Ontario

MINISTRY OF
ENERGY

Electricity Storage: Technology Overview and Ontario Initiatives

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Ontario's Approach to Storage

- Energy storage is a promising technology that can be used to help balance the system, defer investment at different locations on the grid, improve system reliability, and can provide some technical services such as frequency response and voltage control.

- Ontario has taken a prudent approach to understand the value and commercial potential of electricity storage with the following initiatives:

  - IESO has secured 56MW of storage in 3 separate procurements

  - Ministry Smart Grid Fund supports (or is proposing to support) 12 projects that involve storage

  - Completed and upcoming studies on energy storage

  - LDCs have additional customer facing projects that involve storage

- Through the completion of these projects, Ontario will gain a clear sense of the value of storage in various applications.

- This will ensure that the treatment of storage in the revised LTEP will be evidence-based and make technical and economic sense for the grid.

Storage Technology

Technology Overview

- Electricity production must be matched to consumption at all times, and flexible sources of generation are dispatched by the system operator to maintain this balance.
- Electricity storage could help replace or reduce the system's peaking generation plants at peak demand, and provide other technical services (black start, frequency response, voltage control) that are necessary to manage the electricity system.
- Electricity storage historically, (with the possible exception of hydro pumped storage) has been too expensive to be incorporated in the electricity system.
- With recent dramatic falls in cost and improvements in technology, energy storage is beginning to find market opportunities across the electricity network.
- A small number of jurisdictions (e.g. California, Hawaii) are making significant investments in storage due to their respective supply mix and demand curves (lots of solar with large demand spike in early evening).
  - These grids are different from Ontario, and through several initiatives we are learning the value of storage on our system at the bulk, distribution and customer levels.

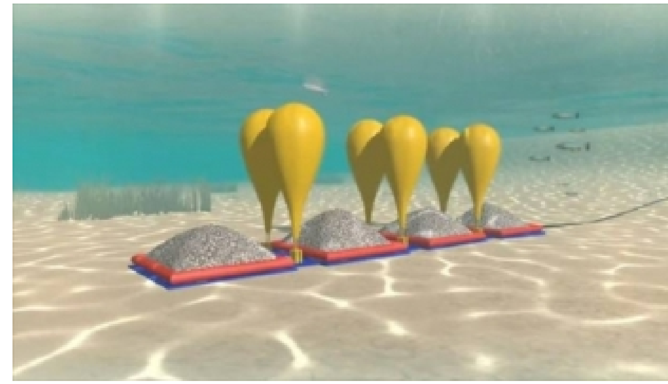
Storage Types and Functions

- There are a number of different types of energy storage that can serve different functions, and that are at different development stages. Energy storage can store energy and then:

Type	Function	Considerations
Flywheel	Dispatch	Nascent technology. Large amount of electricity over short time periods.
Battery	Dispatch	Emerging technologies. Suitable for daily cycles.
Compressed Air	Dispatch	Demonstration phase. Potential for high volume storage.
Pumped Hydro	Dispatch	Mature. Few suitable sites.
Heat/ Ice Storage	Displace Demand	Commercial units available. Small sizes.
Power-to-Gas (hydrogen / methane from water electrolysis)	“Renewable” fuel generation	Demonstration phase. Differs from pure electricity storage. Considered under CCAP.

Examples of energy storage in Ontario

Underwater compressed air storage. Demonstration project is sited at Toronto Island.



