Utility opportunities in energy storage

Mohamed Ahmed, Bob Singh, Bhanu Opathella, Lalitha Subramanian and Bala Venkatesh

Workshop Report
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Ryerson University
Centre for Urban Energy

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Executive Summary

The Centre for Urban Energy (CUE) at Ryerson University organized and hosted a Workshop on Energy Storage (ES) to explore challenges and opportunities for ES in the electrical utility industry. CUE invited key players in the electrical energy delivery system from the province of Ontario to discuss their current experiences with power system challenges as well as their thoughts and ideas on how ES might help in addressing their systems' current and future needs. The objective also included a candid discussion on the gaps and barriers for considering ES (whose inherent capabilities exceed any other equipment in the power system) as an option by power system planners and operators to address their system and customer related current and future needs (both conventional and non-conventional). Members of the Independent Electricity System Operator (IESO -Ontario's Electricity Market and System Operator), Hydro-One (Transmitter), Toronto-Hydro, Hydro-Ottawa, Oakville-Hydro and Oshawa-PUC (LDCs), the Ontario Ministry of Energy (MOE) and the Ontario Energy Board (OEB) all participated in the discussions. Several of these participants also made presentations which included their views on the transformation of the electrical utility business – with ES as a key element. This report is a reflection of the Workshop presenters, contributors and other stakeholders' input. It presents the benefits, challenges and opportunities for ES in Ontario, and Canada, and it also highlights key research questions.

Broadly speaking, Ontario's vision in regards to the electrical system is to enhance efficiency and reliability, improve customer engagement, and integrate clean energy resources [10]. ES will be a main component of the new electrical grid, and has a real role to play in reaching these goals by increasing the robustness, flexibility, and efficiency of the electrical grid, which in turn makes it more economically efficient, and environmentally friendly through the integration of more renewables. ES can help the electrical system deal with many emerging issues including aging

infrastructure, increasingly dynamic loads, pressures to reduce emissions and diversify fuels, and challenges to business models. Despite this vast potential, ES faces a number of questions and challenges moving forward, as the Workshop highlighted.

Key Questions - The Workshop has highlighted the following questions/challenges with regards to the usage of ES:

- What are the primary services ES will deliver?
- How are utilities attempting to monetize ES, and what are the associated benefits and challenges?
- What regulations and policies are needed to enable the usage of ES?
- What is the optimum size and location of ES within the system - the planning challenge?
- What are the risks associated with using ES?
- How are System Operators using and scheduling ES in the operation timeframe?
- How can we quantify the benefits and costs associated with ES for various users of the system?

Key Actionable Items - In order to fulfill the potential of ES in Ontario, the Workshop also identified potential research and development opportunities that could address the above questions/challenges:

- Establish a clearer understanding of current ES investments in Ontario and identify the benefits of using different ES technologies to solve a wide range of power system problems;
- Develop a replicable and transparent method to quantify the benefit and cost of ES investments;
- Propose an appropriate regulatory structure and develop policies that enable investment in and adoption of ES technologies;
- Develop planning methods that identify the sizes and locations for ES; and
- Improvise System Operators methods to utilize ES for beneficial purposes.

Acknowledgements

The Centre for Urban Energy (CUE) would like to express its sincere gratitude to the people who contributed to the planning and running of the Workshop on Energy Storage. First and foremost, we would like to thank the presenters: Gordon Drake, IESO; Ajay Garg, Hydro-One; Gary Thompson, Toronto-Hydro; Jayesh Shah, Oshawa-PUC; and Richard Ford, Ontario Ministry of Energy for their invaluable input, suggestions, and discussions that helped us to shape the vision and content of this report. Secondly, we would like to thank the all the other Workshop attendees, including: Jack Simpson, Toronto-Hydro; David Richmond and Andres Mand, Ontario Energy Board; Norm Fraser, Hydro-Ottawa; and Jeff Mocha and Kishen Pais, Oakville-Hydro.

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Section 1 Introduction

1.1 Background to the Workshop on Energy Storage

Electricity production, transmission, and distribution constitute a vital portion of Canada's economy, both through the sale of electric energy, and by providing energy to industries, commercial establishments, and society at large. The crucial role of electric energy in Canada has led it to play a pioneering role in the evolution of electric energy systems worldwide [1]. Electric grids comprising generation, transmission, and consumption will undergo a fundamental paradigm shift through the introduction of grid-scale energy storage (ES) systems. ES may be a useful asset for Canadian utilities, system operators, and policy makers who are facing intense pressures to provide clean, high quality, reliable, and cheap energy. ES can make the electricity system more robust, environmentally friendly, and economically efficient and is broadly recognized as a main component of the modern, state-of-the-art electrical grid. ES has the potential to provide important services to Ontario and Canada's power systems, including helping renewables to overcome intermittency and uncertainty issues; enabling net-zero buildings; playing a key role in conservation and demand management; providing congestion mitigation for transmission systems; providing energy arbitrage and ancillary services; and even more. Nowadays, ES is not a single technology, rather a set of several technologies that can have vastly different: operating profiles, performance characteristics, and costs. As a result, different ES technologies map to unique needs.

