Ontario

MINISTRY OF
ENERGY

Innovation

~~Foundation~~ Transition Briefing

~~January~~ June 2018

Innovation: Introduction

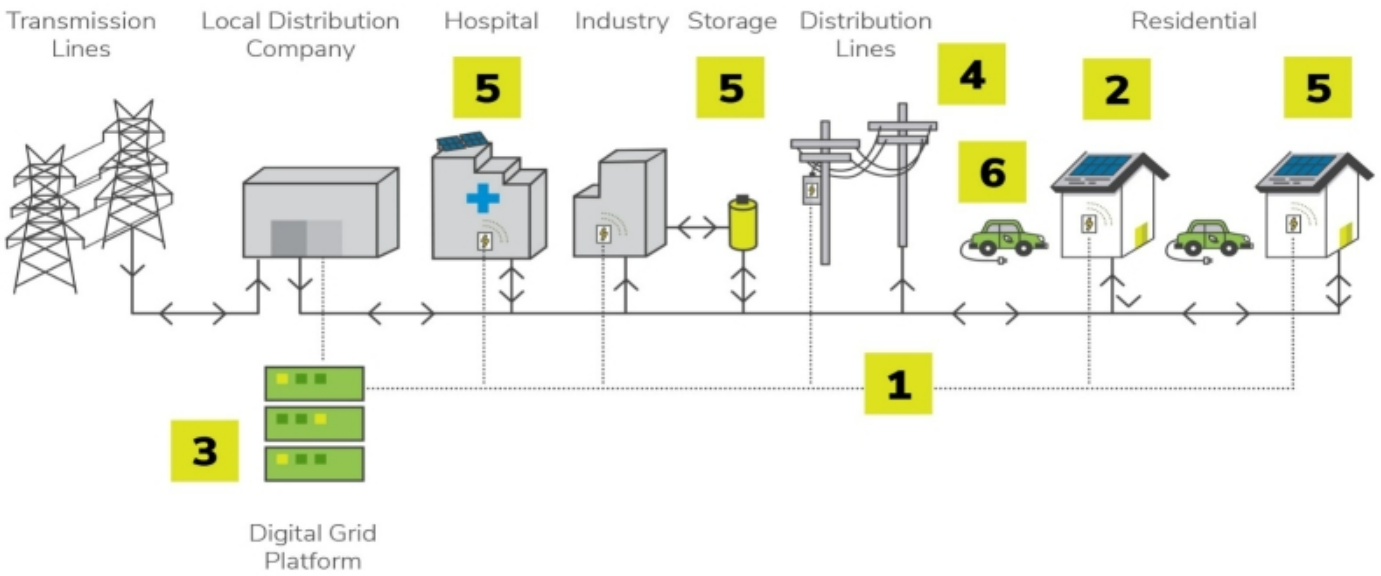
- SLIDE PENDING FEEDBACK FROM ALL UNITS.
- DECK PREPARED ON AN EXPIDITED BASIS.
- Topics:
  - Grid modernization
  - Smart Grid Fund
  - International Energy Demonstration Fund
  - Energy Storage
  - Net Metering
  - Nuclear Innovation

Grid Modernization

Electricity Distribution and Digitization

- Electricity distribution refers to the final step in Ontario's electricity system; delivering high voltage electricity from the transmission network, converting it into lower voltages, and delivering it to homes and businesses.
- Electricity distribution is the responsibility of Ontario's local distribution companies, or LDCs.
- The distribution grid is undergoing a transformation, driven by digitization.
- This transformation bears similarities to changes in the telecom industry as it transitioned from touch-tone phones to cell phones to smartphones.

Components of a Modern Grid



1.Communication lines - Data from smart meters is sent to the LDC using communications infrastructure.
2.Smart meters - In addition to their use for billing, smart meters also provide data on system health for LDCs.
3.Digital grid platform - LDCs use software platforms to analyze data and use that information to make their networks as efficient and reliable as possible.
4.Sensors - Sensors instantaneously feed data back to the LDC about the health of its grid.
5.Distributed energy resources - DERs include renewable generation, energy storage, and microgrids.
6.Vehicle grid integration (VGI) - In the future, EVs can be used to power homes and even support the local network.

Smart Grid Fund

Smart Grid - Overview

- The Smart Grid Fund (SGF) supports innovation in Ontario's electricity sector by providing funding for the development of inventive solutions for Ontario's grids and customers.
- SGF funding has resulted in:
  - Ontario companies testing promising new technologies, solved problems on distribution grids, and commercialized their solutions.
  - Utilities increasing their understanding of how smart grid technologies can benefit the system and their customers, how to increase visibility on their grids, and how to enable electric vehicles and other distributed energy resources
  - Building a culture of innovation in the utility sector by promoting experience and expertise with smart grid solutions.
- The latest call for Smart Grid Fund projects will close June 25th.

Smart Grid Fund – Deployment and Commercialization

- The SGF provides funding for LDC deployments. This support helps LDCs acquire and deploy commercially proven solutions that are still considered risky due to immature technology business cases ~~and the current regulatory framework~~.
- The SGF also promotes the commercialization of new technologies:
  - Recipients are encouraged to provide commercialization updates throughout their contract period; and,
  - A funding stream has been developed to provide targeted support for smart grid companies in Ontario to refine their business cases and seek opportunities to form collaborations and partnerships in order to provide turnkey smart grid solutions.