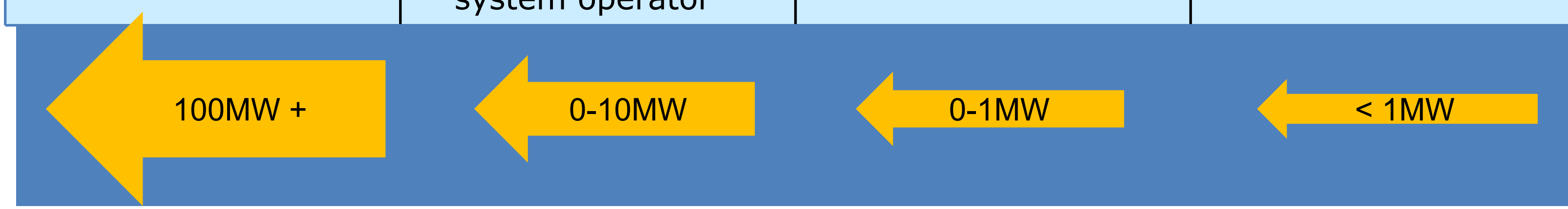
Multi MW Lithium-ion battery. Strathroy, Ontario.

Temporal Power Flywheel storage. Minto, Ontario.

Potential Value of Storage in Ontario

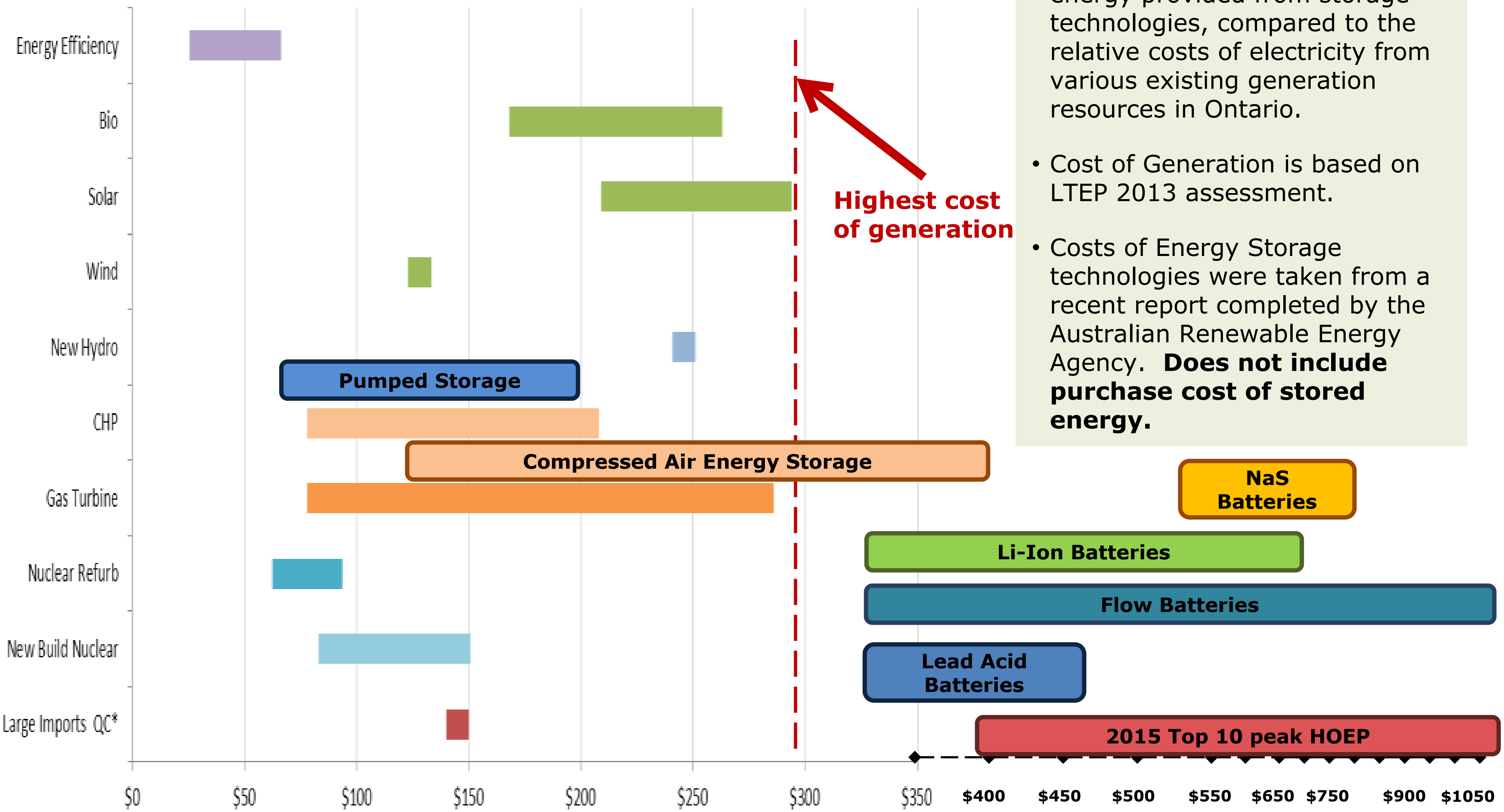
•Energy storage can provide potential benefits from both the system perspective (in-front of the meter) and the customer perspective (behind the meter). Examples include:

System: Bulk Storage	System	System: T&D Support	Customer
• Supply reserve • Shaving seasonal peaks and managing surplus baseload generation	• Integrating intermittent renewable sources • 'Shaving' daily peaks and reducing gas-fired peaking generation • Supplying ancillary services to the system operator	• Reducing congestion and deferring investment in new capacity • Improving reliability • Minimizing system losses	• Distributed energy management • Cost management • Power quality/ voltage control • Back-up power/ resiliency



Typical Size of application

Barriers to Storage: Relative Cost of Electricity ($2015/MWh)



- This table demonstrates cost of energy provided from storage technologies, compared to the relative costs of electricity from various existing generation resources in Ontario.
- Cost of Generation is based on LTEP 2013 assessment.
- Costs of Energy Storage technologies were taken from a recent report completed by the Australian Renewable Energy Agency. **Does not include purchase cost of stored energy.**

Barriers to Storage: Other Factors

- Several other factors can impede the uptake of storage in Ontario:

Financial / Commercial

- The commercial arrangements for integrating storage are being tested but are not well understood
- Project financing can be a challenge if the return-on-investment for storage contracts are too low / uncertain for investors

Regulatory

- Storage can have “diffuse benefits” – the OEB rate process does not enable cost allocation to other beneficiaries, making LDCs cover all costs
- It is unclear how the agencies would treat storage in certain scenarios; LDCs may be constrained from testing new service models

Technology Readiness

- Applications of technology are varied – bulk system, distribution grid, behind-the-meter, power-to-gas
- Many storage technologies are still at demonstration stage and do not have a clear performance record to support broader / greater uptake

Energy Storage Literacy

- Lack of information on relative value and different business models may limit consideration of storage as an option
- Utilities / companies / customers are just starting to explore new business models for storage that address co-benefits and cost-sharing

Storage Initiatives in Ontario

Long Term Energy Plan

- In LTEP 2013, ENERGY made a number of commitments related to Energy Storage.
  - Delivery of these commitments takes time. For example, projects contracted as part of the IESO Phase I procurement will come online in late 2016. Phase II procurement projects are expected to come online in mid 2018. Lessons learned will be gained after these projects have been online for some time.
- For the upcoming LTEP, any decisions on Energy Storage should be informed by ongoing implementation of 2013 LTEP.
- ENERGY could be in a position to make decisions informed by delivery of the 2013 LTEP commitments some time after the upcoming LTEP.

