NSERC
Energy Storage
Technology Network

Leading the Charge

Conference Proceedings
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#LeadingTheCharge

Ryerson University
Centre for Urban Energy
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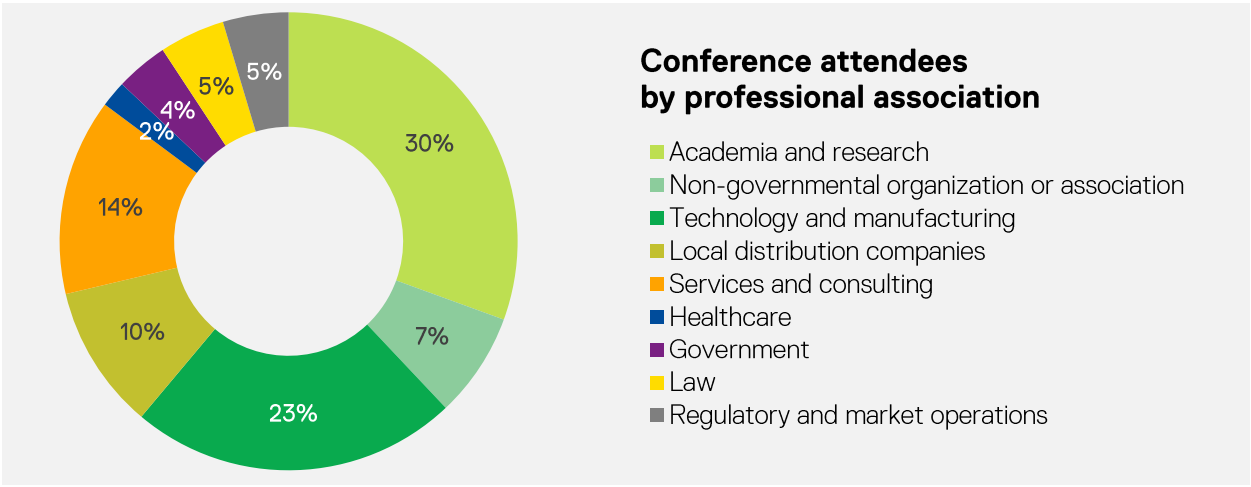
The inaugural *Leading the Charge* Conference took place on Friday, June 24, 2016 at Mattamy Athletic Centre in Toronto. The intention of the conference was to provide a stage for manufacturers, utilities and customers to share their perspectives on the challenges and opportunities of energy storage – an essential technology in Canada's transition to clean energy. Welcoming remarks were provided by Chris Evans, Interim Provost and Vice President Academic at Ryerson University, and Bala Venkatesh, Academic Director of Ryerson's Centre for Urban Energy.

Acknowledgements

The Centre for Urban Energy (CUE) at Ryerson University would like to thank all of our speakers who graciously donated their time, experience and insights.

We would also like to gratefully acknowledge the support from our partners, the Natural Sciences and Engineering Research Council of Canada (NSERC) and the CSA Group, without whom the event would not have been possible.

Last but not least, we extend our thanks to the over 100 conference attendees who enlivened the day with thought-provoking questions and discussion.



Disclaimer

Panel 1: the manufacturers' perspective

Geoff Osborne
Associate, NRStor

Carmine Pizzurro
President, eCAMION

Pratap Revuru
Smart Grid Solutions Architect,
Schneider Electric

Curtis VanWalleghem
Chief Executive Officer, Hydrostor

Moderator:

Jessie Ma
IESO Distinguished Research Fellow,
Centre for Urban Energy at Ryerson University

The deployment of medium and large-scale energy storage technologies has been significantly elevated over the past few years. With climate change, energy storage technologies are gaining more interest as one of the solutions to tackle these issues along with other renewable sources. Our panellists' companies are technology suppliers and developers for commercial use of energy storage systems. They offer solutions for the integration of all components in their storage systems and their safe and reliable connection to the host electric grid along with their proper communication means.

What are your energy storage products and how are they game-changers?

Schneider Electric integrates all aspects of smart grid solutions in their products from protection and control to operation, monitoring, and SCADA systems.

eCAMION is a solution provider for the community energy storage industry, specializing in the integration of battery solutions with advanced grid control functionalities. They have developed grid-connected large-scale energy storage systems in partnership with Toronto Hydro. They also offer solutions for issues related to electrical vehicle charging in dense areas where there are limitations on feeder loading.

NRStor is a developer and operator of energy storage assets. They work closely with the manufacturers to commercialize their technology and products. Their current projects include a 2 MW storage facility based on Temporal Power's flywheel storage technology operating under a contract with IESO and a 1.7 MW compressed air project under development, also with IESO. The company is technology agnostic, and they choose the proper energy storage technology for each application based on their customer's needs,

whether the customer is looking for a clean solution or a reliable one. Their business is mainly focused in the four key areas including: projects with utility subcontractors, residential energy storage, remote community microgrids, and commercial and industrial behind-the-meter projects.

Hydrostor is a technology supplier of compressed air energy storage solutions. Their big innovation is their underwater solution to store compressed air. They can install their storage system anywhere near a coastal area, which has expanded the potential sites for compressed air. Their innovation is two-fold: one is that there are no longer any limitations on where to put the air, in contrast to the conventional compressed air projects which are limited to caverns; the other is that they can boost the efficiency by having their proprietary thermal system.

