ecoENERGY Innovation Initiative
Demonstration Component Public Report

Project: SG-337—The British Columbia Electric Vehicle Smart Infrastructure Project

Date: 2016

BC Hydro
Power smart

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Executive Summary

Governments globally have embraced electric vehicle (EV) technology for its zero tailpipe emissions, which means cleaner air for some policy makers and reduced climate changing emissions (CO2e) for most. The overwhelming endorsement of the technology is further bolstered by the US coined phrase, energy security. Electricity is an energy carrier that can be generated from multiple feedstocks, allowing nations to de-risk their transportation fuel supply like a diversified investment portfolio.

The BC EV Smart Infrastructure project evolved from years of preparation for the commercial launch of EVs in 2011. The project goals are to support EV adoption in BC with public charging infrastructure and mitigate EV charging impacts on the electric grid as most charging takes place at home during the evening peak usage hours. The resulting project scope of work is to:

- deploy 300 level 2 charging stations that service 1-3 hour parking times and 30 DC fast chargers that service en route EV travel with 30 minute recharge times
- develop a data clearing house for compiling usage data from the various charging station networks – easy access to data is required to evaluate the effectiveness of the project and to inform future EV policies and programs
- conduct smart charging[1] demonstrations to inform the utility of the technology pathways for managing or shifting the EV load to off peak hours

PROJECT RESULTS

The overall project was delivered under budget but six months over the original due date of March 2016. The closing project cost was $8,391,801 against the planned budget of $8,802,895. Since the project closing date with NRCan (30 September 2016), BC Hydro has absorbed just under $400k of trailing costs from the project, which still completes the project within budget. The six month extension is attributed to the following factors:

- a six month delay in project commencement date – the planned commencement date was April 2012 but the contribution agreement with NRCan was not signed until October 2012
- securing sites for DC fast chargers took much more time than anticipated – working with local government hosts required individual business negotiations with each one of the 30 station sites.

The lesson learned on infrastructure deployment was to partner with fewer host entities with land or facilities in multiple locations of interest for DC fast charge deployment. For example, the current round of DCFC deployment has targeted large grocery stores with store locations that align with DCFC deployment plans.

BUSINESS MODEL

Operating data from the DC fast chargers indicate that profitability as a standalone business for a regional service is unlikely within 10 years and even less likely given BC Hydro's increase in demand charges as of 1 April 2017. This statement has yet to factor in the cost of sustainment for the charger network. However, BC Hydro and utilities in general are able to make a case for investing in sufficient DC fast chargers to support 2-3% of EV charging as the utility will benefit from revenues for all charging on its system.

One of the remaining hurdles for public EV charging is the need for Measurement Canada approved metrology. None of the public EV charging stations have approved metrology, which is most critical for fast charging as alternative pricing structures such as time-based fees will be highly inequitable for customers. Several factors determine the amount of electricity delivered during a DC fast charging session. The size of an EV battery has the greatest impact: an EV with a 24kWh battery pack may take 10kWh from a DC fast charger in 30min but a 60kWh EV could take over 20kWh, double the energy for the same amount of time.

Inequity aside, time-based fees do improve utilization of a fast charger by encouraging users to unplug after charging is complete or when the charge rate is low at the tail end of a charge session. Since fast charging rates are dynamically dependent on many factors, some sort of hybrid fee structure such as one based on time and energy would be needed to ensure consumer acceptance of EV technology.

[1] Smart Charging is the management of EV charging rate and/or time of charging for a given location or across a utility service territory.

OUTREACH

As a project deliverable, information signage was installed at charging stations to inform and alert pedestrians passing the stations of the benefits of electric vehicles but the unintended consequence of soliciting others to host each station (level 2 and DC fast) resulted in EV ambassadors across the province, which enhanced the outreach value many fold in comparison to a single entity such as BC Hydro doing the same.

EVCLOUD

evCloud[2] has been a repository for charging station usage data since it went live in late 2013. evCloud provides the general public access to aggregate data and raw data to researchers and government to inform EV policy and program development. The constant request for access to data from academia, government and even private sector is a testament to the value of the data.