2013 LTEP Commitments

Commitment	Status	Details
50 MW Procurement	√	**Phase 1**: ancillary services from energy storage resulted in successfully selecting 33.54 MW of storage from 5 providers with 12 different projects and 4 technologies represented (Dec. 2014). Phase I projects due to enter service in late 2016 **Phase 2**: remaining capacity (16.75 MW) was allocated to 9 projects from 5 providers. Phase 2 projects due to enter service in late 2018. Valuable learning opportunities expected in both phases.
Independent Study	√	IESO has produced a report on the value of energy storage, with a focus on the bulk system. The report was published in April 2016. Ministry ~~is commissioning~~ has commissioned a complementary independent study, which will focus on energy storage in the distribution system. This report is expected ~~by Q3~~ in November 2016.
Opportunities in Net Metering	√	The option of enabling energy storage is being considered within net metering / self-consumption policy work in collaboration with CRED
Opportunities in Large Renewable Procurement (LRP)	√	LRP I was open to Energy Storage participation, whereby a qualified applicant could partner with an energy storage provider to take advantage of additional economic value provided by Energy Storage. No applicants took advantage of this opportunity. LRP II will be informed by IESO consultation process and lessons learned from LRP I report-back, including on the integration of energy storage.
Work to Address Regulatory Barriers	√	Ministry, IESO, and OEB with Energy Storage Ontario (ESO) members work collaboratively and continuously to engage ESO and support them through defining sector priorities for removing barriers.

Ontario Projects and Initiatives: IESO 50 MW Energy Storage Procurements

	Alternative Technologies for Regulation	Phase 1	Phase 2
Total Capacity	6 MW	34 MW	16 MW
Contract Type	Frequency regulation 3 year contract	Bulk Ancillary Services (regulation & voltage control) 3 Year Contract Room to seek other revenue opportunities	Capacity Services (system & local) 10 Year Contract Room to seek other revenue opportunities
Technology Portfolio	2MW flywheel facility, provides regulation service. 4MW Li-Ion battery provides regulation service and complements variable windrower production in SW Ontario. Locations: Minto, Strathroy	Mixed: battery, flywheel, hydrogen, thermal Mostly in front of the meter 1 thermal behind the meter project Locations: Toronto, Ottawa, Nanticoke, Kitchener/Waterloo, Hamilton, Markham, Sault	Flow battery, solid battery, compressed air All in front of the meter Locations: East Gwillimbury, Tecumseh, Leamington, Kawartha Lakes, Elmira, Seguin, Goderich, Milton
Avg. project size	3 MW	12 projects, spread out geographically 0.74 – 7 MW range 2.8 MW avg	9 projects in central and southern Ontario 0.5 – 5 MW range 1.75 MW avg
Cost		$42 million over 3 years	$92.3 million over 10 years
Expected In service date	In-service 2014	Up to Q4 2016	Up to Q2 2018

Ontario Projects and Initiatives: Smart Grid Fund

- The Smart Grid Fund is providing funding for Round 2 (R2) storage projects that have already begun. Round 3 (R3) contracts are being finalized.

	Project Title	Description
Round 2	eCamion	3 projects with storage and microgrids: Toronto (Sanofi Pasteur), Sudbury (Science North), Ottawa (Hydro Ottawa).
	eCamion	Whites Lane Microgrid adding storage to existing microgrid.
	Ryerson CUE	Pole mounted storage to facilitate increased deployment of electric vehicles.
	Opus One	Energy storage at Trenton On-Route to improve quality of supply to customer.
	Panasonic	Oshawa microgrid to support critical loads at UOIT.
Round 3	Remote communities	Multiple projects with solar PV, storage, and control systems to reduce reliance on diesel generation.
	Renewable Energy Systems	Support community of Dutton – reduce number and durations of power outages.
	Solantro	Ottawa residential storage systems with residential PV systems to create and demonstrate operation of nano-grids.
	ARDA	Burlington storage to demonstrate operation of microgrid.
	Opus One	Pickering storage coordinated with residential storage systems to create community microgrid.

Ontario Projects and Initiatives: Studies

Navigant: Smart Grid Roadmap published January 2015

- This study found that there is a potential to deliver a net benefit approximately $6.3 billion if there is continued investment in Ontario's smart grid.
- While energy storage assets themselves are not directly smart grid asset, the smart electronics and controls required to integrate energy storage systems seamlessly and to unlock its full value are.
- There is also a strong argument that storage analysis in isolation from smart grid is ineffectual because the ability to extract storage's full value is dependent upon smart grid.