The Centre for Urban Energy (CUE) at Ryerson University organized and hosted a Workshop on Energy Storage seeking to identify challenges and opportunities for ES in Ontario. CUE invited key provincial players to share their experiences with current power system challenges and discuss the potential ways in which ES can help to mitigate some of these issues. Members from the IESO (Ontario's Transmission System Operator), Hydro-One (Transmitter), Toronto-Hydro, Hydro-Ottawa, Oakville-Hydro and Oshawa-PUC (LDCs), Ministry (MOE) and Ontario Energy Board (OEB) participated in discussions while some of these organizations also made presentations which included their views on the transformation of the electrical utility business with ES as a key element. This report identifies, discusses, and summarizes key issues and opportunities for ES in Ontario's power systems as established through the course of the Workshop.

1.2 Motivation for the Workshop

Electric power systems generate, transmit and distribute electric energy in bulk, and the supply of electric energy, from generation to consumption, supplied through transmission and distribution systems, is instantaneous. Until recently, pumped-hydro units were the only technically viable bulk energy storage (ES) systems at grid-scale. In cases where a power system has pumped-hydro units, bulk energy can be generated, stored, and used at a later time. A simple application of this type of ES is energy arbitrage, where electric energy produced during times when prices are low is stored and used during other times when prices are high. In the recent past, technological advances in ES materials and power electronics for grid-scale bulk ES solutions are making a broader variety of ES solutions (beyond pumped-hydro) technically viable for use in electric power systems for applications beyond energy arbitrage. In addition to these technological advancements, ES costs are decreasing while delivered cost of electricity from conventional sources are increasing, further improving the economic viability of ES [2].

Several ES technologies with grid-scale potential are emerging, such as flywheels, underwater compressed air energy storage (CAES), batteries (such as Sodium-Sulphate, Lithium-Ion, etc.), and thermal ES solutions. These ES solutions, composed of varying technologies and designs, possess a myriad of features and can offer services such as frequency regulation, power quality improvement, fast ramping, black start, reactive power control, and renewable energy integration, in addition to traditional energy arbitrage. A good example includes flywheel systems capable of providing frequency regulation services in electric power systems at costs lower than any other service provider. ES solutions also hold the key to unlocking the potential of renewable energy worldwide, where ES systems turn intermittent power output from renewables into dispatch-able sources [3].

While ES solutions are plentiful, grid-scale, commercial-ready technologies are nascent, policy and environmental challenges remain, and utility integration is limited. Recently, in some electric utilities, such as Hawaii ES has become a significant electrical supply resource Figures 1, 2 and 3 illustrate cumulative global installed ES capacity in 2015, and the predicted potential installed capacity for ES in future years (through 2023) by technology type and application, respectively.

Despite these recent forays, there remains an extensive need to unlock the potential of ES technologies, break grid-scale integration barriers, and open doors for the next generation of ES solution's widespread use in power systems.

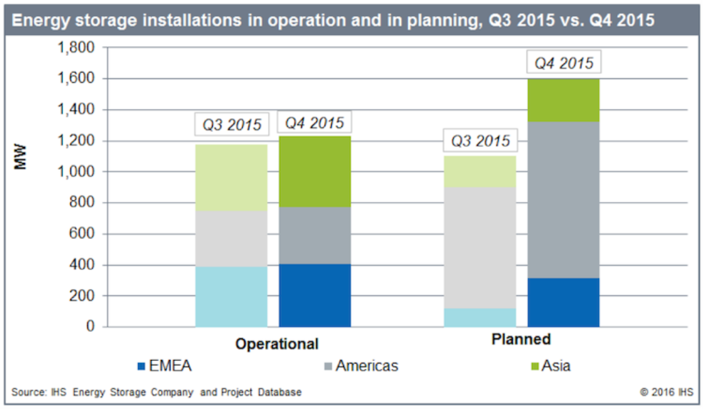

Figure 1 Global Cumulative Installed ES in 2015 [4]

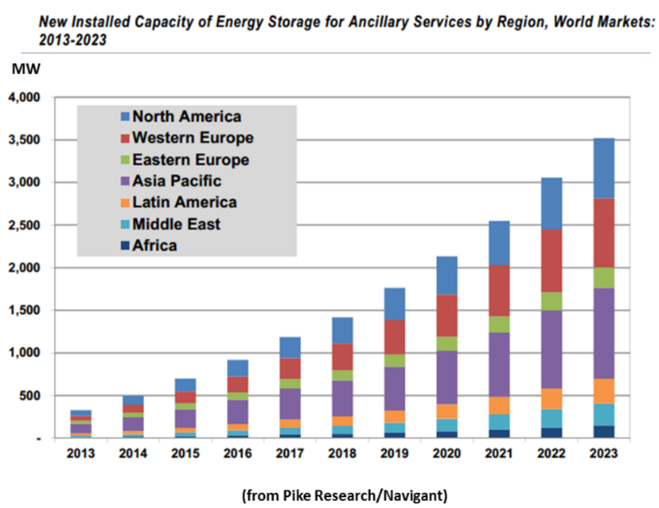

Figure 2 Global Cumulative Future of ES by Region [5]

