric vehicle. Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Electric_vehicle
[76] Wikipedia. (2018, March 9). Electric-vehicle battery. Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Electric-vehicle_battery

measured in ampere hours or in coulombs, with the total energy often measured in watt hours.

The battery makes up a substantial cost of BEVs, which unlike for fossil-fueled cars, profoundly manifests itself as a price of range. In the case of the MiEV 2012 model, the price tag and advertised range is close to proportional between two versions with a different battery,[1] giving the (false) impression that the battery makes up close to 100% of the cost (95% for the higher-priced version). However, some of the price difference comes from extra features in the higher-priced version, plus an unknown price premium, making such a retail price comparison a very bad indicator of actual cost of battery capacity, but nevertheless serves to quantify battery capacity as a premium feature. The few electric cars with over 500 km of range (including Tesla Model S with the 85 kWh battery), are firmly in the luxury segment, as of 2015. Since the late 1990s, advances in battery technology have been driven by demands for portable electronics, like laptop computers and mobile phones. The BEV marketplace has reaped the benefits of these advances. However, Mitsubishi ascribes the price reduction of its 2012 model MiEV, compared to the 2011 model, to "a dramatic reduction in the cost of batteries".[1] The cost of electric-vehicle batteries has been reduced by more than 35% from 2008 to 2014.[2]

Rechargeable traction batteries are routinely used all day and fast-charged all night. Forklifts, for instance, are usually discharged and recharged every 24 hours of the work week.

The predicted market for automobile traction batteries is over $37 billion in 2020.[3]

On an energy basis, the price of electricity to run an EV is a small fraction of the cost of liquid fuel needed to produce an equivalent amount of energy (energy efficiency). The cost of replacing the batteries dominates the operating costs.[4]

Range[77]

Driving range parity means that the electric vehicle has the same range than an average all-combustion vehicle (500 kilometres or 310 miles), with 1+ kWh/kg batteries.[54] Higher range means that the electric vehicles would run more kilometers without recharge.

Japanese and European Union officials are in talks to jointly develop advanced rechargeable batteries for electric cars to help nations reduce greenhouse-gas emissions. Developing a battery that can power an electric vehicle 500 kilometres (310 mi) on a single charging is feasible, said Japanese battery maker GS Yuasa Corp. Sharp Corp and GS Yuasa are among Japanese solar-power cell and battery makers that may benefit from cooperation.[55]

- The lithium-ion battery in the AC Propulsion tzero provides 400 to 500 km (200 to 300 mi) of range per charge (single charge range).[56] The list price of this vehicle when it was released in 2003 was $220,000.[57]

[77] Wikipedia. (2018, March 9). Electric-vehicle battery - Range parity. Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Electric-vehicle_battery#Range_parity

- Driving in a Daihatsu Mira equipped with 74 kWh lithium ion batteries, the Japan EV Club has achieved a world record for an electric car: 1,003 kilometres (623 mi) without recharging.
- Zonda Bus, in Jiangsu, China offers the Zonda Bus New Energy with a 500-kilometre (310 mi) only-electric range.[58][*clarification needed*]
- Tesla Model S with 85 kWh battery has a range of 510 km (320 miles). Tesla Model S has been built since 2012. It is priced around US$100,000.
- The supercar Rimac Concept One with 82 kWh battery has a range of 500 km. The car is built since 2013.
- The pure electric car BYD e6 with 60 kWh battery has a range of 300 km.[59]

3) Highway Capability[78]

As of December 2015, there were over 30 models of highway-capable all-electric passenger cars and utility vans available in the market for retail sales. The global stock of light-duty all-electric vehicles totaled 739,810 units, out of a global stock of 1.257 million light-duty plug-in electric vehicles on the road at the end of 2015.[196] The global ratio between all-electrics (BEVs) and plug-in hybrids (PHEVs) has consistently been 60:40 between 2014 and the first half of 2016, mainly due to the large all-electric market in China. In the U.S. and Europe, the ratio is approaching a 50:50 split.[197] Cumulative global sales of all-electric cars and vans passed the 1 million unit milestone in September 2016.[7]

The Renault–Nissan–Mitsubishi Alliance is the world's leading all-electric vehicle manufacturer. The Alliance reached sales of 500,000 all-electric vehicles delivered globally in October 2017, including those manufactured by Mitsubishi Motors, now part of the Alliance.[31] The Alliance, including Mitsubishi Motors i-Miev series, sold globally 94,265 all-electric vehicles in 2016.[198] Nissan global electric vehicle sales passed 275,000 units in December 2016.[199] The Nissan Leaf was the world's top selling plug-in car in 2013 and 2014.[200] Renault global electric vehicle sales passed the 100,000 unit milestone in September 2016.[201] In December 2014, Nissan announced that Leaf owners have accumulated together 1 billion kilometers (620 million miles) driven. This amount of electric miles translates into saving 180 million kilograms of CO_2 emissions by driving an electric car in comparison to travelling with a gasoline-powered car.[202] In December 2016, Nissan reported that Leaf owners worldwide achieved the milestone of 3 billion kilometers (1.9 billion miles) driven collectively through November 2016.[199]

As of September 2017, Tesla, Inc. ranked as the all-time second best-selling all-electric vehicle manufacturer with more than 250,000 electric cars worldwide since delivery of its first Tesla Roadster in 2008.[29][30] Its Model S was the world's best selling plug-in electric car for two years in a row, 2015 and 2016.[200][203][204][10] In early October 2016, Tesla reported that combined miles driven by its three models have accumulated 3 billion electric miles (4.8 billion km) traveled. The first billion mark was recorded in June 2015 and the second billion in April 2016.[205] BMW is the third best selling all-electric vehicle

[78] Wikipedia. (2018, March 15). Electric car - Highway capable. Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Electric_car#Highway_capable

manufacturer with more than 65,000 i3s sold through December 2016, including the REx variant.[200][206]

The world's all-time top selling highway legal electric car is the Nissan Leaf, released in December 2010, with global sales of more than 300,000 units through January 2018.[9] The Tesla Model S ranks second with global sales of 212,874 cars delivered as of December 2017.[10] The Renault Kangoo Z.E. utility van is the leader of the light-duty all-electric segment with global sales of 25,205 units through December 2016.[207] The following table list the best-selling highway-capable all-electric cars with cumulative global sales of around or more than 20,000 units since their inception through December 2016:

Top selling highway-capable electric cars and light utility vehicles produced between 2008 and December 2016(1)			
Model	**Market launch**	**Global sales**	**Sales through**
Nissan Leaf[208]	Dec 2010	+ 250,000	Dec 2016
Tesla Model S[208]	Jun 2012	+ 158,000	Dec 2016
BMW i3[200]	Nov 2013	~ 65,500(2)	Dec 2016
Renault Zoe[207]	Dec 2012	61,205	Dec 2016
BAIC EV series[209][210][211][212]	2012	42,646(3)	Dec 2016
Mitsubishi i-MiEV family[213]	Jul 2009	~ 37,600	Jun 2016
BYD e6[209][210][214][215][212]	Oct 2011	34,862(3)	Dec 2016
Tesla Model X[200]	Sep 2015	25,524	Dec 2016
Renault Kangoo Z.E.[207]	Oct 2011	25,205	Dec 2016
Volkswagen e-Golf[216][217][218][219][220]	May 2014	24,498(4)	Jun 2016
JAC J3/iEV family[209][210][211][221][222][223]	2010	23,241(3)	Jun 2016

Notes:
(1) Vehicles are considered highway-capable if able to achieve at least a top speed of 100 km/h (62 mph). Several models, such as the Chery QQ3 EV/eQ EV, Kandi EV and the Zotye Zhidou E20, are highway legal in China but do not meet this requirement.
(2) BMW i3 sales includes the REx variant.
(3) Sales in main China only. (4) Sales in Europe and the U.S. only.

4) Charging

Port/Type[79]

In SAE terminology, Level 1 charging refers to using a standard house outlet to charge your electric vehicle. This will take a long time to fully charge your car but when your EV is only used to commute or travel short distances, a full charge is not needed.[18]

240 volt AC charging is known as Level 2 charging. Level 2 charging is similar to household appliances. Level 2 chargers range from chargers you can install in your garage such as ones sold by Tesla to many chargers in public spaces. They can charge an electric car battery in 4–6 hours.[19] Level 2 chargers are often placed at destinations so that drivers can charge their car while at work or shopping. Level 2 home chargers are best for drivers who use their vehicles more often or require more flexibility.

Level 3 charging is also known as DC fast charging. The organization CHAdeMO is working to standardize fast chargers.[20] Level 3 chargers use a 480 V plug and can charge an EV in around 30 minutes. The Tesla Supercharger is the most ubiquitous in the United States and can charge a Tesla Model S in around 20 minutes.[18] Tesla reports that they have 1,043 supercharging stations around the world with more on the way. [21]

Another standards organization, The International Electrotechnical Commission, defines charging in *modes* (IEC 62196).

- *Mode 1* – slow charging from a regular electrical socket (single- or three-phase)
- *Mode 2* – slow charging from a regular socket but with some EV specific protection arrangement (e.g., the Park & Charge or the PARVE systems)
- *Mode 3* – slow or fast charging using a specific EV multi-pin socket with control and protection functions (e.g., SAE J1772 and IEC 62196)
- *Mode 4* – fast charging using some special charger technology such as CHAdeMO

There are three connection *cases*:

- *Case A* is any charger connected to the mains (the mains supply cable is usually attached to the charger) usually associated with modes 1 or 2.
- *Case B* is an on-board vehicle charger with a mains supply cable which can be detached from both the supply and the vehicle – usually mode 3.
- *Case C* is a dedicated charging station with DC supply to the vehicle. The mains supply cable may be permanently attached to the charge-station such as in mode 4.