All photos by Clifton Li (Ryerson University Image Arts '12)

Who are your key client groups, and what is the value proposition that you offer them? What are the problems solved by your products, and how are they better than the status quo?

In many industrial and commercial applications, a little glitch in power can cause a company many problems. Through the Smart Grid Fund, one of eCAMION's units is going

to be installed in the Sanofi Pasteur plant, in partnership with Toronto Hydro, to test their solution in addressing the aforementioned issue. Another opportunity is that an industrial plant can use eCAMION's energy storage solution as a transitional solution to bridge from when they get the glitch to when they restart their co-generation units. These projects are still at the demonstration stage, but as it becomes further tested, it will generate more attention and interest. At eCAMION, they optimize the functionality of the equipment they purchase based on the needs and requirements of the host utility companies.

Schneider Electric has been a major contributor to many energy storage projects. They currently have several projects in various countries, including France and the USA, where they have installed energy storage systems in conjunction with wind and solar projects. They believe that energy storage has a big role in microgrid solutions.

As a service provider to customers, NRStor has a unique and innovative business model. They select which technologies are the most profitable and commercially feasible and they match these technologies to customer needs. Their goal at NRStor is to reduce the risk of using these relatively new technologies, based on their extensive experience and expertise.

Hydrostor looks at two markets. One market is urban city centres, such as Toronto, where they can build a plant in downtown area that acts like a peaking power plant avoiding any transmission bottle-necks. It is noteworthy that their technology does not cause any emissions because in contrast to the conventional generator's fuel which is natural gas, the fuel that Hydrostor uses is the off-peak electricity. In places where there are transmission constraints, the technology used by Hydrostor is environmentally friendly and is an attractive option that is financially comparable to other solutions. The second market is any jurisdiction that has a lot of renewables on the grid and is facing a surplus of energy. Hydrostor soaks up that surplus energy, stores it, and returns it when it is needed—essentially, providing balancing services to the grid. Hydrostor provides maintenance of their system and they guarantee the availability and functionality of the facility for the expected life cycle. Their customers are typically utilities, developers such as NRStor, or large industry electricity consumers that use a minimum of 2-3 megawatts of power.

From a large, multinational perspective, what are Canada's strengths when it comes to energy storage? More generally, what are the key opportunities for energy storage in Ontario, across Canada, and elsewhere?

First of all, energy storage is a broad term. It might be beneficial to think about the question on a service basis, and it can then be approached from a top-down or bottom-up perspective. From a bottom-up perspective, in Canada for example, every house could have a Tesla Powerwall, which is a sizeable opportunity. In addition, on the grid-side there is enormous potential in Canada, especially in Ontario and Alberta, as well as Nova Scotia and remote communities across Canada. Large projects of installing renewables create a demand for energy storage to provide a steady power. IESO also recently released a report that one of the priorities is to supply short-duration regulation services by energy storage. Therefore, we see opportunities at all levels of the supply chain.

Hydrostor and NRStor are focused on building the best technology to offer. At a very high level, renewables are essentially at the second inning of a nine inning game; therefore, it has a long way to go and it will become more important as the game goes on. We are still at the very early stage of energy storage and more applications are going to emerge. Also, the grid-structure in North America is extremely aged and it needs modernizing. That again favours storage. From an opportunity standpoint, Ontario has some differences with other jurisdictions, but across the board, the need and the demand for storage and the cases that make economic sense are growing.

eCAMION has been mainly doing designs around cities; they offer pole-top energy storage and vehicle charging solutions. They are working at the sub-one megawatt power level. They also take a lot of pride and care about the aesthetic appeal of their designs because

they are in the view of the general public. Another critical factor is the safety of their products; they have invested more resources in making their products safer than the initial design of the system.

What are the key technical challenges to implementation? What are the key social/regulatory challenges to market growth of your technology?

Technical challenges: one of NRStor's projects is a flywheel storage system, which is a first-of-its-kind and large-scale project. Of course, because it was new and innovative, there were expected technical challenges. At Schneider Electric, they ensure that the power converters are in line with the energy storage technology. The challenges are to ensure that the complete solution is fully functional. The grid integration piece is a key part of the solution. At eCAMION, they find the safety of their products is a top priority. They expend significant resources to ensure safety in their systems. Working in conjunction with utilities such as Toronto Hydro has been instrumental in achieving their safety goals. At Hydrostor, they do not build or buy any of the technical gear; therefore, there is not much a technical risk there.

Regulatory challenges: storage technologies such as Hydrostor's are in the long-duration and have a large power rating, they essentially act like a generator. There are a few regulatory hurdles in terms of how they purchase power, but in general, energy storage needs many regulatory changes to get the regulations to catch up to the capabilities of storage. One of the issues is that there is no overarching regulatory body; every jurisdiction is doing it differently. However, because Hydrostor's role is just as a supplier they do not get overly involved in regulations. There are also economic challenges that might require regulatory guidelines. For example, the performance of Hydrostor is close to a gas-fired peaking plant, and of course, this traditional approach is lower cost; therefore anything that increases the carbon gas tax is beneficiary to storage solutions.

When NRStor was working on the flywheel project, they required to obtain a generation license although their system is storage. Because this was the first project of its kind, NRStor paved the way for others and have now helped regulatory parties to develop a new energy storage license.