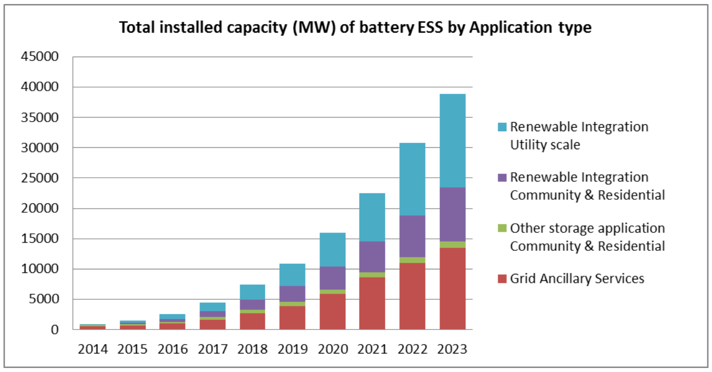

Figure 3 Global Cumulative Future of ES by Applications [6]

1.3 Workshop Objectives

The Workshop focused on utility applications for ES. The specific objectives of the Workshop are outlined as follows:

1) Share and discuss experiences about current power system challenges
2) Discuss how ES can help to mitigate some of these challenges
3) Identify different opportunities for ES to help system operators and planners
4) Illustrate the benefits of using ES in power systems
5) Discuss the current policies for ES connectivity
6) Elaborate on how regulations and policies can be crafted to enable ES

1.4 Workshop Outlines and Agenda

Time	Subject	Speaker
08:45 – 09:00	Breakfast	
09:00 – 09:15	Introductions, welcome and overview	Bala Venkatesh / Bob Singh
09:15 – 09:45	Opportunities to meet system needs with Energy storage	Gordon Drake – IESO (10 min) Wrap up by: Mohamed Ahmed
09:45 – 10:15	Regional Planning and Energy Storage Applications	Ajay Garg – Hydro One (10 min) Wrap up by: Bob Singh
10:15 – 10:30	Break	
10:30 – 11:00	Energy Storage LDC challenges and solutions	Gary Thompson – Toronto Hydro (10 min) Wrap up by: Bala Venkatesh
11:00 – 11:30	Solar-Storage- A New Paradigm	Jayesh Shah – Oshawa PUC (10 min) Wrap up by: Bala Venkatesh

11:30 – 11:45	Energy Storage in Ontario	Richard Ford – Ministry of Energy (5 min) Wrap up by: Bala Venkatesh
11:45 – 12:15	CUE Project Demos	Bob Singh/Bala Venkatesh/Peng Yu
12:15 – 1:00	Lunch, Networking and further discussions	

1.5 Benefits, Opportunities and Challenges of ES

In this Section, the motivations of organizing the Workshop on Energy Storage at CUE at Ryerson University were discussed, and the Workshop objectives and agenda were outlined. The Workshop brought together many key players from Ontario's electricity system and highlighted the differing perspectives of system operators, transmission companies, distribution companies, and system regulators/policy makers on how to deal with the opportunities for and challenges facing ES.

It can be concluded that ES provides solutions to a host of challenges facing today's power systems. By smoothing fluctuations from intermittent renewables (such as wind and solar), ES enables a greater penetration of renewables into the Canadian supply mix. ES can store excess energy created during low demand periods of the day and allow utilities to use this stored energy to meet peak demand more efficiently, provide best load generation facilities, and minimize energy costs for customers. By storing energy in ES units closer to load centers during low load periods and using stored energy during peak times, congestion in transmission and distribution networks can be eased allowing utilities to defer, or even avoid, expensive network upgrades. Further, ES units located closer to load centers can significantly enable power quality, reliability of service, etc. for customers. ES technologies can provide economic and reliable energy alternatives for remote applications; provide services in power systems at the transmission system level such as frequency regulation, ramping, black start, congestion relief, and energy arbitrage; enable services such as demand response, transmission and distribution upgrade deferral, improved reliability, and improved customer service for distribution systems; and provide improved operational capability to system operators across Canada.

In the following sections (Sections 2, 3 and 4), we will capture the fruitful discussions, suggestions and comments from the Workshop attendees. The opportunities and challenges for ES have been categorized based on three levels (i.e. Transmission, Distribution, and System Operators).

This report aims to summarize the needs for using ES in our systems, as well as the challenges system planners and operators may face in selecting and integrating ES.

Section 2 Energy Storage for Transmission Systems

2.1 Introduction

Energy storage has the potential to provide important services to Ontario's power system. Vastly different types of ES technologies are now flirting with commercial viability in utility scale applications, and possess varied characteristics including operating profiles, performance, and costs. As a result, different ES technologies map to unique needs.

At the transmission level, Hydro-One plans for a 30-month window (for 21 regions all over the Province). Hydro-One uses an Integrated Regional Planning Process (IRRP) as shown in Figure 4. The IRRP process considers all alternatives and determines the least costing and most reliable asset procurement strategy that satisfies power supply requirements. It includes all types of assets such as capacitors and transmission lines, but it can be enhanced to consider ES solutions. From a regulator's perspective, OEB wishes to embrace new planning solutions that include ES, while it also advocates on behalf of customers and wishes to ensure the best interests of all customers are considered. The introduction of ES into this well-defined and developed planning process requires that the ES technologies are mature.

