VICTORIA EV CLUB

BCUC REGULATION OF ELECTRIC VEHICLE CHARGING SERVICE INQUIRY EXHIBIT C35-6

June 5, 2018

Mr. Patrick Wruck
Commission Secretary and Manager
Regulatory Support
British Columbia Utilities Commission
Suite 410, 900 Howe Street
Vancouver, BC
V6Z 2N3

Dear Mr. Wruck

Re: BCUC Regulation of Electric Vehicle Charging Services Inquiry – IR-1

Response IR- 1 from: The Victoria Electric Vehicle Association
(DBA the Victoria Electric Vehicle Club)

Attached please find our response to the Information Request No 1 from the BC Utilities Commission dated May 3, 2018.

For ease of reference, our responses are in blue italic text following each question that was posed. The exception is that any associated tables, figures or appendices are in full colour or black text. Listings of Tables and Figures and an index are also provided for cross-referencing purposes.

The Victoria EV Association wishes to thank the Commission for the opportunity to expand on our views concerning electric vehicle charging issues.

For any clarifications or further information please do not hesitate to contact us.

Yours very truly,

James Locke, President
Victoria Electric Vehicle Association
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An Inquiry into the Regulation of Electric Vehicle Charging Service

INFORMATION REQUEST NO. 1 TO VICTORIA ELECTRIC VEHICLE ASSOCIATION

A. BASIS FOR EV CHARGING SERVICE REGULATION EXEMPTION

1.0 Reference: Exhibit C35-2, pp. 4, 9–10
Potential cross-subsidization

On page 4 of Exhibit C35-2, Victoria Electric Vehicle Association (EVA) states: "EVs contribute to gross BC Hydro revenues and do not currently present a cross-subsidization issue," and on pages 9 and 10, it submits two principles based on:

> That the original purpose of public utilities was to make energy (electricity and natural gas) available to all the citizens of a province or state recognizing that it was in the general public interest for urban area ratepayers to financially support the higher costs of providing the utility to rural areas.
>
> There is a lower risk of cross subsidization as each EV contributes additional hydro revenues with no immediate additional grid costs. Each block of 10,000 EVs entering service adds as much as $ 2.3 million per year to gross BC Hydro revenues with minimal cost impacts on the existing electricity grid infrastructure.

As per footnote 12 in Exhibit C35-2, the estimated additional revenue is based on 10,000 EVs @ 13,000 km (Stats Canada 2009) @ 160 Wh/km= 2,080 kWh / year @ 0.11.kWh = $ 2.3 m per year.

1.1 Please clarify if Victoria EVA is assuming that there is zero incremental "cost impact on the existing electricity grid infrastructure" to serve 10,000 EVs, and therefore conclude that there is no cross-subsidization issue at this time.

1.1.1 In Victoria EVA's view, at what level of electric vehicle (EV) uptake would require electricity grid infrastructure upgrades? Would this measure also depend on the demand of a specific region/location? Please discuss.

Response: 1.1. The suggestion that there would be virtually zero incremental cost is based on:

a) Previous public statements by BC Hydro and Hydro Québec officials that a considerable increase in EVs would have no significant impact on the grid (hence costs). Quotes in Appendix A include comments by various utility operators about EV impacts including comments from BC Hydro and Hydro Québec.

b) The recent (May 17) announcement by the Québec government and Hydro Québec that: "Investments of $130 million will be required from Hydro-Québec to add 1600 fast charging stations in Québec within 10 years. <u>These investments will be fully offset</u> by the increase in electricity sales that will result from the increase in the number of electric cars." (Appendix A)

c) Mitigation strategies and technologies that have emerged that could be deployed to prevent future impacts on the grid including load managed technologies, sub metering and even phone apps that alert customers about preferred charging times in real time.

Response 1.1.1. -Uptake required to force grid upgrades:

a) Given the above (Response 1.1.) and at the estimated EV sales rates (Appendix B-1) it may take until 2038 to see a 35% EV light duty vehicle fleet (Appendix B-2) it would appear that it could be two decades before the EV fleet might be expected to have a significant impact on major upstream grid infrastructure.

b) In terms of affecting specific regions or locations, and in particular, the degree to which EVs in the fleet could affect local transformers vs major upstream infrastructure we would defer to BC Hydro who would be in the best position to advise of potential local impacts and under what conditions they might occur.

1.1.2 Does the Victoria EVA consider that public utility investments to own or operate EV charging stations (i.e. DCFC stations) would offset the additional revenues from electricity sales? Please discuss.

Response 1.1.2 – Utility investments

From the Business Case modelling that the Victoria EVA has performed (Appendix C) it appears that there is no business case for DCFC charging without fees that would exceed the cost of gasoline and/or without ancillary sources of revenue or the installation of DCFCs as a competitive advantage for individual businesses.

From Page 1 of the April 4 submission, the additional gross revenue for 10,000 EVs was estimated to be $2.3 million per year. The marginal net revenues are not known as we have no information about overnight wholesale electricity costs. However, if wholesale and transmission costs were 50 % of gross, then net additional revenues from EVs could reach $ 1.1 million per year.

This would only represent funding for about 11 DCFCs per year at $100K each without some form of amortization that recognises that the EV revenues repeat annually and will increase year over year. If the installation cost was amortised over 20 years and the DCFC was self-sustaining from operating revenues (Business case Scenario 2), then about 200 DCFCs could be acquired from the increased revenue from an additional 10,000 EVs (2 per 100 EVs). Hydro Québec asserts that they will be able to finance 1,600 DCFCs from increased electricity sales (Appendix A).

The other issue becomes to what extent public utilities should financially participate in extending DCFC infrastructure to link all BC communities. DCFC infrastructure has virtually no business case at this time for the private sector to invest in DCFCs in remote or sparsely populated areas with no ancillary sources of revenue to offset costs. The arguments for public utility investment in Inter-City DCFCs are that; it is in the public interest in terms of equal access to all residents to EV infrastructure; to provide equity between communities and to accelerate adoption rates to further the goals of the BC Climate Action Plan.

With respect to the deployment of urban DCFCs, all consideration could be given to some form of "optimal EV charging strategy" (Appendix D). Consideration should be given to strategically deploying DCFCs in urban areas in a manner that helps address the needs of EV owners who do not have access to an exclusive parking space for overnight charging their vehicle but that also does not supplant (preferred) residential overnight charging infrastructure in MURBs where persons could access *overnight charging but their Strata Council or landlord is preventing the implementation of EV charging capability.*

2.0 Reference: Exhibit C35-2, pp. 5–6
EV charging stations – Registration process

On pages 5 and 6 of Exhibit C35-2, Victoria EVA states:

> … the registration process be simplified by including the ability to register and deregister Alternating Current electric vehicle charging installations on-line.
>
> … the registration process be simplified by including the ability to apply for registration and de-registration for Direct Current Fast Charging (DCFC) electric vehicle charging installations on-line.

2.1 Please clarify what are the purposes of the proposed registration. Is the Victoria EVA suggesting that the BCUC would store and administer the registration information?

Response 2.1.

After our submission of April 4 we have had an opportunity to review other submissions and conduct additional research on this subject.

a) *The purpose of the proposal for AC and DC charging registration was to be able to track installations; for complaint-handling (under Section 25[1]), for potentially excessive charging of fees or the provision of (DC) charger maintenance (under Section 38[2]) and an orderly process (under Section 41) for decommissioning DC charging infrastructure.*

b) *In terms of AC charging, it has come to our attention that there appears[3] to be sufficient safeguards in the Civil Resolution Tribunal process within the Strata legislation and the tenant Dispute Resolution Service (private chargers) as well as market forces (public chargers) to protect against overcharging for AC charging services. This oversight, combined with the proposed rate transparency requirements of the proposed[4] Subsection 9 b) of the General Tariff would make AC registration unnecessary. Consequently, the proposal to register AC charging stations is withdrawn.*

c) *However for the reasons outlined in a) the suggestion that DC charger installations be subject to registration and Sections (25, 38, 41, 42 and 49)[5] is retained, or that some other equivalent mechanism(s) be used to the same effect.*

2.2 Please clarify what type of information would be requested in the proposed registration. Under what circumstances would de-registrations occur?

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[1] *Section 25 of the BCUC Act regarding the handling of complaints and the authority of the Commission to order remedies and set standards.*
[2] *Section 38 of the BCUC Act regarding maintaining property and equipment and prohibiting discrimination or delay in service*
[3] *The Victoria EVA has received a report of a charge of $60 per month for Level 1 charging in one Strata complex and charges of $2.50 per hour for Level 2 charging in a different Strata complex.*
[4] *Refer to Response 3.1*
[5] *Sections under the BCUC Act Section 41 – pre-authority for the removal of a service 42- obeying lawful orders of the Commission 49- reporting requirements*

Response 2.2-1
The types of information that were suggested were as described Appendix B of Order G-71-16 for the EcoDairy DCFC that included metrics for number of charging sessions, annual energy dispensed and annual revenues. In the anticipation of private sector involvement and the importance of retaining competitive information, the suggestion is reduced to only reporting: 1) confirmation that the DCFC station remains in operations/use and 2) any safety incidents.

Response 2.2 -2
Discontinuance of a DCFC service (deregistration) could have direct impacts on businesses and commerce (eg: Urban DCFC operations serving multiple delivery or taxi companies for which EV DCFC availability would be mission-critical and business-threatening if withdrawn.) This would not only be threatening to the business operations of those that depended on it but detrimental to the EV adoption program through negative public reaction. A deregistration requirement would provide an opportunity for alternatives to be developed and implemented to continue DCFC services for the businesses affected.

3.0 Reference: Exhibit C35-2, pp. 5–6
EV charging stations – proposed changes to the BC Hydro Electric Tariff

On page 5 of Exhibit C35-2, for Alternating Current Electric Vehicle Charging Services (Level 1 and Level 2 AC), Victoria EVA states:

> That the charges for electricity consumption comply with the British Columbia Hydro and Power Authority (BC Hydro) Electric Tariff Terms and Conditions for the Resale of Electricity, Subsection 9.2 of the BC Hydro Electric Tariff Terms and Conditions which states as follows (with suggested revisions underlined):
>
> *i. If a Customer wishes to sell Electricity which the Customer has purchased from BC Hydro to a tenant, of that Customer at the same Premises **or to an owner or operator of an electric vehicle** on a metered basis, then the Customer shall agree that the selling price for such Electricity shall not exceed the price which BC Hydro would have charged had that tenant **or owner or operator of the electric vehicle** been a Customer of BC Hydro. This requirement shall be included in an agreement for resale between BC Hydro and the Customer.*

Similarly, on page 6 of Exhibit C35-2, for DCFCs:

> *i. If a Customer wishes to sell Electricity which the Customer has purchased from BC Hydro to an electric vehicle owner or operator on a metered basis at the same Premises, then the Customer shall agree that the selling price for such Electricity **shall not exceed a multiplier (TBD) of the price** which BC Hydro would have charged had that owner or operator of the electric vehicle been a Customer of BC Hydro. This requirement shall be included in an agreement for resale between BC Hydro and the Customer.*

3.1 With respect to Level 1 and Level 2 AC, does Victoria EVA view that there should be a mechanism to recover the fixed cost of the infrastructure? Why or why not?

Response 3.1

*For purposes of the discussion below, **"fixed costs"** includes capital, operating and all other related costs for AC EV charging with the exception of the cost of electricity*

The issue of recovering for fixed AC charging costs is complex and particularly so in the case of Multi Unit Residential Buildings (MURBs) where there is a need for flexibility to keep costs down but there are also rules about capital expenditures and debt financing of "common property" in Stratas.

There are a number of factors to consider in arriving at an equitable basis for reselling electricity at a MURB:

- a) *The Utilities Commission has jurisdiction over the reselling of electricity.*
- b) *The BC Strata Act that has been recently changed [6] to allow the imposition of user fees (including for "electricity usage") based on the user's rate of consumption, the duration of use or the number of users.*
- c) *There is a need for transparency to protect EV owners from excessive electricity reselling fees or MURB fees intended to discourage EV charging.*
- d) *MURBs have a need to recover fixed costs for retrofit components and proprietary EVSE units.*
- e) *The extent to which there are existing consumer protections against "unreasonable expenses" for user fees (such as charging fees).*
- f) *The Civil Resolution Tribunal process (for Stratas) and the BC Dispute Resolution Service (for apartments) could resolve complaints about overcharging for fixed AC charging costs.*
- g) *Short cost-recovery periods for fixed costs should not be used by MURBs to unreasonably inflate the cost of monthly EV user fees for charging privileges and, by so doing, discourage EV ownership.*
- h) *Including fixed costs within electricity rate regulations or tariffs could result in over or undercharging depending on the circumstances in each individual MURB (EVSEs provided by owner or Strata, cost to wire building, 3rd party billing systems, retro fitting costs etc).*
- i) *Flat monthly fees for electricity based on allocating the total electricity cost between the number of users may be more attractive for initial (small) installations due to the higher cost of web-enabled consumption-based systems or the significantly higher fixed costs[7] of Level 2 managed systems. Monthly fees would be expected to be abandoned in favour of consumption-based fees as the number of charging spaces increased and/or with increased variance in daily kWh used by each EV.*
- j) *The basis on which electricity is resold should be practical and flexible enough for MURBs to levy user fees for electric vehicles of all types including electric bicycles and scooters.*

Overcharging or Otherwise Discouraging EV ownership in MURBs

There are already reported cases of some MURBs (Strata Councils) imposing EV charging fees that discourage EV purchases. In one case a BC Strata Council has imposed an EV charging fee of $2.50 per hour. This amounts to an effective rate of 76 cents per kWh[8] for a generation 1 EV or 38 cents per kW hour for a generation 1.5 EV. In another case, a fee of $60 per month was quoted by the Strata Council for a Level 1 charging outlet. For an average vehicle travelling 1,000 km per month this would amount to an effective rate of 30 cents per kWh[9] or almost three times the BC Hydro customer rate.

