Breaking Ground in Energy Storage: Arcadian Projects Inc. brings Canada's Largest Battery Energy Storage Project Online

A behind-the-scenes look at the Festival Hydro battery energy storage project

Contents

Executive Summary

This paper is a snapshot of energy generation and consumption in Ontario: past, present, and future. With a focus on energy management both before and after the meter, this paper aims to inform class A consumers, local distribution companies (LDCs), and energy decision makers how to decouple energy consumption from economic productivity and confidently take control of their energy use and costs through the installation of battery energy storage systems (BESSs).

As a part of Phase 1 of the Independent Electricity System Operator (IESO) 2014 procurement of regulatory energy storage systems, the Wright Business Park—adjacent to the Festival Hydro transformer station—in Stratford, Ontario was chosen as the site for this pilot project. This paper describes the challenges particular to the Festival Hydro battery energy storage (BESS) project to share the complexity of BESSs as cutting-edge technology for which the electrical code is only now being formulated.

BESSs represent an opportunity to maximize renewable sources of energy generation, stabilizing costly episodes of intermittent energy from the grid, and minimizing costs associated with energy consumption at peak demand. Emerging BESSs also represent a significant step away from traditional models of grid-dependant energy generation and consumption. This allows private members to get in front of the electricity bill and become a stakeholder in the newly emerging energy market.

BESSs are no longer simply short-term storage: they're fully customizable, modular, and scalable systems for before-the-meter and behind-the-meter power management. Battery operating systems and the analytic software to predict peak demand is advanced, the batteries are affordable and accessible, and—with the installation of Canada's largest battery energy storage facility with Festival Hydro—Arcadian Projects Inc. has a proven record of handling the practical challenges of innovative electrical projects from design to installation.

Tags: expert, multi-trade, electrical, electrical systems, electrical code, materials, procurement, installation, system design, project management, local distribution company, LDC, energy policy, energy management, power generation, energy storage systems, distributed energy resource, DER, renewable energy, green energy, alternative energy, ESS, battery energy storage system, BESS, class A consumer, class B consumer, industrial, manufacturing, commercial, greenhouse, refrigeration, data center, utility cannabis, institutions, hospitals, universities, solar, wind, hydro, carbon neutral

Forward by Luke Shantz, CEO of Arcadian Projects Inc.

The evolution of green energy is an amazing show of innovation, technology, determination, and care for our planet. And the latest step, the integration of energy storage systems with green energy generation, is a necessary step.

Globally, the diversity of climate, ecosystems, and human systems are impacted by climate unpredictability, and there are record highs, lows, and general turbulence every year. Traditionally, as human productivity came under stress, we focused on increasing energy generation, but the environmental impacts and costs to health are high. Investment in renewable sources of power, like wind and solar, is also limited when power can only be generated when the conditions are ideal.

Distributed energy resources (DERs) and battery energy storage systems (BESSs) are now cost-effective and available tools that allow: municipalities to generate the power to support their communities; developers the option to become registered power generators; and Class A consumers to create microgrids to allow them to take control of their energy usage, manage their energy peaks, and help stabilize the grid for other users.

Technology has now reached that tipping point when investment in BESS can promise to deliver dividends, and the impact would be immediate: the more DERs we have controlled by predictive software, the more able we would be to predict the amount of power needed and reduce the demand for more generation resources. There are even advantages from a production standpoint as batteries have a relatively small ecological footprint and are reusable as well as recyclable.

Most importantly, BESS technology and DER development would have a significantly positive impact on remote communities and emerging nations in which infrastructure has not been built or has been destroyed—areas in which having access to reliable and renewable energy (and the modern benefits of energy like clean water, affordable power, industry, employment) would be a game changer.

BESSs are modular, transportable, scalable, and key to opening up opportunities in energy production and the energy market. The energy revolution is here.

Forward by Todd Lorentz, COO of Arcadian Projects Inc.

In 2009, the Feed-in-Tariff program was rolling out in Ontario and there were solar panels popping up everywhere. At this time, Arcadian Projects Inc. began with a focus on residential and agricultural FIT and microFIT solar installations, but the company quickly grew to incorporate commercial and industrial projects that married industrial trade clients with energy management solutions.

As COO, I manage operations at Arcadian Projects Inc. as a small, yet nimble, company amply able to complete large and custom jobs. My experience working on high and medium voltage electrical projects, renewables, and managing material supplies for large EPC contractors has given me the background to help these contractors design and build their projects. As a curious twist of fate, I was familiar with the Festival Hydro site in Stratford as I had worked on the installation and build of the then-new transformer station a few years before. With an intimate knowledge of that site, the systems, and how it was built, I ended up as de facto project manager because I was excited to get this project going.

