Energy Storage Overview

IEEE Lunch & Learn

Shivani Chotalia, P.Eng., June 2022

NRSTOR INC

Who Am I?

I'm passionate about clean technology & innovation as well as climate action.

Shivani Chotalia, P.Eng.

- Grew up in Edmonton, Alberta
- Studied Green Process Engineering & Business at Western University / Richard Ivey School of Business
- Involved with Engineers Without Borders
- Opportunities to travel throughout university (China, Ghana)
- Worked with startups and in clean tech (Harvest Biogas, GreenMantra Technologies, Venture for Canada)
- Have been working with NRStor for almost 7 years and currently am the Director of Development & Partnerships
- Founded Bold Realities, a platform for dialogue about reconciliation in corporate Canada
- Volunteer as a mentor for Indigenous youth with Outside Looking In
- Board Member of Environmental Defense Canada
- Advocate for Women in STEM (and got to be in a calendar!)

Agenda

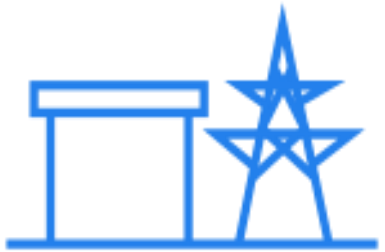
1. About NRStor Incorporated
2. What is Energy Storage
3. Energy Storage Technologies & Project Examples
4. How Does Energy Storage Create Value
5. Applications of Energy Storage & Project Examples
6. Challenges & Learnings
7. Where is the Market Going

NRStor Incorporated

NRStor works closely with communities, utilities and energy consumers to identify opportunities and deliver world class projects

- NRStor was founded in 2012 to develop low cost, reliable energy storage projects that provide value-add services to customers

- Our success stems from our:
  - **Woman-Led Management Team.**
  - **Proven Track Record Deploying First of Kind Projects.**
  - **Partnership-First Business Model.**
  - **Diversified Value Streams and Monetization Strategy.**
  - **Trusted Relationships.**
  - **Impact Investments.**



Utilities

Microgrids

Commercial & Industrial

Distributed & Residential

NRStor's Strategic Partnerships

We build collaborative partnerships across the energy ecosystem with industry-leading technology suppliers, financial institutions, and academic institutions. Here is a snapshot of organizations that we've worked with:

Utility Partners

- ieso – Independent Electricity System Operator
- Énergie NB Power
- hydro one
- Prince Edward Island Canada

Knowledge Partners

- University of Waterloo
- Energy Storage Canada
- Verschuren Centre – For Sustainability in Energy and the Environment
- Ryerson University
- MaRS
- OEA

Technology Partners

- Tesla Energy
- Aecon
- Stantec
- Leclanché – Energy Storage Solutions
- res – power for good
- Hydrostor
- temporal
- Hatch
- Honeywell
- BYD

Indigenous and Community Partners

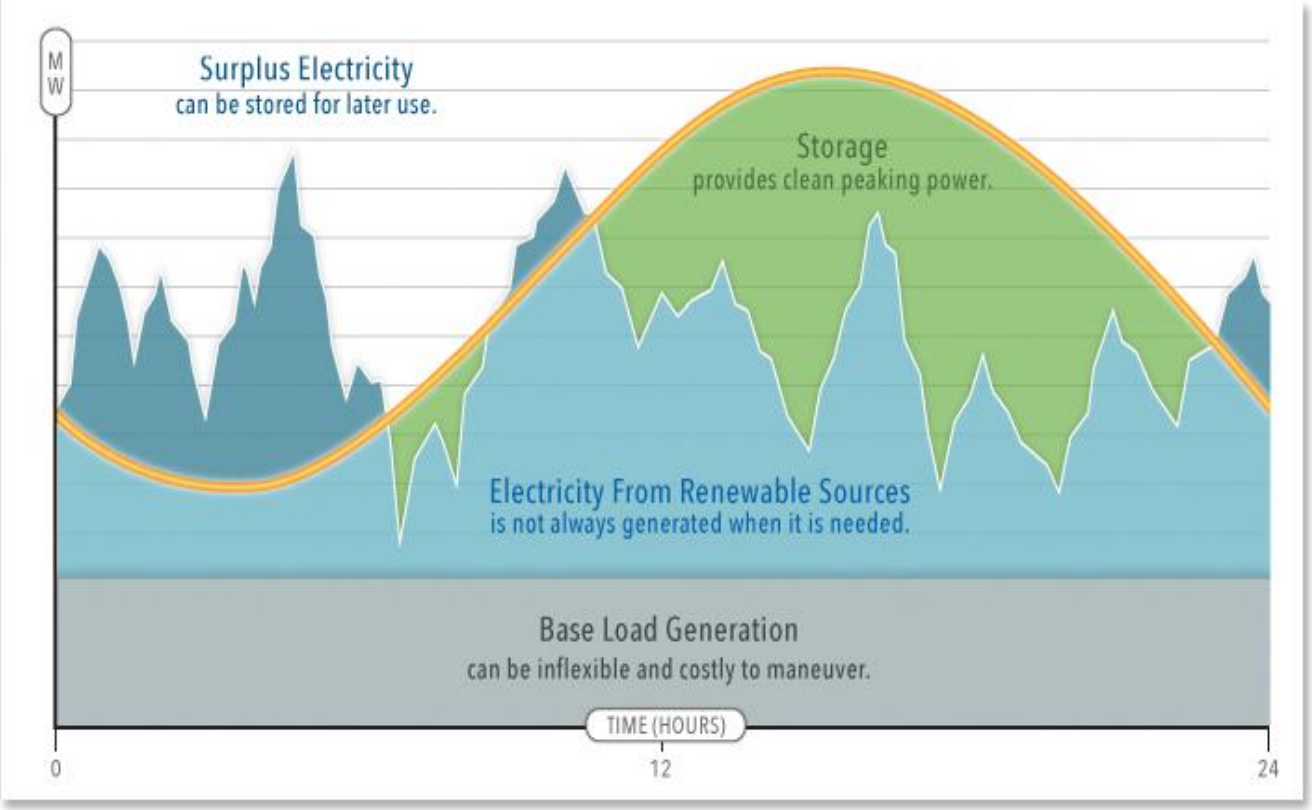
- Arviat Hamlet Council
- Six Nations of the Grand River Development Corporation
- Mi'gmawe'l Tplu'taqnn
- FHQ Developments