This is an example of the aggregate data from evCloud: the combination of level 2 and DC fast charging infrastructure delivered 690,699kWh of electricity, displacing 277,711 litres of fossil fuel, which avoided 639 T CO2e emissions during the last year of the project, 1 October 2015 to 30 September 2016.

SMART CHARGING

The smart charging component of the project demonstrated both business–to–business (B2B) and direct utility pathways for controlling EV charging. In B2B pathways, utilities can employ a standard demand response (DR) protocol such as OpenADR to request load shedding from DR aggregators. In the EV charging world electric vehicle supply providers (EVSPs) such as Greenlots or ChargePoint could act as DR aggregators and respond to utility DR requests with load curtailment of charging stations on their network. However, utilities are more inclined to maintain customer relations and not have a third party come between them. Hence, direct utility pathways that utilize the utility's digital metering network may be more attractive for EV load control but will require more integration effort.

As the replicable factor is a measure of success, several Canadian smart charging products went on to demonstrate in subsequent DR pilots with BC Hydro and others: the controllable load switch by Energate, CrossChasm's EV load control platform with EV and customer feedback loops and AddEnergie's residential version of their commercial level 2 charging station.

CONCLUSION

Everything about EVs is advancing at a rapid pace: faster charging rates, larger batteries, more "intelligence" or autonomy. If utilities are to invest in EV infrastructure and smart charging mitigation measures against impacts on the grid, it would be prudent to invest in an EV technology roadmap with a utility perspective.

1 Introduction

BC Hydro, in partnership with the BC Government, delivered The BC Electric Vehicle Smart Infrastructure project from October 2012 to September 2016, including a 6 month extension. The project had an ambitious scope to deploy 300 level 2 electric vehicle (EV) charging stations, 30 direct current (DC) fast chargers, a charging station data clearing house and a number of smart charging demonstration projects.

DEVELOPMENT AND DEPLOYMENT OF LEVEL 2 CHARGING INFRASTRUCTURE

The 300+ level 2 charging station deployment was conducted through a public call for applicants to install and host charging stations at their facility for public use. The unintended outcome was 100s of EV ambassadors in communities throughout BC.

DEVELOPMENT AND DEPLOYMENT OF DIRECT CURRENT FAST CHARGE INFRASTRUCTURE

The 30 DC fast charger deployment and business model was made possible by the discovery of an exemption in the BC Utilities Commission Act, which allows local and regional governments to operate outside of the regulatory confines of a Public Utility. This exemption enabled these specific organizations to receive compensation for the provision of electricity which resulted in BC having the first by–the–kWh–fee charging network in Canada. All others charging station networks apply flat–rate–per–session or time–based fees. The willingness and enthusiasm of local civic governments to participate and assume the cost of operating the DC fast chargers in their community was a key to the success of this deployment.

[2] evCloud link: https://www.fleetcarma.com/evcloud

SMART-GRID INITIATIVES; EVCLOUD, GRID-AWARE AND SMART CHARGING

EVs have become the "killer app" for smart grid initiatives at public utilities. As a discretionary and sizeable load, EV charging became a target for utilities to encourage with their customers, and manage on the grid. As such, this project aimed to demonstrate the various technology pathways for controlling EV loads on the grid. A series of demonstration projects were devised and deployed to validate either business-to-business (B2B) or direct utility pathways for smart charging with residential customers. The demonstrations enlisted the following technology partners: Greenlots, AddEnergie, SMPC and CrossChasm.

CrossChasm was also a partner in the development of the evCloud, the data clearing house for the three charging station networks in the project: Greenlots, ChargePoint and AddEnergie (rebranded in early 2017 as Flo).