In review, collaboration was key to completing this project. We were able to leverage our partnerships and experience to work closely with engineers and field inspectors to get the system certified. It was no small feat, but we value teamwork and trust the professionalism and expertise of our staff to work through the challenges of getting complex electrical systems safely online.

We are proud of our role in getting Canada's largest operational battery energy storage system successfully installed and running. As a multi-trade contractor, we work on multiple projects at any given time—today we're working on well over 18 projects in various phases of construction. We also run a service group that is in and out of over a hundred customers every month. With our three divisions (Solar & Renewables, Energy Storage & Management, and Industrial Trades) we are able to complete custom yet turnkey projects. Because our timelines do not rely on subcontractors, our clients can rest assured that projects will be completed on time and in budget.

Introduction

In 2017, the total demand for energy in Ontario was 132.1 terawatt-hours (TWh) with the highest demand peak of 21,786 megawatts (MW) occurring unseasonably late in the year on September 25. Although the overall demand in 2017 was down from 2016, demand on the same day of the previous year was only 1700 MW.[1] As demonstrated by this example, regulating and maintaining energy supply in Ontario is not simply a question of increasing supply and decreasing demand, but one of supporting an efficient, responsive, flexible, and reliable system of energy generation and transmission in the face of increasing climate fluctuations and subsequent shifts in demand.[2]

This white paper is an introduction to the energy market in Ontario and a short backgrounder on the recent IESO investment in renewable sources of electricity generation and energy storage systems to increase regulatory capacity (and stability) to the grid. Universally, the availability of reliable and cost-efficient energy is a forefront concern for all users, but larger operators such as local distribution centres[3] (LDCs) and class A consumers can benefit from BESSs from an energy management perspective as it offers all the advantages of decoupling productivity from peak demand and offers an opportunity for one to enter the energy market as a stakeholder in energy production. This may be of special interest to large-scale energy consumers (i.e. class A consumers[4]) that find their energy costs for metered energy plus global adjustment[5] (GA) payments to be second only to their labour costs.

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[1] "2017 Electricity Data," Media Centre, Corporate IESO, *IESO*. Copyright 2018. Accessed September 19, 2018. http://www.ieso.ca/corporate-ieso/media/year-end-data.

[2] Climate change is a major factor considered in IESO's 2016-2020 Strategic Plan. Two of IESO's goals for 2016-2020 are to a) "deliver superior reliability performance in a changing environment," and b) building a "more efficient and sustainable marketplace." For a link to the Strategic Plan, see: http://www.ieso.ca/corporate-ieso/corporate-strategy-and-business-planning/strategy.

[3] Local distribution companies, or local distribution utilities, are equivalent terms used by the IESO to describe the bodies responsible for distribution electrical power from transmission lines into buildings and homes. LDCs are also responsible for billing and answering public concerns about energy use (e.g. power interruptions). For a map and list of LDCs in Ontario. "Find your Local Distribution Company," Overview of Sector Roles, Ontario's Power System, Learn, *IESO*. Copyright 2018. Accessed September 9, 2018. http://www.ieso.ca/findutility/.

[4] All consumers that use 5+ MW a day are categorized as Class A consumers. Users between 1–5 MW can opt-in to become Class A, otherwise they are Class B. In addition, some customers can opt-in as Class A if their peak demand is 0.5 MW or greater, but the option depends on the type of business they have (e.g. refrigeration companies may opt-in). An NAICS code may be used to confirm if this is an option.

[5] The cost of energy includes not only the end-user charge from the meter but additional costs of global adjustment (GA). GA is charged to all end-users of energy but only appears as a separate charge for mid-level consumers (Class B consumers) and high-level consumers (Class A consumers) who are charged a wholesale price on energy. GA calculations are based on the percentage of the consumer's usage at the top five peak demand hours in Ontario from April 30 to May 1. GA is used to fund the growth and maintenance of Ontario's electricity infrastructure, and fund conservation programs to ensure the availability of energy in Ontario. "What is Global Adjustment," Electricity Pricing, Learn, *IESO*. Copyright 2018. Accessed September 9, 2018, http://www.ieso.ca/en/learn/electricity-pricing/what-is-global-adjustment.

On the State of Energy: A Backgrounder on the IESO BESS pilot projects

The OPG, Hydro One, OEB, IESO, and ESA

With approximately 3000 class A consumers and over 13.4 million people[6] in Ontario, maintaining a reliable and cost-efficient electrical grid is a major priority for the Government of Ontario's Ministry of Energy.

For the purposes of this paper, five companies, one private and four crown corporations, make up the major players in energy management in Ontario: Ontario Power Generation (OPG), Hydro One, the Independent Electricity Systems Operator (IESO), the Ontario Energy Board (OEB), and the Electrical Safety Authority (ESA).