Financial Partners

- bdc
- Ontario Centres of Excellence
- RBC
- Canada Infrastructure Bank
- Sustainable Development Technology Canada
- LiUNA! – Feel the Power
- Fengate

Unlocking Value with Energy Storage

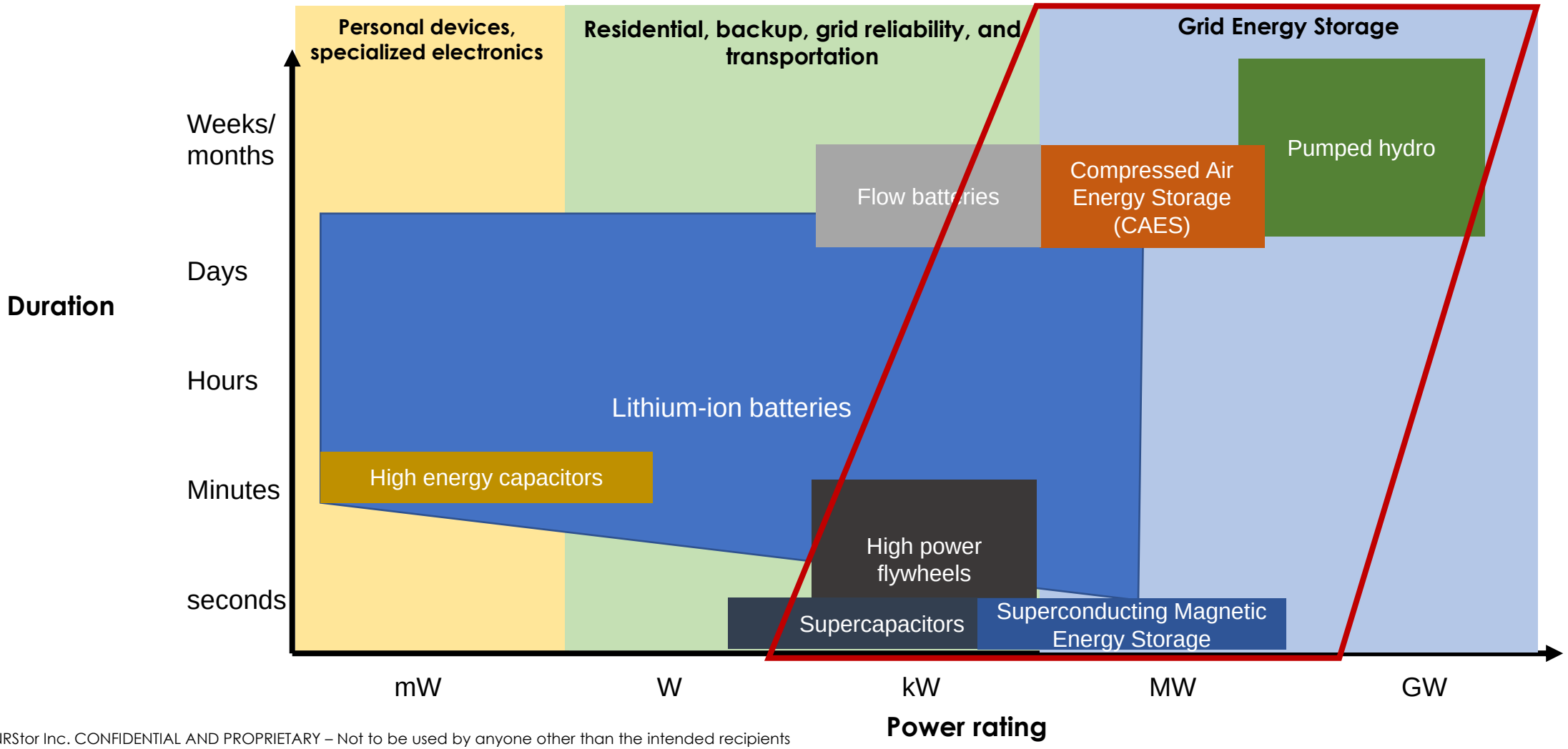
Energy storage can unlock local and system benefits providing better value and utilization at a lower cost



- Energy storage can balance energy supply and demand to maximize the use of renewable energy, and also make the energy system more reliable.
- Energy storage allows wind or solar energy to be stored and used when the wind is not blowing, or the sun is not shining.
- Without energy storage, variable renewable generation (wind and solar) may be limited to ~20% penetration of energy needs. Storage is needed to move beyond that.
- **Energy storage improves the efficiency of the whole system**