2 Results of the Project

2.1 OBJECTIVES

The following project objectives were taken from Section 3 of Schedule A of the contribution agreement and augmented with commentary (in blue) for clarity and alignment with Section 3.1 Project Achievements:

- 300 L2 charging stations for public use in urban areas
- 30 DC fast chargers to enable EV travel along major transportation corridors
- A harmonized data network (EV-Cloud) to centrally collect charging data across multi-vendor charger deployments
- A selection of at least seven (7) signature sites showcasing infrastructure business models and public outreach displays
    - Almost all 456 level 2 charging stations funded through the Community Charging Infrastructure Fund included public outreach displays
    - 13 DCFC stations include public outreach displays
    - 28 of the 30 DCFC stations exemplify the municipal business model
- A selection of at least six (6) signature sites demonstrating Grid-Aware connectivity options where the charging infrastructure can communicate with a utility back-office environment.
    - All but two of the 30 DCFC sites have dedicated, digital, utility revenue meters that send energy and demand data to BC Hydro's Meter Data Management System
    - All 30 DCFC sites utilize an Open Charge Point Protocol to remotely supervise, control, and collect data over a cellular network
- A selection of at least three (3) signature sites demonstrating Smart-Charging options where charging infrastructure loads can be controlled by a utility back-office environment.
    - EV Tech Park – as a test bed, all the smart charging pathways are demonstrated at this site
    - BCIT AFRESH home demonstrates EV load control over the utility meter at the Home Area Network (HAN), using a Smart Energy Profile compliant charging station
    - Fraser Valley Operations – replicates the HAN pathway installed at BCIT
- A selection of at least three (3) strategic sites showcasing business models and/or outreach activities.
    - the Abbotsford Ecodairy demonstrates the private sector model that was enabled through an exemption by the BC Utilities Commission
    - The Ecodairy also demonstrates how a business integrates DC fast charging into an existing business – The Ecodairy is a public education centre for sustainable dairy operations. The facility, including the DC fast charger, is partially powered by a generator that is fueled by biogas derived from an onsite, dairy waste digester. This narrative is included in the educational materials at the centre.
    - Edible Canada is a level 2 station host that actively promotes electric vehicle adoption to strengthen their sustainable brand.
    - Private businesses host DC fast chargers for drawing customers to their retail business: Malakwa Super Market (Malakwa), Clayton Mall (Sechelt), Uptown Mall (Saanich), Canyon Lanes (Boston Bar) and Manning Park Resort (Manning Park). These private businesses co-host the stations with the local/regional government station operators. The Private business provides the land for free.
- An evaluation of signature site case studies, infrastructure planning and installation guidelines, public charging infrastructure business models and Smart Grid interoperability options.

2.2 300 L2 CHARGING STATIONS & 30 DC FAST CHARGERS

All the level 2 and DC fast charge stations were installed in collaboration with public and private community hosts. The DC fast chargers were hosted mainly by local and regional government hosts at community centres and other major community hubs.

The public charging infrastructure deployment fulfills one of the five pillars for supporting EV adoption as described in Section 4.1.1.6 below. The growth of EVs toward mainstream market uptake will displace fossil fuel with renewable electricity in the province of British Columbia. Similar trends are happening in Ontario and Quebec, provinces that also have a significant renewable electricity mix.

2.3 EVCLOUD

The charging station data clearing house was achieve through the negotiated cooperation of station hosts and the electric vehicle service providers (EVSPs), also known as charging networks. The three main networks in BC are Greenlots, Flo (formerly AddEnergie) and ChargePoint.

Academics and government have been continuously requesting evCloud data to further their understanding of the impact of public infrastructure on EV adoption. More recently, oil companies such as Shell have requested results from evCloud to inform their market analysis for DC fast chargers as a business.

2.4 BUSINESS MODEL

As of today, almost all level 2 station hosts in BC offer public charging for free. Public facilities like community centres offer the service to promote adoption of a “greener” vehicle technology while businesses do the same to portray themselves as “good” corporate citizens. Certain retail businesses will benefit from EV drivers shopping at their business while charging. However, the demand for something free is insatiable, and an informal survey of level–2 chargers on any given day finds many long–distance capable EVs occupying the spaces older EVs still require to operate functionally, even within city limits. The City of Vancouver, first to deploy public charging infrastructure, is now among the first seeking to implement a public charging pricing scheme in response. Their goal is to achieve 80% utilization of charging stations, and they are using an approach similar to how they currently manage public parking.