Ontario Power Generation (OPG), Hydro One, OEB, and the IESO are four crown corporations that are responsible for energy generation, operational management, transmission, coordination, and regulation in Ontario. The OPG operates one of the largest power companies in Ontario and produces almost half of the power used in the province[7] and Hydro One owns almost 97% of the transmission lines and maintains 152,000 km of high and low voltage transmission lines all over Ontario. Hydro One, either directly or via one of its subsidiaries, also owns and operates 19 remote distribution systems in northern Ontario as well as several utility companies, including one in Brampton, something that has drawn criticism in the past.[8]

The IESO is an aggregator, controller, and regulator of the electrical grid in Ontario and is responsible for balancing supply with demand load on the grid. Capable of making per-second changes in supply via remote connections to generators and storage systems, the IESO is responsible for the coordination of electricity generation, transmission, purchasing and selling, and rates for power; and as such, both Hydro One and the OPG report to the IESO. The IESO has also been tasked by the Ontario Ministry of Energy to prioritize stability and conservation of the grid and has investigated the current and future potential of distributed energy resources (DERs), including renewable source electricity generators (like solar, wind, biofuel) and energy storage systems (like flywheels and batteries), to stabilize a "smart grid."

The OEB is an impartial, independent energy regulator mandated to provide the Government of Ontario with "unbiased advice," to write new energy policies, license and establish rules for energy companies, monitor the energy market and "establish" "reasonable" energy rates for the province. Essentially, the OEB oversees energy to ensure that public interest is served.[9]

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[6] Statistics Canada. 2017. *Ontario [Province] and Canada [Country]* (table). *Census Profile*. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017. Last updated April 24, 2018. Accessed September 9, 2018. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/Page.cfm?Lang=E&Geo1=PR&Code1=35&Geo2=&Code2=&Data=Count&SearchText=Ontario&SearchType=Begins&SearchPR=01&B1=All&GeoLevel=PR&GeoCode=35.

[7] For more on the structure of Ontario Power Generation (OPG) and the legislative and regulatory bodies that it reports to, see: "Regulatory Reporting," *Ontario Power Generation*. Copyright 2018. Accessed September 9, 2018. https://www.opg.com/generating-power/nuclear/stations/Pages/Reports.aspx.

[8] Kenny, David. "The Hardwiring of Ontario's Power System: Tracing Hydro One's Origins." *Globe and Mail.* March 10, 2015. Updated May 12, 2018. Accessed September 7, 2018. https://www.theglobeandmail.com/report-on-business/the-hard-wiring-of-ontarios-power-system-tracing-hydro-ones-origins/article23397464/

[9] "About Us," *Ontario Energy Board*. Accessed September 12, 2018. https://www.oeb.ca/about-us.

In contrast, the ESA is a private non-for-profit mandated by the Government of Ontario to ensure electrical safety and awareness. It is responsible for certification and product safety, licensing of electrical contractors and master electricians, public education, and regulation of electrical systems (i.e. LDCs) in Ontario.[10]

Balancing demand and supply

Today, over 14,800 MW of electricity is supplied to the grid by renewable generation with 3000 MW of additional power from renewable energy projects due to be under construction by January 2018.[11,12,13] This trend is expected to continue as the IESO predicts that "half of Ontario's installed capacity" will come from the 20,000 MW of renewable energy by 2025.[14]

It is notable that in spite of IESO's commitment to renewable sources of energy generation, nuclear power plants and large hydroelectric plants still produce a great majority of energy supply—or the base supply—in Ontario. It is this disconnect that is bridged by the integration of energy storage systems in general, and battery energy storage systems in particular.

As controller, the IESO coordinates the generation, procurement, and transmission of electricity in Ontario from nuclear, hydro, and renewable sources. And while the IESO is tasked by Ontario's Ministry of Energy to make long-term procurement plans for energy drafted from solar, wind, and water, it must do so while maintaining a reliable supply that meets demand on a per-second basis[15]—but on any given day, energy demand in Ontario varies by more than 10,000 MW.[16]

To provide reliable and flexible supply, the IESO relies on the diversity of its energy portfolio wherein some generators (i.e. nuclear and large hydro plants) are needed to provide the majority of energy supply on any given day and other generators (i.e. biofuel generators, small hydro plants, remote distributed resources, natural gas burning plants) are used to provide regulatory capacity—or the "increase or decrease in output in step with second-by-second changes in demand."[17]

Although the IESO uses advanced analytical software to ensure that supply meets the per-second shifts in demand, intermittent supply is still a danger for microgrids (i.e. class A consumers and LDCs with large electrical infrastructure) whose infrastructure can be damaged in a rapid power down