Energy Storage Technologies

Various Energy Storage Technologies are well-suited for different applications



Energy Storage Technologies

Various Energy Storage Technologies are well-suited for different applications

2MW Minto Flywheel Facility	4MW Strathroy Battery Facility	2MW Goderich CAES Facility
Service: Frequency Regulation	Service: Frequency Regulation	Service: Capacity, Operating Reserve
- Flywheel life up to 100,000 cycles. 30 year+ asset.	- BESS life up to 10,000 cycles. Degrades with usage.	- CAES has no degradation. 30 year+ asset.
- Flywheel RTE ~95%	- BESS RTE 85-95%	- CAES RTE 40-70%

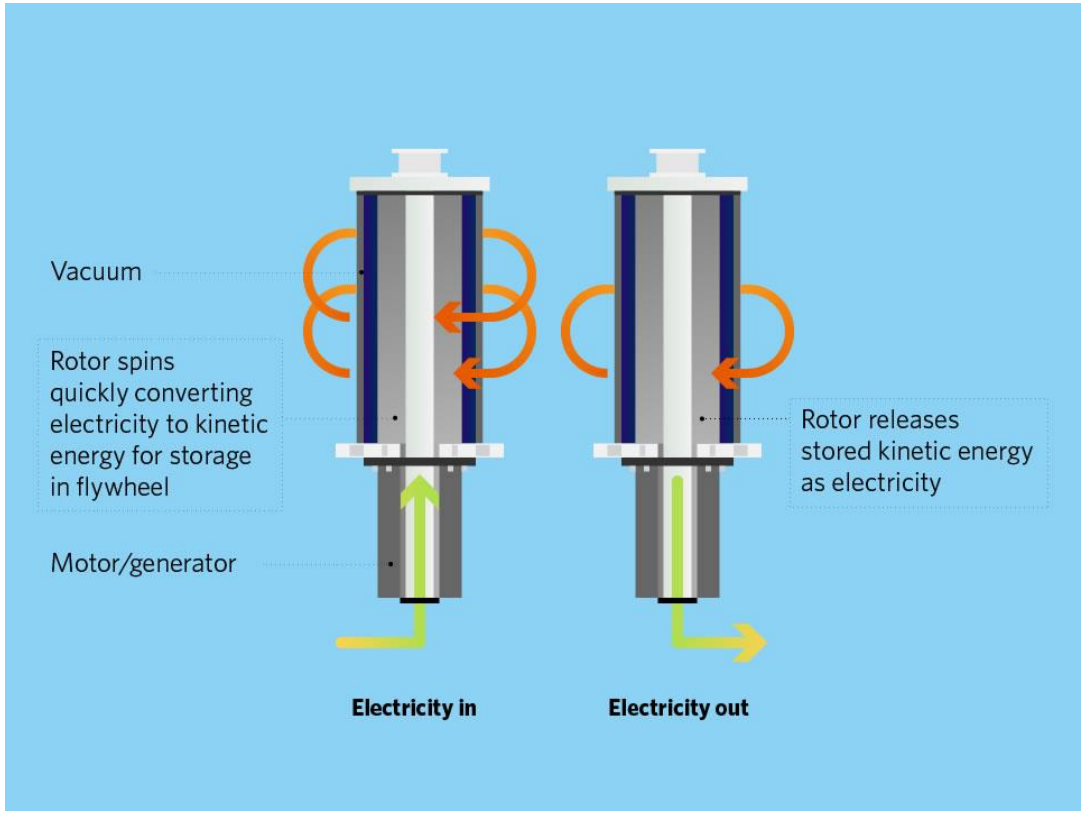
Battery Energy Storage Technology

There are many types of Battery Energy Storage including Lithium Ion, Flow, Solid State, Lead-Acid & Other Chemistries

- Bloomberg New Energy Finance predicts that lithium-ion batteries will cost less than $100 kWh by 2025. Lithium-ion batteries are by far the most popular battery storage option today and control more than 90 percent of the global grid battery storage market.
- Flow batteries are an alternative to lithium-ion batteries. While less popular than lithium-ion batteries—flow batteries make up less than 5 percent of the battery market—flow batteries have been used in multiple energy storage projects that require longer energy storage durations.
- Solid-state batteries contain solid electrolytes which have higher energy densities and well suited for large-scale grid applications.
- Other batteries chemistries under development such Zinc-Ion.

Flywheel Energy Storage Technology

Flywheels are effective for load-leveling and load-shifting applications. Flywheels are known for their long-life cycle, high-energy density, low maintenance costs, and quick response speeds. Motors store energy into flywheels by accelerating their spins to very high rates (up to 50,000 rpm). The motor can later use that stored kinetic energy to generate electricity by going into reverse.