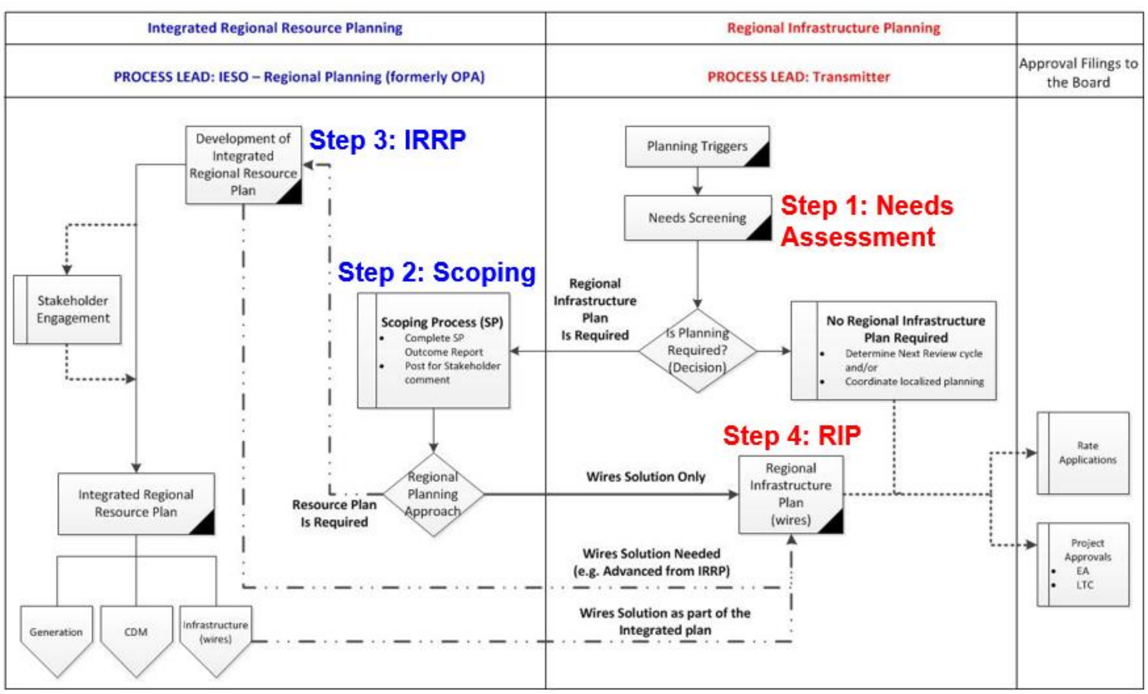

Figure 4 Regional Planning Process [7]

2.2 Benefits

From the workshop discussion, most of the attendees agreed that using ES on the transmission level will have many applications/benefits which can be summarized as follows: to improve power quality and reliability; for voltage and frequency regulation; in helping manage intermittent renewables; to support better planning and management of demand and supply; to help manage congestion on constrained transmission and distribution (T&D) networks/stations; to help address capacity needs; as a means to defer or reduce infrastructure upgrade costs, and particularly their impact on ratepayers; to help address capacity needs; to enable peak load shifting; to further enable the integration of renewables; and to help reduce greenhouse gas emissions.

As a complement to the coverage of these individual benefit streams, a key topic addressed in the Workshop discussions was the aggregation of applications/benefits into financially attractive value propositions. That is important because, in many cases, the value of a single benefit may not exceed the ES cost, whereas the value of combined benefits may be greater than the cost. Characterizing the full spectrum of possible value propositions is beyond the scope of this report; however, some potentially attractive value propositions are characterized as examples:

1) Electric energy time-shift plus transmission and distribution upgrade deferral
2) Time-of-use energy cost management plus demand charge management
3) Renewables energy time-shift plus electric energy time-shift plus electric supply reserve capacity
4) Transportable storage for transmission and distribution upgrade deferral and electric service power quality/reliability at multiple locations

2.3 Opportunities

From the Workshop discussions there are many potential opportunities for ES that can be derived, some notable recent and emerging developments driving these opportunities include the following (in no particular order):

1) T&D Equipment Deferral: The transmission utility planners can use ES technologies instead of reinforcing the system by building new electrical infrastructure – stations, lines, cap banks,

feeders, breakers/switches, etc. The decision to reinforce the system can be deferred by connecting a lesser costing ES technology, with an appropriate techno-economic study justifying the case.

2) Demand Charge Reduction: The increasing interest in managing peak demand, and reliance on 'demand response' programs due to high peak to off-peak ratios of demand profile and constraints on generation and transmission capacities, will increase the potential for ES projects.
3) Congestion Management: Increasing congestion on some transmission lines and stations creates a case for the use of ES to mitigate congestion during peak demand periods.