Panel 2: the utilities' perspective

Gary Thompson
Lead, Generation Planning and System Studies, Toronto Hydro

Neetika Sathe
Vice President, Corporate Development, PowerStream

Samantha Evelyn
Project Manager, Capital Projects, Hydro Ottawa

Moderator:

Bob Singh
IESO Distinguished Research Fellow, Centre for Urban Energy at Ryerson University

There are many different ways energy storage can help the grid. It can provide solutions to traditional power system problems such as capacity short-fall and poor power quality. Energy storage can also help utilities to integrate more renewable sources by increasing the flexibility and balancing power of the grid. However, most utilities are still using the old proven methods for addressing power system problems.

Why are utilities not considering energy storage as an option?

Utilities are not ignorant of the potential of energy storage but they are cautiously approaching it. Local distribution companies (LDCs) in Ontario are going through significant changes right now such as regulatory and structural changes. We are transforming a grid designed in 1920s to a grid that we feel will ultimately best serve the ratepayers in the province. New technologies including energy storage can offer solutions to the problems of the grid. However, the challenge is that for these new solutions to work LDCs first have to go through a period of understanding technologies and specific application details.

LDCs that have grids that are large enough and have staff that can understand and apply energy storage on the system would be more likely to take initiatives in piloting new technologies. There are currently about 69 LDCs across the province and not all of them are of the same size. Toronto Hydro serves about 700,000 customers which represents about 20 per cent of the load in Ontario. Toronto Hydro supports the investigation and innovation side of the business and has allocated resources to look at new generation solutions for the grid. Toronto Hydro also has a team of young, energetic, smart, and dedicated individuals who work in this area. In addition, partnership with organizations like the Centre for Urban Energy provides Toronto Hydro with additional resources to try

and realize those goals. So, in short, Toronto Hydro is trying to discover and as they discover they are trying to apply those discoveries to the benefit of ratepayers.

Many LDCs in Ontario presently believe in the power of energy storage and the question has been changed from “if storage will be realized” to “when storage will be realized?”. The challenge is whether they have the resources to actively study and apply storage or they are going to be only passive observers on this issue.

PowerStream is on the verge of launching a utility-scale microgrid including energy storage in partnership with KEPCO, the largest electric utility in South Korea. They have also been studying storage for residential and behind-the-meter applications. At their own facility in Markham, they have been testing three types of battery storage technologies for the last two and a half years. Since then, they have received many LDCs for tours of their facility which is seen as a sign of ever-increasing interest in storage potential. At Hydro Ottawa, they are looking at battery storage in conjunction with large solar projects as an initial point of investigating storage. There are still major concerns with utilities about how the new assets will operate on the system and what impact these are going to have on grid reliability.

Do you think utilities understand energy storage well enough to make use of it in their operations?

At PowerStream, after three years of involvement with their own pilot project at their facility, they have developed business models and engineering study procedures to match a battery storage technology with a specific site and to provide details such as its required power (kW) and energy (kWh), its type, and how fast the battery should be responding. In addition, they are working with engineering companies over the past few years that provide consulting services in this area and are beginning to understand the technology. It takes the industry some time to understand and adopt the new technology. PowerStream believes that one of the main challenges is economics. When financial calculations are done based only on a single value that energy storage can provide, it is likely not cost effective. In addition, LDCs have not yet adequately understood all the functionalities of energy storage to be able to determine its value. Another issue is how to monitor and evaluate the battery storage assets. For instance, in the case of outage protection, who is going to pay for it? Is it the customers? There might be customers, such as large industries that are significantly affected by outages, who are willing to pay for the use of energy storage to improve their reliability of electricity supply. There are also other aspects such as asset upgrade deferral when integrating large renewables into the grid, which LDCs should be able to put dollar values on. As the values increase over the years and as the cost of storage reduces, there will be a point where it will start to make a lot of economic sense to utilize battery storage. Energy management systems for storage assets and their aggregate impact on the grid are also to be clearly understood before widespread applications begin.

Toronto Hydro has had several innovative projects and was the first LDC in Ontario to receive funding to apply storage on their system. Toronto Hydro thinks that the responsible action by LDCs is not to wait for the financial solution for storage. Instead, they should be integrating the technology ahead of the time. On the other hand, since the revenue from the sale of electricity is fixed, the challenge for LDCs is to look at how they design the grid and to look for potential opportunities where energy storage can add value in a cost effective manner. At Toronto Hydro, projects such as lithium-ion battery storage and compressed-air storage have been operating for some time. As an example, in regards to the design of the grid, building on the concepts of smart grid, the LDC can have an intelligent grid that can isolate faults and provide energy to the isolated parts. Thus, LDCs are going to be looking at what the optimum design is or should be, what type of smart features they need to employ, and where they are going to strategically place those optimally-designed pieces of energy storage. Toronto Hydro believes that, in Ontario, the future of energy storage lies in the heart of the distribution grid.

What has been your experience in using energy storage and where do you see your utility is headed in terms of utilizing energy storage for future needs?

Through a 250 kWh battery storage project at Toronto Hydro, working with eCAMION, which was installed at a community centre in North York, it was learned that the area that the battery was connected to had power during the ice storm of 2013. Toronto Hydro has also had several other projects which have extensively added to their knowledge base on energy storage, including a pole-mounted storage unit under installation in a residential area, in partnership with eCAMION. The project utilizes an aggregated capacity of several storage units across the system through SCADA and there is significant potential to provide energy to critical points in the grid in case of a power loss.