Minto Flywheel Facility

NRStor's 2MW Minto Flywheel Facility has been operating for over 5 years

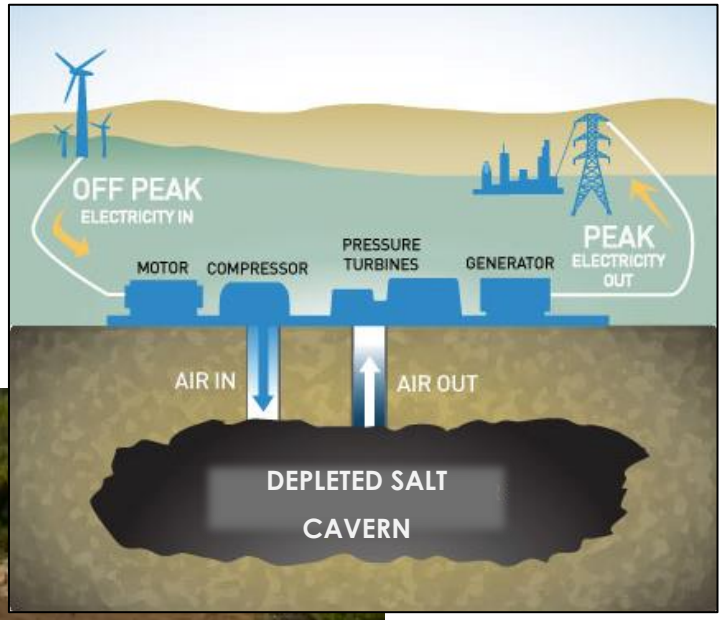
- Minto provides frequency regulation to the Ontario grid under a contract with the IESO.
- Energy storage can respond much more quickly and precisely compared to traditional assets.
- The facility is able to provide ***more than 2x the value*** that traditional resources can provide.
- **Fun Fact:** Every day the surfaces of the flywheels spin a distance equal to going around the Earth almost 3 times (115,000 km per day). Since the facility went online in July 2014, the flywheels have traveled around the world over 8000 times.

Goderich Compressed Air Energy Storage (CAES) Project

The Goderich Project is the first commercial fuel-free Compressed Air Energy Storage (CAES) facility in the world

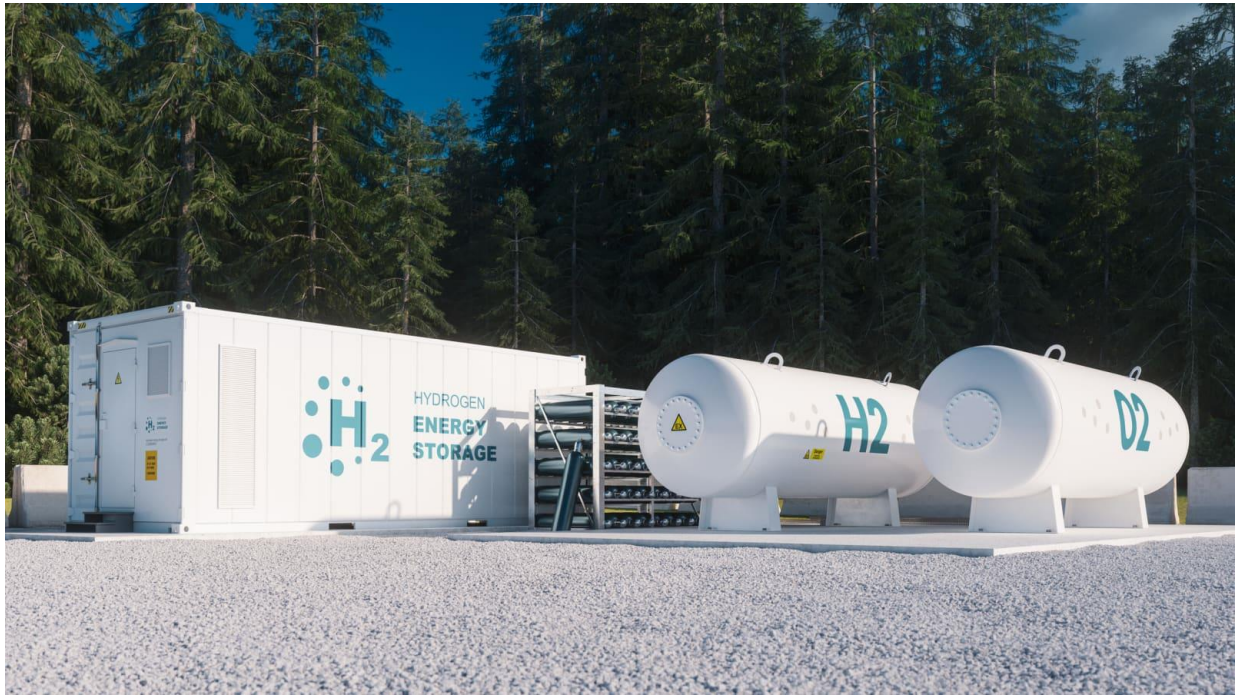
- The Goderich project uses innovative fuel-free A-CAES technology from Hydrostor. A-CAES is a long-duration, non-emitting, cost-effective energy storage solution that can be flexibly sited at locations of high grid need to deliver hundreds of megawatts and 4 to 24+ hours of storage.

- With compressed air storage, air is pumped into an underground hole, most likely a salt cavern, during off-peak hours when electricity is cheaper. When energy is needed, the air from the underground cave is released back up into the facility, where it is heated and the resulting expansion turns an electricity generator. Heat from compression is stored in thermal tanks and reused during the expansion phase.