[6] Order 97 of the Lieutenant Governor dated March 7, 2018 - addition of section 6.9 (2)
[7] Costs as high as $4K per EVSE unit (L2 managed) have been reported
[8] Generation 1 EV - 3.3 kW charging speed ($2.50 / 3.3 kW) / Generation 1.5 – (6.6 kW) ($2.50/6.6 kW)
[9] 1,000 km at 200 Wh/km = 200 kWh resulting in $60/200 kW or 30 cents per kWh

In both cases, the persons who were considering an EV did not proceed with a purchase based on the high cost of charging at their residence.

Recovering Fixed Costs for AC Charging

New Construction

For new MURBs, the fixed costs for EV infrastructure (to provide an electrical outlet to each parking space) should be included at the time of construction. An increasing number of BC municipalities [10] are revising their zoning bylaws to include this requirement for 100% of residential parking spaces. The post-construction fixed costs of the EVSE [11] units could be recovered as an up-front cost to the EV owner or recovered as part of a monthly user fee[12].

Retrofits

For existing MURBs, notwithstanding that EV infrastructure will add value to the property; it is generally the view of existing MURB occupants that non-EV owners should not be required to pay for the fixed costs of retrofitting older buildings for EV owners. The Victoria EVA supports this view, as concerns from non-EV owners about bearing fixed costs are already (anecdotally) showing signs of slowing the provision of additional EV infrastructure.

For MURBs, it is the Victoria EVA's view that there is a need for transparency and regulations to discourage price gouging or the imposition of EV charging fees that would otherwise discourage EV adoption such as; accelerated cost-recovery of the actual fixed infrastructure costs or unreasonably high or opaque fees for EV charging with the intent of the Strata Council avoiding retrofitting their buildings with EV charging capability. MURBs could recover the fixed costs (as defined above) through a monthly parking fee (to gain EV charging access)[13].

Recovering Fixed Costs for Other Land Uses

For commercial land uses, property owners may install EV infrastructure for competitive or customer service reasons and may elect to not recover fixed costs (or even electricity costs). Commercial (shopping centres, parking lots) would have the option of charging a higher parking space rate for EV spaces to recover fixed costs while charging electricity fees in compliance with (the proposed) subsection 9 b) of the General Tariff. In time, it is expected to be beneficial for all EVs owners to be charged fees at commercial properties as a means of discouraging "opportunity charging" in order to help ensure that charging spaces are available to those that need a charge to complete their daily travel requirements.

For Institutional land uses, fixed costs could be recovered through charging higher parking fees at EV stalls to avoid being viewed as "subsidising" EV owners (e.g. Hospitals and Universities). These locations are subject to market conditions as EVs owners would have the option of not charging and parking in a regular parking space. Consequently, a rate for parking (including electricity) should not be problematic [14] [15].

[10] *Richmond, Vancouver and a number of other municipalities in process*

[11] *EVSE – Electrical Supply Service Equipment*

[12] *EVSE units on L2 managed circuits do not currently conform to an open standard and cannot be interchanged with units from other manufacturers. The impact is that the brand of EVSE required is specified by the MURB owner.*

[13] *The monthly fee could be recovered as part of a 3rd party billing system*

[14] *If the premium to park in an EV space is too high, the space will remain vacant which would result in lost revenue*

[15] *For transparency, the lot operator could post signage that the " Parking fees include charges for electricity in compliance with the General Tariff"*

For industrial land uses, recovery of fixed costs would be optional and could also be recovered as part of a parking fee.

For workplaces, property or business owners could also recover for fixed costs through parking fees. It is noted that if they do not charge fees to employees, the EV charging service could be considered to be a taxable benefit to the employee.

This strategy could resolve the challenges of; accounting for the wide variations in fixed (and variable) costs between buildings; preserving transparency in electricity reselling fees and also exposing the non-electricity costs to the oversight processes of the CRT [16] for Stratas and the BC Dispute Resolution Service for tenancies (apartments). MURBs are the most important land use associated with eliminating the major EV charging barrier to increasing EV adoption rates.

This approach would also shield the Utilities Commission from involvement in complex disputes about reselling electricity if any fixed costs (as defined above) were included as part of the charging fee. The existing Strata and Apartment resolution processes would require the property owners to provide documentation of the electricity costs included in any fees as being in compliance with Subsection 9 b) of the General Tariff.

AC Charging Business Models

The need to recover expenses for EV infrastructure and dispensed electricity varies depending on the land use, owner of the EV infrastructure, and the degree to which the infrastructure owner wishes to recover their costs. Commercial centres may not wish to recover all (or any) of their costs, whereas MURBs will wish to recover all costs but not at a profit . The associated billing systems for AC charging should be based on meeting both the EV owner's needs for information and transparency and the EV infratsructure owner's (reseller's) needs to have the necessary data to monitor the results of their individual business model for AC charging.

For example, property owners charging EV owners at commercial or recreational locations should have the option of levying fees for EVs remaining connected to an EVSE unit after the vehicle has completed charging[17] whereas Strata Corporations should not charge EV owners for EVs remaining connected after the vehicle has completed charging.

Appendix E includes typical business models for expenses and revenues according to land use (owner)

Recovering Fixed Costs for DC Charging

The fixed and electricity reselling cost considerations for DCFCs are different:

a) *Costing models indicate that there is no business case for publicly accessible DCFC installations without subsidy assistance or ancillary forms of revenue (Appendix C).*
b) *Larger DCFC installation may involve the additional costs of property acquisition to accommodate their footprint.*
c) *If left unregulated, there would be opportunities for price gouging due to the high demand and the*

[16] *Civil Resolution Tribunal process per the BC Civil Tribunal Act of 2012*
[17] *To increase turnover and/or discourage "opportunity charging"*

captive market potential of fast charging services

d) *To maintain EV adoption momentum and climate action targets, DCFC rates should be less than the equivalent cost of gasoline.*
e) *Rate uniformity and stability for intercity travel is in the public interest in terms of fair and equitable Intercity (community) travel and commerce.*
f) *Private DCFCs for use by larger vehicle classes such as Class 3-8 vehicles or buses or taxis as part of a co-operative operation or chain (i.e. Cardlock for EVs) may need additional revenues (beyond a rate cap) to recover fixed costs.*
g) *The Utilities Commission is perhaps the only body that could provide oversight for DCFC rates.*

On the basis of the foregoing it is suggested that maximum (capped) DC charging rates be regulated through the General Tariff at a higher rate than BC Hydro would have charged had the EV owner been a customer of BC Hydro, in order to encourage private-sector DCFC deployments.

Regulated cap options:

There are perhaps several options that could be considered in arriving at a capped rate. Two possible options could be:

1) *Benchmarked to the residential rate*
   A DCFC cap could be specified as a multiple of the residential rate, but at a multiple that would be less than the cost of gasoline. The DCFC rate could be specified as being the lesser of: X times the cost of the residential rate; or Y % of the equivalent cost of gasoline.
2) *Benchmarked to the price of regular gasoline.*
   A DCFC rate cap per kWh could be linked to; the retail (trailing average) price for regular unleaded gasoline; the average fuel economy of an average light duty vehicle; and the efficiency of an average EV (watt hours per km). These factors could be used to arrive at a maximum (capped) electricity rate for DCFC charging [18] *that responds to changes in the energy market. Higher gas prices would result in a higher cap encouraging additional DCFC investments. The subsequent increased DCFC competition could result in lower DCFC pricing (below the capped rate) over time.*

The determination of a DCFC rate could be through the General Tariff rate-setting process with the objective of striking a balance between; encouraging private sector participation in DCFC infrastructure rollouts through higher rates, and the potential for higher EV sales as the result of lower EV charging rates.

Demand Charges and DCFCs

Utilities may assert that demand charges are an effective means of managing grid loads as businesses have the opportunity to avoid high power consumption by scheduling their operations to avoid high power consumption peaks and further suggest that demand charges are necessary to protect the grid against overloading. DCFC operators, on the other hand may assert that the grid is designed to handle their installations at full load and that there are no practical means of scheduling DCFC use by EV owners to avoid peak periods. If the latter is true, then consideration should be given to discontinuing demand charges at DCFC installations that have been engineered for full load, as demand charges can dramatically increase DCFC operating costs thereby discouraging private sector DCFC installations. Time of Use (TOU) charging could be considered to encourage commercial operators of bus fleets or heavier vehicles that have discretion about charging times, to charge their vehicles off peak.

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[18] *For example an average ICE vehicle with a fuel economy of 10 litres per 100 km at an average gas price of $1.47 would cost $14.70 per 100 km. Using an average of 200 Wh per km (= 20 kWh/100 km), the equivalent electricity cost for an EV owner would be $14.70 /20 Kwh or 73.5 cents/kWh. Applying (say) a 20% discount below the cost of gasoline, the DCFC rate would be 58.8 cents per kWh*

The Measurement Canada Issue

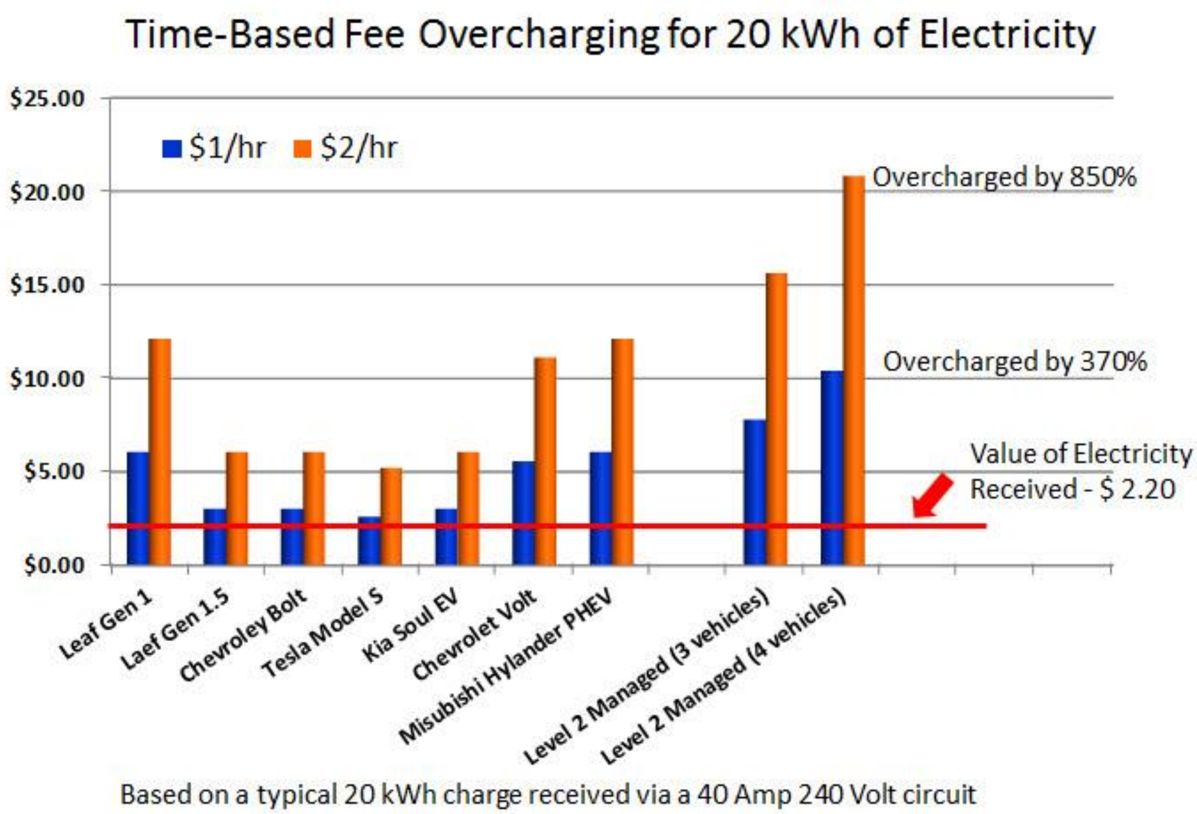
Measurement Canada does not currently permit EV consumption-based fees by the kWh without an approved revenue grade meter. However MC has acknowledged that there are no revenue grade meters approved and apparently no prospect of a standard anytime soon. This is currently resulting in MURBs and other facilities charging by time instead of by energy consumption in kWh.

The concept of promoting time-based fees for EV charging may have originated in such earlier works as the 2013 DOE report[19] that assumed that all EVs would always charge at 3.3 kW. The report was also preoccupied with discouraging EVs from occupying an EV space after a charging session was completed.