There are four plug *types*:

- *Type 1* – single-phase vehicle coupler – reflecting the SAE J1772/2009 automotive plug specifications
- *Type 2* – single- and three-phase vehicle coupler – reflecting the VDE-AR-E 2623-2-2 plug specifications

[79] Wikipedia. (2018, March 10). Charging station - Standards. Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Charging_station#Standards

- *Type 3* – single- and three-phase vehicle coupler equipped with safety shutters – reflecting the EV Plug Alliance proposal
- *Type 4* – fast charge coupler – for special systems such as CHAdeMO

For Combined Charging System (CCS) DC charging, two extra connectors are added at the bottom of Type 1 or Type 2 vehicle inlets and charging plugs to connect high voltage DC charging stations to the battery of the vehicle. These are commonly known as Combo 1 or Combo 2 connectors. The choice of Combo 1 or Combo 2 style inlets is normally standardised on a per-country basis, so that public charging providers do not need to fit cables with both variants. Generally, North America uses Combo 1 style vehicle inlets, most of the rest of the world uses Combo 2 style vehicle inlets for CCS.

5) Speed[80]

The charging time depends on the battery capacity and the charging power. It can be calculated using the formula: *Charging Time [h] = Battery Capacity [kWh] / Charging Power [kW]* [24]

The battery capacity of a fully charged electric vehicle from electric vehicle automakers (such as Nissan) is about 20 kWh, providing it with an electrical autonomy of about 100 miles. Tesla Motors initially released their Model S with battery capacities of 40 kWh, 60 kWh and 85 kWh with the latter having an estimated range of approximately 480 km; as of January 2018 they have two models, 75 kWh and 100 kWh. Plug in hybrid vehicles have capacity of roughly 3 to 5 kWh, for an electrical autonomy of 20 to 40 kilometres, but the gasoline engine ensures the full autonomy of a conventional vehicle.

As the electric-only autonomy is still limited, the vehicle has to be charged every two or three days on average. In practice, drivers plug in their vehicles each night, thus starting each day with a full charge.

For normal charging (up to 7.4 kW), car manufacturers have built a battery charger into the car. A charging cable is used to connect it to the electrical network to supply 230 volt AC current. For quicker charging (22 kW, even 43 kW and more), manufacturers have chosen two solutions:

- Use the vehicle's built-in charger, designed to charge from 3 to 43 kW at 230 V single-phase or 400 V three-phase.
- Use an external charger, which converts AC current into DC current and charges the vehicle at 50 kW (e.g. Nissan Leaf) or more (e.g. 120-135 kW Tesla Model S).

Charging time for 100 km of BEV range	Power supply	Power	Voltage	Max. current
6–8 hours	Single phase	3.3 kW	230 V AC	16 A
3–4 hours	Single phase	7.4 kW	230 V AC	32 A
2–3 hours	Three phase	11 kW	400 V AC	16 A

[80] Wikipedia. (2018, March 10). Charging station - Charging time. Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Charging_station#Charging_time

Charging time for 100 km of BEV range	Power supply	Power	Voltage	Max. current
1–2 hours	Three phase	22 kW	400 V AC	32 A
20–30 minutes	Three phase	43 kW	400 V AC	63 A
20–30 minutes	Direct current	50 kW	400–500 V DC	100–125 A
10 minutes	Direct current	120 kW	300–500 V DC	300–350 A

The user finds charging an electric vehicle as simple as connecting a normal electrical appliance; however to ensure that this operation takes place in complete safety, the charging system must perform several safety functions and dialogue with the vehicle during connection and charging.

Industry

1) Vehicles

Market Context

General[81]

Electric car use by country varies worldwide, as the adoption of plug-in electric vehicles is affected by consumer demand, market prices and government incentives. Plug-in electric vehicles (PEVs) are generally divided into all-electric or battery electric vehicles (BEVs), that run only on batteries, and plug-in hybrids, that combine battery power with internal combustion engines (PHEVs). The popularity of electric vehicles has been expanding rapidly due to government subsidies, their increased range and lower battery costs, and environmental sensitivity. However, at the end of 2016, the stock of plug-in electric cars represented just a small fraction (0.15%) of the 1.4 billion motor vehicles on the world's roads.[1][3]

Global cumulative sales of highway-legal light-duty plug-in vehicles reached 2 million units at the end of 2016,[1] and the 3 million milestone was achieved in November 2017.[4] Sales of light-duty plug-ins achieved a 1.3% market share of new car sales in 2017, up from 0.86% in 2016, and 0.62% in 2015.[5][6] The global ratio between battery BEVs and PHEVs was 66:34 in 2017,[6] up from 61:39 in 2016,[5] and 59:41 in 2015.[7]

As of December 2017, China had the largest stock of highway legal light-duty plug-ins with over 1.2 million domestically built passenger cars.[1][8][9] China's plug-in electric bus stock reached 343,500 units in 2016, out of global stock of about 345,000 vehicles.[2] About 943,600 light-duty passenger plug-ins had been registered in Europe through 2017,[1][10][11] with Norway as the leading market with over 200,000 units.[12]Norway also had the highest market penetration per capita in the world in 2016, and 5% of all vehicles on Norwegian roads were plug-ins.[10] Norway also has the world's largest plug-in segment market share of new car sales, 39.2% in 2017.[13] As of December 2017, the United States had about 765,000 plug-in

[81] Wikipedia. (2018, March 11). Electric car use by country. Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Electric_car_use_by_country

cars,[1][14][15] with California accounting for approximately 48% of cumulative US plug-in sales at over 365,000 units.[10][16] Japan had about 207,200 plug-ins at the end of 2017.[2][17]

United States[82]

As of December 2017, cumulative sales totaled 764,666 highway legal plug-in electric cars since 2008,[10][381] with 52.9% being all-electric cars (BEVs) and 47.1% plug-in hybrids (PHEVs).[28][381] Cumulative plug-in car sales since 2008 reached 250,000 units in August 2014,[382] and 500,000 in August 2016.[28] California is the largest plug-in car regional market in the country, with almost 270,000 plug-in electric vehicles registered through December 2016,[7] and accounts for approximately 48% of cumulative plug-in sales in the American market from 2011 to June 2016. The other nine states that follow California's Zero Emission Vehicle (ZEV)regulations account for another 10% of cumulative plug-in car sales in the U.S. during the same period.[383]

A total 157,181 plug-in cars were sold nationwide in 2016, up 37.6% from 2015,[384] and 194,479 in 2017, up 23.7% from 2016.[381] The plug-in segment passed the 1% market share for the first time in 2017, with 1.13% of the country's total new car sales, up from 0.90% in 2016.[381][384]

As of December 2017, the Chevrolet Volt is the all-time best selling plug-in car with 133,838 units, followed by the Tesla Model S with 118,817, and the Nissan Leaf with 114,827 units.[381][10] Sales in 2017 were led by the Tesla Model S with about 26,500 units, the top selling plug-in car for the third year running, followed by the Chevrolet Bolt (23,297), Tesla Model X (~21,700), Toyota Prius Prime (20,936), and the Chevrolet Volt (20,349), together accounting for 58% of total sales in 2017.[381][385]

California established a program to reduce air pollution in the 1980s. Under pressure from manufacturers, the program was revised to offer only modest support of zero-emission vehicles to promote research and development, and greater support for partial zero-emissions vehicles (PZEVs). Many manufacturers then terminated their electric car programs.[386]

The federal tax credit for new plug-in electric vehicles (PEVs) is worth between US$2,500 and US$7,500 depending on battery capacity.[387][387] Several states have established additional incentives. The government pledged US$2.4 billion in federal grants to support the development of next-generation transport, and US$115 million for the installation of charging infrastructure.

Canada[83]

Cumulative sales of **plug-in electric cars in Canada** passed the 20,000 unit mark in May 2016,[1] and the 30,000 unit mark in January 2017.[2]

[82] Wikipedia. (2018, March 11). Electric car use by country - United States. Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Electric_car_use_by_country#United_States
[83] Wikipedia. (2018, February 28). Plug-in electric vehicles in Canada. Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Plug-in_electric_vehicles_in_Canada

The Chevrolet Volt, released in 2011, is the all-time top selling plug-in electric vehicle in the country, with cumulative sales of 6,387 units through May 2015 (representing over 30% of all plug-in cars sold in the country).[1][3][4]Ranking second is the Tesla Model S with 4,160 units sold through April 2016, followed by the Nissan Leaf with 3,692 units delivered as of May 2016.[1][3][5] The Model S was the top selling plug-in electric car in Canada in 2015 with 2,010 units sold.[3][6]

There were 18,451 highway legal plug-in electric cars registered in Canada as of December 2015, of which, 10,034 (54%) are all-electric cars and 8,417 (46%) are plug-in hybrids. These figures include some used imports from the U.S.[6] Until 2014 Canadian sales were evenly split between all-electric cars (50.8)% and plug-in hybrids (49.2%).[7] The following table presents new car sales by year of all the highway-capable plug-in electric cars available in Canada between 2011 and December 2015.