The engineering of these projects and the development of their control functionalities are other challenges with storage technologies. There are no established standards in Ontario for applying or testing energy storage. Are the batteries really what the manufacturers claim they are?

In the Canadian solar project that Hydro Ottawa is involved in with battery storage, legal issues are one of the main challenges. In addition, the location of the batteries is close to the substation which could create some safety concerns. Protection relaying and communication challenges are some of the other issues that can't be overlooked.

To what extent does current regulation allow utilities to monetize all the benefits — upstream and downstream— of an energy storage application? How do you think regulation can promote the use of energy storage on the grid?

It should be taken into consideration that the value proposition of a small residential battery storage unit is very different than that of a utility-scale storage project. Also, it is wise to not bet on only one storage technology or one application of storage. Our learnings can be applied to different market segments including industrial and institutional customers, providing emergency power to hospitals to avoid the impact of incidents such as ice storms on their services to patients, and remote communities where energy storage can offer price and sustainability benefits. To that end, the benefits of the pilot projects are not only for technology testing but more importantly for business model evaluation including regulatory changes. However, it should be noted that the structure and source of finance in today's grid may be different than the ones in the tomorrow's grid and that

needs to be taken into account in developing the business model for energy storage. In addition, the engagement of customers in the process of adopting new technologies significantly helps in understanding their expectations and finding optimal solutions for their needs.

Keynote address: energy storage in Ontario – experiences to date and opportunities for expansion

Bruce Campbell
President and Chief Executive Officer,
IESO

The transformation in the Ontario's energy landscape from centralized to decentralized power generation requires the power system to adapt to these changes. One of the IESO's priorities is to ensure continued reliability given the large number of moving parts in the sector, which include: the continued expansion of renewables, which is expected to get to 10,700 MW (target of the current long-term energy plan) after the second round of large renewable energy procurement; changes in the management of complex nuclear refurbishment projects with their overlapping schedules and close degree of coordination; the growing consumer engagement since consumers are more than ever taking or considering taking active steps to manage their electricity consumption; and beyond that, the smart grid and the time-of-use rates. A disadvantage is the relatively limited visibility to embedded distributed resources connected in the LDC systems. IESO is working on new market mechanisms intended to increase competition and also with special attention in regards to the Ontario Climate Change Action Plan. With the scope of the continued changes that lie ahead, we are confident that all these changes will expand the opportunities for energy storage.

What are the roles we see for the storage? In 2012 we launched alternative technology projects for providing regulation service and grid-balancing functions traditionally provided by generators. Regulation for IESO is a contracted service to balance generation and demand on a second by second basis. By helping to correct small changes in power system frequency it balances power flows and helps the IESO maintain the reliability of the power system. This quick response is becoming increasingly important as we are integrating Ontario's growing portfolio of renewable resources such as wind and solar and accommodating changes in consumer behaviour that impact the demand for grid-supplied electricity.

Through the Alternate Technologies for Regulation (ATR) initiative IESO aimed to procure up to 10 MW of regulation from alternative sources such as dispatchable loads, aggregated demand response, and storage technologies including batteries and flywheels. Sub-proposals from multiple vendors were considered to test out a number of different technologies. IESO tested regulation from a flywheel and a battery storage system. Over

the course of the three-year contracts IESO's aim was to acquire real-time real-world experience with these assets enabling them to see how these resources behave on their system. Up until this time, the principle supplier of reliable regulation service was pumped energy storage at Niagara Falls and that provided us with our most direct operational experience with storage.

The question we had: could these newer technologies meet the reliability standards of the Niagara Falls pumped energy storage? I am pleased to report that their performance to date has been solid and we are very encouraged by the results we have seen today. There have been important learnings on both sides is dealing with some unexpected operational issues. We can now say with confidence that energy storage technologies such as battery and flywheel can reliably provide regulation service to the power grid and meet the performance standards of traditional pumped energy storage.

Storage facilities have the potential to provide a range of services to support reliability and flexibility of the grid provided that they are the right size and in the right location. From an economic standpoint, storage facilities that provide more than one service have a higher chance of becoming commercially viable solutions. However, storage is not the only option

to provide these services and IESO attempts to provide a balanced portfolio. Nonetheless, in the IESO's long vision of a competitive environment where technology providers compete to offer IESO the required services, energy storage has lots of chance for success due to its operational advantages such as fast response time.

Managing the interrelated issues of variability and uncertainty of renewable production is an important task of IESO. Generation forecasts are inputs into IESO's market-based decision tools and uncertainty of forecast can considerably affect system operation and market efficiency. In addition to providing regulation services, IESO considers three major aspects where energy storage can have a significant contribution. The first aspect is congestion relief where storage units charge during off-peak hours and discharge during peak hours. The second aspect is voltage control. As demand grows and the load profile changes, maintaining voltage has always been a matter that IESO paid close attention to. Transmission connected storage facilities that have voltage control functionalities can help with this issue. The third aspect is emergency preparedness which is the resiliency of the grid facing extreme weather conditions. There have been examples of microgrids that were able to maintain power during outages by utilizing energy storage.