By 2018, the technology has significantly changed with most EVs charging at different speeds from 1.9 kW on a managed Level 2, 40 amp circuit to 7.7 kW on a dedicated 40 amp Level 2 circuit. There are also alternative means of dealing with EVs occupying an EV space after charging is completed[20]. Using time-based fees in 2018 can result in 850% overcharging for electricity as well as additional costs for occupancy time. For example, and as illustrated in Figure 1 below, based on a typical fee of $2 per hour, an EV in a Level 2 managed string of 4 EVs could be overcharged by 850 % as compared to the (BC) residential rate (full table in Appendix F).

Time-based fees are an impediment to EV adoption rates and, in particular, the successful introduction of shared charging circuits in MURBs. There are already reported cases of prospective EV owners in MURBs not proceeding with purchases because of high, time-based charging fees.

Figure 1 Time based vs Energy Consumption Based Fees



[19] https://www.scribd.com/document/380867914/US-DOE-Time-vs-Energy-2013-HighlightedSC

[20] *Billing systems are capable of applying different fees for an EV remaining in a space after charging is completed*

The following revised proposal to the General Tariff is intended to provide transparency, facilitate oversight by third parties, provide flexibility in the total fees levied for charging and reduce costs for charging at locations with a small number of chargers (e.g. MURB retrofits).

Proposed Revisions to the General Tariff (subsequent to the April 4th submission)

That the charges for electricity consumption comply with the British Columbia Hydro and Power Authority (BC Hydro) Electric Tariff Terms and Conditions for the Resale of Electricity, Subsection 9.2 of the BC Hydro Electric Tariff Terms and Conditions which states as follows:

<u>Renumber subsection 9 as subsection 9 a) and revise as per the underlined bold text.</u>

a) *If a Customer wishes to sell Electricity which the Customer has purchased from BC Hydro to a tenant, of that Customer at the same Premises* ***<u>with the exception of electricity for the purposes of charging an electric vehicle</u>***[21] *on a metered basis, then the Customer shall agree that the selling price for such Electricity shall not exceed the price which BC Hydro would have charged had that tenant been a Customer of BC Hydro. This requirement shall be included in an agreement for resale between BC Hydro and the Customer.*

<u>Add new subsection 9 b) for AC (Level 1 and Level 2) EV charging</u>

b) *If a Customer wishes to sell* ***AC Electricity*** *which the Customer has purchased from BC Hydro to an owner or operator of an electric vehicle of that Customer at the same Premises on a metered basis, then the Customer shall agree that the selling price for such Electricity*

   i. *If the basis of consumption is per kWh, the price shall not exceed the price which BC Hydro would have charged had that owner or operator of the electric vehicle been a Customer of BC Hydro.*

   ii. *If the basis of consumption is time-based then the price per hour shall not exceed :*

      1) *for Level 1 or Level 2 circuits, the demand load*[22] *of the electrical circuit in kW times the price which BC Hydro would have charged had that owner or operator of the electric vehicle been a Customer of BC Hydro.*
      2) *for Level 2 managed circuits 1/2 the demand load*[23] *of the electrical circuit in kW times the price which BC Hydro would have charged had that owner or operator of the electric vehicle been a Customer of BC Hydro.*

   iii. *If a flat monthly fee is charged for EV charging, then electricity cost shall be either pro-rated by the consumption of kWh by EVs with access to EV charging facilities, or apportioned by the number of EVs with access to the charging facilities at the same premises and shall not exceed the price that BC Hydro would have charged had the EV owners or operators collectively been charged.*

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[21] *This change is suggested in order to include "tenants" with EVs under the new Subsection 9 b)*

[22] *80% of the maximum circuit load (fuse rating)*

[23] *Per Appendix F even at ½ the demand load leads to overcharging for Level 2 managed circuits. If consumption based pricing is allowed in the future, then the Subsection could be modified to provide that the fees for all Level 2 managed circuits shall be on the basis of consumption in kWh only.*

This requirement shall be included in an agreement for resale between BC Hydro and the Customer.

Add a new subsection 9 c) for DC EV charging

i. *If a Customer wishes to sell **DC Electricity** which the Customer has purchased from BC Hydro to an electric vehicle owner or operator on a metered basis at the same Premises, then the Customer shall agree that the selling price for such Electricity shall not exceed **TBD.***[24]

This requirement shall be included in an agreement for resale between BC Hydro and the Customer.

3.1.1 Would Victoria EVA propose similar wording to other public utilities' electric tariffs, such as FortisBC Inc. (FBC)?

Response 3.1.1
Yes

3.2 With respect to DCFCs, is Victoria EVA suggesting that the BCUC should have a separate regulatory process to determine the multiplier proposed?

Response 3.2
The purposes of suggesting a DCFC rate ceiling or cap is to ensure fairness, equal access, and prevent price gouging while still providing sufficient price stability and flexibility for investment decision-making by the private sector.

3.2.1 If so, who should bear the regulatory cost of such regulatory process? (E.g. DCFC service providers that apply before the BCUC, BC Hydro/FBC, or other)

Response 3.2.1.
To avoid repeated regulatory costs, the objective would be to either have an interim (5 year) fixed cap or a cap linked to a benchmark such as the trailing average price of regular gasoline (per Response 3.1) that would apply to all utilities.

B. INVESTMENTS

4.0 Reference: Exhibit C35-2, p. 1, Appendix C, p. 3; Exhibit C5-2, p. 11; Transcript, Volume 7, p. 338
Exhibit C4-2, p. 18; Exhibit C12-2, Appendix 1, p. 48
Estimating number of DCFC units

On page 1 and Appendix C of Exhibit C35-2, Victoria EVA states:

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[24] *Based on a rate schedule to be determined through the General Tariff rate-setting process with suggestions that the rate be set lower than the equivalent price of gasoline(refer to "Regulated cap options" above)*

> A substantial EV charger rollout will be needed in Level 2 residential charging and (DCFC) charging networks. At the current estimated annual rates of EV sales over the next 5 years (to 2023) between 320 and 615 DCFC units could be required.
>
> A recent California Study indicated that between 1 and 3 DCFC units per 100 EVs will be required.
>
> *Using a rate of 2 DCFCs per hundred EVs, and the estimated range of EV ownership by 2023 of 16,050 from Figure 2 and 30,800 from Figure 1 between 320 and 615 DCFC units could be required by 2023.*

On page 11 of Exhibit C5-2, the City of Vancouver states that "The City expects home charging to be the dominant mode of charging for most EV owners because of the convenience."

On page 18 of Exhibit C4-2, Donald Flintoff submits that "… EV owners charge their cars at home more than 90% of the time…"

On page 49 of the Powertech Labs Inc. report dated October 19, 2016 in Appendix 1 of Exhibit C12-2, it states "Data collected for the EV Project led by Idaho National Lab shows that 80% of EV charge events take place in the home (almost always at level 1 or level 2), while 20% take place in public locations."

Response 4.0

The Victoria EVA has identified three models to arrive at DCFC requirements.

The Energy Model uses the metric that 80% or 90% of charging events will occur at home to project that some of the balance of charging would occur at DCFC locations ti derive the number of DCFCs required.

The Traffic Survey Model uses previous comprehensive traffic survey data (e.g. the USA 2009 Travel Survey) to simulate the charging events (L1, L2 and DCFC) that may be expected to occur to arrive at the number of DCFC units required. The National Renewable Energy Laboratory (NREL) has developed a model (EVI-Pro) to estimate DCFC requirements using travel survey data.

The Traffic Volume Model uses a gap analysis combined with traffic volume data along a highway travel corridor to determine the number of DCFCs required at points along the corridor.

The Victoria EVA has done a comparison of the use of these three models in the British Columbia context and has identified the issues associated with the use of each model [25].

[25] *Victoria EVA comparison of DCFC estimation models: https://tinyurl.com/y8kcnsv9*

Table 1 Alternative Models for Estimating DCFC Charging Requirements

DCFC Estimating Method	Concept	Outcomes	Detriments
Energy Model	80% to 90% of EV charging events will occur at home / 10%-20% of EV charging events will occur away from home	DCFCs per 100 EVs (BC outcome = 0.2 DCFCs per 100 EVs)	Underestimates because an assumption is that there is a DCFC in the immediate vicinity at the time a charge is needed [26] [27]. Does not take peak periods of charging demand into account (queueing). Estimates numbers but not locations
Travel Survey Model	Use a previous comprehensive travel survey to predict EV charging needs	DCFCs per 100 EVs (BC "Outcome" = 1 to 3 DCFCs per 100 EVs in 2023)	Depends on the availability of previous travel survey. Includes DCFCs for use as substitute for resident- based L1 or L2 charging where L1 or L2 are not available Multiple factors, variables and assumptions (the "black box" syndrome) Estimates numbers but not locations
Travel Volume Model	Use gap analysis , hourly traffic flows and EV mix to estimate DCFC requirements,	DCFCs (plugs) per location BC outcome would be locations and number of DCFCs per location	Comprehensive traffic flow data may not be available for all highway segments. Determining "through" vs "local" EVs on a highway segment may require some additional field studies.

The M.J. Bradley report (as referenced in the Commission letter of May 3) refers to the NREL (EVI-Pro) tool to estimate DCFC requirements (Page 12 of the report). This is the same model (EVI-Pro) as reported being used in the California study that was referenced in the Victoria EVA submission of April 4. The M.J. Bradley report represents an example of the use of the Travel Survey Model.

Of concern, is that the Department of Energy USA nation-wide analysis referenced in the M.J. Bradley paper arrived at DCFC estimates of 0.17 per 100 PEVs [28] whereas the California Study using the same EVI-Pro model arrived at DCFC estimates as high as 3.4 DCFCs per 100 PEVs. The reason(s) for this order-of-magnitude variance are unknown.

[26] *In one case (UK) the model produced an estimate of 72 DCFCs being required. The actual number of DCFCs already in service was 1,162.*

[27] *An analogy might be (the use of pay phones) Many more pay phones are needed than the sum of the number of pay phone calls per day. Pay phones (DCFCs) have to be physically located wherever they may be needed and ideally with no waiting queue of users. The Energy Model does not account for these conditions of peak use or location.*

[28] *National Plug-In Electric Vehicle Infrastructure Analysis, Page 15*

The MJ Bradley report also refers to the Georgetown Climate Center (et al) working on a DCFC gap analysis methodology. This gap analysis method is similar to what is already being used in BC to determine "where" DCFCs should be located. The Traffic Volume Model (above) includes a gap analysis but takes it one step further by determining "how many" DCFCs would be required at each location identified from the gap analysis. Natural Resources Canada has independently come to the same conclusion that the Traffic Volume model can be effectively used to estimate DCFC requirements for intercity travel [29]

Notwithstanding that urban DCFCs will be required, estimating DCFC locations required in urban areas by including DCFCs as substitutes for retrofitting MURBs could be undesirable in the long term as it could result in additional daytime loading of the grid. An optimal solution for BC (Appendix D) could include focussing on Level 2 residential overnight charging rather than DCFCs in order to minimize daytime peaks.

In a report authored Georgetown Climate Center and by M.J. Bradley & Associates, titled "Utility Investment in the Electric Vehicle Charging Grid: Key Regulatory Considerations" dated November 2017[30] (GCC-MJBA Report), on page 9, Figure 1 provides the models of utility investment in EV charging infrastructure: (i) business as usual, (ii) make-ready, (iii) owner-operator, and (iv) utility incentive.

4.1 Please clarify whether the California Study specify for what time period would between 1 and 3 DCFC units per 100 EVs be required. Is this ratio applicable for 2023, or some other years?

Response 4.1 (Also refer to Response 4.0 above)
The California Study included Low/High Estimates for DCFC units for 2020 and 2025 and for PEVs and BEVs[31] *as per the following summary Table 2:*

Table 2 Projections for PEV Charging Demand (Table ES.1 from the NREL Study)

Table ES.1: Projections for Statewide PEV Charger Demand

Demand for L2 Destination (Workplace and Public) Chargers (The Default Scenario)			
	Total PEVs	Lower Estimate (Chargers)	Higher Estimate (Chargers)
As of 2017	239,328	21,502	28,701
By 2020	645,093	53,173	70,368
By 2025	1,321,371	99,333	133,270
Demand for DC Fast Chargers (The Default Scenario)			
	Total BEVs	Lower Estimate (Chargers)	Higher Estimate (Chargers)
As of 2017	133,386	2,005	5,877
By 2020	356,814	4,881	13,752
By 2025	729,094	9,061	24,967

Source: California Energy Commission and NREL

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[29] *Forecasting the Need for DCFC Charging Stations along the TC Highway, April 26, 2018* https://preview.tinyurl.com/y8p5q2s5

[30] http://www.georgetownclimate.org/files/report/GCC-MJBA_Utility-Investment-in-EV-Charging-Infrastructure.pdf

[31] *There is issue on whether to size the DCFC infrastructure for PEVs (including PHEVs) or just for BEVs. Sizing DCFC infrastructure for PHEVs increases CO2 reductions and also increases DCFC costs. In addition, there are issues about effectively prohibiting PHEV drivers from using DCFCs as more PHEVs are manufactured with DCFC capability.*

The Victoria EVA submission was based on 2023 and arrived at the 2023 BEV figure of 1 to 3 per 100 vehicles by interpolating the California BEV chart for the years between 2020 and 2025. (Table 3) Straight-line interpolation for 2023 yielded between 1.3% and 3.3% DCFCs for BEVs. The lower mileage of BC vehicles was subjectively considered per the note at the bottom of the table.