Quebec is the regional market leader in Canada, with about 11,000 plug-in electric cars registered as of September 2016, of which, 55% are plug-in hybrids. Registrations in the province totaled 3,100 units in 2015, representing a market share of 0.7% of new car sales, and 45% of total Canadian plug-in electric car sales that year.[8]

A total of 1,969 plug-in cars were sold in 2012, up from 521 in 2011. Sales climbed 57.7% in 2013 to 3,106 units, and in 2014 were up 63.0% from 2013 to 5,062 units, reaching cumulative sales of 10,658 plug-in cars through December 2014. The market share of the plug-in electric car segment grew from 0.03% in 2011, to 0.12% in 2012, and reached 0.27% of new car sales in the country in 2014.[7]

British Columbia[84, 85]

British Columbia is the only place in the country where it is legal to drive a low-speed vehicle (LSV) electric car on public roads, although it also requires low speed warning marking and flashing lights. Quebec is allowing LSVs in a three-year pilot project. These cars will not be allowed on the highway, but will be allowed on city streets.

BC-Hydro and Mitsubishi had previously tested a three-vehicle fleet in British Columbia.[9]

The Government of British Columbia announced the *LiveSmart BC* program which will start offering rebates of up to CA$5,000 per eligible clean energy vehicle commencing on December 1, 2011. The incentives will be available until March 31, 2013 or until available funding is depleted, whichever comes first. Available funds are enough to provide incentives for approximately 1,370 vehicles. Battery electric vehicles, fuel cell vehicles and plug-in hybrids with battery capacity of 15.0 kWh and above are eligible for a CA$5,000 incentive. Also effective December 1, 2011, rebates of up to CA$500 per

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[84] Wikipedia. (2018, February 28). Plug-in electric vehicles in Canada. Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Plug-in_electric_vehicles_in_Canada

[85] Wikipedia. (2018, March 7). Government incentives for plug-in electric vehicles - British Columbia. Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Government_incentives_for_plug-in_electric_vehicles#British_Columbia

qualifying electric vehicle charging equipment will be available to B.C. residents who have purchased a clean energy vehicle.[30][31]

2) Projected Growth[86, 87, 88]

Research, development and deployment and mass production prospects are leading to rapid battery cost declines and increases in energy density. Signs of continuous improvements from technologies currently being researched confirm that this trend will continue, narrowing the cost competitiveness gap between EVs and internal combustion engines. Assessments of country targets, original equipment manufacturer announcements and scenarios on electric car deployment seem to confirm these positive signals, indicating a good chance that the electric car stock will range between 9 million and 20 million by 2020 and between 40 million and 70 million by 2025.

Navigant forecasts that Canadian electric vehicle sales will grow at a compounded annual rate of 29 per cent to reach about 140,000 per year in 2026.

A new research report estimates that Canada will have between 74,000 and 91,000 light duty (LD) plug-in electric vehicles (PEVs) on the road by 2024. In the U.S., between 860,000 and 1.2 million.

According to the Navigant Research report, Electric Vehicle Geographic Forecasts, North America is the strongest market so far for light duty (LD) plug-in electric vehicles (PEVs), with more than 133,000 sold in 2014. The report provides plug-in electric vehicle sales forecasts for North America by state/province, metropolitan area, city, and selected utility service territory.

Currently, PEV sales are concentrated in California, where the vehicles already account for over 3% of the state's total LD vehicle market. State incentives, alongside the mandates of the California Zero Emission Vehicle (ZEV) Program, will likely continue to push PEV penetrations in the state to between 15% and 22% by 2024. Other ZEV Program participating states are expected to see similar growth. Outside of the ZEV states, PEV sales will grow most quickly in jurisdictions with large vehicle markets, high PEV incentives, well-developed infrastructure, and a high PEV index.

This Navigant Research report provides data and forecasts for LD PEV sales in North America, including U.S. states, metropolitan statistical areas (MSAs), and utility service territories and Canadian provinces and cities. The study estimates the number of vehicles that will be in use in specific geographic locations and assesses the potential impacts of anticipated PEV penetration in the most active PEV markets. Market forecasts for LD PEV sales and vehicles in use, segmented by scenario and geographic area, extend

[86] International Energy Agency. (2017). *World Energy Outlook 2017.* OECD.
[87] Marowits, R. (2017, December 13). As Canadians turn to electric cars, charging stations will boom: AddEnergie CEO. Retrieved from CTV News: https://www.ctvnews.ca/business/as-canadians-turn-to-electric-cars-charging-stations-will-boom-addenergie-ceo-1.3720310
[88] Electrical Industry Canada. (2016). Light Duty Electric Vehicle Forecast: 74,000+ by 2024. Retrieved from Electrical Industry Canada: http://electricalindustry.ca/latest-news/1340-light-duty-electric-vehicle-forecast-74-000-by-2024

through 2024. The study also provides analysis of Navigant Research's EV Consumer Survey, which was used to develop the PEV demographic profile.

Key questions addressed:

• Which states, provinces, and cities in North America are most likely to have the largest penetration of plug-in electric vehicles (PEVs)?

• Which metropolitan statistical areas (MSAs) and cities have demographic profiles that match the typical PEV owner demographics in the U.S. and Canada?

• What is the projected size of the North American PEV market over the next 10 years and where will sales grow the fastest?

• How many vehicles will electric utilities have to prepare for in the future?

• What are the vehicle style preferences of PEV prospects?

• What are the anticipated vehicle purchase costs of PEV prospects?

Environment

1) Vehicle GHG Emissions[89, 90]

The **environmental impact of transport** is significant because transport is a major user of energy, and burns most of the world's petroleum. This creates air pollution, including nitrous oxides and particulates, and is a significant contributor to global warming through emission of carbon dioxide.[1][2] Within the transport sector, road transport is the largest contributor to global warming.[1]

Environmental regulations in developed countries have reduced the individual vehicle's emission. However, this has been offset by an increase in the number of vehicles, and increased use of each vehicle.[1] Some pathways to reduce the carbon emissions of road vehicles considerably have been studied.[3] Energy use and emissions vary largely between modes, causing environmentalists to call for a transition from air and road to rail and human-powered transport, and increase transport electrification and energy efficiency.

The transportation sector is a major source of greenhouse gas emissions (GHGs) in the United States. An estimated 30 percent of national GHGs are directly attributable to transportation—and in some regions, the proportion is even higher. Transportation methods are the greatest contributing source of GHGs in the U.S., accounting for 47 percent of the net increase in total U.S. emissions since 1990.[4]

Other environmental impacts of transport systems include traffic congestion and automobile-oriented urban sprawl, which can consume natural habitat and agricultural

[89] Wikipedia. (2018, March 2). Environmental impact of transport. Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Environmental_impact_of_transport
[90] Wikipedia. (2018, March 2). Environmental impact of transport - Cars. Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Environmental_impact_of_transport#Cars

lands. By reducing transportation emissions globally, it is predicted that there will be significant positive effects on Earth's air quality, acid rain, smog and climate change.[5]

The health impact of transport emissions is also of concern. A recent survey of the studies on the effect of traffic emissions on pregnancy outcomes has linked exposure to emissions to adverse effects on gestational duration and possibly also intrauterine growth.[6]

As listed above direct impacts such as noise and carbon monoxide emissions create direct and harmful effects on the environment, along with indirect impacts. The indirect impacts are often of higher consequence which leads to the misconception that it's the opposite since it is frequently understood that initial effects cause the most damage. For example, particulates which are the outcome of incomplete combustion done by an internal combustion engine**,** are not linked with respiratory and cardiovascular problems since they contribute to other factors not only to that specific condition. Even though the environmental impacts are usually listed individually there are also cumulative impacts. The synergetic consequences of transport activities. They take into account of the varied effects of direct and indirect impacts on an ecosystem. Climate change is the sum total impact of several natural and human-made factors. 15% of global CO2 emissions are attributed to the transport sector.[7]

Unleaded gasoline has 8.91 kg and diesel has 10.15 kg of CO_2 per gallon.[14] CO_2 emissions originating from ethanol are disregarded by international agreements however so gasoline containing 10% ethanol would only be considered to produce 8.02 kg of CO_2 per gallon.[15] The average fuel economy for cars sold in the US 2005 was about 25.2 MPG giving around 0.35 kg of CO_2 per mile.[16] The Department of Transportation's MOBILE 6.2 model, used by regional governments to model air quality, uses a fleet average (all cars, old and new) of 20.3 mpg giving around 0.44 kg of CO_2 per mile.[17]

In Europe, the European Commission enforced that from 2015 all new cars registered shall not emit more than an average of 0.130 kg of CO2 per kilometer (kg CO2/km). The target is that by 2021 the average emissions for all new cars is 0.095 kg of CO2 per kilometre.[18]

2) BC GHG Policy[91]

The B.C. government has enacted significant pieces of climate action legislation that frame B.C.'s approach to reducing emissions and transitioning to a low-carbon economy.

The *Greenhouse Gas Reduction Targets Act* sets aggressive legislated targets for reducing greenhouse gases. Under the *Act*, B.C.'s GHG emissions are to be reduced by at least 33 percent below 2007 levels by 2020. Interim reduction targets of six percent by 2012 and 18 percent by 2016 are in place to guide and measure progress. A further emission reduction target of 80 percent below 2007 levels is set for 2050.