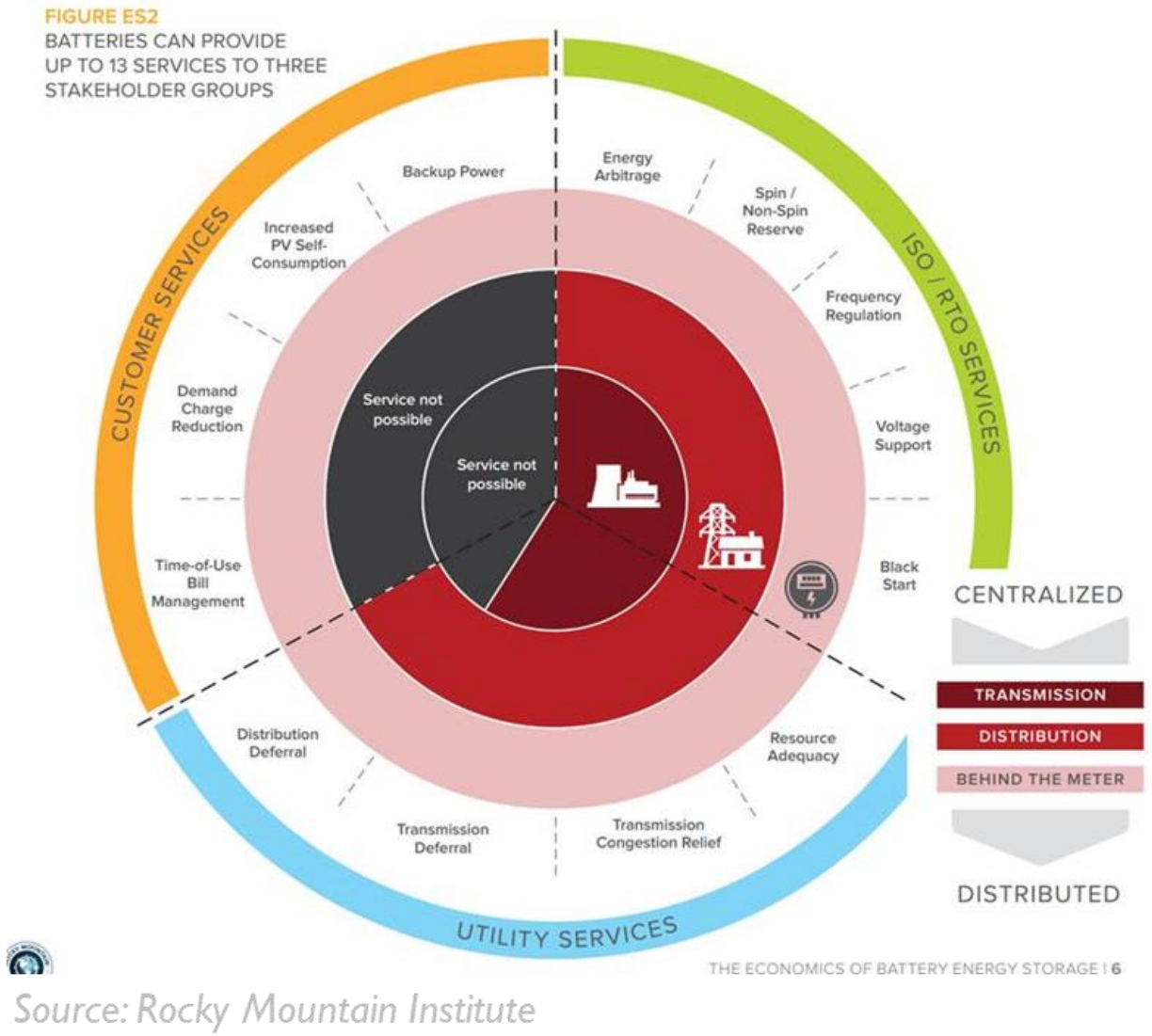


Hydrogen as Long Duration Energy Storage

Hydrogen fuel cells generate electricity by combining hydrogen and oxygen, the process can also be reversed, making it useful for energy storage: electrolysis of water produces oxygen and hydrogen. Fuel cell facilities can, therefore, produce hydrogen when electricity is cheap, and later use that hydrogen to generate electricity when it is needed.



How Does Energy Storage Create Value?



Source: Rocky Mountain Institute

Energy storage resources are capable of providing multiple services at a cost that is lower than the status quo including:

- Firm, Clean Peaking Capacity
- Non-Wires Alternative (NWAs)
- Renewable Generation Integration
- Gas Plant Efficiency Savings
- Demand Response (DR)
- Ancillary Services
- Energy Arbitrage

Providing Value Across the Energy Supply Chain

A portfolio of energy storage assets across the grid can maximize value

UTILITY SCALE ENERGY STORAGE (50-250 MW)

- Provide needed capacity to transition away from fossil fuel generation, and avoid gas build outs
- Provide system services and optimization of the broader grid
- Defer conventional infrastructure costs

COMMERCIAL & INDUSTRIAL STORAGE (10-50 MW)

- Solve power quality issues for major energy consumers in the province
- Save consumers on energy costs
- Provide utility with system services and maximize asset utilization

DISTRIBUTED ENERGY STORAGE (5 kW units)

- A fleet of 10,000+ residential batteries can maximize value to homeowners as well as system operations
- Provide homeowners with improved local power quality and resilience at an affordable cost
- Aggregate assets to provide utility with system services to better manage peak demand and shift loads

Oneida Energy Storage Project

NRStor recently announced the 250 MW / 1000 MWh Battery Energy Storage Project we are developing in partnership with Six Nations of the Grand River Development Corporation, and Canada Infrastructure Bank

Representing the largest project of its kind in Canada, the proposed Oneida Energy Storage project includes development of a 250 megawatt / 1000 megawatt-hour energy storage facility in Southwestern Ontario.

The facility would provide clean, reliable power capacity. It would draw and store existing surplus baseload and renewable energy during off peak periods. Power would be released to the Ontario grid when energy demand is at its peak. In addition, the energy storage facility would help stabilize Ontario's electricity sector by providing important grid balancing services.

By helping to better use the existing assets of Ontario customers, greater efficiencies would be secured leading to a more affordable and cost-effective electricity system.