International Energy Demonstration Fund

International Energy Demonstration Fund - Overview

- Ontario is recognized internationally for its energy sector expertise, with proven success in innovative energy technologies, such as smart grid and energy efficiency technologies.
  - Ontario has the fastest-growing cleantech sector in Canada, with $19.8B in revenue. It is currently home to 5,000 Canadian cleantech and environmental technology companies employing 130,000 people.
  - The growth of Ontario's cleantech and renewable energy sectors could contribute as much as $1B to Ontario's GDP, and 10,700 jobs between 2017 and 2021.
- The International Energy Demonstration Fund (IEDF) pilot was launched in April 2018 to support local innovators that are ready to meet the demand for clean energy technologies in new international markets.
- It was developed in collaboration with industry partners and the federal government, and will provide between $250,000 and $2 million to eligible, selected projects.
- While funding would be provided for projects outside of Ontario (internationally, or on other provinces and territories), funding would be allocated for costs incurred in Ontario only.

Storage Technology

Storage Technology Overview

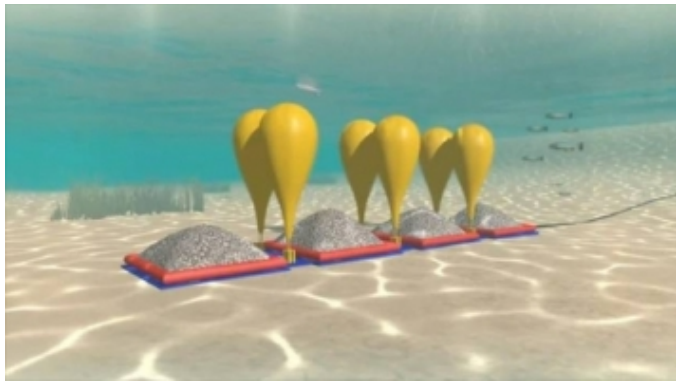
- Electricity production must be matched to consumption at all times.
- Electricity storage could help replace or reduce the system's peaking generation plants at peak demand, and provide other technical services that are necessary to manage the electricity system.
- Electricity storage historically has been too expensive to be incorporated in the electricity system.
- With dramatic cost reductions and improvements in technology, energy storage is beginning to find market opportunities across the electricity network.
- Energy storage works by converting electrical energy into another form of energy, then converting it back to electricity when needed.
- Means of storing electrical energy include batteries, compressed air, as hydrogen, and in water reservoirs.

Storage Technology in Ontario

- Energy storage initiatives in Ontario:
  - IESO has secured 110MW of energy storage in four separate procurements;
  - LDCs have additional customer facing projects that involve storage;
  - Residential customers are using energy storage for backup services, while large industrial and commercial customers use storage to reduce cost.
  - The Ministry's Smart Grid Fund supports over 12 project that involve energy storage.
  - In 2017, Ontario's net metering regulatory framework was amended to enable the use of energy storage paired with renewable distributed generation (customer-sited, behind the meter applications).

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.

See Appendix 2 for additional examples of energy storage.

Distributed Energy Resources

Distributed Energy Resources

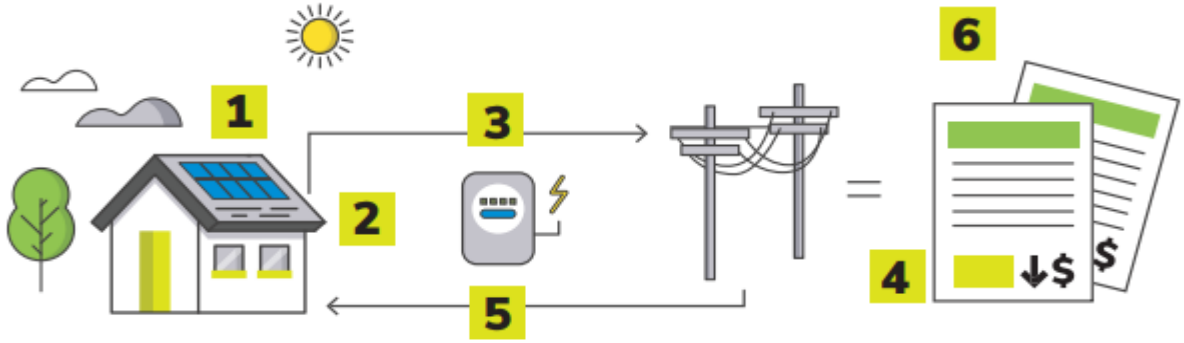
- Distributed Energy Resources (DER) are electricity producing or storing resources and controllable loads that are directly connected to the distribution system or that are located behind a customer's meter and indirectly connected to the distribution system.
  - Today, there are over 4,300 MW of DERs in service and under development in Ontario. Most of this is renewable distributed generation, and more than half of this is solar PV. In the future, DERs in Ontario will increasingly include energy storage, micro-grids and electric vehicles.
- When strategically located and combined with smart communications and control systems, renewable distributed generation can be leveraged as a DER to benefit local distribution companies and their customers:
  - Utilities can defer or avoid certain costly investments in their local distribution networks; and
  - Customers can generate and store their own power, lowering bills and ensuring reliable access to electricity when power from their network is not available.
- The IESO continues to evolve the market to facilitate the participation of all resource types, including DERs, better enabling them to compete to provide wholesale-level services. As barriers to implementing alternatives to transmission and distribution infrastructure are addressed, DERs could provide additional grid services.