[91] British Columbia. (2018). Climate Action Legislation. Retrieved from British Columbia: https://www2.gov.bc.ca/gov/content/environment/climate-change/planning-and-action/legislation

The *Act* provided authority for the Greenhouse Gas Emission Control Regulation and the Carbon Neutral Government Regulation (enacted in December 2008).

B.C.'s revenue-neutral carbon tax puts a price on greenhouse gas emissions, providing an incentive for sustainable choices that produce fewer emissions. The escalating tax was phased in on July 1, 2008. One hundred percent of the revenue generated is returned to taxpayers through other tax reductions. There is also built-in protection for lower-income British Columbians.

The *Greenhouse Gas Industrial Reporting and Control Act* (the Act) enables performance standards to be set for industrial facilities or sectors by listing them within a Schedule to the Act. To uphold B.C.'s commitment to ensuring the cleanest liquefied natural gas (LNG) operations in the world, for example, the Schedule sets a greenhouse gas emissions benchmark for LNG facilities. The Schedule also includes an emission benchmark for coal-based electricity generation operations. The Act streamlines several aspects of existing GHG legislation and regulation into a single legislative and regulatory system, including the emission reporting framework established under the *Greenhouse Gas Reduction (Cap and Trade) Act*. The Act provides authority for the Greenhouse Gas Emission Reporting Regulation, the Greenhouse Gas Emission Control Regulation, and the Greenhouse Gas Emission Administrative Penalties and Appeals Regulation.

The Greenhouse Gas Emission Reporting Regulation requires that industrial operations that emit over 10,000 carbon dioxide equivalent tonnes per year (tCO_2e) report their GHG pollution each year. Operations emitting over 25,000 tCO_2e are required to have their emission reports independently verified. The Regulation defines LNG operations and specifies which emissions are attributable to the emission benchmark as set in the Schedule in the Act. Compliance reporting requirements for regulated operations, including LNG, are prescribed.

The Greenhouse Gas Emission Control Regulation establishes the infrastructure and requirements for issuing emission offset units and funded units. These are the foundational elements that enable compliance with the performance standards listed within a Schedule to the *Act*. The Regulation also establishes the BC Carbon Registry, which enables the electronic issuance, transfer and retirement of compliance units (emission offset units, funded units and earned credits).

The Greenhouse Gas Emission Administrative Penalties and Appeals Regulation establishes when, how much, and under what conditions administrative penalties, including administrative monetary penalties, may be levied for non-compliance with the *Act*. It also outlines the process for seeking appeals after decisions have been made by the Director under the *Act*.

The *Clean Energy Act* sets provincial energy objectives and mechanisms related to electricity self-sufficiency, clean and renewable energy, energy efficiency, greenhouse gas emission reductions and fuel switching to lower-carbon-intensity energy.

The *Greenhouse Gas Reduction (Renewable and Low Carbon Fuel Requirements) Act* sets requirements for the use of renewables in transportation fuel blends and fulfills B.C.'s commitment to adopt a low-carbon fuel standard similar to that of California. The Act provides authority for the Renewable and Low Carbon Fuel Requirements Regulation (enacted in December 2009), which is decreasing the amount of carbon in B.C.'s transportation fuels.

The *Greenhouse Gas Reduction (Emissions Standards) Statutes Amendment Act* focuses on reducing GHG emissions from certain industrial operations while increasing opportunities in the bioenergy sector. For example, waste-management operations (including landfills, composting facilities and sewage treatment plants) are required to manage GHGs by reducing emissions or capturing them. They then have the option of realizing the economic opportunity presented by the waste's energy-generating potential. The *Act* provided authority for the Landfill Gas Management Regulation (enacted in January 2009). Additionally, the *Act* enables regulation of zero and net-zero GHG emissions for electricity generation. This bill amended the *Environmental Management Act*, the *Forest Act* and the *Forest and Range Practices Act*.

The *Greenhouse Gas Reduction (Vehicle Emissions Standards) Act* enables implementation of a government commitment made in the 2008 Throne Speech to match vehicle greenhouse gas emission standards to those laid out in California's 2004 Low-Emission Vehicle II regulations. The *Act* was to be brought into force by regulation, but this was superseded by the enactment of federal legislation that aligned with the U.S. EPA and brought Canada and B.C. into a harmonised North American standard. Vehicle emission standards cut GHG emissions by 30 percent relative to 2008 models—a reduction of 600,000 tonnes of GHG emissions annually. This means better fuel efficiency and cost savings for British Columbians. The *Act* also enables the regulation of zero-emission vehicles. **(not in force)**

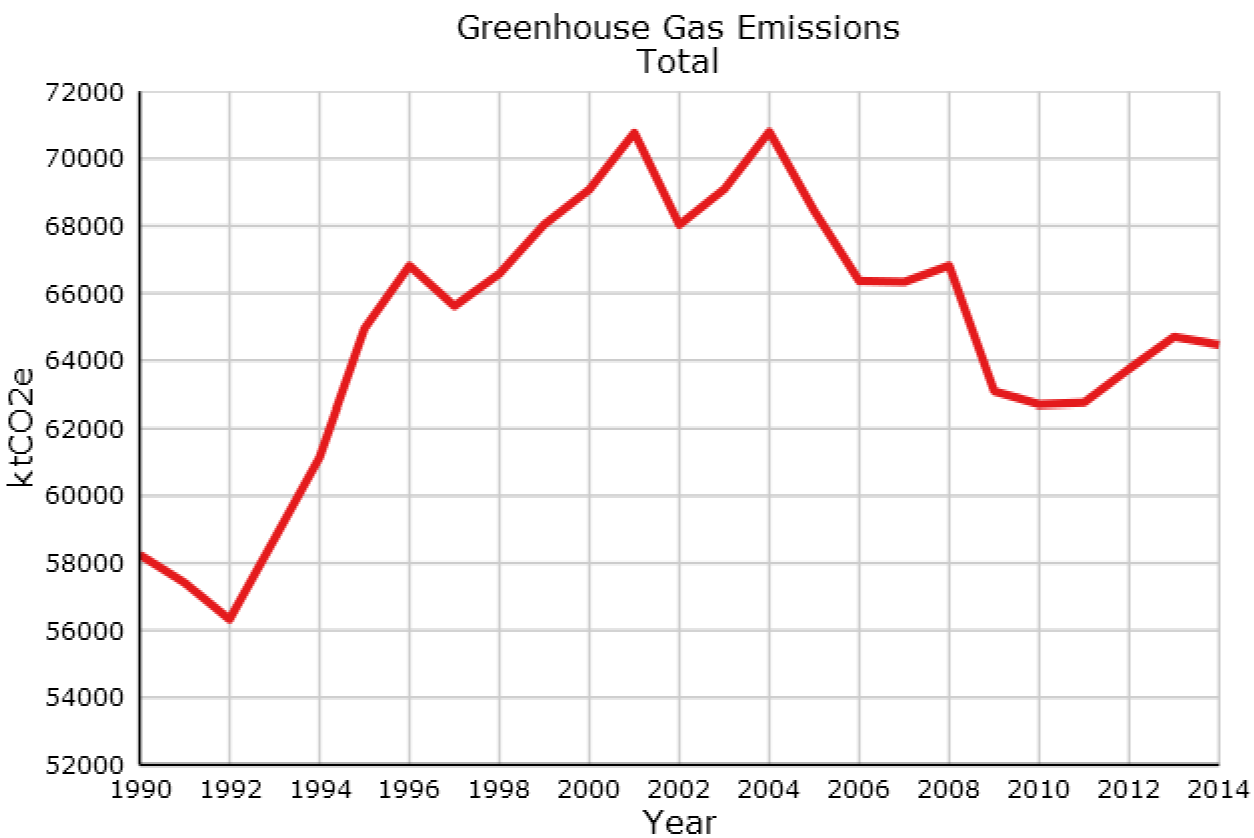
The *Local Government (Green Communities) Statutes Amendment Act*, referred to as Bill 27, supports local governments in reducing greenhouse gas emissions, conserving energy and working towards creating more compact and sustainable communities. The amendments require GHG emission reduction targets in local Official Community Plans and Regional Growth Strategies, and supporting policies and actions.

The *Utilities Commission Amendment Act* encourages public utilities to reduce greenhouse gas emissions, take demand-side measures, and produce, generate and acquire electricity from clean or renewable sources. It provided authority for the Demand-Side Measures Regulation (enacted in November 2008), which sets out rules to be used by the BC Utilities Commission in assessing proposed demand-side measures from utilities.