As the EV market matures and EVs come with larger batteries (longer driving range), level 2 station usage will transition from a necessity for local driving to destination charging. Day trips in excess of 50 or 100km in one direction may require a recharging session before completing the round trip. Longer trips will require level 2 charging at intermediate destinations. Hotels or motels are examples of ideal businesses for hosting level 2 stations. In 2017, the Chevy Bolt became the first “accessible”, non–luxury, long–range EV to come to market with a range of 385km, marking the turning point for level 2 station usage.

Unlike level 2 charging, DC fast charging remains as critical EV infrastructure that enables EVs to compete with the incumbent petroleum fueled vehicles in terms of utility.

Implementing DC fast charging infrastructure requires a completely different business model than that of level 2 networks. First, the cost of building a DC fast charge station is comparatively high. Whether the proponent of the infrastructure is a public utility or a private business, the regulatory framework needs to be explored and navigated. Properties that are suitable to facilitate charging at any time, day or night, in terms of accessibility, visibility and safety of the users, must be identified and obtained. It is significant to note that, despite the barriers to entry, non–electricity energy companies like Shell are exploring DC fast charging as potential new business.

2.5 OUTREACH

The outreach objective of the project was delivered through info graphics designed to be attention grabbing on signage installed at both level 2 and DC fast charging stations. As a follow through, BC Hydro established an electric vehicle landing page, **bchydro.com/ev**. Many other electric utilities such as Hydro Quebec have similar comprehensive educational signage and web content on electric transportation.

2.6 SMART CHARGING

The project team completed seven smart charging demonstrations. The results will inform BC Hydro and its peers of smart charging solutions to consider in future EV demand response programs. As a result, the three main tech providers to the project, Greenlots, AddEnergie and CrossChasm, have gone on to scaled up smart charging demonstrations with BC Hydro and other utilities, furthering the cause to mitigate the impacts of EV charging on the grid.

3 Project Achievements

The overall project was delivered under budget but six months past the original due date of March 2016. The closing project cost was $8,391,801 against the planned budget of $8,802,895. Since the project closing date with NRCan (30 September 2016), BC Hydro has absorbed just under $400k of trailing costs from the project, which still completes the project within budget. The six month extension is attributed to the following factors:

- six month delay in project commencement date – the planned commencement date was April 2012 but the contribution agreement with NRCan was not signed until October 2012
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The lesson learned on infrastructure deployment was to partner with fewer host entities with land or facilities in multiple locations of interest for DC fast charge deployment. To address this, the current round of DCFC deployment has targeted large grocery stores with store locations that align with DCFC deployment plans.

3.1 SUMMARY OF ACHIEVEMENTS

This section covers achievements for the following: public EV infrastructure deployments, a harmonized data network—evCloud – and smart charging demonstrations.

3.1.1 PUBLIC EV INFRASTRUCTURE DEPLOYMENTS

The public EV charging component of this project had two main goals: to support EV adoption with public charging infrastructure, and to perform outreach and awareness. EV charging at present is divided into three options (see Table 1 below, which describes the characteristics of each) and the public EV charging deployments comprise two sub-projects: 300 level 2 charging stations and 30 DC fast charging stations.

Table 1. Attributes of EV Charging Options

Charging Type	Power	Time (per 100km)
Level 1	1kW (dedicated 120V wall outlet)	16–20hrs
Level 2	3–6kW (similar to stove or drier circuit)	3–6hrs
DC Fast Charging	50+kW (electrical demand of a gas station)	30min

3.1.2 HARMONIZED DATA NETWORK – EVCLOUD

In a nascent EV market, government and academics are hungry for data on charging station utilization. Governments need data to inform future funding programs and academics need data to analyze so they can advise government. At the same time, a handful of EV service provider (EVSP) start-ups are grappling for market share, making it a challenge to collect data from multiple sources. EV service providers are charging station network operators similar to cell phone companies that operate a telecom network to provide a service through end devices that are connected on the network.

evCloud was built through this project as a clearing house for EV charging data gathered from all participating EV service providers. Figure 11 below is a screen shot of the evCloud landing page on the internet. The general public is permitted to visit the site to glean aggregate data such as total tons of GHG emissions avoided to date. Government and academic partners have the further ability to sign up for an account to download the full data set for charging station utilization. Simon Fraser University, the University of Victoria and the University of British Columbia have already made use of the data as have various levels of government, including Metro Vancouver. At this point, there is no sustainment funding for evCloud, which might mean the loss of the analytical tool going forward.