Table 3 DCFC Requirements

DCFC Requirements from California Study

		Demand for DCFC Fast Chargers (The Default Scenario)				
		Total BEVs	Low Estimate	High Estimate	Low Ratio	High Ratio
	As of 2017	133,386	2,005	5,877	1.5%	4.4%
	by 2020	356,814	4,881	13,752	1.4%	3.9%
Interpolated	by 2023				1.3%	3.3%
	by 2025	729,094	9,061	24,967	1.2%	3.4%

For DCFC estimate in Appendix C , Two (2) DCFCs per 100 EVs was used
based on: slightly less than average between low and high
as BC annual mileage lower than average and USA

In the California Study, PHEVs were treated separately (as charging via Level 2) and assumed to not use DCFC charging. However, PHEV vehicle architecture is changing with more PHEVS now becoming available with DCFC capability[32]. This trend of PHEVs using DCFC facilities is expected to continue as more PHEVs approach ranges of 50 km or more. It is considered to be impractical to prevent PHEVs from using DCFCs; consequently PHEVs also need to be considered in DCFC requirements.

4.2 Does the California Study discuss distance travelled per EV to conclude such 1-3 DCFC units per 100 EVs ratio? If so, is there any evidence to indicate that the distance travelled in California and BC is similar or dissimilar?

Response 4.2

FHWA Highway Statistics 2013 Table VM-1M Light Duty Vehicle ***- 18,095 km/yr.***
http://www.fhwa.dot.gov/policyinformation/statistics/2013/

Cdn Travel Survey 2009 Figure 11 Page 13 Light Vehicles 15,366 km/yr (Canada) ***- 12,900 km/yr BC***
http://oee.nrcan.gc.ca/publications/statistics/cvs/2009/index.cfm

The BC Vehicle Miles travelled (VMT) would be expected to be less in BC than California but VMT is only one of many factors considered in the EVI-Pro model.

4.3 Does the California Study provide any assumptions regarding home charging vs. public charging? If so, please compare with the California Study with the 80%-90% home charging submissions as referenced above.

[32] *Mitsubishi Outlander PHEV*

Response 4.3

Intercity DCFC Requirements

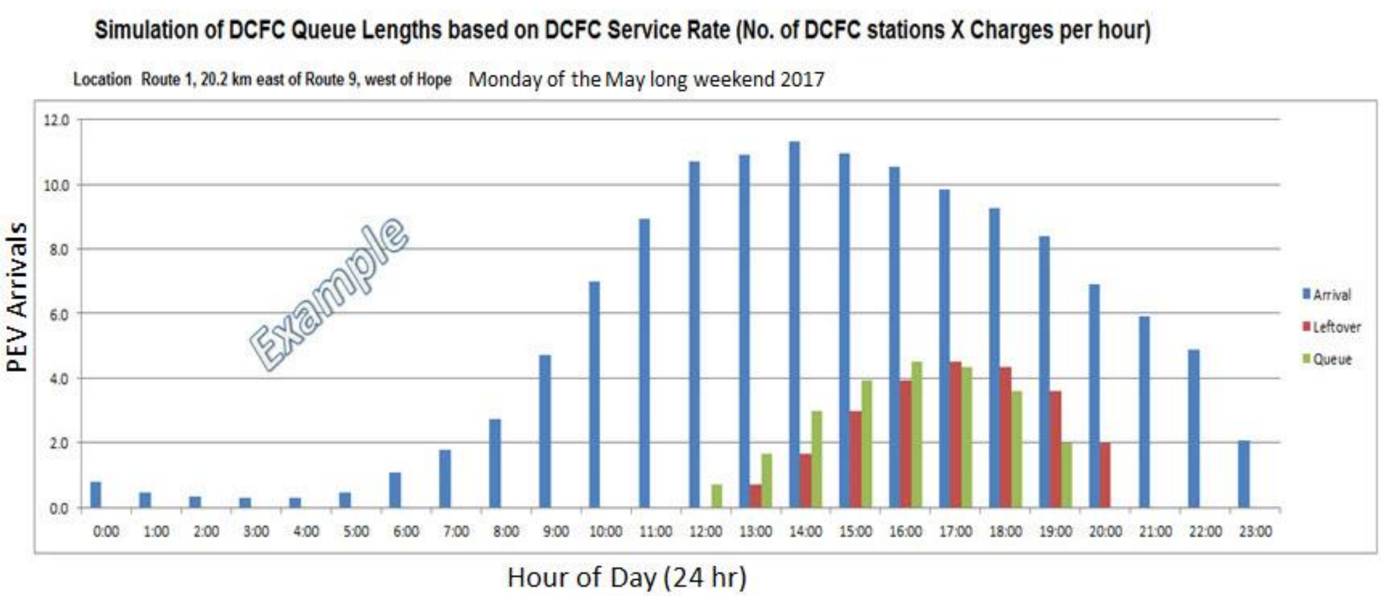
The California model, which is based on the same National model referred to in the M.J. Bradley report, does take L1 and L2 residence into account but also includes DCFC requirements for urban residences that do not have charging capability as well as DCFCs for "emergency use". A comparison of the methodologies is included in the Table in Response 4.0 above.

It is apparent that Travel Survey Models for DCFC requirements in their current state of development may not form a basis for producing practical information for DCFC planning purposes. A more promising approach would be to use the Travel Volume Model to determine estimates for the Inter-City DCFC requirements.

In Victoria EVA's view, the Traffic Volume Model is currently the most effective means of determining DCFC requirements for intercity travel. The Ministry of Energy, Mines and Petroleum submission (page 6), indicated that with a spacing of 50 km (adjusted for mountainous terrain), "approximately 200 Level 3 (DCFC) charging stations would be required at a minimum to allow for travel along all of BC's primary and secondary corridors". We do not know the number of DCFCs assumed per location but we understand that the 200 figure currently does not include the volume analysis piece of the Travel Volume Model.

Figure 2 illustrates a Traffic Volume Model that could be used to determine DCFC plug requirements and queuing impacts at a highway DCFC location.

Figure 2 Travel Model Example



PEV = Plug in Electric Vehicle (BEV or PHEV)

Urban DCFC Requirements

In terms of urban DCFCs requirements, it is Victoria EVA's view that DCFC assessments should be based on the needs and conditions identified at the municipal level taking into account local conditions[33]. To achieve a more optimal use of DCFCs and infrastructure funding that avoids stranded assets, DCFC locations in urban areas would be best determined by stakeholders in the community working along with the utilities. In this respect the PG&E stakeholder-based EPIC model [34] could be a good starting point for developing guidelines for determining urban public DCFC requirements. The objectives would be; to meet local needs for DCFCs, avoid DCFCs as a substitute for viable residential charging, maximize the use of existing grid resources, and ensure a viable customer base for each DCFC location.

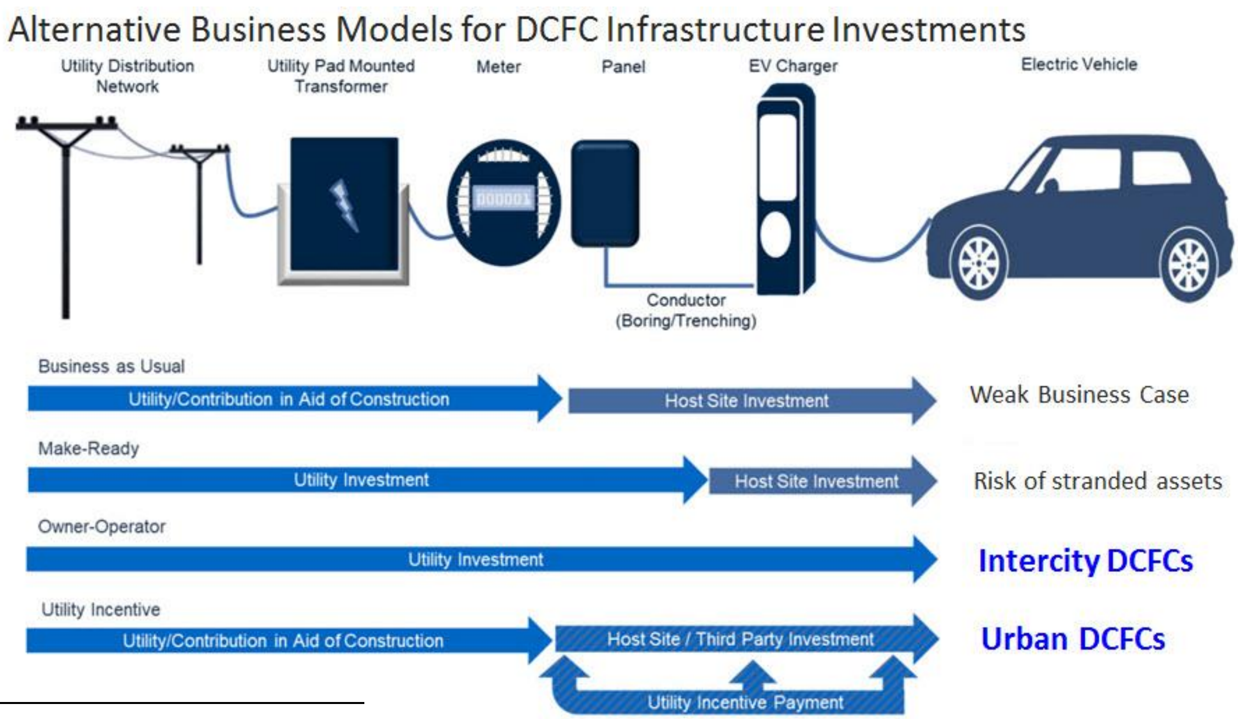
The result is that the combination of public InterCity and Urban DCFCs required in the next five years is in the hundreds. Implementation may prove challenging in terms of the availability of sufficient resources to fund, plan, and install the DCFC units required.

4.4 In Victoria EVA's view, which business model as referenced in the GCC-MJBA Report is most appropriate to invest in DCFC infrastructure if there's "a need for between 5.3 and 10.3 DCFC installations per month for the next 60 months." Please discuss.

Response 4.4

In Victoria EVA's view the preferred business model for utility DCFC investments would be based on the model(s) that could result in; a rapid increase in DCFC installations, meeting EV owner's needs, favorable economics and risk avoidance. Figure 3 below summarises the Victoria EVA's view of the models that could apply to meet these objectives.

Figure 3 Alternative DCFC Business Models



[33] *Such as the presence or absence of access to an off street exclusive parking space in each neighbourhood*
[34] *Electric Program Investment Charge (EPIC) https://tinyurl.com/y9956aj9*

The Business as Usual model for DCFC would not be expected to increase DCFC installations due to the weak business case for DCFCs (fees would have to be higher than the gasoline equivalent). The Make-Ready model (as described by M.J. Bradley) could separate the functions of site selection from the utility perspective and site selection from the host perspective, thereby increasing the risk of stranded assets. If the site selection were jointly selected, the Make Ready model partially offsets DCFC costs and is more akin to the Utility Incentive Model.

The Owner-Operator Model is preferred for Intercity DCFC locations where there is a need for a rapid increase in DCFC deployment, province wide coverage, and responsive maintenance in view of the reality of revenues falling short of costs. In time, with higher adoption rates and lower DCFC unit costs, perhaps some Intercity DCFC installations could migrate to the Utility-Incentive model.

At the Nanaimo Community Input Session, Ms. Turner suggested:

> … The research that I've done so far has indicated that the battery capacity for a full EV used to be 250 kilometres. It's now up to 383 in the particular vehicle that I was looking at.
>
> In two or three years perhaps that capacity will have increased, and therefore the need for charging stations will be reduced, just by virtue of not being concerned.[35]

4.5 Please comment on Ms. Turner's submission that when vehicle capacity increase, the distance range available will also increase. Thus, the need for charging stations will be reduced.

Response 4.5

There are very few EVs in operation today in terms of the total fleet size. Although initially destination (L2) charging requirements were estimated to be 20% for the long term they are now expected to be less (< 5%) in view of increased battery sizes in entry-level EVs (now 40 to 60 kWh). However, over 99 percent of the fleet is still to be electrified, therefore in spite of increased range, an increased number of destination L2 charging stations are expected to be needed to keep pace with EV adoption rates.

In terms of Inter-City DCFC charging, substantial increases in infrastructure are anticipated for at least a decade. DCFC charging stations are required for long distance travel once the initial (overnight) charge has been depleted. There is considerable additional expense for a battery in a vehicle that would be capable of a full travel day of (say) 800 km (8 hours at 100 km/h) without stopping to recharge. This would require a vehicle with a 160 kWh battery with an additional cost (over a 60 kWh battery) of about $20,000 USD (@$200/kWh). Even with battery costs expected to drop to $100 USD /kWh by 2023-2025, there are currently no vehicles with this range in the market and they would be expected to gain limited long-term market share (hence fleet penetration) due to the additional cost. Additionally, there are still practical trade-offs between increased battery weight and the associated increase in energy consumption (Whr/km) to carry the extra weight.