Project Highlights:

- Largest battery storage project in North America and amongst the largest in the world
- $400M to $760M net savings to Ontario ratepayers*
- 4.1 Million tonne reduction in CO2*
- Over 900,000 hours of local employment*
- Significant Indigenous ownership in low carbon infrastructure assets

**over the 20-year life of the asset*

Arviat Clean Energy Microgrid Project

NRStor is working in partnership with the Hamlet of Arviat in Nunavut to develop the territory's first major clean energy microgrid project, targeting >50% diesel reductions

The Project will include:

200 kW Bifacial Solar System

1.6 MW Wind Turbines

2 MW / 2 MWh Battery Energy Storage

Preliminary analysis shows that over 20 years, this project could:

- Prevent over 160 thousand tonnes of CO_2 from entering the atmosphere
- Avoid burning ~ 30 million litres of diesel fuel

Cecil Virtual Power Plant (VPP) Project

Canada's first home battery virtual power plant featuring the Tesla Powerwall

BRINGING AFFORDABLE RESILIENCY TO THE DOWNTOWN CORE

THE OPPORTUNITY

We are launching the first major residential battery (Tesla Powerwall) rental program in Canada in one of Canada's most densely populated and electrically congested neighbourhoods. Our project will provide affordable resiliency to homeowners while delivering much-needed local and system-wide services to reduce electricity costs and emissions while avoiding costly substation upgrade infrastructure.

We want to support Toronto's ambitious sustainability targets through an equally ambitious VPP pilot project.

BENFITS OF ENERGY STORAGE

Homeowners

- **Increased Resiliency:** Onsite storage improves power quality and better protects essential systems.
- **Peak Energy Cost Reductions:** Optimizing local energy consumption based on TOU price signals reduces peak energy charges to customers.

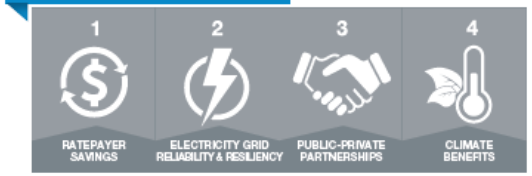
Toronto Hydro & City of Toronto

- **Utility Benefits:** Toronto Hydro will be able to better manage peak demand and defer conventional infrastructure costs, while improving local power quality & resiliency.
- **TransformTO Goals:** This project directly supports the City's TransformTO storage and climate objectives.

Ontario's Independent Electricity System Operator

- **System Services:** Energy storage can deliver system services including DR, OR, etc.
- **DER Test Services:** The microgrid can deliver new IESO DER services including ramping, transactive energy, etc.

BENEFITS FOR TORONTO



COST-EFFECTIVE, QUICK DEPLOYMENT

The Tesla Powerwall is a rechargeable lithium-ion home battery that optimizes energy usage. Homeowners living in the service area (below) are eligible to rent a Tesla Powerwall for **$29.99/month**, plus a one-time connection charge of **$1,500**, representing a >50 lifecycle cost savings compared to a standard direct system purchase.

STRATEGIC SITING: ELIGIBLE ZONE

Energy storage can be strategically sited to deliver a combination of local and system-wide benefits.

Our project will aggregate a "fleet" of Tesla Powerwall units connected to the Cecil street substation to act as a decentralized battery. Customers located in the Spadina and College area of Toronto will be eligible to participate in this program (subject to additional pilot terms and conditions):

GOVERNMENT PRIORITY

"Our government is building an electricity system that works for the people,.. We are taking a comprehensive, pragmatic approach to building the modern, efficient, and transparent electricity system that the people of Ontario deserve".

– Hon. Rod Phillips, MoECP

ABOUT NRSTOR INC.

NRStor is an industry-leading energy storage project developer. We provide innovative solutions based on our unparalleled understanding of energy storage technologies, their costs, and the benefits they can provide.

We have earned our reputation as a leader in energy storage. NRStor built the first commercial flywheel storage project in Canada and is now building the first commercial fuel-free compressed air energy storage project in the world. We have over 100MW of lithium ion battery projects in development and a growing pipeline of exciting innovative projects.

A CONSORTIUM THAT CAN EXECUTE

- **NRStor:** Battery developer/owner, commercial ops. manager
- **MPOWER:** Canada's certified installer of the Tesla Powerwall
- **Enbridge Gas:** Utility integration and overall program growth
- **Toronto Hydro & City of Toronto:** Utility connection and integration
- **Tesla Energy:** Tesla Powerwall supplier and aggregation platform

TESLA POWERWALL FUNCTIONALITY

- Save on energy during on-peak hours
- Receive alerts in the event of a power outage
- Rely on a 12 to 24-hour backup power supply for your essential appliances and devices in your home
- Monitor your home energy use in real-time on your phone from anywhere

Control Your Energy from Anywhere

Seamlessly monitor and automatically manage your Powerwall, solar panels, Model S or X anytime, anywhere with the Tesla App.