2.4 Challenges

Clearly, there are important challenges to be addressed before the full potential of ES is realized. At the highest level, in most cases ES costs exceed expected benefits for a variety of reasons. Based on discussions at the Workshop, the challenges can primarily be summarized as follows:

1) ES technologies have high costs relative to expected benefits. To a large extent, pricing of electric energy and services does not enable a business case for owners of ES units.
2) Regulators are looking to examine and determine various costs and benefits from ES and a mechanism to attribute them to various components of a power system.
3) Utilities have limited familiarity with ES technologies and solutions. Hence, it remains a challenge to embrace ES solutions for these stakeholders.
4) There is a need to add infrastructure to control and coordinate ES units. At this time, such methods and infrastructure do not exist in utility control rooms. This aspect remains a challenge.

The following research and development opportunities have been identified as ways to address some of the important challenges that limit the increased use of ES:

1) Establish a consensus about value propositions for different ES solutions/technologies.

2) Develop market potential estimates, risk and reward sharing mechanisms, and model rules for the utility ownership of ES units in utilities. Further, ES solutions might be modular or distributed and such configurations require consideration in this development.
3) Characterize, understand, and communicate the societal value proposition for ES and identify and develop standards, models, and tools that accurately reflect this value.
4) Develop case studies to compare between ES and the other large infrastructures and then use them to identify the barriers which have to be overcome before ES can get a bigger piece of Ontario's energy infrastructure investment.

Section 3 Energy Storage for Distribution Systems

3.1 Introduction

Energy storage in the transmission realm tends to be a different from ES in the LDC realm. In a distribution network, a single energy source (asset) (i.e. ES) will have a huge impact on system performance in normal operation (i.e. voltage profile and system losses) and in emergency conditions (i.e. system restoration and network reconfiguration). This is why LDCs will give ES serious consideration.

For example, today, when distributed generation technologies cause local voltage issues, static synchronous compensators (STATCOMs) are often the only fast-moving voltage regulating solution. Such STATCOM solutions are expensive. ES and other new, cheaper ways of reducing voltage could solve local issues at a fraction of the cost of STATCOMs. The extensive need for smart energy sources, such as ES, which can help enable the emergence of microgrids, is also driving demand for distributed ES (Figure 5). ES can also enhance system performance by storing electricity at off-peak times and releasing it into the distribution system during peak times. ES can also help increase the penetration of renewable distributed generation by minimizing load criteria on feeders, injecting MW and/or VARS, and storing excess energy generated to overcome the lack of coincidence between load and PV supply, which can cause voltage rise. In the future, each house or single entity might become a "powerhouse", with all the traditional power generation, transmission, and distribution becoming a back-up. The market is changing drastically, with gas prices, ES, and solar power prices reducing rapidly, and increasing demands for microgrids with smart equipment (to increase system resilience), and ES can play an important role.

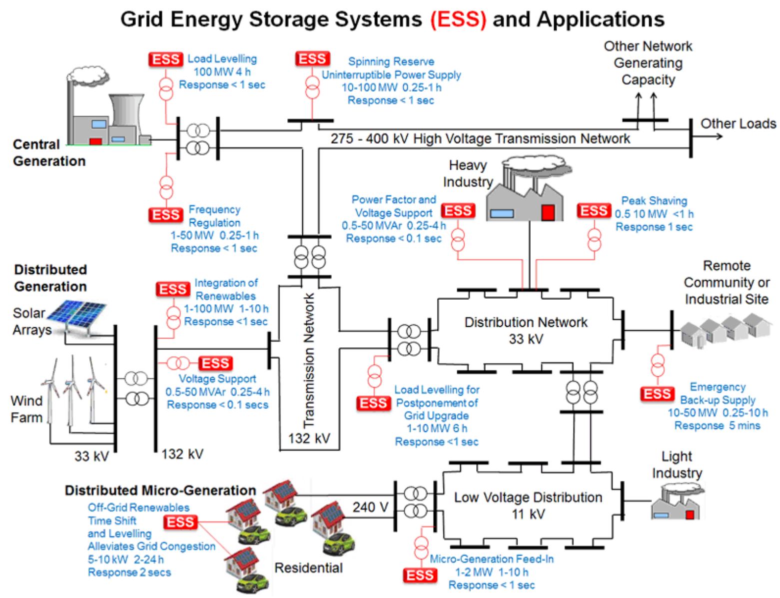

Figure 5 Distributed Energy Storage [8]

Utilities face multi-million dollar investment decisions regarding ES, and as such require rigorous testing and validation of any technology before integration and implementation. Accordingly, utility partners are also keen to engage in research, development and demonstration via pilot projects that will not only improve ES technologies and the options that they have to choose from, but also provide much needed critical new understandings of the impact that ES can have on the grid, and hence on their operations.

3.2 Benefits

For Toronto-Hydro, one of the largest LDCs in Ontario, ES is an item of great interest, and there are several potential benefits that ES can bring to them. Operationally, ES provides a necessary, system internal energy source. It enables a degree of flexibility to move energy within the system, without relying on external sources. Power quality continues to be an issue for LDCs in general, which ES can help mitigate. ES can provide local short-term supply when an outage occurs. It can ensure critical facilities like hospitals have a secure power supply during an outage. At the same time, with an ES unit currently being installed in a new building downtown, there are technical considerations needed to deal with its effect on the local system. From a financial perspective, ES can be used to defer line upgrades. ES can be used where there are no generation facilities within the grid, and can thus provide black start capability.