Another consideration could be the advantage of installing sufficient DCFC infrastructure to support all EV generations. Lower cost, first generation used EVs with lower battery capacities are important to the

[35] Transcript, Volume 7, p. 338.

electrification effort in terms of dealing with the "issues of social and demographic equity"[36] and will need DCFC charging capability for many years to come. (Appendix D Item #3)

C. RATES

5.0 Reference: Exhibit C35-2, p. 14
TOU rates

On page 14 of Exhibit C35-2, Victoria EVA states:

> However, a concern with the application of TOU rates could arise if large numbers of EV users manually or start charging automatically at the beginning of the off peak rate period thereby creating a new peak grid loading issue

5.1 Please provide examples of jurisdictions or studies/reports regarding the concern that TOU rates may create a new peak grid loading issue.

Response 5.1

The issue of TOU rates is jurisdictional-specific. In some jurisdictions there are already TOU rates in effect for all high energy domestic appliances (water heaters, clothes dryers) and TOU rates were implemented to address peak daytime grid loads. In other jurisdictions, peak daytime solar energy production may also play a role in terms of curtailment strategies that are needed to address grid oversupply caused by base power emanating from nuclear or coal sources.

British Columbia does not have a TOU rate structure. Although BC does not have the base load issue that comes with nuclear, fossil fueled or solar sources, we have no information if there are currently any daytime grid load issues that would justify a TOU rate structure. Further, in order to avoid net revenue losses it would be necessary to balance any TOU rate decreases with rate increases at other times of the day. This could prove to be controversial without a strong business case.

Turning to the concept of TOU rates for EVs, the intended purpose of a TOU rate should be addressed first. If the purpose of a TOU rate is to encourage EV owners to charge at night (grid load mitigation), then TOU rates are only one of several alternatives to accomplishing this objective. If the purpose is to provide an (even) lower electricity rate to encourage EV ownership then the effectiveness and equity of such a proposal should be part of the discussion.

The issue of TOU rates causing a grid peaking problem is dependent on the percentage of EVs in the fleet. If EV sales were 30% by 2030, EVs would only represent 6% of the fleet (per Victoria EVA's projections in Appendix B-2). By 2030 then, it is unlikely that EVs would impact on the larger grid, but they could possibly have some local grid implications. In the longer term, daytime EV charging during grid peaks could become an issue unless effectively mitigated.

Table 4 below outlines grid loading mitigation alternatives (including TOU) and the potential advantages and detriments for each alternative.

[36] Page 4 MJ Bradley Report: Utility Investment in Electric Vehicle Charging Infrastructure

Table 4 Grid Load Mitigation Alternatives

Grid Load Mitigation Alternative	Advantages	Detriments
TOU	Encourage night EV charging	Possible localized grid peaks as EV users may start their charging sessions at the start time of lower TOU rates. Possible long term (2040+) grid peaks? Forfeit additional revenue (dryers, water heaters, EVs) or increase rates at the other TOD to compensate. Loss of additional EV revenue that could be used for DCFC infrastructure. Negative reaction from non-EV owners if EVs are the "justification" for TOU.
Voluntary charging times (lawn sprinkler model) 7pm to 12 am / 12am to 6am	Low/no cost. Repeated misuse could possibly be "enforced" through smart meter data.	Potential inconveniences but could be mitigated by allowing exceptions on the honour system, such as arriving home late.
Smart meter on EV (and other water heater, dryer) circuits	Reduces long term grid peaks.	Cost. Consumer reaction to utility (BC Hydro) control of "down meter" circuits.
Total Residence Demand	Higher form of load management. The equivalent of having demand rates on an individual residence.	Cost and negative consumer reaction

D. HYDROGEN FUEL CELL TECHNOLOGY

6.0 Reference: Exhibit C19-2, p. 2
Fuel Cell Electric Vehicle (FCEV)

On page 2 of Exhibit C19-2, British Columbia Ministry of Energy, Mines and Petroleum Resources states that “The Province is active in promoting the uptake of zero emission vehicles (ZEVs), including battery-electric, plug-in hybrid, and fuel cell vehicles.”

In February 2016 the Province announced an investment of $40 million for the CEV Program. The funding will be distributed over three years (2017-18, 2018-19, and 2019-20) to:

- Continue point-of-sale purchase incentives of up to $5,000 for battery electric vehicles and $6,000 for hydrogen fuel cell electric vehicles. When combined with SCRAP-IT program incentives, total savings could be up to $11,000 for a new electric vehicle, and $12,000 for a hydrogen fuel cell vehicle.[37]

6.1 Please indicate whether Victoria EVA represent any FCEV members. If so, how many members own and/or drive FCEVs relative to Victoria EVA’s total membership?

[37] Exhibit C12-2, Appendix 3, FACTSHEET: Clean Energy Vehicle Program/Innovative Clean Energy Fund, dated March 27, 2017.

Response 6.1 *There are no members in the VEVC club that have a FCEV*

6.2 In Victoria EVA's view, from a user perspective, please compare the pros and cons of FCEVs relative to battery electric and plug-in hybrid electric vehicles.

Response 6.2 *Table 5 outlines the pros and cons in the view of the Victoria EVA with respect to FCEVs vs PHEVs and BEVs*

Table 5 Pros and Cons of FCEVs, PHEVs and BEVs

Vehicle Type	Pros	Cons
FCEV	Although Refueling time[38] has been claimed as an advantage it can be effectively argued that total refueling time for FCEVs is actually more than BEVs (Appendix G) Note: "Range before refuelling" is no longer a pro for FCEVs as equivalent cost BEVs now have higher ranges (Model 3 has 536 km of range vs Mirai at 499 km)	Expensive to purchase. Entry level FCEV is $75K CDN.
		Expensive to maintain (due to relative complexity).
		Expensive to operate: hydrogen equivalent cost is $5 USD per US gallon or 78 cents per kWh as compared to BEV.
		Predetermined major vehicle component expiry date (Appendix H). FCEV will stop operating in 14th year forcing tank replacement. Could possibly be uneconomical to replace tanks and restore degraded fuel cell.
		Expensive refueling infrastructure. Entry level hydrogen station is $2 million USD[39].
		FCEVs well-to-wheel emissions from methane source are 5.5 kg CO2 per kg hydrogen. If electrolysis used FCEV only 1/3 as efficient as BEV.
		Not an optimal environmental alternative for British Columbia.
PHEV	Range before refuelling (some, but not all PHEVs[40]) Travel flexibility in absence of BEV infrastructure	Extra cost of two motive power sources
		CO2 emissions.
		Operating costs depending on use of IC engine
BEV	Lower cost than FCEV Low TCO (Total Cost of Ownership) Lower InterCity entry level refueling infrastructure - $100K. Lowest well-to-wheel CO2 emissions of any vehicle due to renewable BC grid.	Higher cost than PHEV.
		Current lack of availability of all body styles.
		Shortage of DCFC infrastructure.

[38] *Total refueling time for FCEV per 12,900 km (Average BC annual mileage) is arguably longer than a BEV (Refer to Appendix G) as only 20 % of charging events occur in highways, otherwise FCEVs require travel time to (and from) refueling stations.*

[39] *https://www.scribd.com/document/381053753/NREL-Hydrogen-Fuel-Station-Costs*

[40] *Source: US Dept. of Energy: 2018 Fuel Economy ratings of all US vehicles www.fueleconomy.gov*

Summary

FCEVs represent neither a cost effective nor environmentally-optimal alternative for BC. FCEVs cost more to purchase, operate and maintain, require order-of-magnitude more costly infrastructure and because of BCs renewable energy source of electricity, FCEVs offer no CO2 advantages (Appendix K-3) over PHEVs. There are no known advantages to BC using electrolysis as a source for hydrogen as BC has terrain-storage options for any surplus electricity generation.

6.3 In Victoria EVA's view, from a charging infrastructure perspective, please compare and contrast the pros and cons of FCEVs relative to battery electric and plug-in hybrid electric vehicles.

Response 6.3

The Victoria EVA is concerned about the diversion of Climate Action funding to hydrogen infrastructure as hydrogen vehicle infrastructure is not viable in BC for Light Duty Vehicles, nor is it the optimal solution for GHG emissions in BC (Appendix K).

Table 6 outlines a comparison of the pros and cons of the infrastructure requirements for FCEV, PHEV and BEV vehicles

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Table 6 Vehicle Charging Infrastructure Comparison for FCEVs, PHEVs and BEVs

Infrastructure Type	Pros	Cons
FCEV	Although charging speed has been claimed as an advantage it can be effectively argued that total refueling time for BEVs is actually less than a FCEV (Appendix G). Any asserted charging speed advantage for FCEVs may not materialize, or may be limited to Intercity trips and/or be short-lived[41] [42] .	Urban refills require driving to a hydrogen dispensing station (15 minutes plus) as they will not be as conveniently located as gas stations[43]. InterCity refills may also require additional travel to/from refuelling points.
		Cost per kWh dispensed is at least 7 times the cost of electricity[44].
		Entry-level cost of hydrogen station ($2 million[45]) would make them less available.
		Requires travel to obtain fuel. Even in the longer term extensive travel would be required for a fill up as hydrogen stations would be confined to industrial/commercial areas.
		Higher station down-time would be expected due to the complexity of hydrogen stations and access to highly-trained certified hydrogen service technicians. There would be no alternative fueling available. FCEV would be stranded with no options (e.g. L2 for a BEV or PHEV).
PHEV	Fuel infrastructure for longer range use (gasoline) is in place.	PHEVS could conflict with BEVs at DCFCs if insufficient DCFC facilities.
BEV	Charging speed for most Urban (daily) trips. Convenient home charging, Usually no requirement to stop to recharge. "Recharging" consist of the 10 seconds it takes to plug in the BEV. Most efficient use of electricity. Charging is a clean, safe process free of any airborne pollutants. Charging stations more likely to be directly adjacent to amenities (food, shopping).	Long distance Inter-City travel requires stops to recharge depending on vehicle battery range[46].
		PHEVs could compete with BEVs for DCFC infrastructure unless DCFC infrastructure keeps pace with demand. Bans of PHEVs at DCFCs are unlikely and impractical[47].

[41] FCEV dispensing speeds can be affected by available pressure and temperature. Reduced dispensing tank pressures will slow charging speed until the compressors can restore pressure.
[42] DCFC charging technology being rolled out includes 250-350kW DCFC chargers capable of adding the equivalent of 5 kg of hydrogen (83 kWh to the wheels) as electricity in 14 to 20 minutes vs ~ 10 minutes. Longer range (500 km) EVs further reduce any intercity speed advantage as stops could more generally coincide with rest/refreshment breaks.
[43] If the proposal is to construct hydrogen electrolysis stations at point-of-use (as implied), it is unlikely that these stations will be permitted in residential areas. The Victoria EVA is in the process of researching this zoning issue further.
[44] Hydrogen fuel (California) has been reported to run between $13 and $16 per kg. Taking the lowest cost of $13 per kg this amounts to the equivalent of 0.78 per kWh ($13/16.65 kWh/kg (33.3 kWh energy per kg H2 X 50 % for thermal losses)).
[45] NREL National Renewable Energy Laboratory Technical Report NREL/TP-5400-56412 Comparing Hydrogen Station Cost calculator Results with other recent estimates.
[46] BEV basic models are moving to 240 km (40 kWh) and 320 km (60 kWh) ranges with higher end models at 500 km) (100 kWh).
[47] As reported in at least one jurisdiction (Beverly Hills CA).

Appendix A EV Adoption Impacts on the BC Grid

Issue of cross-subsidization - La Presse May 17, 2018 (translated into English)

“ The Québec government is taking great steps to increase the number of electric vehicles on the roads. It gives Hydro-Québec the mandate to line the territory with fast charging stations, which the Crown Corporation insists can do without any impact on electricity rates."

"It's a pretty unique model that is only winners," said Hydro-Québec spokesman Louis-Olivier Batty, about the bill tabled the day before by the Couillard government to establish a service public fast charging. Investments of $ 130 million will be required from Hydro-Québec to add 1600 fast charging stations in Québec within 10 years. These investments will be fully offset by the increase in electricity sales that will result from the increase in the number of electric cars, says Hydro.

Issue of total Grid Demand as reported by the CBC April 4, 2016[48]

BC Hydro:
"We started looking at this quite early on, as far back as 2007," Tsang said of BC Hydro's efforts.
One study by the University of Victoria's Pacific Institute for Climate Solutions found that even in winter, when electricity demand is highest, B.C. had the unused capacity on its grid to charge nearly 2.4 million light-duty vehicles — almost all the 2.8 million registered vehicles in the province."

"Even the most optimistic projections of electric vehicle adoption still represent a really gradual load growth on utilities' grids," Tsang said. "So in terms of generation and transmission, that large perspective, most utilities wouldn't have any problem meeting that demand."

Hydro Québec:
Hydro-Québec calculated that an electric car would use about the same amount of energy in an average year as a hot-water heater, and is just as confident about its ability to meet overall electricity needs.

"We did our homework and we could easily, in Québec, welcome a million electric vehicles without having to make any major investments in our infrastructure or systems," spokesman Louis-Olivier Batty said.