IESO's two-phase energy storage procurement has received an enormous amount of interest in Ontario and internationally. In phase one, more than 400 proposals were received and out of these, 12 projects, totalling just under 30 MW, were chosen. The technologies included thermal energy storage, stationary batteries, flywheel, and hydrogen. These projects are presently in the process of getting connected. Three of the projects will provide regulation services and nine projects will provide voltage control and reactive power support to the local grid. IESO aims to maximize the learnings from this project through their three-year contracts and expects to widely share the findings with the industry. In phase two of the procurement there have been 133 proposals submitted to IESO out of which five projects will be selected and the contract term in this case will be ten years. These projects will build up IESO's direct experience with the various technologies and how they can succeed in meeting the expectations.

The IESO's Conservation Fund was created more than a decade ago to invest in innovative technologies and operational models on the demand side of the grid. One of the success stories is Temporal Power, manufacturer of flywheel storage that received $200,000 in conservation funds in 2010 for the development of their flywheel technology. Two years later, they were one of the companies who were chosen in the IESO's competition program

to build a facility to provide regulation service and to manage unbalance between supply and demand. The Conservation Fund covers all residential, industrial, and commercial sectors. Recently, $500,000 was dedicated towards the building of a power house by PowerStream. In addition, three distinguished research fellows at the Centre for Urban Energy have been funded through this program to conduct research in three areas of integration of urban energy planning, integrated delivery of electricity, gas and water conservation, and energy storage.

One remaining question is when we are going beyond pilot projects and when we get to a real business. In terms of that, IESO intends to buy services and not the technologies. Currently, IESO schedules about 100 MW of regulation range on a daily basis for which about 250 MW capacity is contracted. IESO expects these numbers to go up in future and storage has a great potential to contribute to this services.

Finally, there are questions that the energy sector in Ontario must address to extract the maximum value for energy storage:

- From the operational perspective, how do we coordinate the local, regional, and provincial benefits of storage?
- From the regulatory perspective, does Ontario's regulatory framework adequately recognize the characteristics of energy storage?
- From a market perspective, how storage will be best integrated into the markets and how it will support the transition to a low carbon economy?

Panel 3: the customers' perspective

Brad Cochrane
Director, Energy Management, York University

Brian Hewson
Senior Manager, Strategic Policy, Ontario Energy Board

Michael Lithgow
Manager of Energy and Sustainability, Sunnybrook Hospital

Brett Smith
Manager, Distribution and Grid Modernization, Ontario Ministry of Energy

Moderator:

Sean Conway
Public Policy Adviser, Gowling WLG

What are the environmental, social and economic benefits of energy storage for customers?

A lot of the focus on storage today within our policy has been on the benefits for the transmission system or distribution system and less time has been spent on understanding the benefits to residential, industrial, and commercial customers where energy storage can be adopted. Energy literacy has been a persisting challenge for the ministry and different agencies to try to build the baseline knowledge in the general public about what investments are made in the electricity sector and why they are important and what it means to them on a general level. One aspect is trying to help customers understand what their bills mean. One of the recent initiatives in this regard is time-of-use which was introduced within the last ten years. The idea behind that is to get people to understand what the impacts of their decision making and their consumption are by giving them a tool to actively observe and monitor their electricity usage and modify their behaviour. This helps not only the customers but also the grid through a shift in the consumption time.

The benefit of storage is one of the most difficult to understand and the literacy gap in this area is a one of the biggest challenges for this industry. It is difficult for the customers to understand what the value of storage is and how it impacts their bills. Therefore, there should be more efforts in building benefit cases for storage. Even the ministry does not clearly know what that full range of benefits looks like in practice. Identifying the benefits, proving them in real-world projects, and presenting them to customers are therefore critical steps for the sector as a whole.

The community storage project in partnership with eCAMION and PowerStream's Power House project are two examples that are funded by the ministry's Smart Grid Fund. These projects will help understand how customers behave and how we can respond to that behaviour, as well as how customers and the utility can both benefit from storage assets. Present storage technologies tend to be expensive and trying to identify all their benefits, in an attempt to bring the beneficiaries together to build an appropriate business model and increase the value of storage, can contribute to their acceptance by the customers. For instance a business model could be developed where the utility also benefits from the storage assets behind the meter in residential houses or industrial facilities to, for example, balance their grid or solve system issues. IESO recently released a technical report on different ranges of benefits for storage in the distribution level and the industry has done its independent studies over the past years as well. All of these information will be shared with the partners in the sector including industries, utilities and potential customers.

How can energy storage benefit your individual stakeholders?

At Sunnybrook Hospital, there is a high sensitivity to electricity disruption and it can put lives in danger. The infrastructure at the hospital can handle the regular outages in the grid fairly well for up to 72 hours and there is a redundancy of emergency resources and on-site

generators. However, short-term fluctuations and voltage sags are problematic to the hospital's continuity of service. There are about 20 to 30 incidents per year that fall in this category.