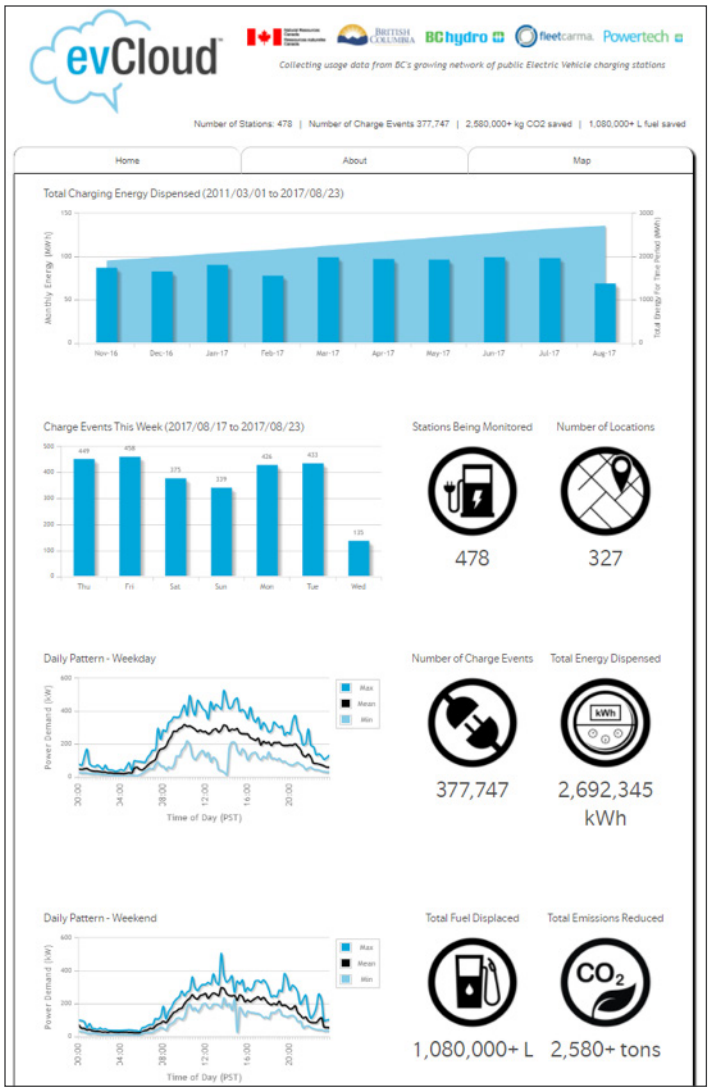


Figure 1. evCloud Screen Shot

EVCLOUD EVALUATION

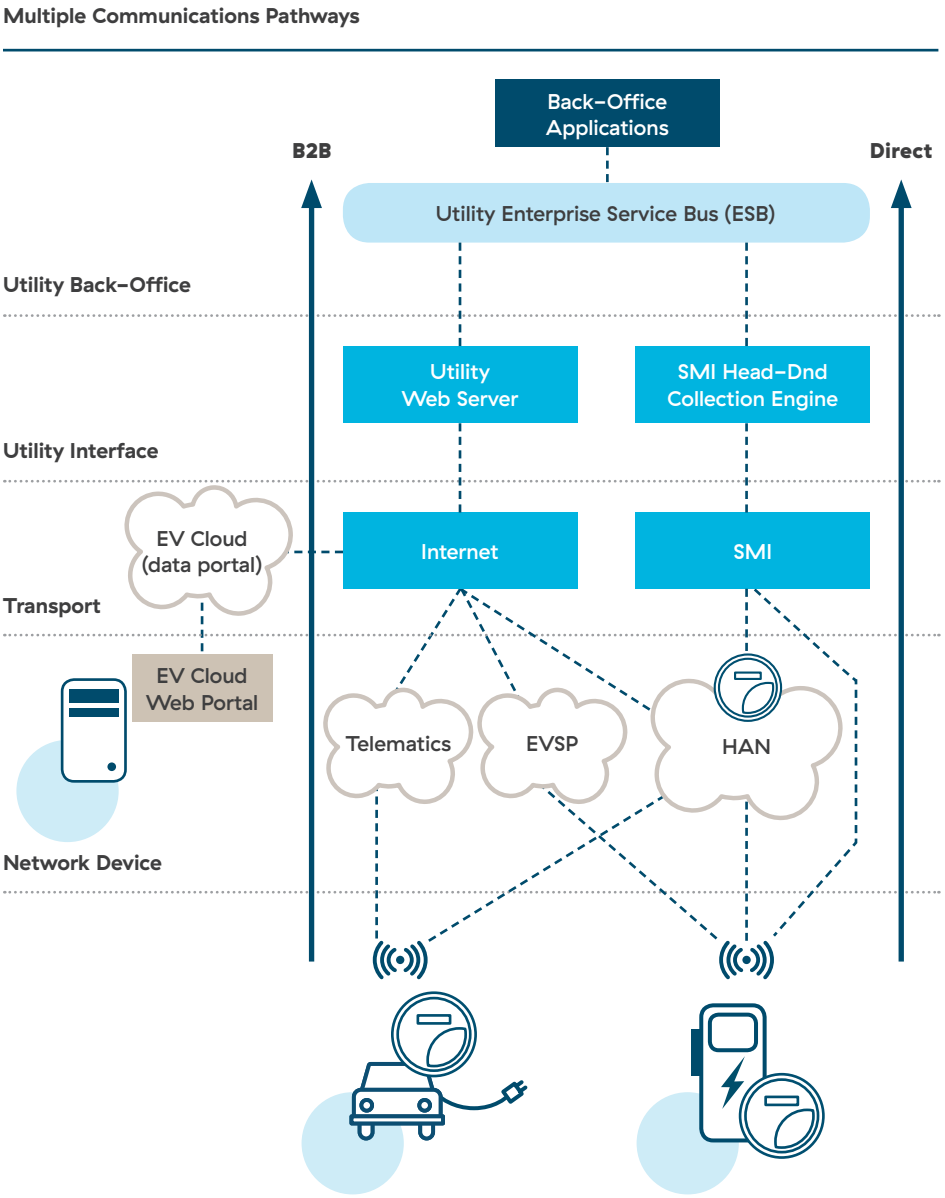
evCloud has proven its value through the consistent requests from government and academia to access the data. BC Hydro has used evCloud for planning of future infrastructure deployments through assessing the effectiveness of existing deployments. evCloud has also proved useful through its analysing and reporting of beneficial outcomes of the initial project by way of avoided GHG emissions. Ongoing updates will be required and will only happen if sustainment funding is put into place to maintain the linkages to other applications with which evCloud is currently integrated.

3.1.3 SMART CHARGING (SMART GRID INTEROPERABILITY) DEMONSTRATIONS

The smart charging demonstrations are intended to inform BC Hydro and the utility industry of the various technology pathways for EV load control to lessen EV charging impacts on the grid. Analytical focus is currently on residential customers as the bulk of EV charging takes place at home after the afternoon commute, which lands sharply on the early evening residential peak for the utility.

The demonstrations are presented in detail, in a separate Appendix. They will fall under one of the two types of pathways illustrated in Figure 2 below.

EV Smart Grid Project Definition



BREAKDOWN PATHWAYS TO:

1. B2B paths:
Use of third party service providers and /or infrastructure

2. Direct Paths:
Use of utility SMI infrastructure

Figure 2. Technology Pathways for EV Load Control

Note: SMI stands for Smart Metering Infrastructure, a name given to BC Hydro's digital metering technology that utilizes a telecom network for remote reading, status and control functions. The generic industry term is Advanced Metering Infrastructure (AMI).