[10] "Role of ESA," Role & Governance, About ESA, *Electrical Safety Authority*. Accessed September 9, 2018. https://www.esasafe.com/about-esa/role/.
[11] Renewable energy sources include energy from wind turbines, solar panels, bioenergy, and hydroelectric dams. Bioenergy plants produce methane gas from the fermentation of animal or plant waste (e.g. the waste from foresting or farming), which is then burned to provide electricity to the grid. Bioenergy plants currently produce 25% of the renewable energy distributed today and is "considered to be carbon neutral." "Energy Resources: How They Work," Ontario's Supply Mix, Learn, *IESO*. Copyright 2018. Accessed September 9, 2018. http://www.ieso.ca/learn/ontario-supply-mix/energy-resources-how-they-work.
[12] "End of Coal." The Ministry of Energy, Northern Development and Mines, *Ontario Government*. December 15, 2017. Updated July 16, 2018. Accessed September 9, 2018. https://www.ontario.ca/page/end-coal.
[13] For a map of energy generation in Ontario, https://www.opg.com/generating-power/documents/map_of_operations.pdf. Created by Ontario Power Generation. Dated January 2017. Accessed August 27, 2018. IESO's map http://www.ieso.ca/localContent/ontarioenergymap/index.html
[14] "End of Coal." The Ministry of Energy, Northern Development and Mines, *Ontario Government*. December 15, 2017. Updated July 16, 2018. Accessed September 9, 2018. https://www.ontario.ca/page/end-coal.
[15] The challenge of relying on renewable energy sources, in particular solar and wind, to power a grid is the difficultly of producing reliable supply for shifting load profiles with inconsistent wind or daylight hours. For example, solar production of energy is tied to not entirely predictable occurrence of strong daylight hours. For solar-based production in Ontario, production would decrease with decreasing daylight hours over a day and over a year. Wind-based production of energy is also viable and predictable, and also produces variable power generation. As this paper demonstrates, batteries systems are integral to stabilizing renewable energy supply to balance demand.
[16] "Managing a Diverse Supply of Energy," Ontario's Supply Mix, Learn, *IESO*. Copyright 2018. Accessed September 9, 2018. http://www.ieso.ca/en/learn/ontario-supply-mix/managing-a-diverse-supply-of-energy.
[17] "Managing a Diverse Supply of Energy."

(blackout), or trickle down (brownout) when demand outstrips supply. Class A consumers have few options but to install behind-the-meter gas- or oil-powered backup generators, but these are increasingly insufficient buffers against systems and equipment damage to sophisticated and sensitive automation and electrical systems.

Phase 1 of the IESO pilot project: Investing in regulation services and renewable energy

In other words, IESO's regulation services attempt to balance, in real time, total system generation to total system load, after transmission losses, in order to correct short-term variations in power system frequency. As a controller, the IESO uses automatic generation controls (AGCs) integrated into generation plants to change energy output and requires having a "[m]inimum of ±100 MW of automatic generation control (AGC)" and a "[m]inimum overall ramp rate requirement…[of] 50 MW/minute" available at all times.[18]

In 2016, the IESO decided that the capacity for regulation services needed to increase to meet predictions of fluctuation and the plans included adding 50 MW of regulation every hour (in addition to the existing minimum of 100 MW) by 2017.[19] It is significant then that after receiving 42 submissions for up to 350 MW of regulation, the IESO awarded the tenders to Hecate Energy Ontario Storage VII, LP, and Saturn Power Inc. for their plans to add 55 MW of regulation capacity via battery energy storage systems (BESSs).[20]

DERs and BESSs for LDCs and Class A Consumers

Although the IESO is invested in using BESSs to increase renewables generated supply and increase regulation capacity, these two are not entirely exclusive. "BESSs are technology agnostic," to quote Richard Cook, CEO of Wattco. BESS are modular, scalable, portable, and cost-effective, and the operational and predictive software required to maximize the efficacy of BESS is advanced enough to predict peak demands with 1 – 1.5 hours notice.

And the same technology that IESO is using to support and supply the grid is accessible to class A consumers to create private, behind-the-meter microgrids.

For the first time since the 2009 Green Energy Act and the Feed-in Tariff (FIT) program helped plant wind farms and solar panels across Ontario, there is an opportunity for class A consumers to not only manage their energy and consumption costs, but to become a stakeholder in the energy market (i.e. e.gcontrol, buy, and sell energy) via the installation of BESSs.

[18] "Ancillary Services Market," Markets and Related Programs, Market Operations, Sector Participants, *IESO*. Copyright 2018. Accessed September 9, 2018. http://www.ieso.ca/en/sector-participants/market-operations/markets-and-related-programs/ancillary-services-market.
[19] The IESO plans including increasing regulation capacity to 250–300 MW by 2020. http://www.ieso.ca/en/sector-participants/market-operations/markets-and-related-programs/ancillary-services-market
[20] "Energy Storage Projects Selected to Provide Essential Grid-Balancing Service," News Releases, Media, Corporate IESO, *IESO*. November 28, 2017. Accessed September 9, 2018. http://www.ieso.ca/en/corporate-ieso/media/news-releases/2017/11/energy-storage-projects-selected-to-provide-essential-grid-balancing-service.