Renewable Distributed Generation Integration Fund

- The IESO's Renewable Distributed Generation Integration Fund will support opportunities for DER operators, distributors, the IESO, the OEB and the Ontario government to demonstrate and learn how DERs can be better integrated into grid operations, planning, forecasting, and how regulatory frameworks can better recognize their value.
- The program will also align with the energy storage and regional planning initiatives, as well as the Market Renewal Program, as applicable.
- The IESO plans to deliver the program in a series of calls, specific to targeted investigation areas.
- The first call, planned for 2018, will target virtual net metering demonstration projects.
- IESO will seek input on future investigation topics, such as:
  - Non-wires alternatives used for distribution capacity deferral
  - Enhanced DER aggregation models
  - Hosting capacity/interconnection processes
  - Alternative metering/telemetry for providing data for DERs to distributors/IESO
  - Alternative distribution services

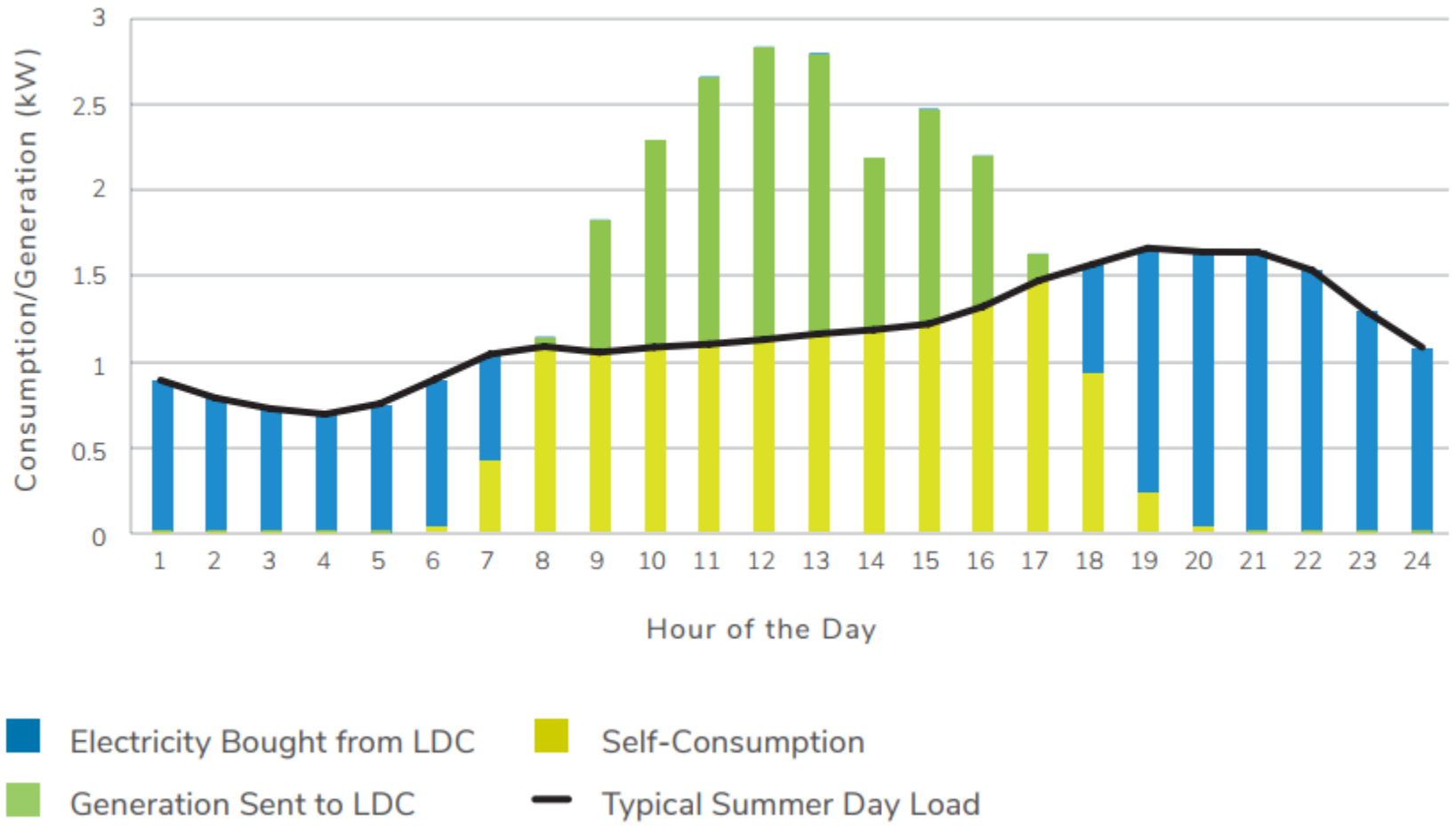
Net Metering

~~Net Metering:~~ How Net Metering Works



1. Solar panels mounted on the roof of the house generate electricity
2. The electricity generated is used to power the house first.
3. Any extra electricity generated is sent to the local grid.
4. Net-metered customers receive credits on their electricity bill for electricity sent to the local grid.
5. Electricity is drawn from the local grid when the home's electricity needs are higher than the amount of electricity generated by the solar panels.
6. Net-metered customer's monthly electricity charges are calculated based on the difference between the amount of electricity used from the local grid and the credits received from any electricity sent to the local grid from the solar panels.

Net Metering: Typical Summer Day with a Residential PV System



Net Metering: Ontario's Current Net Metering Framework

- Since 2015, Ontario has had a Net Metering Regulation (O. Reg. 541/05) in place since 2005, which requireds local distribution companies (LDCs) to offer net metering to customers on request.
  - Electricity conveyed to the grid is valued at retail rates and credited to the customer's electricity bill.
  - Bill credits can be carried forward to offset future electricity bills.
  - Customers can offset up to 100% of their load.
  - Fixed charges are not affected by net metering.
- Currently, a customer is eligible to net meter if:
  - Generation is from a renewable energy source.
  - Electricity is generated by the customer primarily for customer's own use.
  - Electricity is conveyed directly to load.
- Uptake of net metering has been relatively limited since the launch of the FIT programs in 2009:
  - By the end of 2016, there were approximately 983 facilities representing 12 MW of net-metered generation capacity
    - The average project size was 12.4 kW, 87% of facilities were solar PV, 77% of capacity was solar PV.

Ontario's Net Metering Framework

- Net metering is enabled through regulation (O. Reg. 541/05: Net Metering), which requires electricity distributors to allow eligible generators to convey electricity into the distribution grid for a credit and to bill those customers on a net-metered basis.

- Ontario electricity customers can participate in net metering by applying to their distributor to connect a renewable generation facility (e.g. solar panels) to their home or business and requesting to be net-metered.

- A customer is eligible to net meter if:
  - Electricity generation is from a renewable energy source and generated by the customer primarily for customer's own use; and