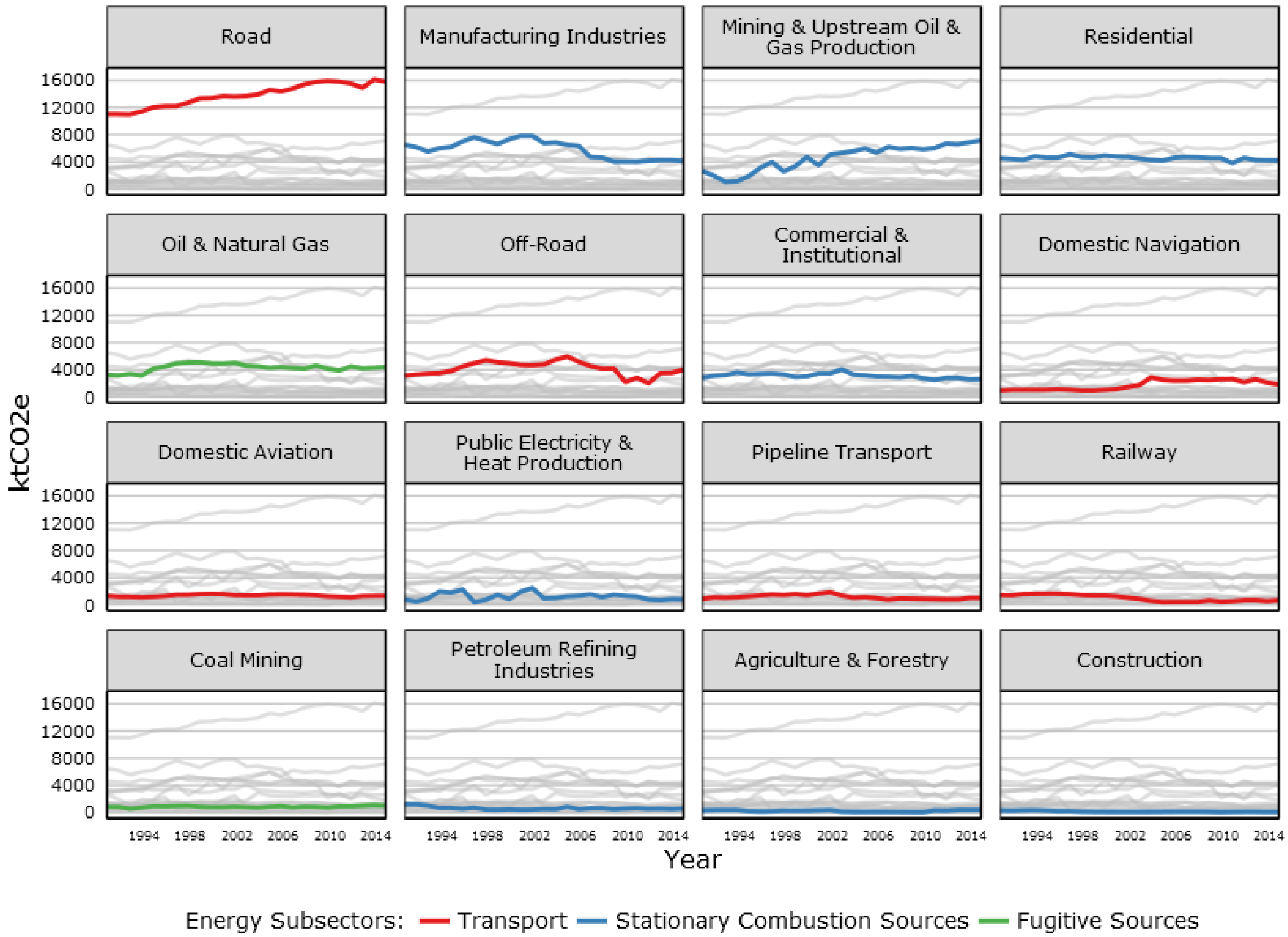
B.C.'s *Energy Efficiency Act* sets energy performance standards for devices that use, control or affect the use of energy, such as household appliances, heating and cooling systems, lighting and some industrial equipment.

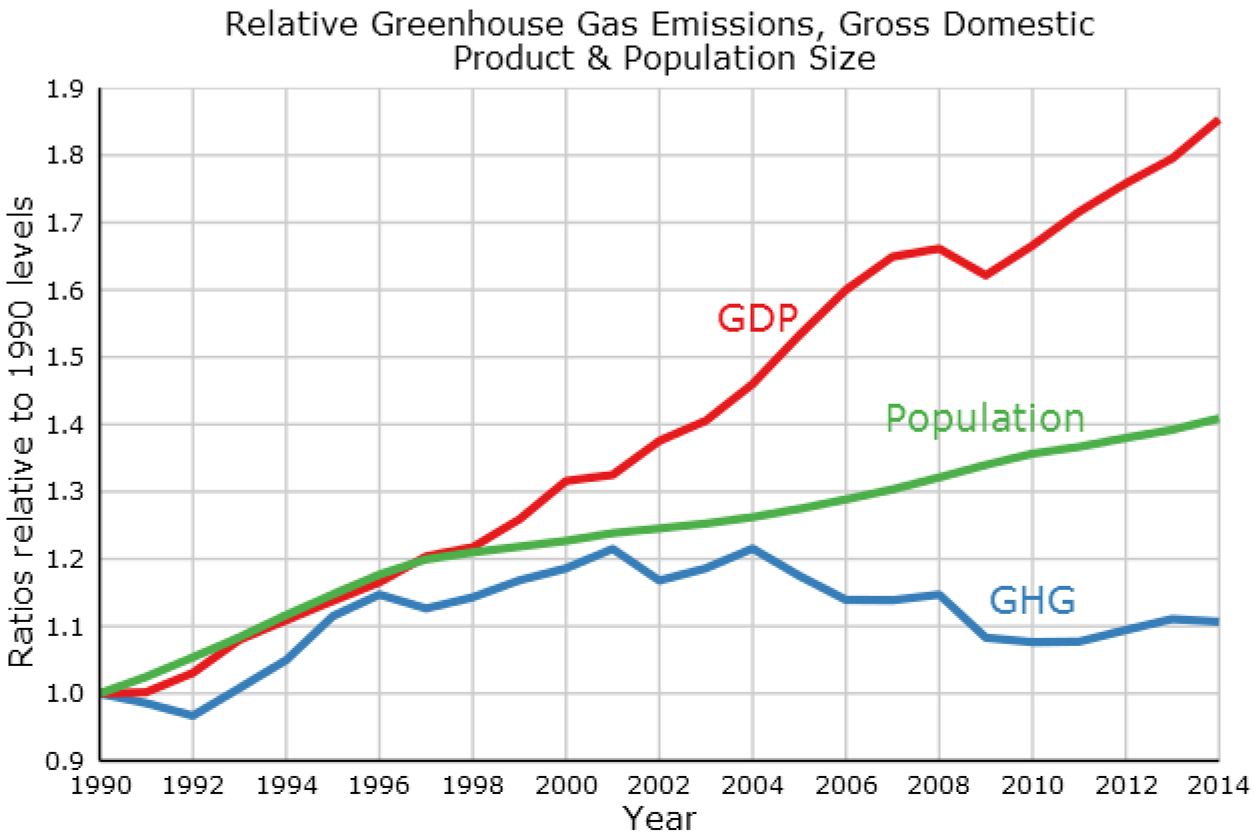
In December 2014, the B.C. Building Code introduced new energy-efficiency requirements for houses and small buildings. These include the Solar Hot Water Ready requirement, a provincial regulation that communities can voluntarily adopt. It requires new single-family homes in adoptive communities to be built to accommodate installation of solar hot water systems.

BC GHG Emissions[92]



[92] British Columbia. (2016, August). Trends in Greenhouse Gas Emissions in B.C. (1990-2014). Retrieved from British Columbia: http://www.env.gov.bc.ca/soe/indicators/sustainability/ghg-emissions.html


Road
Manufacturing Industries
Mining & Upstream Oil & Gas Production
Residential
Oil & Natural Gas
Off-Road
Commercial & Institutional
Domestic Navigation
Domestic Aviation
Public Electricity & Heat Production
Pipeline Transport
Railway
Coal Mining
Petroleum Refining Industries
Agriculture & Forestry
Construction
16000
12000
8000
4000
0
ktCO2e
1994 1998 2002 2006 2010 2014
Year
Energy Subsectors: Transport Stationary Combustion Sources Fugitive Sources


Relative Greenhouse Gas Emissions, Gross Domestic Product & Population Size
Ratios relative to 1990 levels
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
Year
GDP
Population
GHG

Appendix B
Model

Model 1: Light Vehicle Projection Model for All of BC without EVs or AVs

Year	BC Driving Population	Total LVs	LVs/Potential Driver	LV Sales	LV Total + Sales	LV Sales Growth Rate	LV Retirement % from total	LV Retirements
2020	3,894,100	3,195,097	0.82	247,931	3,379,393	1.5%	6%	184,296
2021	3,941,400	3,257,989	0.83	251,650	3,446,748	1.5%	6%	188,759
2022	3,987,200	3,320,907	0.83	255,425	3,513,414	1.5%	6%	192,507
2023	4,032,700	3,386,218	0.84	259,256	3,580,164	1.5%	6%	193,946
2024	4,077,700	3,452,278	0.85	263,145	3,649,363	1.5%	6%	197,085
2025	4,121,700	3,519,361	0.85	267,093	3,719,370	1.5%	6%	200,009
2026	4,165,100	3,587,453	0.86	271,099	3,790,460	1.5%	6%	203,007
2027	4,208,800	3,656,629	0.87	275,165	3,862,618	1.5%	6%	205,989
2028	4,251,300	3,726,652	0.88	279,293	3,935,922	1.5%	6%	209,270
2029	4,292,800	3,798,128	0.88	283,482	4,010,134	1.5%	6%	212,006
2030	4,332,900	3,869,949	0.89	287,734	4,085,863	1.5%	6%	215,914
2031	4,370,700	3,942,085	0.90	292,051	4,161,999	1.5%	6%	219,914
2032	4,402,900	4,015,636	0.91	296,431	4,238,517	1.5%	6%	222,880
2033	4,436,200	4,090,200	0.92	300,878	4,316,514	1.5%	6%	226,314
2034	4,468,700	4,164,685	0.93	305,391	4,395,591	1.5%	6%	230,906
2035	4,500,400	4,239,751	0.94	309,972	4,474,657	1.5%	6%	234,906
2036	4,532,100	4,315,373	0.95	314,621	4,554,372	1.5%	6%	238,999

