EV Charging Guidelines for Electric Utilities

Electric Vehicle Infrastructure Development Project **EVID-2005**

Public Report: Project Overview and Results (V 1.0)

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Contents

Project Introduction and Overview

This Project de-risked and validated novel solutions for electric vehicle (EV) charging, and demonstrated how the solutions can be applied to address key barriers to EV adoption. The Project specifically focused on Electric Vehicle Energy Management Systems (EVEMS), and open protocols for:

- command and control of charging stations
- demand response (DR)
- roaming
- payment

This report is focuses on EV charging guidelines for utilities, and demand response in particular. The report details the DR demonstration between BCIT's ten Level 2 EV chargers at its Energy OASIS facility and the local electrical utility BC Hydro.

Background

Electrical utilities across Canada and the world face increasing demand for electricity. The shift toward greener transportation places more burden on these utilities. EV charging represents a new electrical load for utilities to accommodate, and the timing of charging events can present challenges as demand for electricity varies greatly depending on the time of day.

Building new power generation plants is extremely costly, and construction timelines can easily span several years. Some forms of generation, such as coal and nuclear generation, do not "throttle" their output. Some of these plants are capable of varying their output, but this can introduce thermal stress on the plants, reducing their operational longevity. With steady, constant generation output, but fluctuating demand for power, strategies for creating balance in the grid are needed.

One such strategy is demand response (DR). The US Federal Energy Regulatory Commission defines DR as "Changes in electrical usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized."

Basically, when load on the grid is high, utilities can send signals (often pricing signals) to customers to reduce load. Customers may receive financial compensation or a reduction in their utility bill as reward for reducing their electrical consumption during these times.

DR is an important tool for utilities and customers to be able to reduce electrical demand during peak consumption periods. From a utility perspective, it is far more cost-effective to reduce demand than to increase generation capacity.

From the EV market development perspective, EVSE platforms are increasingly networked and more broadly connected to EV energy management systems. Many are intelligent with fully integrated, smart charging capabilities such as advanced messaging, monitoring, demand response, and advanced analytic capabilities. Developing standards and open protocols governing interoperability of these smart EV

charging technologies will ultimately help to support integration with emerging grid technologies and large scale EV deployments.

This report describes this project's demand response demonstration in which BCIT used its NRCan-funded Energy OASIS facility to demonstrate DR with the local electrical utility BC Hydro. Energy OASIS is an acronym for Open Access to Sustainable Intermittent Sources.

As a scaled down version of Canada's next generation electricity grid, BCIT's Energy OASIS provides a unique Applied Research Development and Demonstration proving ground for academia and entrepreneurs to test and validate evolving concepts and technologies relating smart microgrid, energy management and green transportation. The Energy OASIS facility consists of a large, 250 kW photovoltaic canopy over a parking lot at BCIT's Burnaby campus. The solar canopy is connected to a four-quadrant grid-aware inverter that is capable of islanding from the grid, and seamlessly re-connecting to the grid. The inverter is also connected to a 500 kWh lithium-ion battery energy storage system (BESS). The main loads on the system are two DC fast chargers, and ten Level 2 EV chargers.

The ten Level 2 EV chargers at the Energy OASIS facility were used as part of this project to demonstrate DR with the local electrical utility, BC Hydro.

Open Automated Demand Response

In this current project, and several past projects, BCIT has demonstrated commitment to using open, non-proprietary, standard approaches to communications related to EV charging, energy management, and smart grid technologies in general. For this project, BCIT selected the Open Automated Demand Response (OpenADR) standard to communicate and facilitate DR events.

OpenADR is a research and standards development effort for energy management led by North American research labs and companies. OpenADR development is led by the OpenADR Alliance, whose mission is to foster the development, adoption and compliance of the OpenADR standards through collaboration, education, training, testing and certification. It an open global standard that enables utilities and EV charging system operators to automatically communicate DR signals with each other and their customers using a common language over existing IP-based communications networks.

Agreements

In October, 2019, BC Hydro and BCIT signed an agreement to perform DR events on the collection of ten Level 2 EV chargers at BCIT's Energy OASIS facility between November 20, 2019 and March 12, 2020. According to the agreement, BC Hydro would send either email or text message a participation request to BCIT one day before the DR event. BCIT agreed to reply to the requests indicating whether they would, or would not participate. Ultimately, BCIT participated in all requested events, but the convention in responding to DR signals is to confirm participation.

BC Hydro and BCIT signed another agreement for the DR events to continue during the April 2020 to March 2021 timeframe. The mechanism for triggering the DR events changed, with BC Hydro generating the events using their Gridwise platform.

Project Execution

BCIT both created software, and used off-the-shelf software in order to create a system to perform the DR events on its collection of ten Level 2 chargers at the Energy OASIS facility. BCIT used the Open Automated Demand Response (OpenADR) protocol to facilitate the DR events, and became a member of the OpenADR Alliance in order to stay current with developments and changes to the OpenADR standard.