  - Electricity is conveyed directly to load prior to any electricity being conveyed to the distributor's distribution system, regardless of whether it is stored in an energy storage device.

- Key characteristics of Ontario's net metering framework include:
  - Electricity conveyed to the grid is valued at retail rates
  - Bill credits can be carried forward up to 12 months to offset future electricity bills;.
  - Customers can offset up to 100% of their load over the course of a year; and
  - Only volumetric charges can be reduced through net metering; Net-metered customers continue to pay fixed charges on their electricity bills.

~~Net Metering: Enhancing Ontario's Net Metering Framework~~

- ~~Ontario's 2013 Long-Term Energy Plan (LTEP) identified the opportunity to expand and enhance Ontario's existing net metering framework, and conducted stakeholder and public engagement on proposed net metering updates between 2015 and 2017.~~
- ~~The Ontario's updated net metering framework is intended to support customer choice in generating clean, renewable energy, help reduce load on the electricity system and enable innovative technologies and customer-utility relationships.~~
- ~~Part one of the Net Metering Regulation amendments came into force on July 1, 2017. These updates include:~~
  - ~~Establishing a credit carryover period at a consecutive 12-month period;~~
  - ~~Removing the 500 kW project capacity size limit;~~
  - ~~Enabling the pairing of energy storage with renewable energy systems; and~~
  - ~~Allowing existing net-metered customers to opt-in to the updated program.~~
- ~~In addition, the Mministry of Energy is undertaking a cost-benefit analysis to determine whether investments should be made to enable province-wide Time of Use billing for residential and small business net-metered customers.~~

Changes to Ontario's Net Metering Framework: New Business Models

Third-party ownership:

- Regulatory changes to O. Reg. 541/05 come into force October 1, 2018.
- Third Party Generators will be able to own or operate net-metered generation facilities on behalf of customers where there is an agreement for the sale of electricity between third party generators and the customer.

Virtual net metering demonstration projects:

- Regulatory changes to O. Reg. 541/05 come into force October 1, 2018.
- Distributors will be able to accommodate virtual net metering demonstration projects, if they choose to, and only if the project is selected as part of the IESO-administered Renewable Distributed Generation Integration (RDGI) Fund.
- The IESO plans to issue a call for virtual net metering proposals in Q3 2018.

Changes to Ontario's Net Metering Framework: Consumer protection

- The Ministry has implemented a number of regulatory changes that will introduce new third-party ownership net metering and virtual net metering business models into the marketplace.
- To ensure that consumers are able to make informed decisions about these business opportunities, and to protect consumers from unfair business practices, the government has introduced the following regulatory changes:
  - Changes to O. Reg. 541/05 to come in force October 1, 2018 require distributors to receive confirmation from customers that they have received appropriate information about the renewable generation system.
  - Third party net metering generators must be licensed as an electricity retailer by the OEB and will therefore be covered by regulations and codes.
  - The regulation under the *Energy Consumer Protection Act* (ECPA) will cover third party net metering consumers by requiring disclosure and other measures to ensure consumers have protection and recourse for any unfair business practices.
  - The regulatory changes to O. Reg. 389/10 will come into force October 1, 2018.