BESSs are one form of distributed energy resources[21] (DERs) that are small, grid-connected, and electricity producing (or controlled load capable resources) that can:

- Stabilize energy production from renewable sources by storing it during peak times and releasing it during low-production times
- Adds flexibility to the grid (to amp up or decrease) and regulation to the grid during times of unexpected peak demand
- Support renewable energy generation as a more reliable DER
- Support behind-the-grid systems (e.g. class A consumer or a data centre) during times of intermittent power as a carbon-neutral backup generator
- Reduce infrastructure costs to the micro-grid (for a private behind-the-meter class A consumer or an LDC) due to blackout and brownouts
- Reduce reliance on the grid for power during peak times—buy low
- Reduce GA payments
- Allow renewables owners to store energy and sell it back to the grid—sell high
- Provide modular, scalable, flexible, reliable, clean and renewable energy to remote locations

For private, behind-the-meter applications in particular, BESS is now widely available for all commercial, industrial, and institutional applications due to advancements in battery and analytical software technology. By incorporating BESSs into your infrastructure, diverse industries like greenhouses (e.g. cannabis grow operations), data management centres, manufacturing plants (e.g. automotive, steel), and institutions like hospitals can minimize costs related to grid instability. Class A consumers interested in creating their own microgrid to can expect a BESS to provide:

- Carbon-neutral and seamless protection (as back up generator with a one-second response time) from the damages of intermittent supply
- Protection from infrastructure and productivity costs due to electrical systems damage
- Insulation from wholesale energy costs and GA charges from using power from the grid during peak demand times
- Potential to become a stakeholder in the energy market by integrating, e.g. North solar-generated power to the grid

Installing your own BESS is now a practical opportunity to create an affordable, cost-effective, reliable, flexible, and scalable energy management system that can be tailored to your unique requirements.

[21] Distributed energy resources (DERs) can include wind turbines, solar panels, heat generating plants, small hydroelectric generators, electric vehicles, electricity storages (like batteries), small natural gas-fuelled or biofuel generators, electrical water heaters, ad HVAC systems. DERs are characterized by small capacities, flexible and modular energy generation or storage capabilities, and ancillary function to primary forms of generation (like nuclear and large hydro plants. They have been growing in Ontario and have been reported to account for 2000 MW from solar alone. The IESO supports DER projects through the IESO Conservation Fund. "Distributed Energy Resources," A Smarter Grid, Ontario's Power System, Learn, *IESO*. Copyright 2018. Accessed September 9, 2018. http://www.ieso.ca/en/sector-participants/market-operations/markets-and-related-programs/ancillary-services-markethttp://www.ieso.ca/en/learn/ontario-power-system/a-smarter-grid/distributed-energy-resources

The Festival Hydro Battery Energy Storage Pilot Project: Arcadian Project Inc. Installs the Largest BESS in Canada

Festival Hydro in Stratford, Ontario was chosen to host the largest battery energy storage system (BESS) in Canada to date because its transformer station was relatively new and had the capacity to accommodate the 8 MW project requirements.

Specifications

From November 2017 to February 2018, under contract to Saturn Power/Ellis Don, Arcadian Projects Inc. installed four systems with a total capacity of 8.8 MW at the Festival Hydro BESS facility. It is the largest storage system in Canada with 40.8-megawatt hours of power. The 8.8-MW system is capable of storing enough electricity to power 10,000 houses, or one-third the population of Stratford[22], for 1 hour.

Figure 1: Exterior building

Figure 2: Outdoor Power System – Overview 1

Figure 3: Outdoor Power System – Overview 2

[22] In 2016, the population of Stratford was 31,053 and the population in Ontario was 13,448,494. Statistics Canada. 2017. *Stratford [Population centre], Ontario and Ontario [Province]* (table). *Census Profile*. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017.

Figure 4: Substation

Figure 5: Power Busway Eaton 2MW Inverters & Transformer

The batteries and battery management operating system were provided by Oregon-based Powin Energy, a leader in integrated energy storage systems in North America.

> **"The system is extremely modular. And the stack comes stand alone with its own battery management system built right in it. Basically, it looks after itself."**
>
> **-** *Quote from Nick Ashbaugh, project manager with Powin Energy and site superintendent with Ellis Don on the Festival Hydro BESS project.*

The system is comprised of 296 lithium iron phosphate battery stacks (set between 2.4 and 3.6 volts) organized into four battery cell arrays—two 2-MW 3-hour systems and two 2.4-MW 6-hour systems—separated into two different systems of inverters. Although custom stacks are available through Powin Energy, this project uses the stand-alone and modular Powin Stack140 that is scalable from 124 kW and up and stands about 4x3x6.5 ft^3.