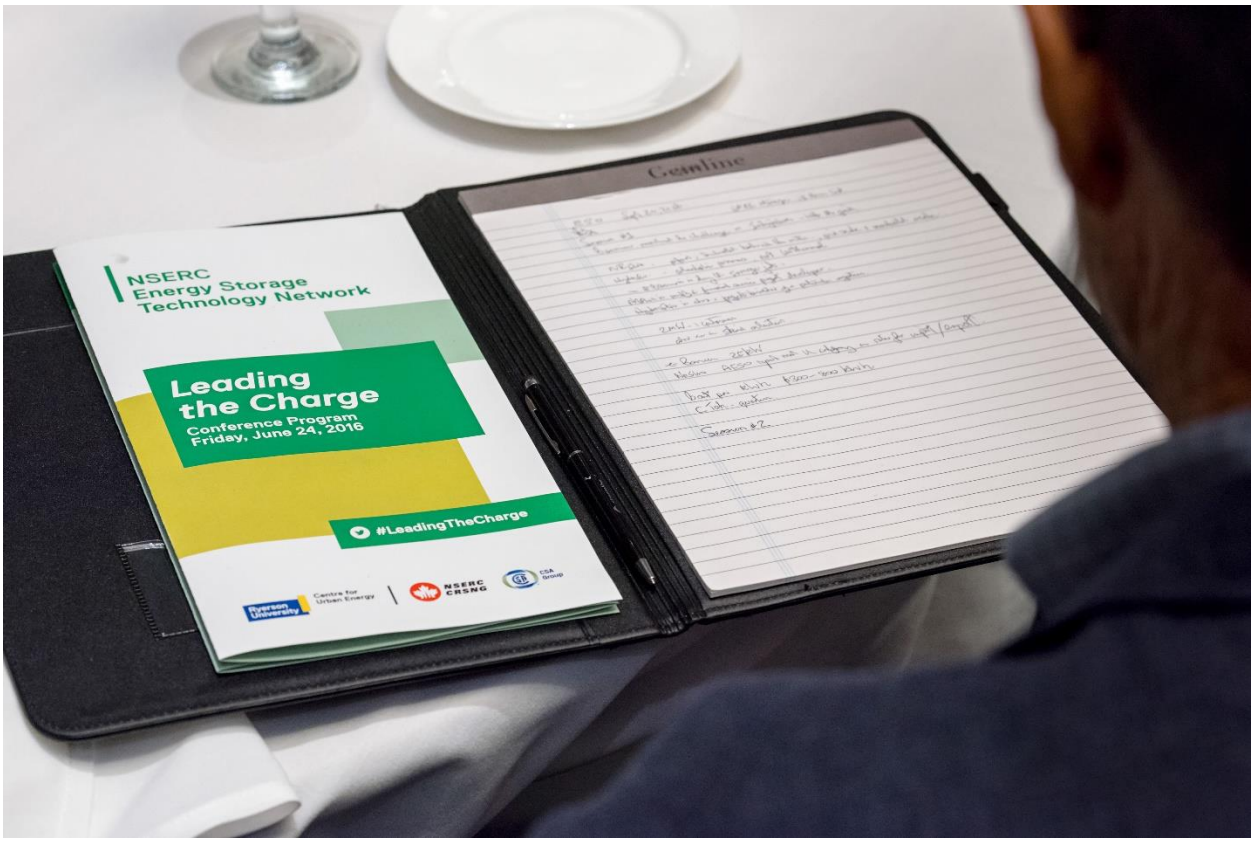
As an example of this type of incidents, Mr. Lithgow described a recent interruption during a very hot day in Toronto where the loading on the feeders was high due to the high usage of air conditioning in the neighbourhood. More importantly, it was windy all day long and wind gusts were quite strong at times. The two feeders that supply the hospital run through treed areas and are difficult to access. There was a voltage sag at 6:30 in the morning where the voltage dropped down to 20 per cent of the normal voltage and this caused all the boilers and chillers in the hospital to shut down. A lot of the affected equipment did not come back up on their own. At 2:30 pm on the same day, there was another sag to 30 per cent and later at 7:00 pm another sag to 50 per cent. Problems that these type of short-term fluctuations can cause include: potential for higher surgical infection rates, loss of cooling of medical equipment which keeps them from being used, and lack of steam for processing surgical instruments. So this is the area that we hope that energy storage can have an effective role in improving the safety for our residents. Although the financial case of potential solutions are of course important, the safety of our patients is what really counts.

Universities also have a lot of similarities to hospitals on how they are affected by short-term interruptions in the grid voltage, as medical research is carried out in university's research centres. Barriers to the usage of storage include: time and staff resource constraints, reliability issues, accessibility to financial resources to fund the projects, and low risk thresholds at institutional models.

Does the regulatory framework fully capture the value proposition of energy storage?

Electricity customers' attitudes and expectations are changing rapidly. Both small and large customers have already started to adapt to newer technologies and energy management systems to obtain more control and choice over their energy use. This, in turn, will be changing a critical part of the electric system that we have been working with for a long time, to the point that the customer asks the utility for a different service based on their own needs. The Ontario Energy Board recognizes that customers want more information and they are working with the utilities and the IESO to find ways to enhance the information access system so that utilities can provide that information to the customers, including the developers of energy storage technologies. The Ontario Energy

Board have been encouraging the utilities to engage with their customers about their expectations and needs and, if necessary, to change their plans to reflect the input they received from customers. It is important to consider how the system is going to be designed to also meet the needs of future customers such that all the customers have a reliable, quality power supply at a reasonable price, because one of the key mandates of the board is to protect the interest of consumers. Innovations by the sector, such as developing storage opportunities or new technologies to communicate better across the system, are crucial to achieve these goals. New policies on planning and grid modernization are required and the board encourages utilities to look at ways to undertake behind-the-meter distributed energy resources with the customer. The Ontario Energy Board is constantly working with utilities to look at how different projects performed by utilities benefit the system and how customers are getting value from these energy systems.