~~Net Metering:~~ Ontario's Current Net Metering Framework

- Since 2015, Ontario has ~~had a Net Metering Regulation (O. Reg. 541/05) in place since 2005, which~~ required local distribution companies (LDCs) to offer net metering to customers on request.
    - Electricity conveyed to the grid is valued at retail rates and credited to the customer's electricity bill.
    - Bill credits can be carried forward to offset future electricity bills.
    - Customers can offset up to 100% of their load.
    - Fixed charges are not affected by net metering.
- Currently, a customer is eligible to net meter if:
    - Generation is from a renewable energy source.
    - Electricity is generated by the customer primarily for customer's own use.
    - Electricity is conveyed directly to load.
- Uptake of net metering has been relatively limited ~~since the launch of the FIT programs in 2009~~:
    - By the end of 2016, there were approximately 983 facilities representing 12 MW of net-metered generation capacity
        - The average project size was 12.4 kW, 87% of facilities were solar PV, 77% of capacity was solar PV.

~~Net Metering:~~ Enhancing Ontario's Net Metering Framework

- ~~Ontario's 2013 Long-Term Energy Plan (LTEP) identified the opportunity to expand and enhance Ontario's existing net metering framework, and conducted stakeholder and public engagement on proposed net metering updates between 2015 and 2017.~~
- ~~The~~ Ontario's updated net metering framework is intended to support customer choice in generating clean, renewable energy, help reduce load on the electricity system and enable innovative technologies and customer-utility relationships.
- Part one ~~of the Net Metering Regulation amendments~~ came into force on July 1, 2017. These updates include:
  - Establishing a credit carryover period at a consecutive 12-month period;
  - Removing the 500 kW project capacity size limit;
  - Enabling the pairing of energy storage with renewable energy systems; and
  - Allowing existing net-metered customers to opt-in to the updated program.
- In addition, the ~~M~~ministry ~~of Energy~~ is undertaking a cost-benefit analysis to determine whether investments should be made to enable province-wide Time of Use billing for residential and small business net-metered customers.

Smart Grid

~~Technology~~ Overview - Storage Technology

- 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.
- 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.
- 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~~ With dramatic ~~falls in~~ cost reductions 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.~~

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 110MW of energy storage in 4 separate procurements;
  - Ministry Smart Grid Fund supports projects that involve storage;
  - The Ministry and IESO have completed separate studies on energy storage; and,
  - LDCs have additional customer facing projects that involve storage.
- Lessons learned through these initiatives helped inform the ~~M~~ministry's grid modernization platform~~, as outlined in the 2017 Long-Term Energy Plan (LTEP)~~
- ~~The LTEP outlines~~ and identify steps to overcome barriers so that Ontario's ratepayers can enjoy the full benefits of energy storage, where cost-effective.

Types of Energy Storage

- Ontario recognizes three different types of electrical energy storage (IESO Storage Study – 2016). All types of storage suffer losses – they are not 100% efficient, and some amount of power is lost in the storage process.
  - Type 1 – Discharging electricity back to the grid / end user:
    - Power is drawn from the grid or directly from a generation source, stored, then discharged in the form of electrical energy.
    - This type of storage is the primary focus of the IESO 50MW procurement.
  - Type 2 – Offsetting future electricity needs:
    - Electrical power is used to heat or cool materials that are later used for thermal conditioning.
    - This type of storage is commercially available and is predominantly a customer asset with limited grid benefits.
  - Type 3 – Removing the power from the grid to offset other fuels:
    - Hydrogen generation using electrolysis is a good example of this type of storage; so is electric mobility.
    - This type of storage is become increasingly common as the fuel and transportation sectors move to alternative / clean fuels.