Figure 6: Battery Stack - 1

Figure 7: Battery Stack - 2

Each stack holds seventeen battery packs and each pack holds thirty-two battery cells as well as an integrated operating system (OS) that monitors the battery (e.g. for temperature, voltage, and current) and tells facility exactly what each cell is doing at any given time in order to manage the health and longevity of the battery.

Figure 8: Close-up Battery Stack

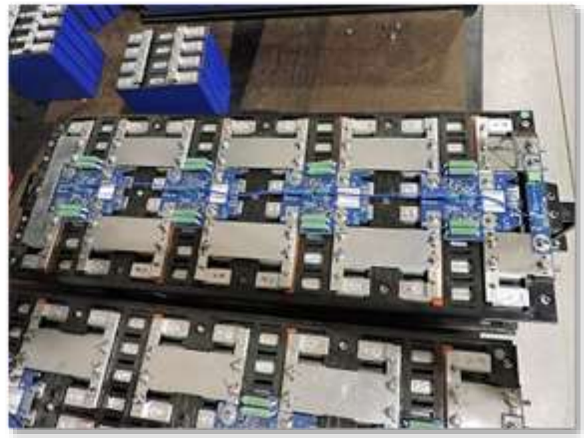

Figure 9: Powin Lithium Ion Cell

With an “extremely aggressive timeline”[23]in place, Arcadian Projects Inc. was selected to handle all the typical new build electrical work for the building facility (such as lighting, HVAC, and fire alarm systems), as well as all of the work unique to the BESS including:

Figure 10: Control Centre

- Wiring in the auxiliary power and the charger power
- Connecting all associated transformers
- Building and assembling inverters
- Placement and installation of inverters
- Laying all the ground work
- Putting in all the cable trays for cable management
- Installation, tie-in, and CSA conformance of AC components, cables, switchgear, and transformers
- Installation, tie-in, and CSA conformance of DC components, cables, from the battery to the inverters
- Wiring all the communication cables for the system
- Installing medium voltage interconnect consisting of switchgear, transformers, underground cabling, and installation.

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[23] "…Ontario is at the forefront of deploying energy storage for frequency regulation, voltage control, and reactive power support," said Geoffrey Brown, President of Powin Energy. "This will be the largest installation in Powin's history and—much like our recently commissioned project for Southern California Edison—will be deployed on an extremely aggressive timeline.” “Powin Energy Scores 52.8 MWh Energy Storage Portfolio: Will be largest energy storage rollout in Canada,” News Release, Powin Energy, *MarketWired*. June 15, 2017. Accessed September 3, 2018. http://www.marketwired.com/press-release/powin-energy-scores-528-mwh-energy-storage-portfolio-otcqb-pwon-2222056.htm

Figure 11: System Cable Tray -1

Although Arcadian Projects Inc. was hired for a typical EPC installation, it soon became clear that this was going to be a design-build project. The reality of problem-solving the largest BESS in Canada is that cutting-edge technology requires pioneering design, equipment, and installation—when the project began nothing was standard. Fortunately, projects like the Festival Hydro BESS and companies like Arcadian Projects are setting the standard.

Figure 12: System Cable Tray - 2

Figure 13: Overhead Cabling

Figure 14: House Panel

Challenges & Collaboration

1. **One challenge was time.** Given Geoffrey Brown's description of the "extremely aggressive timeline,"[24] Lorentz recalls that "when [he] arrived, there was nothing there but a field." By the time Arcadian Projects came on board, the design required revision and timeline was short. Arcadian Projects had to move quickly to get the engineering approvals and procurement process in place and fortunately, they were able to leverage their relationships with their suppliers and advisors to push [the project] forward.

   "Extremely aggressive timeline."

   - *Quote from Geoffrey Brown, Renewable Energy Leader and President of Powin Energy.*

2. **Seamless and dependable service.** Arcadian Project's team structure—from project manager to the on-site trades personnel—ensured a seamless and dependable delivery of service. Steve Douglas, the field inspector on site for the DC integration (and Senior Technical Codes Specialist for QPS Evaluation Services Inc. and past president of the International Association of Electrical Inspectors of North America) recalls that "[Lorentz] was very good at helping us to problem solve whenever an issue was identified. But it wasn't just [him]. There was also a very good electrical foreman. He was the type of [person] that if he said he would do it, it would be complete and done very well." Arcadian Projects has a nimble and certified workforce of 50+ in their multi-trade contracting group to service the commercial and industrial sector, including electrical, mechanical, millwrighting, and HVAC.