PROJECT PARTNERS

ENBRIDGE · TESLA ENERGY · MPOWER · TORONTO HYDRO · NRSTOR

Considerations When Developing Energy Storage Projects

We have encountered many challenges & lessons learned while working to develop a new industry

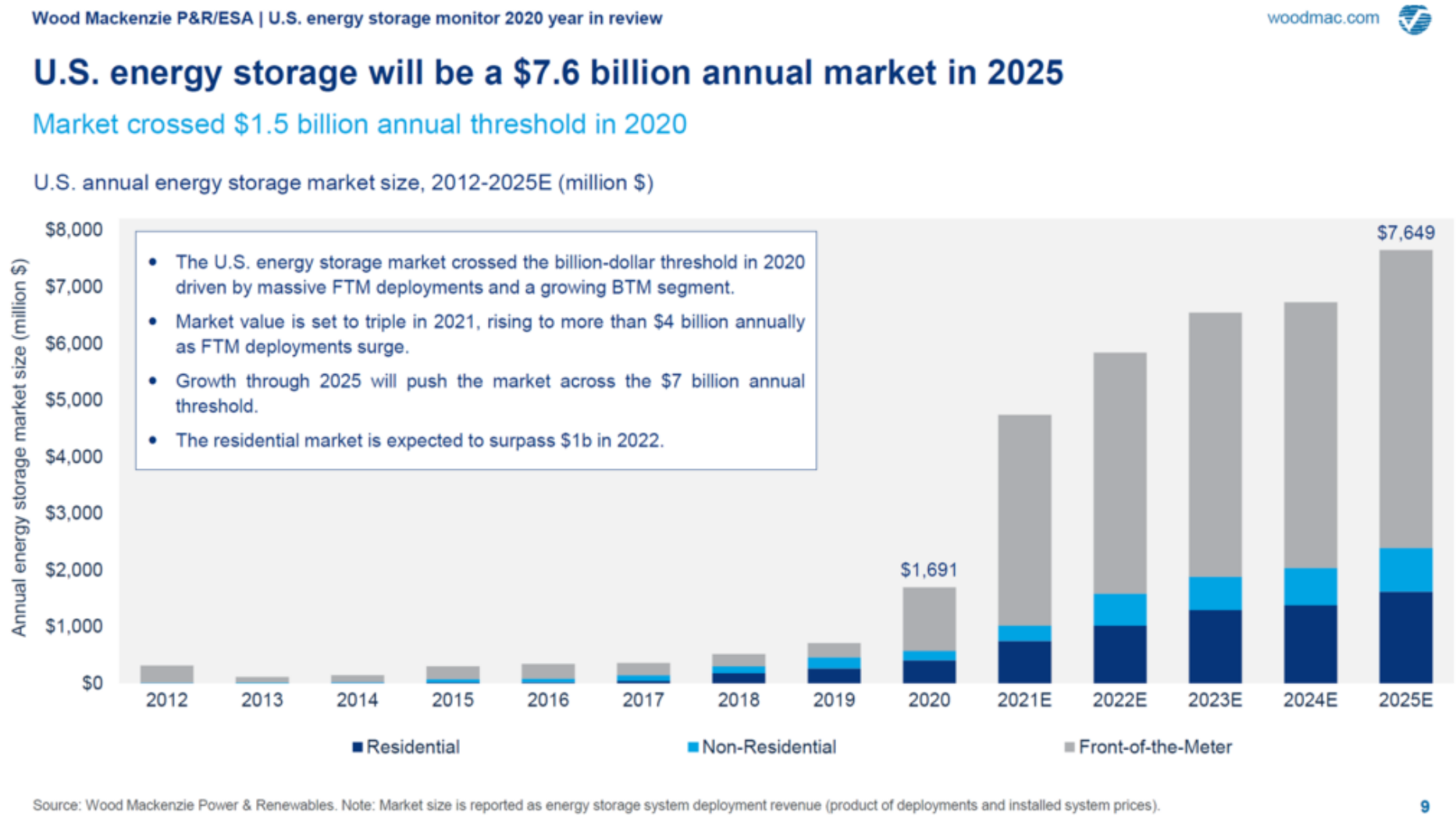
- **Project Specific Design:** Each project is unique in its requirements and objectives. Energy storage is not a one-size-fits all solution. There is a wide diversity of technologies and project designs that must be suited to the particular application.

- **Permitting:** Processes for permitting energy storage have not been defined in many jurisdictions. This can cause significant delays and must be addressed by regulators. Ex: Goderich Project

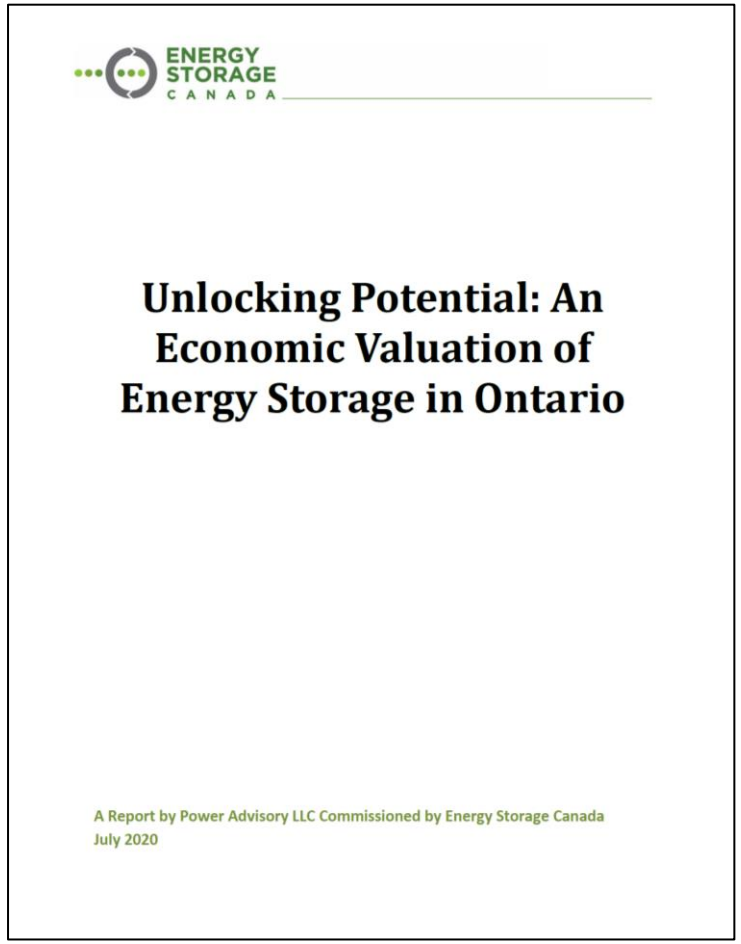
- **Regulatory Barriers:** Regulator barriers and resistance to change still exist in many jurisdictions. Options must be assessed on an even playing field, factoring in long term clean energy targets and the cost of carbon. Ex: Utility Integrated Resource Plans, Nunavut IPP Program