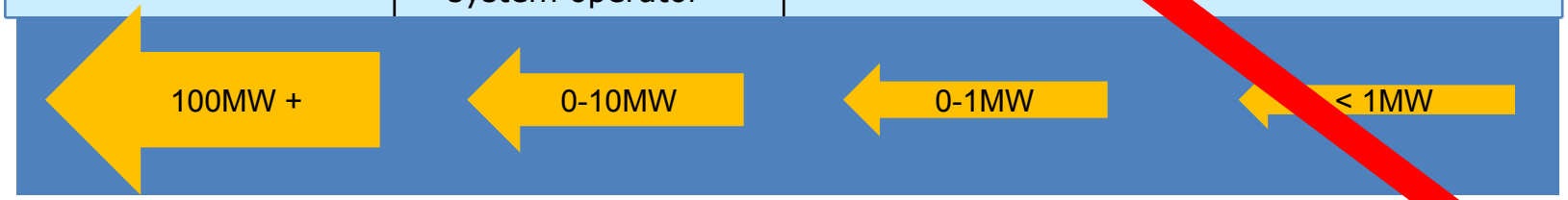
Using Energy Storage

- ~~Energy storage is the only grid asset that acts both as a load and a generator. As such, traditional regulatory and market rules may not accommodate this technology.~~
- Energy storage can perform a wide range of services depending on:
  - Where it is connected, such as:
    - A customer asset behind-the-meter,
    - In a residential neighbourhood (the "grid edge"),
    - Next to a large load front-of-meter,
    - Paired with renewable generation,
    - Next to a high-voltage transmission asset;
  - The reason for connecting the storage, including:
    - Ensuring smooth grid operation (known as "ancillary services"),
    - Providing customer reliability and power quality,
    - Providing capacity services to the grid on demand; and
  - The composition of the electricity grid, which is characterized by:
    - Daily and seasonal changes in demand,
    - The energy supply mix and its ability to respond to demand changes, and
    - The public policy environment and how it influences infrastructure investments and regulatory frameworks for the energy sector. (what does this mean?)

Potential Value of Storage in Ontario

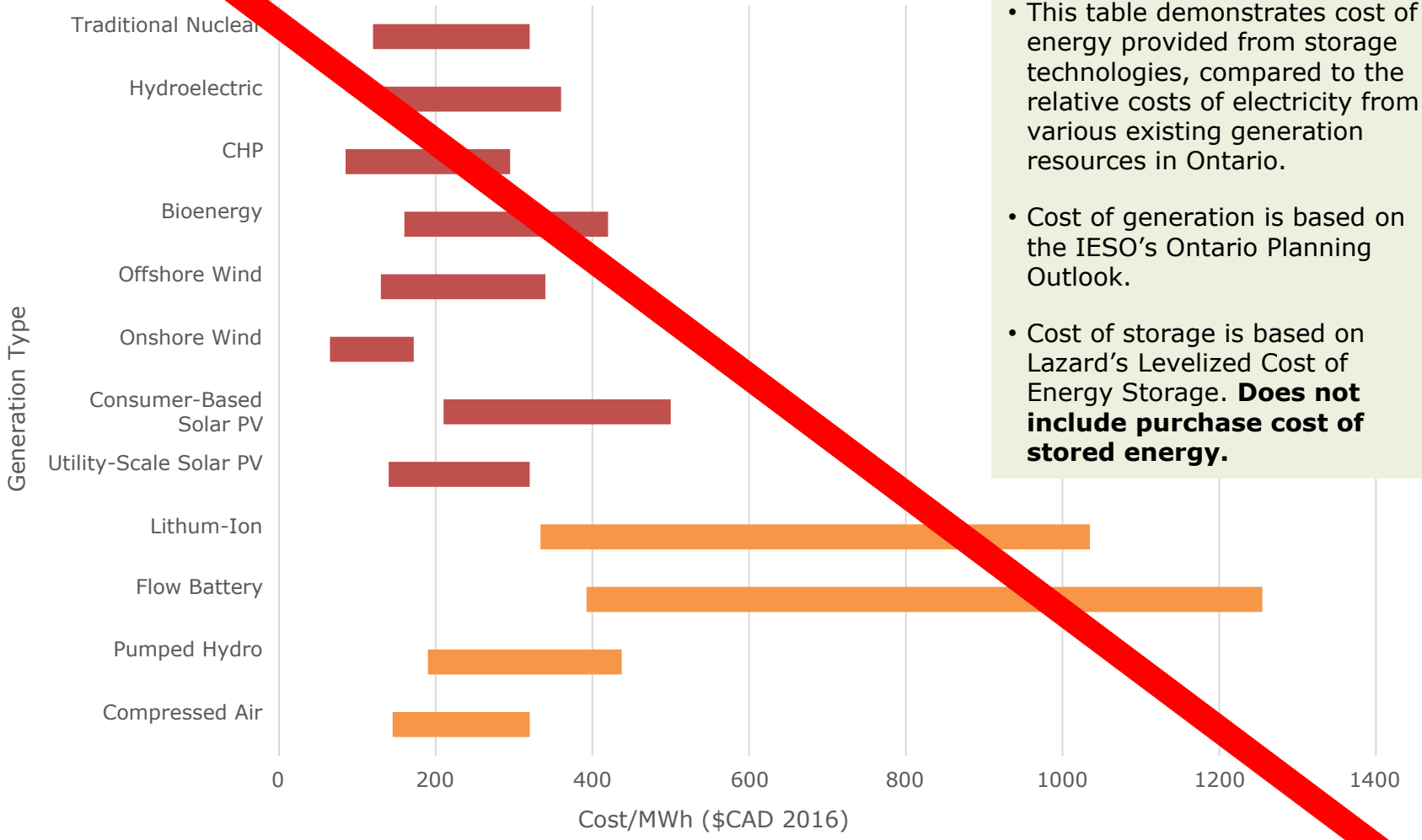
Energy storage can provide potential benefits from both the system perspective (in-front of the meter) and the customer perspective (behind-the-meter). Examples include:

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 ($2016/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 the IESO's Ontario Planning Outlook.
- Cost of storage is based on Lazard's Levelized Cost of Energy Storage. **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