3. **Real time troubleshooting and collaboration.** In Canada, electrical systems must undergo either 1) a full certification program to certify equipment, or 2) a field evaluation. Given the innovative nature of BESSs, the equipment used in the pilot project was not ready to warrant the cost of certification. This is typical in BESS and custom projects, which require field inspection. Ontario also maintains a unique policy that requires all large projects to submit electrical designs to the Electrical Safety Authority[25] (ESA) for plan reviews, which are then followed up with an ESA report to a local field inspector. Field inspections, collaboration, and effective communication with various invested bodies is a significant component of BESS build projects.

   The Festival Hydro BESS necessitated multiple meetings between project managers, engineers, and field inspectors to troubleshoot the electrical design while the installation was in progress.[26] In addition to troubleshooting electrical issues in real time, passing the field inspection required extensive collaboration. Discussions occurred between Nick Ashbaugh

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[24] "Powin Energy Scores 52.8 MWh Energy Storage Portfolio."

[25] The Electrical Safety Authority (ESA) is an administrative authority mandated by the Government of Ontario to enhance public electrical safety in the province. Functioning as a safety regulator and advocate, the ESA is responsible with "identifying and targeting leading causes of electrical safety risk; ensuring compliance with regulations; promoting awareness, education and training; and collaborating with stakeholders to improve the state of electrical safety in Ontario." The ESA works with the following regulations: 164/99 (The Ontario Electrical Safety Code), 570/05 (Licensing of Electrical Contractors and Master Electricians), 22/04 (Electrical Distribution Safety for Licensed Distribution Companies, LDCs), and 438/07 (Electrical Product Safety for the approvals of industrial and commercial electrical products before sale). "Role of the ESA," Role & Governance, About Us, *Electrical Safety Authority*. Accessed September 3, 2018. https://www.esasafe.com/about-esa/role/.

[26] Compliance in Ontario, prior to the field inspection, uniquely requires a design plan review by the ESA after which a report is received by the local field inspector to dialogue with supervisors on-site. Steve Douglas (senior technical codes specialist, QPS Evaluation Services Inc, and past president of the International, Association of Electrical Inspectors of North America), in discussion with author, August 15, 2018.

(then the site superintendent for Ellis Don and now a project manager for Powin Energy), Arcadian Projects COO Todd Lorentz, QPS field inspector Steve Douglas, Stephan Williams (Director of Development Engineering for Powin Energy) and a representative from the Electrical Safety Authority.

4. **Compliance with multiple safety codes.** Steve Douglas, the QPS field inspector on site, notes that "one issue in the Canadian system is that there are no rules right now specific to energy storage systems." As mandated by the Government of Ontario, the Electrical Safety Authority (ESA) is a safety authority and regulator and electrical systems in Ontario are required to comply with Ontario Electrical Safety Code (from the ESA) and Canadian Electrical Code (CE code), both of which may vary on technical details. Although certification in Canada requires compliance with CSA, regulatory bodies—like the CSA Group and QPS, both nationally accredited organizations recognized for third-party testing and certification in Canada—in Ontario consult with American codes like the UL[27] and the National Code.

   Douglas explains that field inspections ensure safety and that updating the CE Code is in progress. "I am chairing a task force meeting on September 21, 2018 to draft rules to go in the CE Code. Currently, we have rules on what can't be done, but we don't have good rules on what you can do. [That said,] there has been work to update [the code in Canada] since last June when we filed for a change of scope for Section 64: On Renewable Energy Systems.[28] Section 64 deals with solar energy systems in the code but not BESSs. Because these systems are so large and new, it is faster and more cost effective to go with the field evaluation."

5. **Real time problem solving: High voltage.** Given the nature of energy storage, BESSs have a lot of power stored at a specific amp. With short circuit and high voltage components, even routine aspects of electrical systems require extra consideration.
   Section 36 of the CE Code (High Voltage Installations) lends general requirements for interlocking systems (such as solar energy systems), but it does not consider the specificities of BESS. More consultation and changes to the code are required.

   Beyond the challenges of inspecting two different types of BESSs being tested at Festival Hydro, Douglas highlighted the difficulties of the battery system that had each battery system connected to a single inverter that connects the BESS with the generating system and converts the direct current (DC) to alternating current (AC). (In contrast, the other system contained a series of batteries, each with its own inverter. The two systems are part of the IESO pilot project to gather data on BESSs.) The challenge of a single inverter, from a system design perspective, is that although more efficient, short circuit currents are very dangerous.

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[27] UL LLC is a safety consulting company based in Illinois approved for safety testing by federal government of the United States (US). The UL code is a standard for the US but their regulations are standard references when developing new code in Canada, and abroad.