Year	BC Driving Population	Total LVs	LVs/Potential Driver	LV Sales	LV Total + Sales	LV Sales Growth Rate	LV Retirement % from total	LV Retirements
2037	4,564,400	4,391,270	0.96	319,341	4,634,714	1.5%	6%	243,443
2038	4,596,000	4,467,507	0.97	324,131	4,715,401	1.5%	6%	247,894
2039	4,626,500	4,544,140	0.98	328,993	4,796,500	1.5%	6%	252,360
2040	4,655,900	4,621,225	0.99	333,928	4,878,067	1.5%	6%	256,842

Model 2: Net ICE Vehicle Projection for All of BC

Year	ICE Sales	Total ICE	ICE % of LV	ICE % of LV Sales
2020	242,926	3,179,623	99.5%	97.5%
2021	244,155	3,232,735	99.2%	95.9%
2022	245,070	3,281,312	98.8%	94.0%
2023	245,683	3,327,117	98.3%	92.0%
2024	246,004	3,367,904	97.6%	89.6%
2025	246,042	3,403,339	96.7%	87.0%
2026	245,804	3,432,798	95.7%	84.2%
2027	245,297	3,455,742	94.5%	81.1%
2028	244,525	3,471,308	93.1%	77.8%
2029	243,493	3,479,473	91.6%	74.2%
2030	242,202	3,478,486	89.9%	70.4%
2031	240,655	3,467,668	88.0%	66.3%
2032	238,854	3,447,453	85.9%	62.0%
2033	236,800	3,416,763	83.5%	57.4%
2034	234,493	3,374,599	81.0%	52.6%
2035	231,932	3,323,035	78.4%	47.5%
2036	229,117	3,262,029	75.6%	42.2%
2037	226,047	3,191,148	72.7%	36.7%
2038	222,719	3,110,318	69.6%	30.8%
2039	219,133	3,019,436	66.4%	24.8%
2040	215,285	2,918,382	63.2%	18.5%

Model 3: Personal Plug-In Electric Vehicle Projection Model for All of BC

Year	Total Personal PEVs	PEV % of LV	PEV Sales % of LV	PEV Sales	PEV Retirement % (assumed)	PEV Retirements
2020	14,234	0.45%	2.0%	5,006	7%	420
2021	21,309	0.65%	3.0%	7,495	7%	420
2022	31,244	0.94%	4.2%	10,355	7%	420
2023	44,397	1.31%	5.6%	13,573	7%	420
2024	61,119	1.77%	7.1%	17,141	7%	420
2025	81,749	2.32%	8.8%	21,050	7%	420
2026	106,624	2.97%	10.7%	25,294	7%	420
2027	136,072	3.72%	12.8%	29,868	7%	420
2028	170,419	4.57%	15.0%	34,767	7%	420
2029	209,989	5.53%	17.4%	39,990	7%	420
2030	255,102	6.59%	20.0%	45,533	7%	420
2031	306,077	7.76%	22.7%	51,395	7%	420
2032	363,234	9.05%	25.7%	57,577	7%	420
2033	426,891	10.44%	28.8%	64,077	7%	420
2034	496,586	11.92%	32.0%	70,898	7%	1,203
2035	571,761	13.49%	35.5%	78,040	7%	2,865
2036	652,259	15.11%	39.1%	85,504	7%	5,006
2037	738,058	16.81%	42.9%	93,294	7%	7,495
2038	829,115	18.56%	46.8%	101,412	7%	10,355
2039	925,402	20.36%	51.0%	109,860	7%	13,573
2040	1,026,903	22.22%	55.3%	118,642	7%	17,141

Model 4: Shared Autonomous Vehicle Projection Model for All of BC

Year	Total AV	Total AV (w/ sharing)	Total AV (continuous use)	AV % of LV	AV Sales % of LV	AV Sales from EV Sales	AV Sales	EV Sales Deduction	AV Retirement
2020	1,240	826	551	0.04%	0.5%	3.0%	1,240	150	
2021	3,945	2,630	1,753	0.12%	1.1%	6.0%	2,705	450	
2022	8,351	5,567	3,712	0.25%	1.7%	9.0%	4,406	932	
2023	14,703	9,802	6,535	0.43%	2.5%	12.0%	6,352	1,629	
2024	23,255	15,503	10,336	0.67%	3.3%	15.0%	8,552	2,571	
2025	34,273	22,848	15,232	0.97%	4.1%	18.0%	11,018	3,789	
2026	48,031	32,021	21,347	1.34%	5.1%	21.0%	13,758	5,312	
2027	64,816	43,211	28,807	1.77%	6.1%	24.0%	16,785	7,168	
2028	84,925	56,617	37,744	2.28%	7.2%	27.0%	20,109	9,387	
2029	108,667	72,444	48,296	2.86%	8.4%	30.0%	23,742	11,997	
2030	136,361	90,907	60,605	3.52%	9.6%	33.0%	27,694	15,026	
2031	168,341	112,227	74,818	4.27%	11.0%	36.0%	31,980	18,502	
2032	204,950	136,633	91,089	5.10%	12.4%	39.0%	36,609	22,455	
2033	246,546	164,364	109,576	6.03%	13.8%	42.0%	41,596	26,913	

Year	Total AV	Total AV (w/ sharing)	Total AV (continuous use)	AV % of LV	AV Sales % of LV	AV Sales from EV Sales	AV Sales	EV Sales Deduction	AV Retirement
2034	293,500	195,667	130,444	7.05%	15.4%	45.0%	46,954	31,904	
2035	344,956	229,970	153,314	8.14%	17.0%	48.0%	52,695	37,459	1,239.66
2036	401,085	267,390	178,260	9.29%	18.7%	51.0%	58,834	43,607	2,705.24
2037	462,063	308,042	205,362	10.52%	20.5%	54.0%	65,385	50,379	4,406.08
2038	528,074	352,049	234,700	11.82%	22.3%	57.0%	72,362	57,805	6,351.78
2039	599,302	399,535	266,357	13.19%	24.3%	60.0%	79,781	65,916	8,552.22
2040	675,941	450,627	300,418	14.63%	26.3%	63.0%	87,656	74,745	11,017.57

Model 5: Kilometres Driven Projection for All Vehicle Types in BC

Year	Avg yearly KMs driven	Total KMs Driven LVs	Total KMs Driven EVs	Total KM's Driven AV	Total KMs Driven ICEs
2020	12,369	39,518,928,860	176,058,312	15,332,839	39,327,537,708
2021	12,230	39,845,488,835	260,613,904	48,246,447	39,536,628,483
2022	12,093	40,160,092,730	377,837,464	100,989,334	39,681,265,932
2023	11,958	40,491,261,940	530,890,496	175,810,770	39,784,560,675
2024	11,824	40,818,839,163	722,653,320	274,960,964	39,821,224,880
2025	11,691	41,145,957,666	955,756,823	400,691,240	39,789,509,604
2026	11,560	41,472,287,294	1,232,609,757	555,254,214	39,684,423,322
2027	11,431	41,798,550,016	1,555,422,349	740,903,972	39,502,223,695
2028	11,303	42,121,861,527	1,926,226,810	959,896,241	39,235,738,477
2029	11,176	42,448,938,578	2,346,895,244	1,214,488,564	38,887,554,770
2030	11,051	42,767,205,908	2,819,155,356	1,506,940,477	38,441,110,076
2031	10,927	43,076,470,922	3,344,604,268	1,839,513,675	37,892,352,980
2032	10,805	43,388,727,908	3,924,720,740	2,214,472,190	37,249,534,978
2033	10,684	43,699,412,411	4,560,875,998	2,634,082,557	36,504,453,855
2034	10,564	43,996,854,098	5,246,068,506	3,100,613,990	35,650,171,602
2035	10,446	44,288,226,244	5,972,581,667	3,603,389,149	34,712,255,428
2036	10,329	44,573,293,452	6,737,155,608	4,142,784,611	33,693,353,233
2037	10,213	44,849,231,788	7,537,989,403	4,719,179,641	32,592,062,744
2038	10,099	45,116,829,729	8,373,136,212	5,332,956,213	31,410,737,304
2039	9,986	45,376,757,325	9,240,852,148	5,984,499,026	30,151,406,152
2040	9,874	45,629,675,130	10,139,570,321	6,674,195,515	28,815,909,295

Model 6: Gasoline Consumption and GHG Emissions for the Net ICE Vehicle Fleet in BC

Year	EV Energy Consumption (kWh)	AV Energy Consumption (kWh)
2020	35,211,662	3,066,568
2021	52,122,781	9,649,289
2022	75,567,493	20,197,867
2023	106,178,099	35,162,154
2024	144,530,664	54,992,193
2025	191,151,365	80,138,248
2026	246,521,951	111,050,843
2027	311,084,470	148,180,794
2028	385,245,362	191,979,248
2029	469,379,049	242,897,713
2030	563,831,071	301,388,095
2031	668,920,854	367,902,735
2032	784,944,148	442,894,438
2033	912,175,200	526,816,511
2034	1,049,213,701	620,122,798
2035	1,194,516,333	720,677,830
2036	1,347,431,122	828,556,922
2037	1,507,597,881	943,835,928
2038	1,674,627,242	1,066,591,243
2039	1,848,170,430	1,196,899,805
2040	2,027,914,064	1,334,839,103