IESO: Energy Storage (Transmission) published April 2016

- Energy storage facilities can provide a wide range of services needed to reliably operate the power system in Ontario including: regulation, voltage control, operating reserve, and flexibility. However, energy storage is not the only option for providing these services.
- To enable energy storage to provide these services, the facilities must be appropriately sized and located in those areas of the system where they can provide these services without restrictions or limitations.

Ministry: Energy Storage (Distribution) to be published Fall 2016

- The Ministry study will focus on the distribution system benefits of Energy Storage, as well as upstream benefits, if applicable. It will assess opportunities for Energy Storage to provide value at the distribution level. It will account for and build on the IESO study, where appropriate.
- ~~Procurement for provision of this report is complete. Contract to be issued June 2016.~~
- The contract for this study has been awarded to Essex Energy. The final report is expected in November 2016.

Ontario Projects and Initiatives: Regulatory Barriers

- In 2013 the OEB Storage Working Group reviewed storage issues and produced a public report on regulatory barriers to storage. Key findings include:
  - No licence for storage similar to generation or transmission – as a result, it was unclear how a storage providers was regulated.
  - No clarity in treatment of storage in net-metering schemes.
  - Storage may provide benefits to multiple stakeholders who may not be contributing to the costs of installing / operating.
  - Storage providers may be charged network charges and Global adjustment on stored energy, not just energy consumed in the storage process.
- After the report, the OEB created a specific licence for storage. ENERGY is also proposing changes to the net-metering / self-consumption program regulation (O. Reg. 541/05) that will clarify use of energy storage.
- Energy Storage Ontario, an industry association, identifies regulatory barriers as a key concern. The Ministry and agencies continue to engage the ESO to better understand its key interest areas for removing barriers. A recent submission from ESO is being evaluated by Ministry staff for further consideration.
- The Ministry's independent study will also look at regulatory barriers.

Energy Storage Ontario

- The ESO was founded in 2012 and is the only such industry association in Canada. Patricia Phillips is the current Executive Director.
- Since inception, the ESO has engaged with the Ministry at political and staff levels, as well as the agencies.
- The ESO has sought leadership from the Ministry to evaluate the benefits of storage and identify favourable policies for the industry. The Ministry's position is that Ontario remains a North American leader in deploying storage technology and is evaluating the results of current initiatives before making specific policy recommendations.
- Other key ESO interests:
  - New MW procurement targets
  - Quantifying environmental benefits
  - Quantifying value of storage to offset surplus baseload generation (large-scale storage installations)
  - Export opportunities
- A Working Group between ESO, Ministry and agencies has been contemplated to discuss these and other issues related to storage in Ontario. The Ministry continues to engage ESO to scope this type of joint work.

Board Composition	Home Company
Rob Harvey (Chair)	Hydrogenics
Ka-Ming Lin (Vice-Chair)	ORTECH Power
Alexander McIsaac (Treasurer)	NRStor
Nicolas Musynski (Secretary)	RES Canada
John Wright (Advocacy Council Chair)	Northland Power
Mark Tinkler	Customized Energy Solutions
Gary Thompson	Toronto Hydro
Milosz Zemanek	Torys LLP
Cam Carver (Advisory Board)	Totally Green
Annette Verchuren (Advisory Board)	NRStor (CEO)