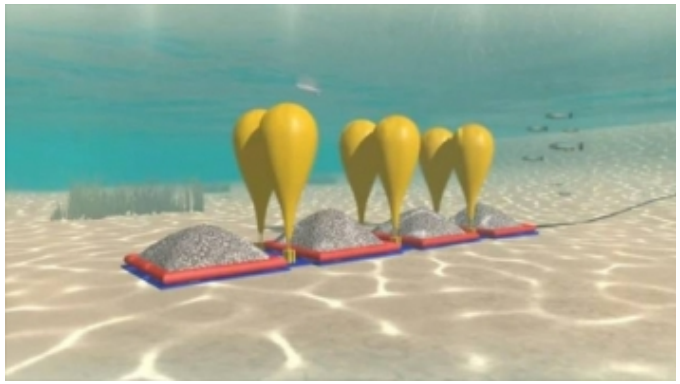
- Applications of technology are varied – bulk system, distribution grid, behind-the-meter, power-to-gas
- Many storage technologies are still at demonstration stage and do not have a clear performance record to support broader / greater uptake

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

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.

See Appendix 2 for additional examples of energy storage.

Recent Successes of Electricity Storage in Ontario

- The IESO recently completed an RFP for regulation service, an important grid-balancing function that matches generation and demand on a moment-by-moment basis. These services are important for the stability of the power system. The winning parties - Hecate Energy in Loyalist Township and Saturn Power in Owen Sound – will provide 55MW of energy storage.
- In November 2017, NRStor announced the signing of a $120M financing facility with Swiss based SUSI Energy Storage Fund (SESF), to facilitate rolling out behind-the-meter (BTM) energy storage solutions at commercial, industrial, and institutional customer sites in Canada.
- The Ministry has also amended the Global Adjustment (GA) regulation to ensure that in-front-of-the-meter Class B energy storage facilities are only charged GA on energy that they do not return to the grid. This regulation will come into effect on July 1, 2018.

Smart Grid - Overview

- The Smart Grid Fund (SGF) was launched in 2011 to support innovation in Ontario's electricity sector. Innovation has produced a wide range of technologies – home energy management, grid automation, energy storage, microgrids, cyber security and EV integration.
- Through the ~~F~~fund, Ontario companies have solved problems on distribution grids, and utilities have increased their understanding of how the smart grid can benefit the system and their customers.
- ~~As part of the government's grid modernization strategy, t~~The Ministry ~~will~~ is building on this success ~~by~~ through a renewed and enhanced ~~the~~ Smart Grid Fund, which launched in April 2018.~~.~~
- ~~An enhanced Smart Grid Fund, to be launched in Q1 2018, will The goal is to~~ The fund's focus is on encouraging a culture of innovation ~~within the electricity sector~~ that explores new solutions for integrating many technologies, tests new business models, integrates electricity and other energy resources and generates new ideas for advancing grid modernization.

~~Original~~ Smart Grid Fund to Date

- There have been 3 calls for applications for the SGF. The initial call showed where the innovation sector saw the greatest commercial opportunities. ~~The Ministry used subsequent rounds to try and target particular technology types and outcomes.~~
- Each call for applications was met with an over-subscription of applications for the program to review and select applicants from.
- ~~The 2016 program survey of LDC and vendor applicants clearly indicated that SGF was enacting the objectives of the Fund by supporting companies with commercialization prospects both in Ontario and abroad, strengthening Ontario's position in the sector, and enabling LDCs to learn and work with emerging technologies.~~
- ~~Further, 100% of LDC respondents in the SGF survey indicated that the SGF changed their perceptions on piloting new technologies, while over 90% indicated that the program supported validating these technologies and identifying use cases.~~

Rounds	Technology Focus Area
2011 - Round 1	• Technology neutral. Projects focussed on home energy management systems (HEMS), grid automation, data analytics, and cyber security.
2013 – Round 2	• Open call, but applications focussing on distributed energy resources was encouraged (electric vehicles, energy storage and microgrids).
2015 – Round 3	• Open call, but with applications for high-value smart grid technologies and functionalities identified in *Ontario Smart Grid Assessment and Roadmap*.

Renewed SGF Objectives

Objective	Actions
1. Address Barriers to Grid Modernization	Target funding for utilities that will help address barriers to grid modernization in Ontario, and reduce risk and uncertainty in smart grid deployments.
2. Advance Ontario's Innovation Economy	Open and targeted calls for technology demonstrations that will create jobs and economic development opportunities for innovators with an Ontario presence that are seeking to commercialize and export smart grid technologies.
3. Position Ontario at the Forefront of Smart Grid	Support the demonstration of the innovative utility business models, emerging smart grid technologies, and other initiatives that both respond to changes in the sector and have the potential for generating value for Ontario's utilities and ratepayers.