"It would be two to three per cent of electricity sales in the province."

Issue of Localized Loads

There may be localized transformer issues if (say) all the 8 or 10 family homes served by the same transformer where to get EVs. Some utilities (we believe that it was San Diego Power & Electric) ask that families let them know if they acquire an EV so that they can monitor the respective local transformer should other families also go electric.
Toronto:
Already areas like downtown Toronto have trouble meeting local demand for electricity, according to the Toronto Atmospheric Fund, the city government's climate agency.

[48] http://www.cbc.ca/news/technology/canada-electric-cars-electricity-system-1.3526558

"The system will have problems if everyone starts plugging in electric vehicles," said Julia Langer, the organization's CEO. "We don't have any spare electricity, and … for a bunch of reasons that has to do with transformer capacity. They're really ancient."

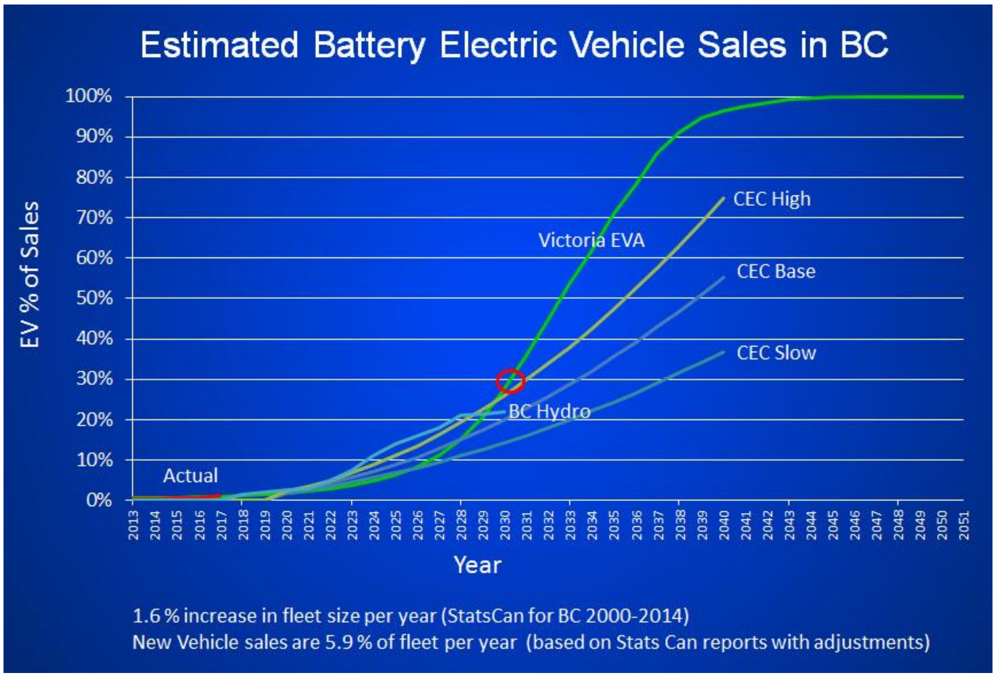
BC Hydro and Hydro Québec

But BC Hydro's Tsang and Hydro-Québec's Batty are confident their companies can predict and manage the added load. "We're generally able to detect that with our vast metering infrastructure," Tsang said. "We anticipate some overloading, but these transformers are very robust. They'll be able to withstand that, and we'll be able to go in and upgrade."

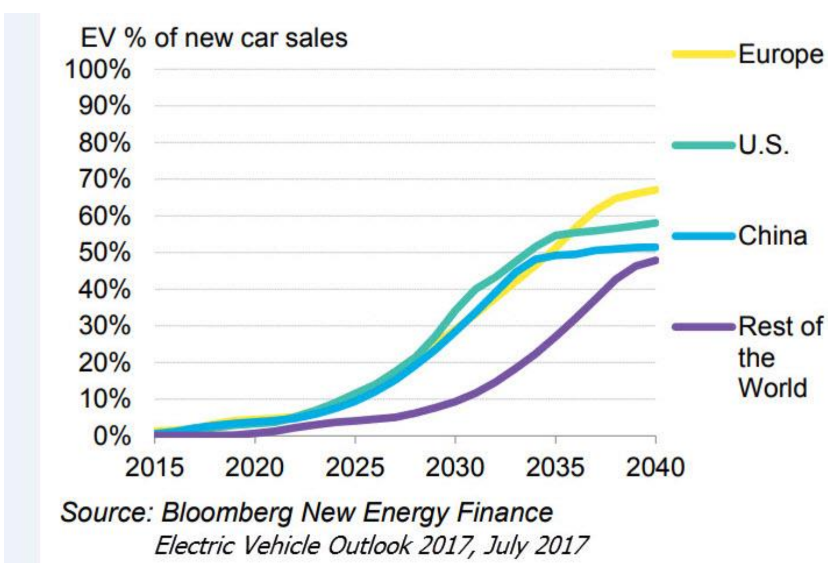
Appendix B -1 BC Light Duty Vehicle Sales Estimates

Figure 4 below is an overlay of the BC Hydro and Commercial Energy Consumers Association (CEC) EV sales projections per their submissions, onto the Victoria EVA estimate for EV sales. As of this writing the BC Hydro and CEC assumptions for fleet vehicle growth are unknown. From Bloomberg (below) there appears to be an emerging consensus around "30 by 30" (the red circle on the graph) - 30 percent EV sales by 2030.

Figure 4 Estimated LDV Battery Electric Vehicle Sales in BC

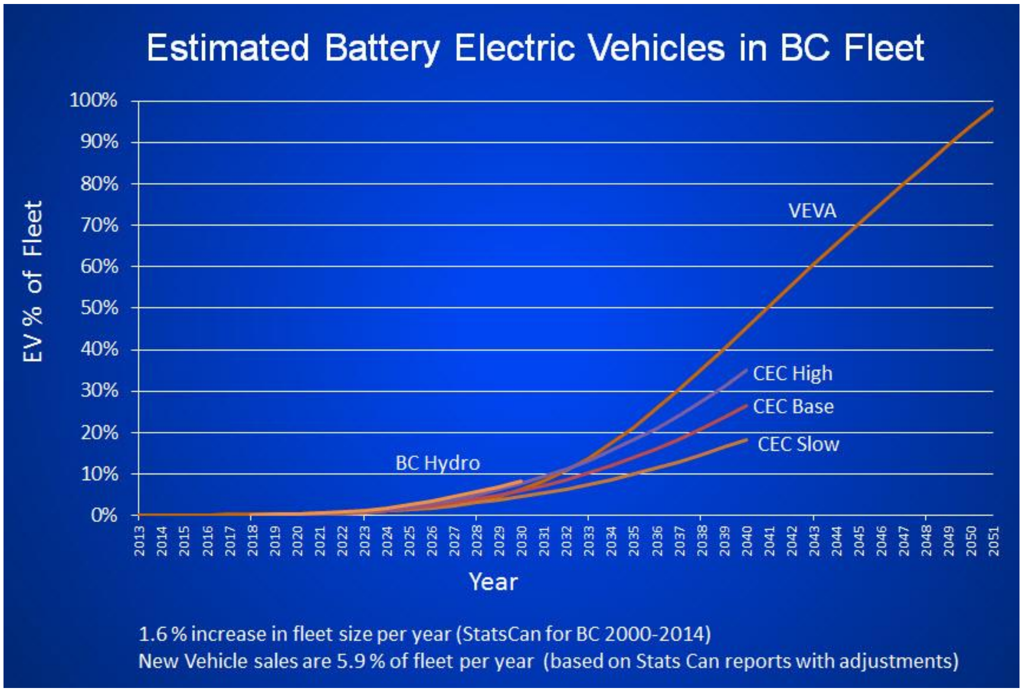


From Figure 4 the CEC "Slow", "Base" and BC Hydro estimates are lower than the latest Bloomberg long term EV sales projections:



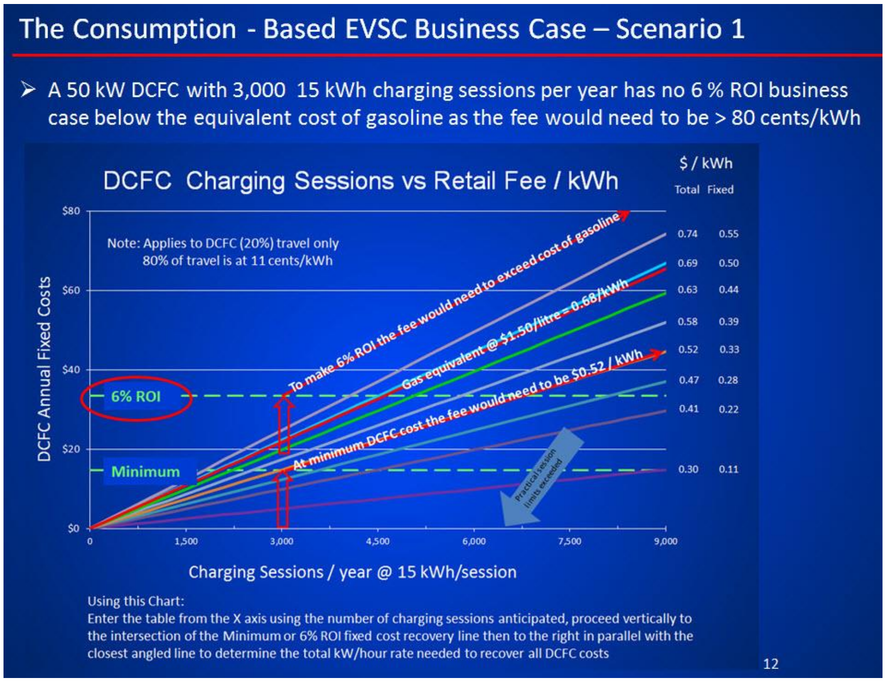
Appendix B -2 BC Light Duty Vehicle Fleet Estimates

The implications of higher EV sales on the BC Fleet are that even if EV sales reach 30% by 2030, the EV composition of the BC Light duty fleet would not reach 30% until 2037 (Victoria EVA estimate)

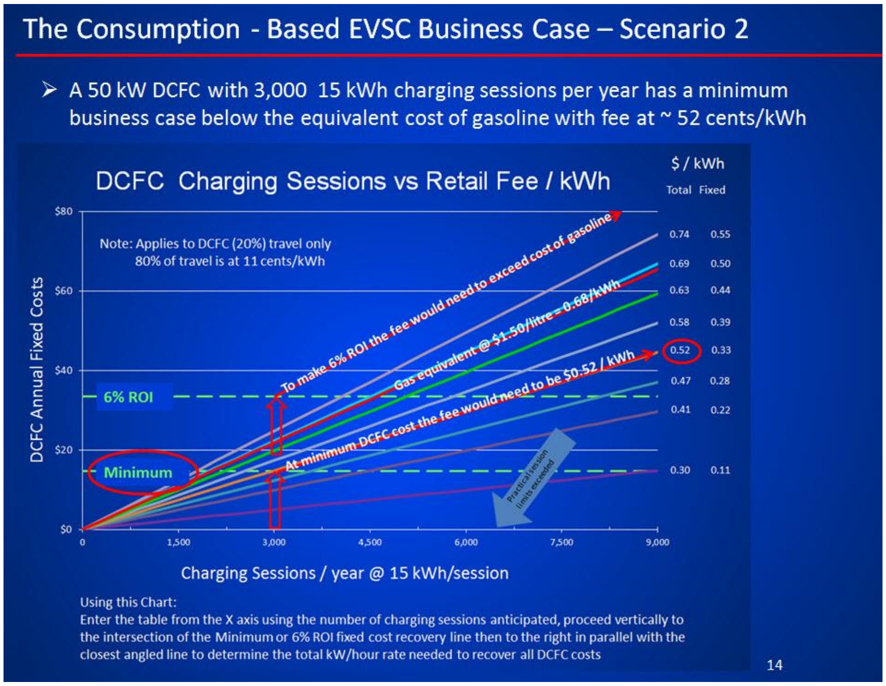


Appendix C – DCFC Business Case Scenarios (from April 4 Victoria EVA submission)

To make a 6% ROI at 3,000 sessions per year with a 50 KW DCFC, the charging fee would need to be > 80 cents per kWh (higher than the cost of gasoline at $1.50 per litre for a 9 litres/km vehicle).



To break even with the initial DCFC 100% subsidized at 3,000 sessions per year with a 50 KW DCFC, the charging fee would need to be 52 cents per kWh.



Appendix D – Potential Optimal EV Charging Strategy

An optimal EV charging strategy would consist of matching EV charging needs with the electrical grid characteristics in a manner that produces the lowest GHG emissions with the least impacts on the grid.