Panel 4: safety and implementation

Paul Marot
President, Virelec

Mohammad Sedighy
Principal Consultant and Associate, Technologies Business Practice, Hatch

Erik Spek
Chief Engineer, TUV SUD Canada

Moderator:

Bhanu Opathella
IESO Distinguished Research Fellow, Centre for Urban Energy at Ryerson University

What kind of safety issues —chemical, mechanical and electrical— do you think that utilities and the general public should be concerned about?

Many types of storage technologies are available in the market and each type has its own safety issues. For instance, in battery storage systems, safety issues could include possible risk of fire as well as transportation and handling difficulties, and in flywheel storage systems, a safe and reliable containment for the high-speed rotating part is essential. Let's take a step back and look at the question from another perspective. If the question is only that "are these products safe?", then the answer could only be yes or no. However, this answer is not sufficient for a more engaged audience and we need to provide more details. The safety assessment of these products requires a set of appropriate standards. On the other hand, these standards can be developed from knowing where these products will be placed and how they will be used. These standards for energy storage are not available yet. After Hurricane Sandy hit the shoes of New York City area in October 29, 2012, sixteen electric cars caught fire while being parked in a parking lot. The origin of the fire was later identified as residual salt damage inside the vehicle control units submerged in seawater for several hours due to the flood. The US government then took action to develop new standards to address this condition and TUV SUD carried out the required tests.

During the last decade, what sort of safety improvements did we observe in energy storage technologies? What level of safety improvements do we expect in the coming decade?

Lots of steps have been taken and new test protocols developed to make energy storage safer by learning from past experiences. For instance, less toxic materials are being developed and used for new battery storage systems. We are moving in the right direction but it does not happen overnight. Another important aspect to have in mind when we talk about safety is that energy storage products, such as lithium-ion batteries, are designed to

operate within a specified limits such as the temperature range and the maximum loading. If these limits are violated it could cause safety issues. So, the storage systems must have a fail-safe mechanism in place to avoid any problems.

What are the available testing and verification techniques, safety codes, standards, and regulations? What kind of improvement do we need?

There are about 20 to 22 protocols for testing storage systems developed by different organizations. Unfortunately, when you have so many organizations doing the same thing, you will see all different sorts of variations between these codes. This makes it difficult to decide which one you need to use for your products. Nonetheless, these codes are for the conditions that we are familiar with. On the other hand, there are other conditions that we might not yet be aware of and require more rigorous testing. New standards are required for charge management, life cycle, duty cycle, and efficiency measurement in battery storage systems. Moreover, the codes and test procedures that utilities use to allow a new unit to be connected to the grid are not very adaptive to new energy storage technologies. A portion of the tests that are currently carried out during the commissioning phase seem

to be more appropriate to be performed beforehand in the factory, in a controlled environment.

What are the challenges of grid integration of energy storage? What kind of grid evolution we need?

There are practical difficulties that the industry must investigate in detail. For instance, one challenge is how to communicate to distributed energy resources connected to a feeder and to send transfer trips when there is a fault incident in the upstream power grid. This process is essential to ensure that the distributed units do not interrupt the regular operation of protective devices that utilities use in their system. However, the extra transfer trip increases the cost of the project; less expensive options, such as auto-disconnection of the distributed unit, can be beneficial in these cases. Moreover, modularization of storage systems can significantly contribute to mitigating implementation and maintenance challenges, especially under tight commissioning schedules.

Appendix

I. Conference program

Welcome

The Centre for Urban Energy is proud to lead a five-year, $5 million pan-Canadian network of 15 universities and 26 industry and government partners focused on the future of energy storage — an essential technology in the Canadian transition to clean energy.

The NSERC Energy Storage Technology Network (NESTNet) collaboratively explores many different types of energy storage, including flywheels, lithium-ion batteries and compressed air, while determining how best to integrate these technologies into electricity grids. In addition, researchers consider the implications arising from the increasing adoption of energy storage and how consumers will perceive, adopt and interact with these technologies. By partnering with the private sector, NESTNet enables directed progress — without duplication of efforts — towards a strong domestic Canadian energy storage industry that is also competitive in the global marketplace.

As our energy systems transform to integrate storage technologies, cooperation from all sectors is needed. With that in mind, we welcome you to the inaugural *Leading the Charge* Conference. This conference provides a stage for manufacturers, utilities and customers to share their perspectives on the challenges and opportunities of energy storage.

We would like to offer our sincere thanks for joining us today and gratefully acknowledge the support from our partners, without whom this event would not have been possible.

ryerson.ca/nestnet

The Centre for Urban Energy at Ryerson University is an academic-industry partnership that explores and develops sustainable solutions to urban energy challenges such as the advancement of smart grid technologies, energy policy and regulatory issues, storage, electric vehicles, net-zero homes and renewables.

ryerson.ca/cue

About the speakers

In order of appearance.