3.3 Opportunities

By reviewing several different applications for ES, we may open up value streams from new untapped areas. For example, there are new value streams that can come from customers who can use ES to make better use of time-of-use or demand charges, or as a tool for their energy efficiency/conservation processes. These value streams can be accessed by looking where ES is being installed (either behind or in front of the meter). ES has a very good potential market at the distribution level. ES is especially relevant in jurisdictions like Ontario where baseload power generated mostly by nuclear and hydro are slow in responding, as it provides much-needed flexibility. It is advantageous for the distribution and transmission sectors, as it can be used as a tool to defer staged investments. It is expected that this will enable large consumers (i.e. industrial customers) to have more control over their use of energy and the timing of that use. ES is green energy's silver bullet and therefore is very significant.

3.4 Challenges

Many view ES as a "Holy Grail" for current and future technical challenges. However, the current big barrier is the cost. This is why ES is being procured at experimental scales by LDCs today, in order to test out some of its capabilities. Limited procurements have helped to fuel development and reduce costs, but there's still a big gap to fill. To address the economics, both the cost and values should specifically be considered to quantify the value that ES can provide.

Other unresolved issues remain to be addressed. One such issue is ES not being a typical asset, like a breaker or an arrestor, and therefore being something new that crews and first responders need to understand how to work with. As an energy source, linesmen need to be aware that it's a hazard, and equipment needs to be in place to ensure their safety. ES is something that, like other assets, LDCs need to realize the full value of – a fact that bears on its implementation in manual vs. automatic operation (need for four quadrant inverters). While consumers could store energy during off-peak hours, and utilize it at high peak times, the question remains of how to deal with the utility's corresponding loss of revenue. Because of legacy issues resulting from the way the system was designed in an earlier period, integrating storage requires accommodations to be made, and these entail capital costs.

To work better in the future, a more interactive procurement development process is needed – bringing competitors of storage together with representatives from LDCs to collaborate on what can be done and where the opportunities might be. The current IESO stakeholder group working on the RFP for Fast DR (Demand Response) is a good example.

Section 4 Energy Storage for System Operators

4.1 Introduction

The Independent Electricity System Operator (IESO) provided an overview of the recent IESO ES procurement process, and also discussed what the IESO saw on the horizon for ES projects in the Province. Generally speaking, the supply outlook remains positive, but plans need to be put in place to move toward increased levels of responsiveness and efficiency. What's important is keeping the grid in balance, considering that it derives 60% of its energy from nuclear power. The growing level of renewables on the system has added complications and, in any case, change is continuous and inevitable. The key to managing the grid is readiness and flexibility. The system has seen change over the years - the natural gas-fired plants that have taken the place of coal, for example. They are fast-acting but have high minimum outputs, meaning reduced flexibility. Hydro resources have also lost some flexibility, due to both equipment and regulatory issues. On the other hand, the ability to dispatch large parts of the growing fleet of renewables has added flexibility. Now, ES, with the ability to respond in timescales ranging from milliseconds to hours, can provide some of that sought-after flexibility.

Pumped hydro has been the vastly predominant form of storage in North America, but, especially in Ontario, other forms are beginning to take a larger share. Historically, Ontario has explored the benefits of ES as far back as the 1950s with the introduction of the Sir Adam Beck pumped hydro project at Niagara Falls. Recently, this exploration has picked up pace. The IESO's 2012 procurement of alternate technologies for regulation chose three projects, two of them ES projects: a 2MW flywheel and a 4MW Li-ion battery, both commissioned in July 2014. Hydro-One and Toronto-Hydro have also added storage on distribution lines. The IESO embarked on an ES procurement proper in 2014. The expected projects are implementations of Ontario's 2013 Long-Term Energy Plan, which identified the potential role of ES in Ontario's electricity system. The IESO, with its now merged former entity Ontario Power Authority, jointly developed a framework to procure 50 MW of technologically diverse ES for Ontario. This procurement plan came in two phases: in Phase 1, the IESO selected 33.54 MW of projects in July 2014, and in Phase 2, the IESO selected the remaining 16MW, with a focus on the ability of storage to provide capacity. In the IESO

RFP, "Grid Energy Storage" means a commercially available technology that is connected to the transmission and distribution system and is capable of absorbing grid energy (charging), storing it for a period of time, and then injecting the energy (discharging), less reasonable losses, back into the grid or its equivalent. The IESO sees value in all three operations.

The IESO 2014 Storage RFP used the 2012 Alternative Technologies for Regulation (ATR) RFP framework as a starting point but went further, providing for other storage services over various timeframes, such as operating reserve, ramping, and load-following, in addition to the ancillary services focus of the ATR. It included definitive contracts to provide clarity for all respondents to understand the legal requirements if they were selected, and also a fairness commissioner as part of the process. The projects were selected for each of four geographic envelopes including Southern Ontario (uncongested, transmission connected), Southern Ontario (congested areas, transmission and distribution connected), and Northern Ontario (congested, weaker transmission connectivity). The minimum project sizes were 2MW for transmission connected projects, and 0.5MW for distribution connected projects.