Model 7: Charging Station Requirement Projections for PEVs and Shared AV

Year	Capacity L2	Capacity DCFC	Coverage (highway) DCFC	New Capacity DCFC	New Capacity L2	New Coverage DCFC	DCFC Capital Expense	L2 Capital Expense
2020	603	8	112	3	217	112	$8,030,991	$2,428,998
2021	959	13	112	5	356	0	$335,039	$3,984,677
2022	1,475	20	112	7	516	0	$485,746	$5,777,067
2023	2,172	29	112	9	697	0	$656,156	$7,803,779
2024	3,070	41	112	12	898	0	$846,151	$10,063,425
2025	4,191	56	112	15	1,121	0	$1,055,688	$12,555,484
2026	5,555	75	112	18	1,364	0	$1,284,787	$15,280,202
2027	7,183	97	112	22	1,628	0	$1,533,526	$18,238,504
2028	9,097	123	112	26	1,913	0	$1,802,035	$21,431,923
2029	11,316	153	112	30	2,220	0	$2,090,487	$24,862,541
2030	13,863	187	112	34	2,547	0	$2,399,101	$28,532,942
2031	16,760	226	112	39	2,897	0	$2,728,132	$32,446,168
2032	20,028	270	112	44	3,268	0	$3,077,872	$36,605,686
2033	23,690	319	112	49	3,662	0	$3,448,645	$41,015,360
2034	27,736	374	112	55	4,047	0	$3,811,250	$45,327,883
2035	32,123	433	112	59	4,386	0	$4,131,285	$49,134,120
2036	36,847	497	112	64	4,725	0	$4,449,769	$52,921,897
2037	41,914	565	112	68	5,067	0	$4,771,802	$56,751,899
2038	47,325	638	112	73	5,412	0	$5,096,786	$60,616,997
2039	53,086	715	112	78	5,760	0	$5,425,407	$64,525,339
2040	59,200	798	112	82	6,114	0	$5,758,288	$68,484,360

Model 8, part 1: PEV and Shared AV Charging Costs Projections for BC

Year	Capital Expenses	Maintenance Expenses	Energy Cost - All PEV/AV	Annual PEV/AV Charging Cost per Vehicle	PEV/AV Charging Cost per Kilometer	Replacement Costs, Charging Stations	Retirements, Charging Stations (not inflated)
2020	$8,615,077	$690,348	$4,466,992	$480	$0.04		
2021	$3,636,045	$946,404	$7,203,350	$484	$0.04		
2022	$5,385,033	$1,323,507	$11,237,324	$495	$0.04		
2023	$7,427,423	$1,843,425	$16,785,373	$507	$0.04		
2024	$9,775,667	$2,529,056	$24,073,942	$521	$0.04		
2025	$12,442,969	$3,404,476	$33,340,386	$534	$0.05		
2026	$15,443,266	$4,494,985	$44,833,879	$547	$0.05		
2027	$18,791,213	$5,827,159	$58,816,323	$560	$0.05		
2028	$22,502,180	$7,428,893	$75,563,255	$573	$0.05	$4,738,079	$3,781,388
2029	$26,592,240	$9,329,455	$95,364,767	$587	$0.05	$10,992,839	$8,615,077
2030	$31,078,179	$11,559,532	$118,526,432	$600	$0.05	$4,723,222	$3,636,045
2031	$35,977,493	$14,151,282	$145,370,261	$613	$0.06	$7,119,014	$5,385,033
2032	$41,308,397	$17,138,388	$176,235,666	$626	$0.06	$9,989,884	$7,427,423
2033	$47,089,833	$20,556,104	$211,480,470	$639	$0.06	$13,373,113	$9,775,667
2034	$52,930,972	$24,414,122	$251,197,693	$653	$0.06	$17,308,170	$12,442,969
2035	$58,340,298	$28,689,444	$295,144,999	$667	$0.06	$21,836,778	$15,443,266
2036	$63,876,800	$33,395,446	$343,466,710	$681	$0.07	$27,002,974	$18,791,213
2037	$69,613,825	$38,550,337	$396,361,891	$695	$0.07	$32,853,182	$22,502,180
2038	$75,544,979	$44,171,961	$454,030,051	$709	$0.07	$39,436,292	$26,592,240
2039	$81,682,643	$50,279,024	$516,684,162	$724	$0.07	$46,803,738	$31,078,179
2040	$88,038,920	$56,891,092	$584,550,711	$739	$0.07	$55,009,587	$35,977,493

Model 8, part 2: PEV and Shared AV Charging Costs Projections for BC

Year	Cumulative Capital Invested	Cumulative Amortization	Cumulative Interest	Hydro Rate	Total PEV/AV Charging Service
2020	$12,396,465	$1,239,647	$1,673,523	0.120	$6,830,863
2021	$16,032,510	$1,603,251	$2,164,389	0.123	$10,314,143
2022	$21,417,543	$2,141,754	$2,891,368	0.126	$15,452,199
2023	$28,844,966	$2,884,497	$3,894,070	0.129	$22,522,868
2024	$38,620,633	$3,862,063	$5,213,785	0.133	$31,816,784
2025	$51,063,602	$5,106,360	$6,893,586	0.136	$43,638,448
2026	$66,506,868	$6,650,687	$8,978,427	0.140	$58,307,291
2027	$85,298,081	$8,529,808	$11,515,241	0.143	$76,158,723
2028	$108,756,952	$10,875,695	$14,682,189	0.147	$97,674,337
2029	$137,726,953	$13,772,695	$18,593,139	0.151	$123,287,360
2030	$169,892,310	$16,989,231	$22,935,462	0.155	$153,021,426
2031	$207,603,784	$20,760,378	$28,026,511	0.159	$187,548,054
2032	$251,474,642	$25,147,464	$33,949,077	0.163	$227,323,131
2033	$302,161,920	$30,216,192	$40,791,859	0.167	$272,828,433
2034	$359,958,092	$35,995,809	$48,594,342	0.172	$324,206,158
2035	$424,691,902	$42,469,190	$57,333,407	0.176	$381,167,850
2036	$496,780,462	$49,678,046	$67,065,362	0.181	$443,927,519
2037	$576,745,290	$57,674,529	$77,860,614	0.185	$512,772,842
2038	$665,134,322	$66,513,432	$89,793,133	0.190	$587,995,145
2039	$762,542,523	$76,254,252	$102,943,241	0.195	$669,906,427
2040	$869,613,536	$86,961,354	$117,397,827	0.200	$758,839,631

Model 9: AV Charging Station Requirement Projections for BC

Year	AV Charging Kilometers	AV Vehicles Adjusted for Ride Sharing	AV Vehicles Adjusted for Continuous Use	Kilometers/Vehicle/Day	AV Charging Capacity
2020	15,332,839	826	551	51	23
2021	48,246,447	2,630	1,753	50	73
2022	100,989,334	5,567	3,712	50	155
2023	175,810,770	9,802	6,535	49	272
2024	274,960,964	15,503	10,336	49	431
2025	400,691,240	22,848	15,232	48	635
2026	555,254,214	32,021	21,347	48	889
2027	740,903,972	43,211	28,807	47	1200
2028	959,896,241	56,617	37,744	46	1573
2029	1,214,488,564	72,444	48,296	46	2012
2030	1,506,940,477	90,907	60,605	45	2525
2031	1,839,513,675	112,227	74,818	45	3117
2032	2,214,472,190	136,633	91,089	44	3795
2033	2,634,082,557	164,364	109,576	44	4566
2034	3,100,613,990	195,667	130,444	43	5435
2035	3,603,389,149	229,970	153,314	43	6388
2036	4,142,784,611	267,390	178,260	42	7427
2037	4,719,179,641	308,042	205,362	42	8557
2038	5,332,956,213	352,049	234,700	42	9779
2039	5,984,499,026	399,535	266,357	41	11098
2040	6,674,195,515	450,627	300,418	41	12517