In British Columbia:

- the electrical grid is 97% renewable (from hydro)
- excess power during off peak periods is re-pumped
- there are currently no significant wind, solar geothermal or other renewable sources
- personal solar sources have substantial ROIs due to BC's latitude (sun angle) and climate

Under these power source and grid conditions, the optimal EV charging strategy could include the following:

1. Personal EVs are charged overnight at the owner's place of residence or (if travelling) the place of overnight accommodation.
2. BC Municipalities pass Zoning Bylaws requiring EV infrastructure in new construction based on land use. Residential and accommodation land uses to have 100% of their parking spaces "EV ready".
3. The importing of used first generation EVs (2011 -2019) as well as subsequent used EVs is actively pursued as a means of increasing EV adoption rates for those that cannot afford new vehicles[49].
4. Inter-City DCFCs are strategically placed at intervals between all communities to accommodate first generation and subsequent EVs in sufficient numbers to avoid queuing.
5. Urban DCFCs are primarily installed for the purposes of facilitating daytime business charging for transportation, delivery, tourism and other private business operations.
6. Urban DCFCs are also installed to serve those that do not have access to exclusive parking spaces and for use by those requiring an occasional "emergency" charge[50].
7. Deployments of Urban DCFC charging stations place additional loads on the (BC) daytime grid; therefore DCFCs should not be deployed as a substitute for viable residential, commercial or industrial Level 1 or Level 2 charging infrastructure.

[49] As EVs represent a new product in an existing fleet of over 2.7 million ICE vehicles there will be a decades-long shortage of domestically-sold EVs. A strategy to encourage the importation of used EVs would be a win-win with lower operating costs for lower income earners (with a saving in disposable income) and lower emissions.

[50] EV owners that have access to exclusive charging but that did not receive a charge overnight or have urgent long distance travel.

Appendix E Business Models for Reselling AC Electricity

Table 7 AC Charging Business Model Expenses and Revenues for Typical Land Uses

Expenses & Revenue	Land Use / Owner				
	MURBs New	MURBs Retrofits	Commercial	Institutional	Recreational
Expenses					
Hydro/ Utility customer	LO	LO	LO	LO	LO
Basic EV Infrastructure	LO	LO	LO	LO	LO
Wiring to parking space	LO	Opt E	LO	LO	LO
EVSE	EV	Opt E	LO	LO	LO
Maintenance	LO	LO	LO	LO	LO
Wifi	LO	LO	LO	LO	LO
Billing System Cost	LO	LO	LO	LO	LO
Overheads	LO	LO	LO	LO	LO
Revenues					
Resold Electricity	LO3	LO3	LO3	LO3	LO3
Monthly access fees[51]	EV	EV	No	No	No
EV connected but not [52] charging	No	Opt R	Opt R	Opt R	Opt R
Parking fee	No	No	Opt R	Opt R	Opt R

Key

EV – EV owner

LO – Land owner or Lessor

LO3 – to Land Owner or Lessor from EV owner directly or via a third party (billing system)

Opt E – Optional Expense by LO or EV owner

Opt R - Optional Revenue to LO from EV owner

[51] Advanced billing systems should be capable of levying monthly access fees and forwarding the associated revenue to the LO

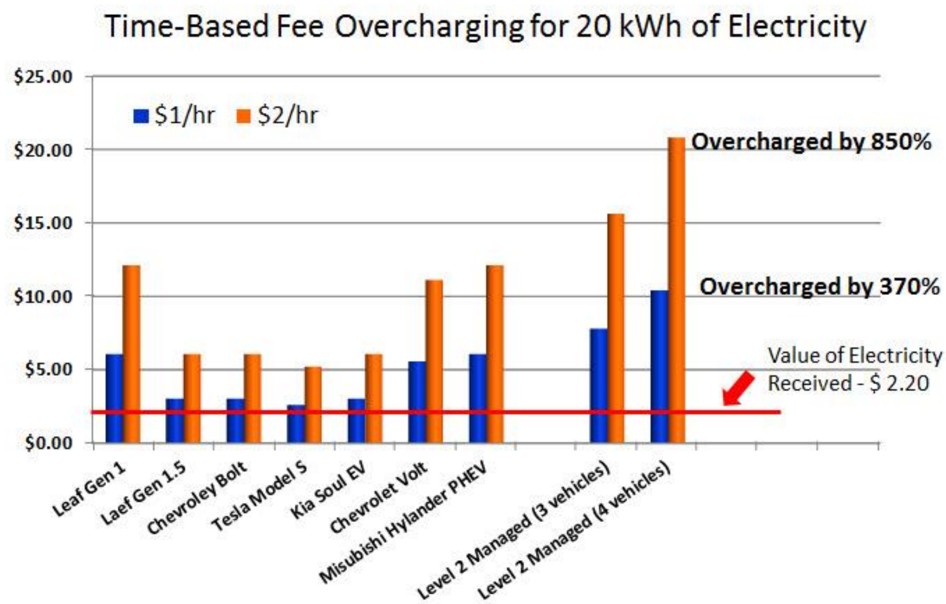
[52] Similarly, advanced billing systems should also be capable of levying connect fees (after charging) and forwarding the associated revenue to the LO

Appendix F

Time-based (per hr) vs Consumption based (kWh) Charging fees

Time based fees could result in EV owners being as much as 847 % overcharged for electricity

Figure 5 Time-Based Overcharging



Based on a typical 20 kWh charge received via a 40 Amp 240 Volt circuit

Table 8 Time- based fees by Vehicle Make and Charging Speed

Level 2 Charging Fees based on Time (per hr) or Consumption (per kWh)

Assumptions:

20	kWh dispensed
240	Volts
32	40 Amp circuit (32 Amp load)
7.7	kW maximum charging speed under ideal conditions
$ 0.11	Residential rate (BC)

Vehicle (EV or PHEV)	Charging Speed (kW)	Time-based Fee $ 1.00	Time-based Fee $ 2.00	Consumption Fee $ 0.11	Consumption Fee $ 0.11	Over/Under Charged $ 1.00	Over/Under Charged $ 2.00	% Over/Under $ 1.00	% Over/Under $ 2.00	Equivalent $ per kWh $ 1.00	Equivalent $ per kWh $ 2.00
Nissan Leaf (2011/2012)	3.3	$ 6.06	$ 12.12	$ 2.20	$ 2.20	$3.86	$9.92	175%	451%	$ 0.30	$ 0.61
Nissan Leaf (2013 - 2017)	6.6	$ 3.03	$ 6.06	$ 2.20	$ 2.20	$0.83	$3.86	38%	175%	$ 0.15	$ 0.30
Nissan Leaf (2018)	6.6	$ 3.03	$ 6.06	$ 2.20	$ 2.20	$0.83	$3.86	38%	175%	$ 0.15	$ 0.30
Chevrolet Bolt	7.2	$ 2.78	$ 5.56	$ 2.20	$ 2.20	$0.58	$3.36	26%	153%	$ 0.14	$ 0.28
Tesla Model S*	7.7	$ 2.60	$ 5.21	$ 2.20	$ 2.20	$0.40	$3.01	18%	137%	$ 0.13	$ 0.26
Kia Soul EV	6.6	$ 3.03	$ 6.06	$ 2.20	$ 2.20	$0.83	$3.86	38%	175%	$ 0.15	$ 0.30
Chevrolet Volt	3.6	$ 5.56	$ 11.11	$ 2.20	$ 2.20	$3.36	$8.91	153%	405%	$ 0.28	$ 0.56
Hyundai Ioniq	7	$ 2.86	$ 5.71	$ 2.20	$ 2.20	$0.66	$3.51	30%	160%	$ 0.14	$ 0.29
Mitsubishi Outlander PHEV	3.3	$ 6.06	$ 12.12	$ 2.20	$ 2.20	$3.86	$9.92	175%	451%	$ 0.30	$ 0.61
Level 2 managed (3 vehicles)	2.6	$ 7.81	$ 15.63	$ 2.20	$ 2.20	$5.61	$13.43	255%	610%	$ 0.39	$ 0.78
Level 2 managed (4 vehicles)**	1.9	$ 10.42	$ 20.83	$ 2.20	$ 2.20	$8.22	$18.63	373%	$\boxed{847\%}$	$ 0.52	$ 1.04

* Charging speed restricted by power available rather than the vehicle

** Charging speed minimum of 8 amps per vehicle

Appendix G - FCEV vs BEV total charging times

A common assertion is that FCEVs take less time to "refuel" than BEVs. However this assertion is based on the underlying gas station model that assumes that 100% of BEV charges are at a DCFC or L2 away from the personal residence.

However, when the reality that BEVs can be charged at home 80 % of the time is taken into account, and that FECVs need to travel to (and frequently from) a refuelling station 80 % of the time, <u>the total time for refueling for BEVs can be argued as being less than FCEVs</u> by 3 hours a year in British Columbia.

The table below illustrates the refuelling time of FCEVs and BEVs taking into account home charging for BEVs and the requirement for a FCEV to travel to a refuelling facility. The BEV takes less time and also time that can be spent shopping or dining rather than attending the vehicle while it is being driven to a refuelling site and while it is being refueled.

Table 9 Comparison of FCEV and BEV refueling time

Comparisson of FCEV vs BEVs for refueling time

Time to Refuel per **12,900 km** - Average Canadian mileage for Light Duty Vehicle

Assumptions

	12,900	km per year
80%	10,320	km local travel
20%	2,580	km long distance travel
FCEV	5	kgH2 per 500 km (Mirai 5 kg/312 miles - 500 km)
FCEV	500	km range
FCEV	20	minutes to travel to charging station for local trips
FECV	10	minute refueling time
BEV	200	wH per km (320 km range)
BEV	320	km range

Total Driver Time required to fill FCEV

FCEV	10,320	Local km	21	fills at	30	min per fill up	619.2	min	Includes time needed to travel (only to a H2 fuelling station (15 min)
	2,580	Long distance km	5.2	fills at	10	min per fill up	52	min	Assumes that hydrogen station is en route
							671	min	
						or	**11.2**	hrs	**Total Time spent refueling FCEV**
									Note: Driver has to be with vehicle on trip to refuel and during refueling

Total Driver Time required to Charge BEV

BEV	10,320	Local km	32	charges	0.5	min per connect	16	min	Assumes local that EV charging is at home or at work
	2,580	Long distance km	8.1	charges	60	min per charge	484	min	Assumes that long distance EV charging is en route
							500	min	
						or	**8.3**	hrs	**Total time spent recharging BEV**
									Note: Driver does not have to be with vehicle while charging

Appendix H Vehicle Hydrogen Tank Expiry Dates

Excerpt (Page 86) from the 2017 Toyota Mirai Owner's Manual re hydrogen tank expiration dates

Hydrogen tanks

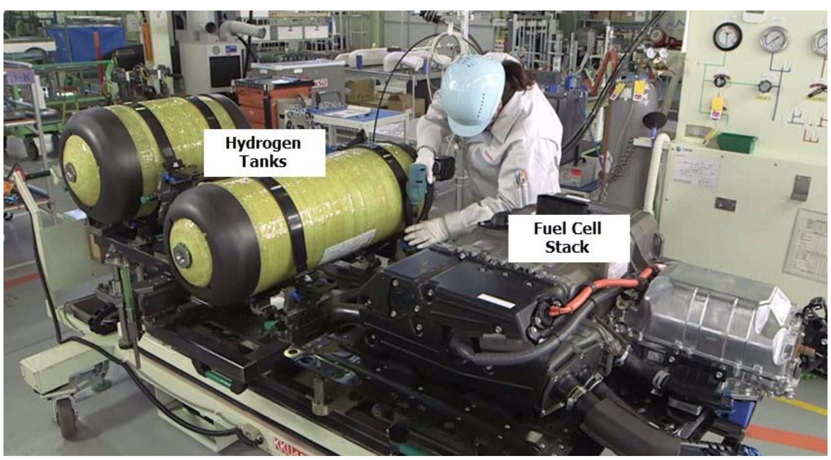
- The hydrogen tanks are the high-pressure storage containers that are filled with compressed hydrogen gas. The vehicle can be refueled at hydrogen stations.
- The hydrogen tanks have an expiration date. Vehicles with expired hydrogen tanks must not be driven or refueled until the hydrogen tanks are replaced. The expiration date is written on the inside of the fuel door. Consult your Toyota dealer.
- When disposing of the hydrogen tanks or the hydrogen tank valves, consult your Toyota dealer for details.

Source Page 86 of the 2017 Toyota Mirai Owner's Manual

The labels observed on Toyota Mirai re-fueling doors have indicated expiry dates of 14 years from the date of manufacture).

It is not inconceivable that the combination of the costs of hydrogen tank replacement and degradation of the fuel cells would result in hydrogen vehicles being scrapped in their 14th year. Plug in Hybrid vehicles and Battery Electric vehicles (with battery refurbishing) in salt-free environments like BC may be serviceable for decades.

Figure 6 FCEV Hydrogen Tank and Fuel Stack Locations



Appendix J Cost-Effectiveness Issues with Fuel Cell Electric Vehicles (FCEVs)

Several outstanding issues remain with respect to the cost-effectiveness of FCEVs.

1) FCEV vehicles are relatively expensive to purchase with no corresponding (to battery) cost reductions forecast for the future.
    - Although increased production volumes have some prospect of reducing costs, production costs for FCEVs consist of components that do not have known opportunities for substantial cost reductions as compared to battery costs in BEVs that are continuing to fall at 8-10% per year.
    - FCEV vehicles, due to their complexity, are more costly to manufacture than conventional ICE or battery-electric vehicles.