BCIT used the nebland OADR Services website to provide the Open ADR Virtual Top Node (VTN) server functions. Nebland is in the process of rebranding itself to 'GridFabric', and its website is now located here:

https://www.gridfabric.io/

BCIT developed software to create an OpenADR Virtual End Node (VEN) client that responds to the signals coming from the nebland VTN server in order to actually perform the DR events. It is this BCIT VEN client that throttles down the charging rate of the collection of BCIT EV chargers for the duration of the DR events.

BC Hydro requested that each DR event have a duration of 4 hours, and BCIT and BC Hydro mutually agreed that the rate of charging would be reduced by approximately 50% for the duration of each DR event.

Specifically, BCIT implemented DR signaling such that each Level 2 charger reduce the amperage delivered from a maximum of 32 amps down to a maximum of 8 amps. BCIT can change the maximum amperage delivered to different values, but the 8 amp maximum achieved the results both parties were looking for.

BCIT participated in all DR events requested by BC Hydro in the time period of the first agreement which was Oct 2019 – March 31, 2020.

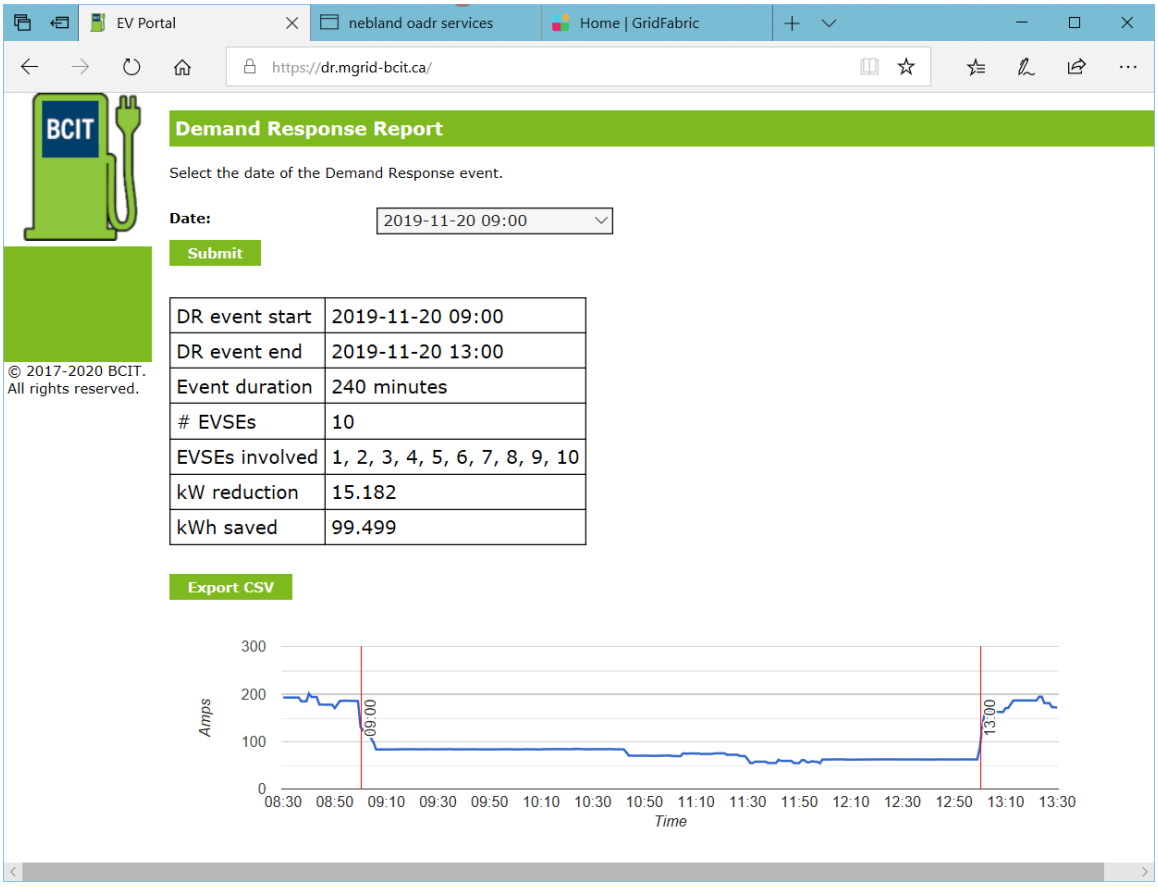
For the term of the second agreement, which was April 2020 to March 2021, BC Hydro generated the OpenADR events using their Gridwise platform tool. The OpenADR events were sent to BCIT's system, which then in turn curtailed the load of the collection of ten EV chargers as described above.

Outcomes

BCIT created a website to display the results of the DR events. The site is located here:

https://dr.mgrid-bcit.ca/

Below is a screenshot of a sample DR Report from the website.