Model 10: AV Sharing Adjustment

Year	AV Actual Kilometers Driven	AV Energy Used in (kWh)	AV Energy Saving from Ridesharing in kWh	AV Cost of Energy without Ridesharing	AV Cost of Energy Used with Ridesharing	AV Cost Saving with Ridesharing	Total EV & AV Energy Used in kWh
2020	10,221,892.95	2,044,379	1,022,189	367,681	245,121	122,560	37,256,041
2021	32,164,298	6,432,860	3,216,430	1,187,028	791,352	395,676	58,555,640
2022	67,326,223	13,465,245	6,732,622	2,549,287	1,699,524	849,762	89,032,737
2023	117,207,180	23,441,436	11,720,718	4,553,402	3,035,601	1,517,801	129,619,535
2024	183,307,309	36,661,462	18,330,731	7,306,492	4,870,995	2,435,497	181,192,126
2025	267,127,493	53,425,499	26,712,749	10,924,337	7,282,891	3,641,446	244,576,863
2026	370,169,476	74,033,895	37,016,948	15,531,896	10,354,597	5,177,299	320,555,847
2027	493,935,982	98,787,196	49,393,598	21,263,850	14,175,900	7,087,950	409,871,666
2028	639,930,827	127,986,165	63,993,083	28,265,171	18,843,447	9,421,724	513,231,527
2029	809,659,043	161,931,809	80,965,904	36,691,724	24,461,149	12,230,575	631,310,857
2030	1,004,626,984	200,925,397	100,462,698	46,710,891	31,140,594	15,570,297	764,756,468
2031	1,226,342,450	245,268,490	122,634,245	58,502,231	39,001,488	19,500,744	914,189,344
2032	1,476,314,793	295,262,959	147,631,479	72,258,177	48,172,118	24,086,059	1,080,207,107
2033	1,756,055,038	351,211,008	175,605,504	88,184,755	58,789,837	29,394,918	1,263,386,207
2034	2,067,075,993	413,415,199	206,707,599	106,502,351	71,001,567	35,500,784	1,462,628,900
2035	2,402,259,433	480,451,887	240,225,943	126,990,145	84,660,097	42,330,048	1,674,968,220
2036	2,761,856,407	552,371,281	276,185,641	149,795,431	99,863,621	49,931,810	1,899,802,403
2037	3,146,119,761	629,223,952	314,611,976	175,073,367	116,715,578	58,357,789	2,136,821,833
2038	3,555,304,142	711,060,828	355,530,414	202,987,340	135,324,894	67,662,447	2,385,688,071
2039	3,989,666,017	797,933,203	398,966,602	233,709,355	155,806,237	77,903,118	2,646,103,633
2040	4,449,463,676	889,892,735	444,946,368	267,420,429	178,280,286	89,140,143	2,917,806,800

Appendix C
Information on Suppliers of Level 2 Charging Station Equipment

Level 2 Charging Station Manufacturers (non-exhaustive)

Source: http://pluginbc.ca/charging-program/manuf_list/

MANUFACTURER	DATA TRACKING*	LOAD MANAGEMENT	**LOCAL SUPPLIER**
AddEnergie & Flo	All units	On some units	Cascadia Sales; Cielo Electric; Electrum Charging; Flo; PowerPros Electric; Motorize; Renegade Electric
AeroVironment	No	On some units	ChargeHub; Cielo Electric; Electrum Charging; Perkuna Engineering; PowerPros Electric
BMW	On some units	On some units	BMW
eMotorwerks / JuiceBox	Yes	On some units	Autochargers; eMotorwerks
Bosch	No	No	Cielo Electric; Electrum Charging; Renegade Electric
ChargePoint	All units	On some units	Autochargers; Foreseeson; Gemini Electrical Services
EVSE LLC	All units	No	EVSE LLC
EFACEC	All units	All units	Electrum Charging
Elmec	No	No	ChargeHub; Cielo Electric; Elmec
Leviton	On some units	On some units	Cielo Electric; E.B. Horsman & Son; Electrum Charging; Nedco; PowerPros Electric; Renegade Electric

Liberty Plugins	All units	Yes	Electrum Charging; Liberty Plugins
JuiceBar	On some units	On some units	Paul Young
PowerPost	No	No	PowerPost
SemaConnect	All units	On some	Cielo Electric; Electrum Charging; SemaConnect
Siemens	On some units	On some units	Cielo Electric; Home Depot; Motorize
Sun Country Highway	Optional or standard on all units	Optional or standard on all units	Cielo Electric; Electrum Charging; Perron Electric; PowerPros Electric; Sun Country Highway; Motorize
Thermolec	Connected to utility	All units	RVE – EV Solutions for condos
EVoCharge	Yes	Yes	EVoCharge
WattZilla	No	No	WattZilla

Appendix D
Information on Suppliers of DCFC Charging Manufacturers

DCFC Charging Manufacturers (non-exhaustive, North America only)

Source: https://chargehub.com/en/electric-car-charging-guide.html

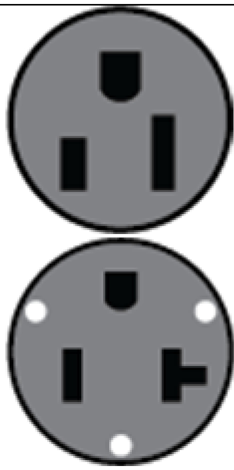
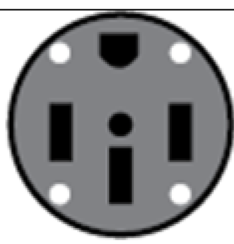
Network/Operator		Membership Required?	Region
ChargePoint		Yes	USA + Canada
Blink (CarCharging)		Yes	USA + Canada
SemaConnect / SemaCharge		Yes Activate and pay directly from the ChargeHub app	USA + Canada
NRG eVgo		Yes	USA
Aerovironment		Yes	USA
Greenlots		Yes	USA + Canada
FLO		Yes	Canada

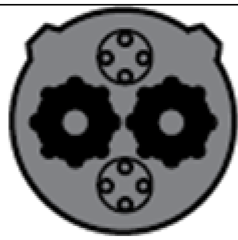
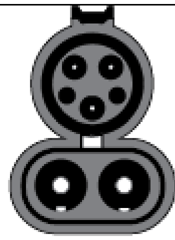
OP Connect		Yes	USA
GE WattStation		Yes	USA + Canada
Circuit Électrique		Yes	Québec, Ontario
myEVroute		Yes	Ontario
Tesla (Superchargers et Destination)		No, but limited to Tesla vehicles	USA + Canada
Sun Country Highway		No	USA + Canada
Volta		No	USA
Doc Borné		No	USA + Canada
Astria		Yes	USA + Canada
Azra		Yes	Québec
Non-networked stations		No	USA + Canada

<u>Appendix E</u>
Connector Types for EV Charging

Connector Types

Source: https://chargehub.com/en/electric-car-charging-guide.html

Connectors		Level	Asian Makes	US/EU Makes	Tesla
Wall outlets (Nema 515, Nema 520)		1	With adapter	With adapter	With adapter
Port J1772		2	Yes	Yes	With adapter
Nema 1450 (RV plug)		2	With adapter	With adapter	With adapter

CHAdeMO		3	Yes	No	With adapter
SAE Combo CCS		3	No	Yes	No
Tesla HPWC		2	No	No	Yes
Tesla supercharger		3	No	No	Yes

Appendix F
CEC Research Document List

- Automated Vehicles
    - AV Implementation – VTPI
- Batteries
    - Battery Cost Impact on EV – Online Articles
    - Battery Tech – Young et al
    - Dyson Battery Investment – The Guardian
- Forecasts and Statistics
    - Auto Industry Outlook – McKinsey
    - BC Census Metropolitan Area and Census Agglomeration Population Estimates 2001-2011
    - BC Census Metropolitan Area and Census Agglomeration Population Estimates 2011-2016
    - BC Charging Stations by Area & Town from Charge Hub
    - BC Development Region, Regional District and Municipal Population Estimates 2001-2011
    - BC GHG Emission Inventory – BC Stats
    - BC Sub-Provincial Population – BC Stats
    - Canadian Vehicle Survey – NRCan
    - Electric Load Forecast 2012 – BC Hydro
    - Energy Outlook 2018 – BP
    - Environmental Impact – Brussels
    - EV Implications – BC Hydro
    - Fuel Consumption Guide – NRCan
    - Global EV Outlook 2017 – IEA
    - Household Estimates and Projections – BC Stats 1
    - Household Estimates and Projections – BC Stats 2
    - Household Estimates and Projections – BC Stats 3
    - Metro Vancouver Vehicle Count – ICBC
    - New Vehicle Sales – StatCan
    - NYC EV Study – NYC
    - Vehicle Fuel Economy Forecast – IEA
    - Vehicle Lifespans – Bento et al
    - Vehicle Market Review – DesRosiers
    - Vehicle Tech Market Report – Oak Ridge
- General
    - Charging Networks List – ChargeHub
    - Charging Station Viability – UCLA
    - Charging Tech and Standards – EVTC
    - EV Charging Guide – FleetCarma

  - EV Market Analysis – Accenture
  - EV Policy Report Card – SFU
  - EV Range Anxiety – Transportation Research
  - EV Study – SFU
  - EV Wikipedia
  - Northern BC EV – Ministry of Energy and Mines
  - PEV Energy Consumption – Iowa State
  - Plug In Charging
  - Solar EV Charging – NREL
- Infrastructure Planning
  - Canadian EV Infrastructure Deployment – ECOtality
  - Charging Station Costs – RMI
  - DCFC Gap Analysis – Fraser Basin Council
  - EV Charging Installation – Hydro Quebec
  - EV Infrastructure Deployment – BC Hydro
  - EV Infrastructure in US – NREL
  - EV Infrastructure Requirements – Newfoundland
  - Grid Integration – Navigant
  - PEV Handbook – EERE
  - Street EV Charging Pilot Project – Toronto
- Regulation and Law
  - EV Accessibility – California
  - EV Charging Accessibility – California
  - EV Charging Accessibility – DSA
  - EV Charging Accessibility PP – DSA
  - EV Charging Law – Pratt Energy Law
  - EV Charging Regulations Condos – Ontario
  - EV Charging Station Standards – BC Hydro
  - EV Regulation Inquiry – BCUC
  - EV User Fees – Vancouver
  - Hydro RRA – BC Hydro
  - Manitoba Electricity Rates – Manitoba
  - Ontario EV Regulation – OEB
  - Ontario Rates – OEB
  - Quebec Rates – Hydro Quebec
  - Strata EV Charging – Choa
  - Utilities Law and EV Charging – Capitol Research