System operators (SOs) need to receive new knowledge and expertise regarding ES. As ES becomes a tangible reality for system planners and operators, challenges evolve, including how to plan, schedule, coordinate, and operate an electrical system considering the integration of ES devices of different types and applications. SOs will also need to provide system planners with new data, macroeconomic models, power system planning algorithms, and products tested and demonstrated in real-world environments, which will facilitate and enable complex decision making. These tools will help planners to gain invaluable insight into power systems planning considering these new ES systems. There is a need for new market rules and performance standards for ES resources. SOs need to gain insightful knowledge to inform policy makers to shape future policies, regulations, and social perceptions while contemplating large ES projects to improve power systems and the business of delivering energy.

4.2 Benefits

From a system operations perspective, the IESO will work to integrate ES projects into the operation of the grid and to assess their capabilities. This includes proving them over operating time-frames, providing ancillary services, and providing bulk energy and transmission services such as energy time-shift, ramping and load- following, operating reserve, and congestion management. From a market operations perspective, it will be important to integrate ES devices into the electricity markets to identify opportunities for future market mechanisms. ES can benefit system operators in various ways. ES can be used for ancillary services such as frequency regulation, operating reserves, voltage support, and black-start. In fleet optimization ES offers renewable connection - when fuel is available, renewable energy sources like wind and solar power are really flexible. For demand profile optimization ES can help in peak shaving, shaping the demand profile and controlling the morning peak

4.3 Opportunities

ES has a great opportunity to participate in power system services within the IESO day-ahead and real-time operating time frames. In their 35MW procurement, respondents were allowed to propose contract terms - not less than three or more than ten years - but weighting was used to influence shorter-term contracts. This method was intended to facilitate learning and allow the IESO to move to enduring mechanisms later. Payment for services commences after ES projects have been built, tested, and verified, so that risk lies with the developer. There were tight RFP timelines, consistent with the expectations of the local ES community. Ontario was recognized externally as a “fast mover” on the ES file in advance of California’s much larger procurement of ES technologies.

Overall, there was a tremendous response to the RFP, with more than 400 proposals submitted, showing how actively engaged the ES sector was. In July 2014, 12 successful projects from 5 proponents were announced totaling 33.54 MW: Canadian Solar Solutions Inc. (battery, 4MW), Convergent Energy and Power LLC (battery & flywheel, 12MW total), Dimplex North America Ltd. (thermal, 0.74MW), Hecate Energy (battery, 14MW), and Hydrogenics Corp. (hydrogen, 2MW) [9]. All of the contracts have been signed for these projects. Future potential for ES from a system operator perspective will depend on the following factors: clear price signals for existing services that signal value for technology developers and transparency of emerging system needs from an evolving supply mix and sector; enabling competition to provide a level playing field across technologies; the provision of Locational Marginal Price (LMP) signals, where ES can help a lot to improve overall system welfare.

4.4 Challenges

Many of the current rules were created at a time when we couldn't store energy. Today there are challenges in determining how ES should fit into the equation – it's not a generator, but has generation capabilities; it's not load, but has load capabilities. Today, in most jurisdictions, when ES is loading, it is charged at retail rates, but when generating, it is only paid wholesale rates – this is a real economic gap that needs to be addressed. We would need to look at making changes to the regulations in order to optimize these resources.

Behind-the-meter applications can be adequately dealt with through existing demand response programs, although the demand response programs will need refining. Conversely, large storage devices like flywheels, are wholesale service providers – not retail loads. There are other areas where market rules could be augmented to treat wholesale storage as a set of distributed export nodes – not just bringing the power back as electricity, but also as a range of commodities and services with positive reliability and environmental attributes. As an example, outside of just the barriers in electricity regulation, there are also opportunities for augmentations to the wider provincial energy policies that could be made to increase the economic and environmental value of storage. Turning surplus renewable power into hydrogen for oil refineries is one example, where offsetting the conventional hydrogen source that refiners use today with renewably generated hydrogen can be environmentally more valuable than using this stored renewable energy for power generation, even during periods of peak electricity demand. To realize this opportunity we need to set environmental policy to allow renewable hydrogen supplies, from off-peak electricity generation, to compete with the blending of biofuels for Ontario's Renewable Fuel Standards. The result is Ontario's refiners are added as a domestic wholesale market for Ontario electric power. The refiners would compete alongside exports to neighboring states or provinces. This would likely provide a more supportive off-peak power market and allow Ontario consumers to benefit from the green benefits they paid for when the electricity was first generated.

Other challenges with ES remain from a system operator perspective, some of which can be summarized as follows:

(1) Identify a proper proportion of ES for Ontario to have in its unique system. This is not necessarily trying to set an optimal amount of ES; it's more a case of determining the system's reliability needs and how to meet them.

(2) Promote competition in spinning reserves and ancillary services markets that allow many other qualifying facilities to bid in. This is important as IESO will follow the NERC task force which is looking for the services needed to provide voltage control and frequency regulation. Systems are evolving, and needs can be met in a variety of ways.