The page shows the start and end time of each events, the duration of the event in minutes, the number of Electric Vehicle Supply Equipment (EVSE) involved in the event, the kW reduction of the event, and the number of kWh saved as a result of the event. A graph of the event is displayed, and a .CSV file of the detailed event data can be downloaded.

In total, BC Hydro requested 15 DR events in the time period of the first agreement, which was late October, 2019 to March 31, 2020. BCIT participated in all 15 events. During the period of the second agreement, which was April 2020 to March 2021, BC Hydro generated, and BCIT participated in, 38 DR events. The result of each DR event is summarized in the table below. It is worth noting that on the following three dates: Dec. 16, 2019, Dec 23, 2019, and Jan 15, 2020, there were very few people on campus, so the number of EVSEs involved in the DR events on those dates is low. Similarly, the entire period covered by the second agreement was affected by the COVID-19 pandemic, which greatly reduced the number of students and staff on campus, and therefore the number of EVs charging.

DR Event Date	# EVSEs	EVSEs Involved	kWh Saved
2019-11-20	10	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	99.499
2019-11-27	10	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	87.618
2019-11-29	10	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	84.2
2019-12-05	10	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	78.331

2019-12-10	10	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	93.528
2019-12-16	5	2, 3, 4, 6, 8	53.264
2019-12-23	0		15.441
2020-01-15	0		5.658
2020-01-21	10	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	62.873
2020-02-03	10	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	78.189
2020-02-11	9	1, 2, 3, 4, 5, 6, 8, 9, 10	67.479
2020-02-20	10	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	88.741
2020-02-26	10	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	90.829
2020-03-06	10	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	99.236
2020-03-12	10	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	84.011
2020-10-07	4	1, 3, 5, 10	-19.188
2020-10-09	3	1, 3, 4	14.348
2020-10-15	4	2, 3, 5, 10	4.764
2020-10-21	6	2, 3, 4, 5, 8, 10	28.712
2020-10-23	4	2, 4, 6, 10	30.242
2020-10-27	3	2, 4, 6	13.593
2020-11-03	4	1, 4, 5, 10	-0.915
2020-11-05	6	1, 3, 4, 5, 7, 10	37.227
2020-11-09	5	1, 4, 5, 8, 10	21.365
2020-11-16	1	3	-4.283
2020-11-19	1	2	-13.042
2020-11-24	3	3, 5, 8	0.301
2020-11-25	6	3, 5, 6, 7, 8, 10	18.598
2020-11-27	2	5, 7	8.99
2020-11-30	4	3, 5, 8, 10	10.283
2020-12-01	3	3, 5, 7	16.429
2020-12-03	3	5, 7, 9	19.399
2020-12-08	2	1, 6	-5.457
2020-12-11	1	1	3.652
2021-01-04	7	1, 2, 3, 4, 5, 6, 8	10.744
2021-01-06	4	4, 6, 7, 10	-0.634
2021-01-11	3	2, 3, 6	-7.736
2021-01-13	3	1, 3, 6	9.215
2021-01-15	5	1, 3, 5, 6, 7	-14.165
2021-01-19	5	1, 3, 4, 5, 6	1.142
2021-01-21	9	1, 2, 3, 4, 5, 7, 8, 9, 10	53.506
2021-01-28	9	1, 2, 3, 4, 5, 6, 8, 9, 10	5.765
2021-02-01	8	1, 3, 4, 5, 6, 7, 9, 10	21.665
2021-02-03	5	3, 4, 5, 8, 10	1.731

2021-02-05	4	3, 5, 7, 9	27.484
2021-02-08	5	1, 3, 5, 7, 10	32.962
2021-02-09	5	3, 5, 6, 9, 10	22.071
2021-02-11	6	1, 2, 5, 7, 8, 10	33.51
2021-02-16	8	1, 2, 3, 5, 6, 7, 8, 10	57.505
2021-02-18	6	1, 3, 4, 6, 8, 10	38.509
2021-02-19	4	3, 8, 9, 10	5.946
2021-02-22	4	1, 3, 4, 10	30.076
2021-02-24	7	2, 3, 4, 5, 6, 7, 10	48.054
Total:	296		1,651.265

Conclusion

The Project results have helped to de-risk and validate using the OpenADR standard to control the load of collections of Level 2 EVSEs. With total energy savings from the DR Project exceeding 1.6 Megawatt hours, it is fair to say the project has been a success. The current COVID-19 pandemic has affected the results of the project, as particularly during the second term of the demonstration period, there were few EV drivers using BCIT's Energy OASIS system. As students and staff return, usage will increase, and it may be worthwhile to resume DR events.

BCIT successfully developed and demonstrated open source software using the OpenADR standard to command and control Level 2 Chargers. The open source software is available for download for utilities, municipalities, and other EV charging network operators to use.