4 Conclusion and Follow-up

Everything about EVs is advancing at a rapid pace: faster charging rates, larger batteries, and more "intelligence" or autonomy. If utilities are to invest in EV infrastructure, and smart-charging-as-mitigation-measures against the impacts on the grid, then it would be prudent to invest in an EV technology roadmap with a utility perspective.

4.1 POTENTIAL FOR REPLICATION

Replication for DC fast charging stations and smart charging are already underway at BC Hydro. The following covers cost trends for DC fast chargers as well as smart charging.

DCFC

As with all new technologies, the prices drop after the initial market introduction. Since the first DC fast charger purchases in 2013, the prices have dropped as much as 30%. However, the installation cost will not drop unless manufacturers start catering to Canada's unique utility voltage of 600V rather than the 480V used everywhere else. We are already seeing signs of this accommodation with a recent RFP for DC fast chargers.

Approaching 5 and 10 years post project, more and more DC fast charger sites will follow the design and layout of Tesla Super Chargers with the ability to accommodate fast charging for multiple EVs at one site with the potential for reducing the cost per charge port. As the fast charger power rating for EVs rise and the expectation is for multiple charger ports per site, onsite energy storage will begin to play a role in reducing the demand charges for these fast charging hubs.

Smart Charging

It is still too early to discern any cost trends for the EV smart charging market. New smart charging products are just arriving on the market. BC Hydro has yet to launch any customer programs for EV demand response. Hydro is still testing customer acceptability with products and solutions that may or may not be scalable for a utility application.

Note that the all the smart charging demonstrations focused on having the "smarts" off the vehicle in smart charging stations or smart load control devices. As the auto industry piles the smarts into their products, embracing autonomous driving, connected vehicles and the internet of everything, it will be foolish and impossible for utilities to ignore the option of directly communicating with the EVs themselves for smart charging.

4.2 PROJECT MONITORING

BC Hydro will continue to monitor the public and smart charging infrastructure for the follow-on period stipulated in the contribution agreement with NRCan.

EV infrastructure & evCloud

BC Hydro will continue to maintain the 30 DC fast chargers that are operated by the municipal hosts. For as long as it remains relevant, Hydro will continue to use evCloud to monitor level 2 stations and will assess the overall usage data collected. Without sustainment funding in place for evCloud, though, evCloud may not have the longevity to be relevant for the full five-year follow-on period. A spin-off Canadian company, Mogile, is currently developing a similar, but more robust, charging-station data warehouse platform that may be a suitable alternative.

Smart Charging demonstrations

Most of the demonstrations sites continue to operate primarily as charging services for the host facility. Some of the sites maintain the smart charging features in the day to day use of the charging infrastructure. For example, scheduled EV load curtailment was implemented at BC Hydro's Edmonds campus parkade to avoid adding to the daily peak load of the facility. In other cases, the smart charging aspect remains dormant after the load control demonstration was performed for project stakeholders. The FVO demonstration site is only using the charging stations for staff EV charging.

4.3 NEXT STEPS

The following next steps are needed for BC Hydro to transition from demonstrations to business operations.

Smart Charging Technologies

Several of the technologies tested have also been applied to demand response (DR) pilots at BC Hydro. The CrossChasm EV load control platform will be utilized in a 50–participant DR pilot. The residential version of the AddEnergie stations that were installed at Edmonds were selected for the same EV DR pilot.

DCFC

BC Hydro is contemplating an offer to take over full operations from the municipalities once the regulatory framework is in place for the utility to operate the stations as a new class of service.

Measurement Canada will need to work closely with industry to determine a path to compliance for the EV charging industry as none of the charging station manufacturers have Measurement Canada compliant metering onboard their equipment. Regardless of this, there are thousands and thousands of public charging stations across Canada and the number of installs is growing.

DCFC deployments must quickly transition from single charger per site installations to multiple chargers or charge ports per site to meet growing demand. Two immediate benefits are reducing wait times and increasing utilization.

EV Technology Roadmap

As noted at the beginning of Section 5, BC Hydro will explore collaboration opportunities with utility and other EV stakeholders for developing an EV technology roadmap. CEATI[3] and EPRI[4] are to possible forums for pursuing collaboration on an EV technology roadmap.