(3) How is the system operator planning to dispatch ES in the absence of a market context? What will the signal be, how will it be optimized, in particular in the context of the dispatch to the other participants in the system? Answers to these questions will help developers of ES solutions to best build their business cases.

(4) The system operator defines the desired operational characteristics necessary to effectively and efficiently meet system needs and then reduce barriers to valuing those operating characteristics. That said, main jurisdictions have – for historical and other reasons – long term contracts with only certain resources.

Section 5 Summary and Conclusions

The CUE Workshop on Energy Storage was very successful in terms of variety of the attendees' backgrounds (System Operators, Planners, and Policy Makers), which led to enriched discussions because everyone was bringing different angles from which to look at ES. This report summarizes the recommendations of the Workshop that need to be addressed to facilitate the integration of ES on a large scale. CUE is excited to formulate these recommendations into its research and development work. This will add important practicality dimensions to CUE research work and improve outcomes for all stakeholders.

The alignment of storage, from planning to operation, allows flexibility and creates an opportunity to make this a bigger market for some of the more traditional players (e.g. wind). Storage can offer improved operating flexibility for the inflexible or intermittent generation, and if these supplies can be better integrated into the market, then this could open up opportunities for targeted CHP to be placed in urban load centers in a far greater way than is the case today.

We must create an operational platform that can manage such a diverse set of storage options and allow them to work together in real time. There is a tremendous need to prioritize the storage and use of renewable power we have already paid for before considering exporting it to other markets. While the IESO's 35 MW ES procurement is establishing commercial projects, they are also great learning opportunities that can provide real operating data to inform the process, and to make regulatory changes that will help to eliminate barriers for future commercial-scale projects. There is a need to think outside the electricity silo to grow the potential for renewables. The regulatory structure is not ideally configured for this today, and the OEB could resolve this in future.

Other barriers are principally about economics and the value versus cost proposition. The particular niche it fills will limit the application of a given storage option, and this narrower band of value would have to pay for the total cost. This is the biggest barrier today. The amount of surplus wind or solar energy that storage can recover today doesn't add enough value to overcome that barrier. The IESO and former OPA 50 MW storage procurement will help to better understand where those facilities will deliver value. This will help develop the needed understanding, but what we don't have in Ontario is a market that can monetize these things. Maybe the evolution in Ontario will be toward markets like we are having with demand response (DR Auction).

Storage providers were functioning with minimum information about the needs of grid operators. The needs were clearly articulated in the storage pilots and efforts are continuing in this direction. The learnings from those pilots will be beneficial, to both storage providers and the system operators. It is very important to improve transparency in a way that help storage solution providers get creative and come up with solutions that better fit or anticipate needs.

Section 6 References

[1] "Standing Senate Committee on Energy, the Environment and Natural Resources, Now Or Never: Canada Must Act Urgently to Seize its Place in the New Energy World Order, 2012 " *at* http://www.parl.gc.ca/Content/SEN/Committee/411/ENEV/DPK-Energy/home-e.htm, .

[2] A. Castillo and D. F. Gayme, "Grid-scale energy storage applications in renewable energy integration: A survey," *Energy Conversion and Management,* vol. 87, pp. 885-894, 2014.

[3] "Council of the Federation Canadian Energy Strategy Working Group Canadian Energy Strategy: Progress Report to the Council of the Federation," http://www.canadaspremiers.ca/phocadownload/publications/cof_energy_strategy_2013_eng.pdf, July 2013.

[4] Energy Storage Industry Off and Running in January 2016, [Online]. Available: http://www.renewableenergyworld.com/articles/2016/01/energy-storage-set-for-record-year-in-2016.html.

[5] How Energy Storage Will Grow, New Energy News More, [Online]. Available: http://nenmore.blogspot.ca/2013/03/how-energy-storage-will-grow.html.

[6] Market Trend for ESS, Green Energy Storage, [Online]. Available: http://www.greenenergystorage.eu/en/market-overview/.

[7] Planning Process Working Group Report to the Board The Process for Regional Infrastructure Planning in Ontario, Ontario Energy Board, [Online]. Available: http://www.ontarioenergyboard.ca/oeb/_Documents/EB-2011-0043/PPWG_Regional_Planning_Report_to_the_Board_App.pdf

[8] Energy Storage Systems, [Online]. Available: http://nl.nec.com/nl_NL/global/environment/energy/nec_aes/index.html.

[9] L. Kula, Outcome of the IESO's Storage RFP and What's Next?, IESO. [Online]. Available: http://www.appro.org/images/stories/content/ESS/Kula,_Leonard.pdf

[10] Achieving Balance Ontario's Long-Term Energy Plan. Ontario Ministry of Energy. [Online]. Available: http://www.energy.gov.on.ca/en/ltep/achieving-balance-ontarios-long-term-energy-plan/

Location

147 Dalhousie Street
Toronto, ON M5B 2R2

Mailing Address

350 Victoria Street
Toronto, ON M5B 2K3

Contact Us

416-979-5000 x2974
cueinfo@ryerson.ca

/CentreForUrbanEnergy

@RyersonCUE

ryerson.ca/cue

Ryerson University

Centre for Urban Energy