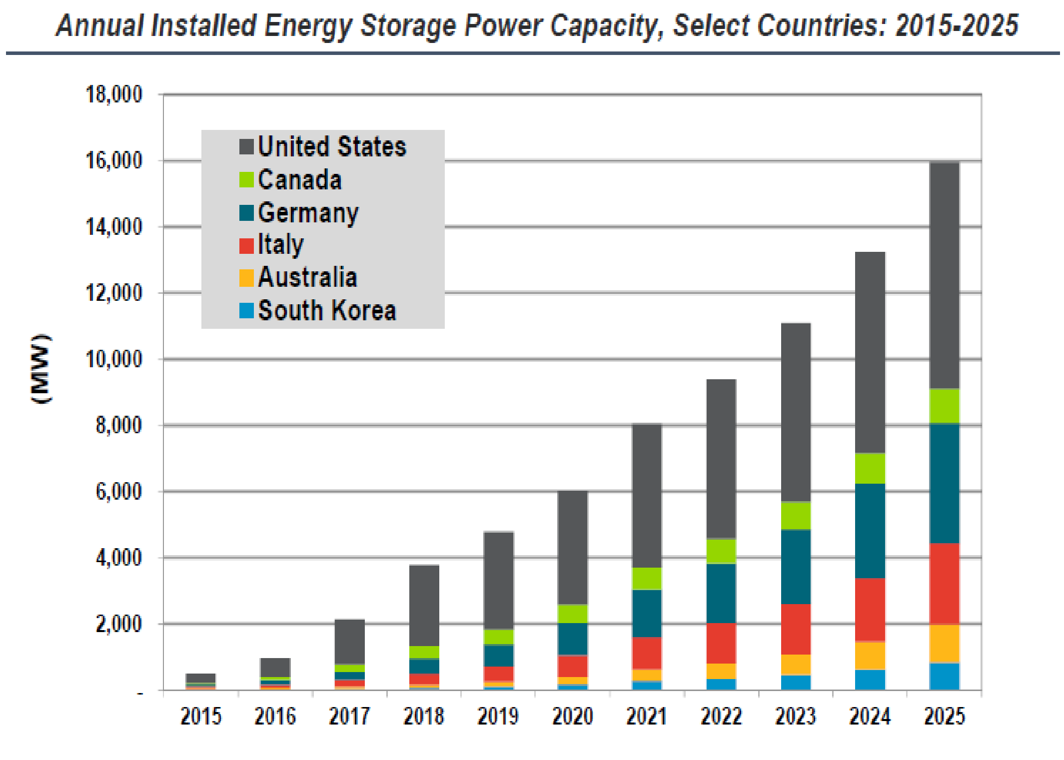
Future of Electricity Storage

- Prices are expected to drive down as more projects are demonstrated / implemented on commercial terms around the world. Given the range of services that storage can provide to different market participants, it is possible that storage becomes an economically viable solution in the short-to-medium term.
  - On June 22, IESO recently opened an RFI for Regulation Service (having dispatchable assets to help correct short-term imbalances between supply and demand). The IESO believes that storage could economically compete with other traditional generation technologies.
  - Storage assets can provide multiple services. If there are storage technologies already connected to the grid, they can enhance their economic returns by applying for and receiving multiple service contracts.
- Ongoing discussions with ESO on barriers to continue throughout summer. The Ministry is also evaluating Smart Grid Fund projects to identify barriers to technology integration – this will include LDC and storage industry perspectives related to actual storage projects in Ontario.
- The Ministry's independent storage study will finish during LTEP and will be publicly released. The storage industry is expected to use the study as baseline for drafting their LTEP submissions to the Ministry.
- LTEP will also be instructed by information from all storage initiatives and relevant studies:
  - Lessons learned from procurements
  - Smart Grid Fund results
  - IESO, Ministry studies
- Storage will also be considered in the context of the Climate Change Action Plan.

Appendices

Global Trends 2016 and Beyond

- The Chart on the right demonstrates projected installed capacity for Energy Storage systems, with total capacity reaching 16 GW by 2025, a 16-fold increase.
- Navigant Research anticipates that Energy Storage will become a viable part of the grid in the near term, due to a combination of:
  - technology improvements;
  - changing regional regulatory and market drivers;
  - a growing concentration of variable generation.



(Source: Navigant Research)

- Reliability considerations are expected to be among the key drivers, with a particular niche in areas with unstable grids and frequent outages, where Energy Storage could provide value on its own, or as part of a microgrid solution.