2) FECV vehicles are expected to be expensive to maintain.
    - There is no available data on FCEV maintenance expenses but they would be expected to be more to maintain than EVs due to their considerable additional complexity.

3) FCEV vehicles are expensive to operate with no known future hydrogen cost reductions on the horizon.
    - Hydrogen pricing is currently at $13 to $16 USD per kg (California) and equates to more than $5 US per gallon when compared to a gasoline vehicle or 0.78 to 0.96 US cents per kWh when compared to a battery electric vehicle.
    - Studies indicate that prospective alternative vehicle customers are highly sensitive to operating cost. The combination of high purchase costs and high operating costs for FCEVs does not bode well for higher FCEV adoption rates.

4) FECV vehicles have a predetermined expiry date for a major component (refer to Appendix F-1).
    - Like BBQ tanks, the FCEV high pressure tanks have a limited useful life before replacement is mandatory and the vehicle stops operating[53]. The cost of replacing the high pressure tanks could conceivably make them impractical to refit with new tanks.

5) FECV vehicles require expensive re-fueling infrastructure.
    - Entry-level hydrogen stations are $2 million USD for a dispensing capacity of 180 kg of hydrogen per day[54] (36 Totoya Mirai FCEVs)
    - The higher entry-level costs for hydrogen refuelling would increase the cost to connect smaller communities that are separated by terrain (mountains or deserts). In contrast, an entry-level fast charger station consisting of 2 DCFC units (32 vehicles per day) might cost about $200K.

6) FCEV vehicles would represent a suboptimal solution to CO2 reductions in BC (and many other jurisdictions) (Refer to Appendix E).

Hydrogen produced from steam reformed methane releases 5.5 kg of CO2 to the atmosphere per 1 kg of hydrogen produced. Each FCEV vehicle using 1 kg of hydrogen per day (100 km) would result in the

[53] Although not confirmed, it is likely that the vehicle computer will prevent the vehicle from starting after the expiry date in the same manner as vehicles that require Diesel Emissions Fluid (DEF) will shut down engine restarting after the DEF is exhausted (after a short warning period).

[54] National Renewable Energy Laboratory (NREL) hydrogen Station Cost Estimates

addition (well-to-wheels) of 2 metric tonnes of CO2 to the atmosphere per year. If hydrogen was produced via electrolysis, only one third of the source electrical energy would be delivered to the FCEV wheels as compared to a battery electric vehicle.

7) FECVs are electrically inefficient. Using electricity to produce hydrogen results in only 1/3 of the original electrical energy reaching the wheels as compared to battery electric vehicles (Refer to Appendix G-2).

Appendix K-1 The Viability of Hydrogen Fuel Cell Electric Vehicles (FCEVs) in British Columbia

Table 1 lists the conditions needed for FCEVs to be effective in producing lower "well-to-wheels" CO2 emissions than conventional ICE vehicles or BEV vehicles whose power source would come from the existing BC grid. The source of the information is the 2013 Argonne National Laboratory analysis of the GHG emissions associated with alternative fuels and fuel sources when used in mid-size and SUV vehicles[55] (Refer to Appendix F-1).

Hydrogen from electricity via hydrolysis is only one third as efficient as using electricity directly to power electric vehicles (Appendix K-2). Although hydrolysis may have some application in jurisdictions with "waste" electrify generation, such as may occur in southern US States (refer to footnotes 54 and 55), BC does not have these conditions

Table 1 Conditions Required for Hydrogen as a transportation fuel

No.	Condition Needed	Present in British Columbia
1.	The carbon intensity[56] of the BC grid exceeds the well-to-wheels (WTW) equivalent of 240 Grams of CO2e per mile with steam-reformed hydrogen production without CO2 sequestration (Appendix K-3). **OR**	No
2.	The carbon intensity of the BC grid exceeds the well-to-wheels equivalent of 140 Grams of CO2e per mile with steam- reformed hydrogen production with CO2 sequestration (Appendix K-3). **OR**	No
3.	BC has surplus energy production (wind[57], solar[58], hydro) that cannot be effectively or economically stored (i.e. otherwise "wasted"[59]) that could be used for hydrolysis **AND** the carbon intensity of the BC grid exceeds the Well-to-Wheels equivalent of 50 Grams of CO2e per mile (Appendix K-3). **AND**	No
4.	It is practical to construct local (service station model) hydrolysis plants that would produce, purify, compress and store hydrogen for FCEV refuelling without transporting the hydrogen to dispensing-only stations (Appendix K-3).	No

As BC power used for electricity generation is 97% from renewable sources (hydro) and virtually all electricity that would be used for BEVs would be expected to be from renewable sources there are no opportunities to use FCEVs powered by methane to reduce CO2 emissions lower than BEVs powered by the BC grid.

[55] US Dept. of Energy 2013 Emissions and Energy Use Model (aka GREET Model)

[56] Carbon Intensity (CI) is the amount of GHG emissions, measured on a well-to-wheel (WTW) basis, per unit of energy of fuel delivered to the vehicle. GHG emissions are the sum of the CO2 equivalent (CO2eq) emissions of three gases, CO2, CH4, and N2O, weighted by their 100-year global warming potentials from the International Panel on Climate Control (IPCC). In this document, CI is expressed in g CO2eq/kBtu.

[57] Some European countries may have excess power generation at night that cannot be efficiently stored.

[58] Southern US States may have excess solar energy that might be used for electrolysis hydrogen.

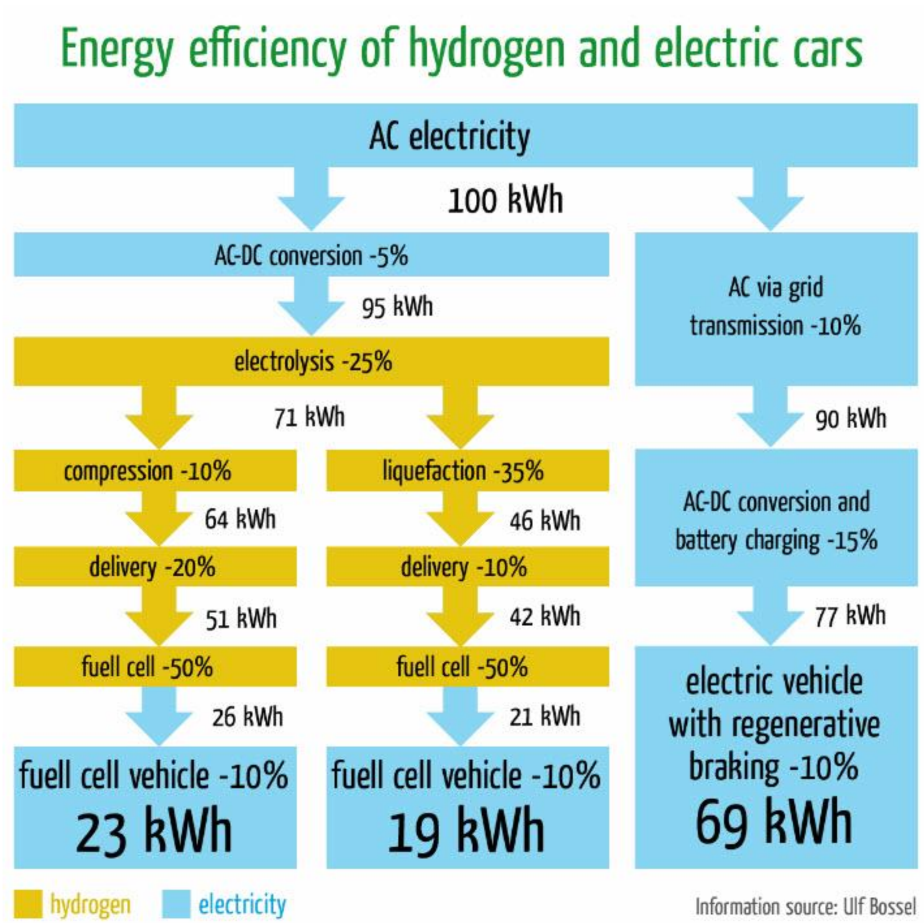
[59] The issue with the "excess" or "wasted" electricity argument is the 70 % loss in efficiency of FCEVs vs BEVs and the extent to which other forms of storage such as batteries or elevated water reservoirs are becoming an economical means of storing excess power.

Appendix K-2 Energy Efficiency of Hydrogen and Battery-Electric Vehicles

The following chart indicates the energy efficiency of electricity being used to provide motive power to a FCEV or a BEV.

The option of steam-reformed methane as a hydrogen source is not included as it would also result in the production of 5.5 kg of CO2 per kg of hydrogen.

Figure 7 Energy Efficiency of Hydrogen vs All-electric vehicles



Detractors to this chart claim that it does not take into account excess or "wasted" electricity production from renewables. This issue is discussed in Appendix K-1 Table 1, and the related footnotes.

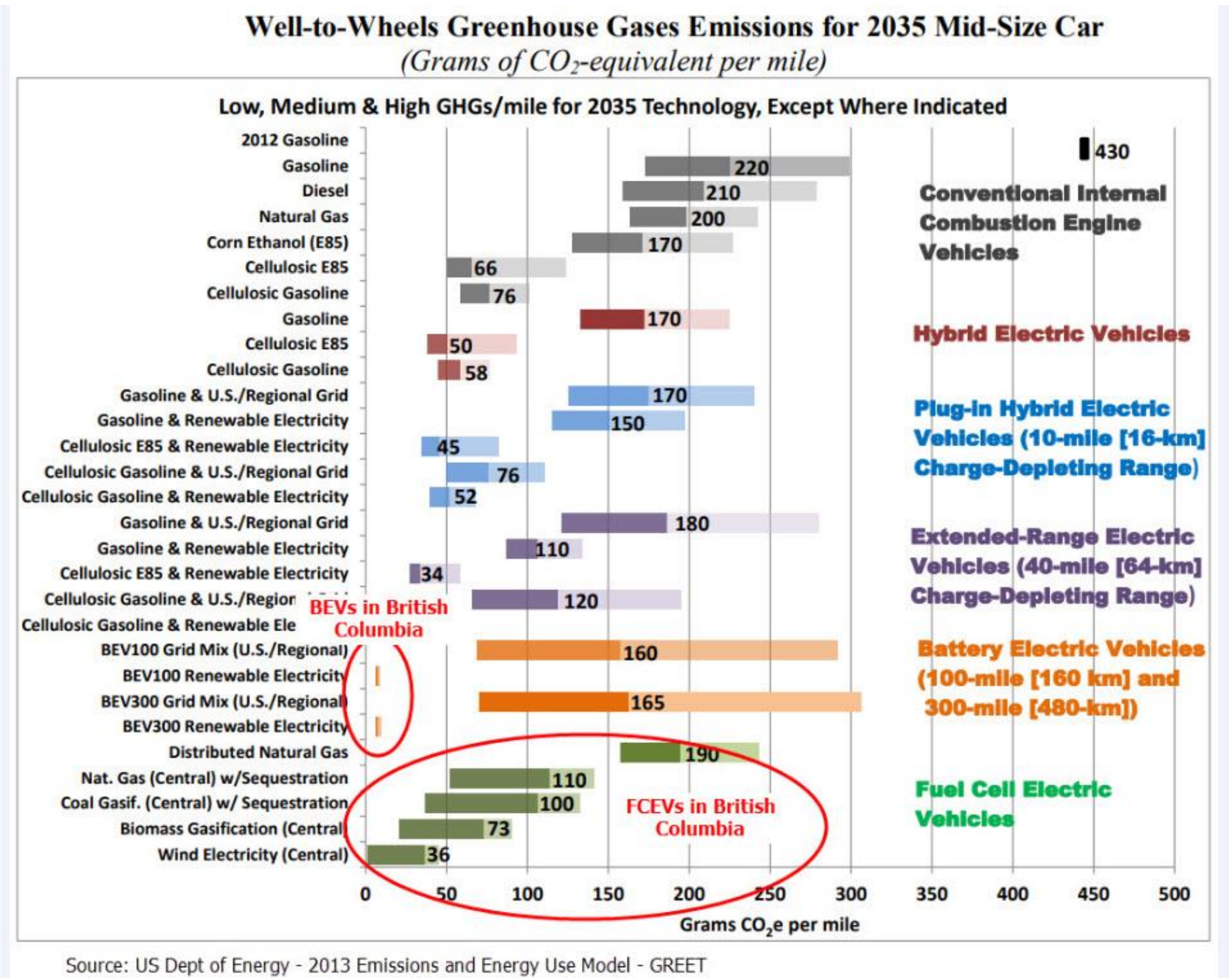
Appendix K-3 Well-to-wheel Greenhouse Gas Emissions

Source: US Dept. of Energy, Argonne National Labs, GREET model

Figure 5 represents the well-to-wheel impacts of Greenhouse Gas Emissions for a 2035 mid-size vehicle using a broad spectrum of fueling sources from gasoline to hydrogen.

As BC power used for electricity generation is 97% from renewable sources (hydro) and virtually all the electricity that would be used for EVs would be expected to be from renewable sources, there are no known opportunities to use FCEVs fueled either from a methane or hydrolysis source to reduce CO2 emissions lower than EVs powered from the existing BC grid.

Figure 8 Well-to Wheels Greenhouse Gas Emissions in CO2e per mile



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