[28] "With increased changes in technology associated with renewable energy systems, the Canadian Electrical Code (CE Code) 2012 edition has incorporated Section 64 to apply to the installation of these systems. Section 64 provides direction for the installation of specific equipment such as inverters, stationary fuel cell systems, small and large wind systems, micro-hydropower systems, hydrokinetic power systems and storage batteries and includes general requirements that would apply to each of the systems mentioned. While these systems are not yet common throughout Canada, they are appearing in certain areas and will only increase in numbers." McDonald, Pierre. "Renewable Energy Systems: A Walk Through CE's Section 64," *Electrical Industry Canada*. No date. Accessed September 9, 2018. http://electricalindustry.ca/latest-news/567-renewable-energy-systems-a-walk-through-ce-s-section-64.

The site superintendent with Ellis Don, Nick Ashbaugh, also recalled the DC system as a challenge. “Yes, there were some current rating issues that needed to be worked out. We also needed to decide how we were going to design the DC system to handle a short circuit rating. That would have been something that was talked out by the group.” Safety is a paramount concern when designing a BESS. “With bidirectional systems, with AC and DC, you have to have workers and electricians safe during the construction. The system has to be engineered to lock out the system from both sides, depending on what side the current is running at that moment, and it must do so seamlessly. [This is called interlocking.] So, interlocking a system like that was a challenge that everyone worked on because it is more of a design detail. The short circuit current ratings from the batteries are more of an electrical engineering concern but figuring out which components work with that–like what disconnects to use or disconnects versus breakers–are conversations we had with Arcadian and the electrical engineers.”

Ashbaugh noted that Arcadian Projects was also able to complete the high voltage work that was required. “It was the first time that Powin did any work in Canada, so Arcadian was able to set in and go through all the code compliance issues that were found with the system.” Being as that Powin was from the US they had different ratings, so they were able to step in and let us know where the problems were and give us suggestions on how to fix them. “They were able to walk us through those things and helped out tremendously in the final design to set us up to meet code in Canada. …It was a huge help.”

6. **Design and production of custom components.** Although the Powin stacks are designed to be modular (“drop-in, plug-and-play”), much of the larger storage system work was custom and required long lead times. With only four months to complete the project, Arcadian Projects worked directly with manufacturers to develop products and leveraged their relationship with their suppliers to get the project completed on time. For example, although the Festival Hydro BESS has been operating safely since February 2018, custom breakers have been designed with a manufacture and install date of October 2018. Arcadian Projects designed the system and ensured, that both before and after the install, that the Festival Hydro BESS was safe and operational at launch.

Moving forward with industry partners happy to work with them again, Arcadian is uniquely positioned to meet a project of any size in distributed energy resources (DER), energy storage project (ESS), and renewable energy generation.

Conclusion

The future for all scales of energy use lies in energy storage systems (ESSs) and battery energy storage systems (BESSs) to provide a reliable, scalable, modular system (drop-and-play, stack-and-play, move-and-play) in which batteries are only promising to get better and more cost-effective.

* At time of printing, the IESO had not yet confirmed the availability of the project results from phase one of the BESS pilot project. Should the project goal results be released, this paper will be updated to include them.

About Arcadian Projects

Arcadian Projects is committed to providing the best energy and industrial solutions to help our customers reduce their energy consumption, meet energy conservation goals, and improve facility operations.

We continuously strive to deliver long-term service and technical support, while acting with the utmost consideration for safety in all aspects of our projects. With our passion for sustainable energy and our commitment to client satisfaction, our diverse and experienced team continues to stand out from others. We have the capability to complete all aspects of our energy projects in-house with an approach that is safe, cost-effective, and efficient. Potential partner project financing available for energy projects.

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Testimonial by Stephan Williams, Director of Development Engineering for Powin Energy

“Canada’s largest battery energy storage facility could not have been built without Arcadian’s expertise and on-the-fly problem solving. Their knowledge of local codes, deep electrical theory comprehension, and, not least, their dependability and endurance through tough challenges made the Stratford BESS project a huge success.

I highly recommend these hard-working professionals when high-quality work is required at competitive rates. I’m keeping them on speed dial for all future Ontario projects.”

Testimonial by Steve Douglas, Senior Technical Codes Specialist for QPS Evaluation Services Inc. and past president of the International Association of Electrical Inspectors of North America (IAEI)

“Some think they’re qualified, but they aren’t. Arcadian Projects [Inc.] is absolutely one of the good ones.”

Testimonial by Richard Cook, Founder and CEO of Wattco

“Arcadian Projects has the expertise, experience and ingenuity to make the Festival Hydro battery energy storage project happen. It is Canada’s largest energy storage system installed, completed successfully and on time. *I want the world to know that*.”