Other Examples

Jurisdiction	ES programs	Key Drivers	Res. Retail Price (¢/kWh)
Hawaii resource-poor island issues	Hawaiian Electric (HECO) issued an RFP in 2014 for 60-200 MW of battery storage, intended to use for renewables integration, but now HECO reports plan will likely be delayed by a year – original target was 2017 (contract negotiation appears to be the cause).	• **Energy Security & Reliability** – (resource-poor island issues) 6 small isolated island grids, 90% of supply fueled by oil and coal, 10% renewables including hydro. Aggressive renewables targets in a severely constrained grid require some form of storage or interconnection.	**~ 30 ¢** (highest in the US)
Japan resource-poor island issues	$100M in funding made available to cover roughly 30% of ES cost for coupling with DG Up to $10K for residential Li-Ion coupled with DG & Up to $100K for businesses	• **Energy Security & Reliability** – Japan is extremely constrained on Capacity, particularly after having to re-evaluate nuclear – looking to integrate renewable supply to enhance energy security (completely import dependent for fuel). • **Economic Development** – Japan has been one of the leading global jurisdictions in battery technologies & this helps support further growth of the industry in light of the heightened global deployment interests	**~ 30-40 ¢**
Germany	30% repayment bonus - PV+ES syst . Under 30kW	• **Energy Security & Reliability** – Capacity is constrained & high DG penetration – looking to address issues from too much solar, reduce over-export & integrate better • **Economic Development** – new life for PV industry and incentive for ES industry	**~ 50 ¢**
S. Korea	Korea Electric Power Corp. (KEPCO) just installed country's first ES for frequency regulation, with reported plans to scale up to 500 MW by 2017. In 2011, South Korea announced it would invest $5.94 billion USD in energy storage by 2020, one third on R&D and the rest on infrastructure.	• **Economic Development** – S. Korea is another major player in global ES market with leading manufacturers like Samsung and LG.	**~ 20-25 ¢**

Energy Storage Technologies

- Energy storage systems come in many different sizes, and types of capabilities. Different kinds of storage technologies perform a variety of roles and are used to support various needs at customer sites, the distribution system, and the bulk electricity system.

Batteries

- Lithium-ion batteries and liquid electrolyte "Flow Batteries" are able to store excess electricity from the grid and release that supply back into the grid. Capable of changing their output in less than one second, some types of batteries are now being used by grid operators to quickly balance variations in load to regulate frequency. Battery systems are also often found at the distribution system level and at individual customer sites. Other forms of battery technology are at various stages of technological development and show promising future potential as well.

Flywheels

- Like batteries, flywheels can both store and quickly release energy as needed. Flywheels use a rotor placed within in a vacuum to store and then discharge kinetic energy.

Energy Storage Technologies (cont'd)

Compressed Air

- Compressed air uses off-peak energy to pump air into a containment area such as an underground mine, where it is held until needed. It is then released through a combustion turbine. In some cases, this may be done in conjunction with natural gas fuel, which increases the efficiency of the generator to provide more efficient energy during peak hours.

Electric Vehicles

- Electric vehicles - and their batteries - can be considered as both controllable load during periods of lower demand and, with the appropriate technologies, a source of supply during times of higher demand. Using smart electric vehicle charging stations, customers would supply the grid or use the electricity to meet their own energy needs.

Fuel production

- Electricity can be used as an input in the production of other types of fuels such as hydrogen and biofuels, which can also act as an energy storage medium. These fuels can then be used to generate electricity to send back into the grid at optimum times – or for other non-electrical energy needs. Off-peak electricity can also be used for compressing natural gas – an emerging need in the transportation sector.

Energy Storage Technologies (cont'd)

Thermal Energy

- Not all stored energy necessarily comes directly back to the power grid as electricity. Off-peak energy can be stored as thermal energy, which can then be used to supply heating and/or hot water needs, reducing electricity consumption during on-peak periods. Ice storage systems do just the opposite where off-peak energy is used to make large blocks of ice to help cool buildings during peak hours.

Magnetic fields

- Magnetic fields are capable of storing electrical energy, and when coupled with superconductors, the storage potential can be significant. Some pilot projects involving superconducting magnetic energy storage are currently under development at various laboratories and utility equipment providers around the world. However, the future success of these new forms of energy storage devices is highly dependent on the cost of the superconductors themselves.