Bala Venkatesh
Professor, Electrical and Computer Engineering; Academic Director, Centre for Urban Energy at Ryerson University

Chris Evans
Interim Provost and Vice President Academic, Ryerson University

Jessie Ma
IESO Distinguished Research Fellow, Centre for Urban Energy at Ryerson University

Geoff Osborne
Associate, NRStor

Carmine Pizzurro
President, eCAMION

Pratap Revuru
Smart Grid Solutions Architect, Schneider Electric

Curtis VanWalleghem
Chief Executive Officer, Hydrostor

Birendra Singh
IESO Distinguished Research Fellow, Centre for Urban Energy at Ryerson University

Ajay Garg
Manager, Reliability Standards and Compliance, Hydro One

Neetika Sathe
Vice President, Corporate Development, PowerStream

Gary Thompson
Lead, Generation Planning and System Studies, Toronto Hydro

Sean Conway
Public Policy Adviser, Gowling WLG

Bruce Campbell
President and Chief Executive Officer, IESO

Brad Cochrane
Director, Energy Management, York University

Brian Hewson
Senior Manager, Strategic Policy, Ontario Energy Board

Michael Lithgow
Manager of Energy and Sustainability, Sunnybrook Hospital

Brett Smith
Manager, Distribution and Grid Modernization, Ontario Ministry of Energy

Bhanu Opathella
IESO Distinguished Research Fellow, Centre for Urban Energy at Ryerson University

Paul Marot
President, Virelec

Mohammad Sedighy
Principal Consultant and Associate, Technologies Business Practice, Hatch

Erik Spek
Chief Engineer, TUV SUD Canada

Notes

NSERC Energy Storage Technology Network

Leading the Charge

Conference Program
Friday, June 24, 2016

#LeadingTheCharge

Ryerson University | Centre for Urban Energy | NSERC CRSNG | CSA Group

Agenda

8:30am **Coffee and registration**

9:00 **Welcoming remarks**

Bala Venkatesh

Chris Evans

9:10 **The manufacturers' perspective**

This panel will explore the value proposition offered by energy storage products and discuss the technical and regulatory barriers to implementation. It will also forecast paths to growth and maturity for energy storage, both in Canada and abroad. Questions considered could include:

• What are your energy storage products and how are they game-changers?

• Who are your key client groups, and what is the value proposition that you offer them?

• What are the key opportunities and challenges for energy storage in Ontario, across Canada and elsewhere?

• How do you see unit costs for your technology in five, 10 and 15 years?

• What is your company doing to drive down unit costs?

• What are Canada's strengths when it comes to energy storage?

Featuring:

Geoff Osborne

Carmine Pizzurro

Pratap Revuru

Curtis VanWalleghem

Jessie Ma (Moderator)

10:10 Break and networking

10:30 **The utilities' perspective**

Energy storage is being touted as a game changer for Ontario, where the electrical grid is expected to see a much higher level of wind and solar integration in the next decade than exists today. This panel will discuss opportunities and barriers of using storage to address grid challenges, taking into consideration technical, regulatory and economic factors. By exploring drivers and enablers of energy storage, it will also shed light on the path of transformation for LDCs in Ontario. Questions considered could include:

• Most utilities are still using the old proven methods for addressing power system problems. Why aren't they considering energy storage as an option?

• Do you think utilities understand energy storage well enough to make use of it in their operations?

• What has been your experience in using energy storage to date?

• Where is your utility headed in terms of utilizing energy storage for future needs?

• To what extent do current regulation allows utilities to monetize all the benefits — upstream and downstream — of an energy storage application?

• How do you think regulation can promote use of energy storage on the grid?

• What do you think are some of the grid challenges with energy storage at all different levels — transmission, distribution and utilization?

Featuring:

Ajay Garg

Neetika Sathe

Gary Thompson

Birendra Singh (Moderator)

11:30 **Lunch and keynote**

Energy storage in Ontario: Experiences to date and opportunities for expansion

Bruce Campbell

Introduced by Sean Conway

12:45pm **The customers' perspective**

This panel will discuss energy storage from the point of view of both commercial and residential customers. Questions considered could include:

• What are the environmental, social and economic benefits for customers?

• How can energy storage benefit your individual stakeholders?

• How much will energy storage cost? Will it help ratepayers save money on their energy bills?

• How can energy storage benefit large customers such as hospitals in the event of weather-related incidents and blackouts?

• Are there any unintended consequences we should consider?

Featuring:

Brad Cochrane

Brian Hewson

Michael Lithgow

Brett Smith

Sean Conway (Moderator)

1:45 Break and networking

2:15 **Safety and implementation**

This panel will exchange ideas about the safety and implementation challenges of energy storage systems from a testing, grid integration and social perspective, as well as discuss how to improve and enhance public awareness. Questions considered could include:

• What kind of safety issues — chemical, mechanical and electrical — do you think that utilities and the general public should be concerned about?

• During the last decade, what sort of safety improvements have you observed in energy storage technologies? Are they satisfactory or do we need further improvements?

• What level of safety improvements do we expect in the coming decade?

• What are the available testing and validation techniques, safety codes, standards and regulations? Are they sufficient?

• What are the challenges of implementation and grid integration of energy storage?

• What kind of grid evolution do we need?

• Can we expect islanded grids in near future?

• Do you think energy storage provides more value to cities like Toronto or to rural communities where renewable resources are plentiful?

• What are the benefits of energy storage to northern isolated community grids?

• Based on your experience with energy storage, how critical do you think societal acceptance is?

• Do you think energy storage also faces a challenge of NIMBYism?

Featuring:

Paul Marot

Mohammad Sedighy

Erik Spek

Bhanu Opathella (Moderator)

3:15 **Closing remarks**

Bala Venkatesh

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