Agency Funding for Energy Sector Innovation

Energy Efficiency Innovation Funds

- **IESO Conservation Fund ($9.5 million per year)**
  - The Conservation Fund provides financial support for innovative electricity conservation technologies, practices, research, and programs.
  - Example of funded project: Development and demonstration of an intelligent energy management solution for multi-unit residential buildings (MURBs):
    - Uses a range of wireless, cloud-enabled building system sensors and controls to minimize the energy required to heat, cool, and ventilate buildings.
    - Partners: Timbercreek Asset Management, Navigant.
- **IESO LDC Innovation Fund ($70 million from 2015 to 2020)**
  - The LDC Innovation Fund is open to LDCs to support pilot and market testing of new measures, programs and delivery models under the 2015 to 2020 Conservation First Framework (CFF).
  - Examples:
    - Toronto Hydro Data Centre Pilot, testing the savings and costs of energy optimization measures for data centres.
    - Hydro One Low-Income Air Source Heat Pump Pilot, offering direct installation of heat pumps to electrically-heated low-income customers.
- **IESO LDC Collaboration Fund ($25 million from 2015 to 2020)**
  - Encourages LDC-to-LDC and LDC-natural gas utility collaboration under the CFF.
  - Example: Greater Toronto Hamilton Area (8 LDC) joint procurement for Save On Energy Small Business Lighting delivery services – an estimated savings of 12% of the overall planned program costs.

Nuclear Innovation

Ontario's Nuclear Innovation

- Ontario's nuclear industry is a source of innovation, job-creation and export opportunities.
  - Ontario's nuclear sector is comprised of more than 180 companies and supports approximately 60,000 jobs;
  - Nuclear is part of Canada's national science and innovation sector, involving over 30 universities and six major research centres, many of them located in Ontario; and
  - Canadian nuclear reactor technology has been exported to Argentina, Romania, South Korea, China, Pakistan and India.
- Ontario's expertise in nuclear energy has also enabled it to be a leading jurisdiction in nuclear medicine.

<u>Nuclear Medicine – Medical Isotopes</u>

- Ontario's nuclear reactors transform chemical elements, such as cobalt, into isotopes that can diagnose and treat life-threating diseases.
- Cobalt-60 is a key medical isotope used for 10 million cancer therapy treatments around the world each year. Currently, approximately 70 per cent of the world's supply of medical grade Cobalt-60 is produced in Ontario.
- New and innovative applications for medical isotopes continue to emerge, for instance, Cobalt-60 harvested in Ontario was used to sterilize mosquitos to combat the spread of the Zika virus.

Ontario's Nuclear Innovation (cont'd)

Nuclear Research – Emerging Technologies

- Ontario's nuclear industry (e.g., academia, government agencies, private-sector) are pursuing a number of nuclear innovations for energy and non-energy applications, including:
  - Small Modular Reactors (SMRs): SMRs are a new generation of nuclear power reactors with smaller footprints than convention reactors and the promise of lower costs from mass production;
  - Nuclear Fuel Research: Technological innovations could lead to the recycling of used nuclear fuel or alternatives to uranium fuel to power nuclear reactors; and
  - Hydrogen: Ontario's nuclear technology could be used for large-scale hydrogen production. Hydrogen is a source of low-carbon energy that has the potential to replace gasoline for transportation or natural gas for heating.
- The Ministry of Energy will continue to monitor emerging technologies and collaborate with nuclear industry partners to explore opportunities for nuclear innovation.

Ontario's Nuclear Innovation (cont'd)

Nuclear Research – Emerging Technologies

- Ontario's nuclear industry (e.g., academia, government agencies, private-sector) are pursuing a number of nuclear innovations for energy and non-energy applications, including:
  - Small Modular Reactors (SMRs): SMRs are a new generation of nuclear power reactors with smaller footprints than convention reactors and the promise of lower costs from mass production;
  - Nuclear Fuel Research: Technological innovations could lead to the recycling of used nuclear fuel or alternatives to uranium fuel to power nuclear reactors; and
  - Hydrogen: Ontario's nuclear technology could be used for large-scale hydrogen production. Hydrogen is a source of low-carbon energy that has the potential to replace gasoline for transportation or natural gas for heating.
- The Ministry of Energy will continue to monitor emerging technologies and collaborate with nuclear industry partners to explore opportunities for nuclear innovation.

Appendix – Energy Storage Technologies

Types of Energy Storage

- Ontario recognizes three different types of electrical energy storage:
  - Type 1 – Discharging electricity back to the grid / end user:
    - Power is drawn from the grid or directly from a generation source, stored, then discharged in the form of electrical energy.
    - This type of storage is the primary focus of the IESO 50MW procurement.
  - Type 2 – Offsetting future electricity needs:
    - Electrical power is used to heat or cool materials that are later used for thermal conditioning.
    - This type of storage is commercially available and is predominantly a customer asset with limited grid benefits.
  - Type 3 – Removing the power from the grid to offset other fuels:
    - Hydrogen generation using electrolysis is a good example of this type of storage; so is electric mobility.
    - This type of storage is become increasingly common as the fuel and transportation sectors move to alternative / clean fuels.

Storage Technologies and Functions

- Electrical energy storage focuses on storing electrical power through electro-chemical reactions (e.g. batteries, hydrogen generation), thermal energy (e.g. heat, cold), or kinetic energy (e.g. flywheels, compressed air storage).
- There are a number of different types of energy storage that can serve different functions, and that are at different development stages:

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