Pumped Storage

- Pumped storage is essentially hydroelectric power that takes advantage of lower-priced periods to pump water into a reservoir, and then releases the water when needed. Presently, it is the most established and widely used form of energy storage in the world. Ontario has one large-scale pump generation project: Ontario Power Generation's pump-generation facility in Niagara, which has been operating since 1957. This 174 megawatt facility has helped meet peak supply, manage surplus conditions, provide regulation services, and operating reserve.

IESO Report Findings

- Energy storage facilities can provide a wide range of services to the power system in Ontario . However, energy storage is not the only option for providing these services.
- Up to the early 2020s storage could manage some surplus baseload generation (SBG) but most opportunities are seasonal (not daily) as SBG persists for majority of day.
- In Ontario's major load centers energy storage technologies could alleviate transmission constraints by time-shifting energy.
- Energy storage technologies that are capable of providing multiple services are more likely to become economically viable.
- In order for energy storage facilities to provide services to the power system, they need to be appropriately sized and connected at locations where existing transmission limitations do not impede their ability to provide the targeted services.
- Energy storage providers seeking to connect facilities to the IESO-controlled grid should target those areas of the system where they can provide multiple services to the IESO-controlled grid, the IESO-administered markets and local market participants.

Key Stakeholder Perspectives

LDCs

- Select distributors that collaborated with the IESO procurement and SGF recipients are actively testing the different uses and value of electricity storage on the grid.
- Almost all LDCs are owned by municipalities that rely on dividends from the distributor. Electricity storage projects funded by an LDC could be viewed as risky of lowering that dividend.

OEB

- A primary objective of the Board is to protect the interests of consumers with respect to prices and the adequacy, reliability and quality of electricity service. Electricity storage regulation will be reviewed with this objective in mind, although other OEB objectives are to promote conservation and demand management, and to facilitate the implementation of a smart grid in Ontario.

IESO

- IESO believes energy storage can be used to provide some of the services needed to reliably operate the power system including: regulation, voltage control, operating reserve and flexibility.
- Based on its recent procurement experience, it expects that it might be able to provide regulation service at a cost that is comparable to the cost of traditional providers (e.g. hydroelectric generators).

Commercial and Industrial Customers

- Primarily interested in voltage control and back-up power to prevent significant losses in production (e.g. hours lost on an assembly line, vaccine manufacturing).

Residential Customers

- Limited interest among customers that receive a reliable service from LDCs, although interest where service interruption without back-up could endanger those reliant on electrical medical devices. Interest also for off-grid customers.

Energy Storage Ontario (ESO) (members include Hydrogenics, Horizon, Enbridge, Torys)

- ESO, which represents Ontario’s storage industry, believes policy changes are needed with respect to treatment of the wholesale market charge and global adjustment, to allow storage to compete with other infrastructure options. It is expected to seek additional storage capacity targets during LTEP consultations.

Timeline of storage activity in Ontario

2012	IESO procurement: Alternate Technologies for Regulation	2 projects with 6MW storage
2014	IESO Storage Procurement Phase 1	12 projects with 34 MW storage
	Ministry Smart Grid Fund Round 2	5 of the projects incorporate storage (2.25MW)
2015	Navigant Report – Smart Grid Roadmap	"the ability to extract storage's full value is dependent upon smart grid"
2016	IESO Storage Procurement Phase 2	9 projects with 16MW storage
	Ministry Smart Grid Fund Round 3	6 of the projects incorporate storage (3.6MW)
	OPG refurbishment of Sir Adam Beck Pumped Storage	Will extend life of 174MW storage asset by 50 years
	Commercial Launch of Tesla Powerwall	3kW storage units for residential use
	IESO report – Energy Storage (transmission level)	Identifies opportunities for storage to provide system services
	Ministry procured Independent Report – Energy Storage (distribution level)	Will identify opportunities for storage within distribution networks