- **Interconnection Studies:** Many jurisdictions do not yet recognize the unique characteristics of energy storage in their study processes. The purpose of energy storage is to operate to alleviate system constraints, however studies analyze "worst case" scenarios where storage contributes to and exacerbates congestion, artificially limiting the ability of storage to solve grid issues

The Market for Energy Storage Continues to Grow Rapidly



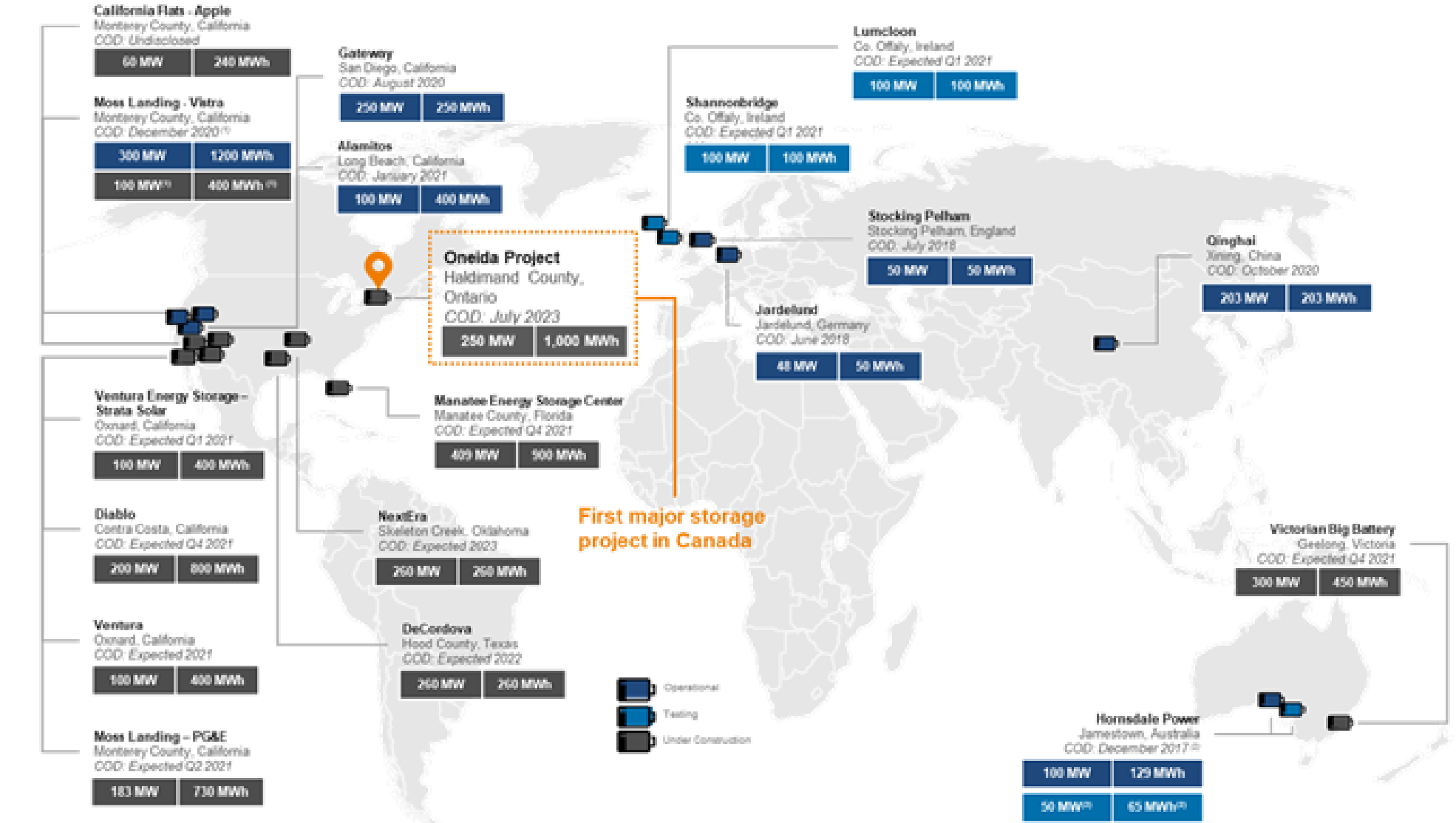
Energy Storage Has Large Potential to Create Savings Across Canada



- Energy Storage Canada conducted a third party study finding that **1000 MW of energy storage** deployed in Ontario over the next decade can provide as much as **$2.7 Billion in total savings for Ontario ratepayers**
- *https://www.energystoragecanada.org/unlocking-potential*

- Ontario's Independent Electricity System Operator (IESO) has identified significant capacity shortfalls in the province and is currently beginning RFP processes to address capacity and reliability needs

Energy Storage Is Being Deployed At Scale Globally

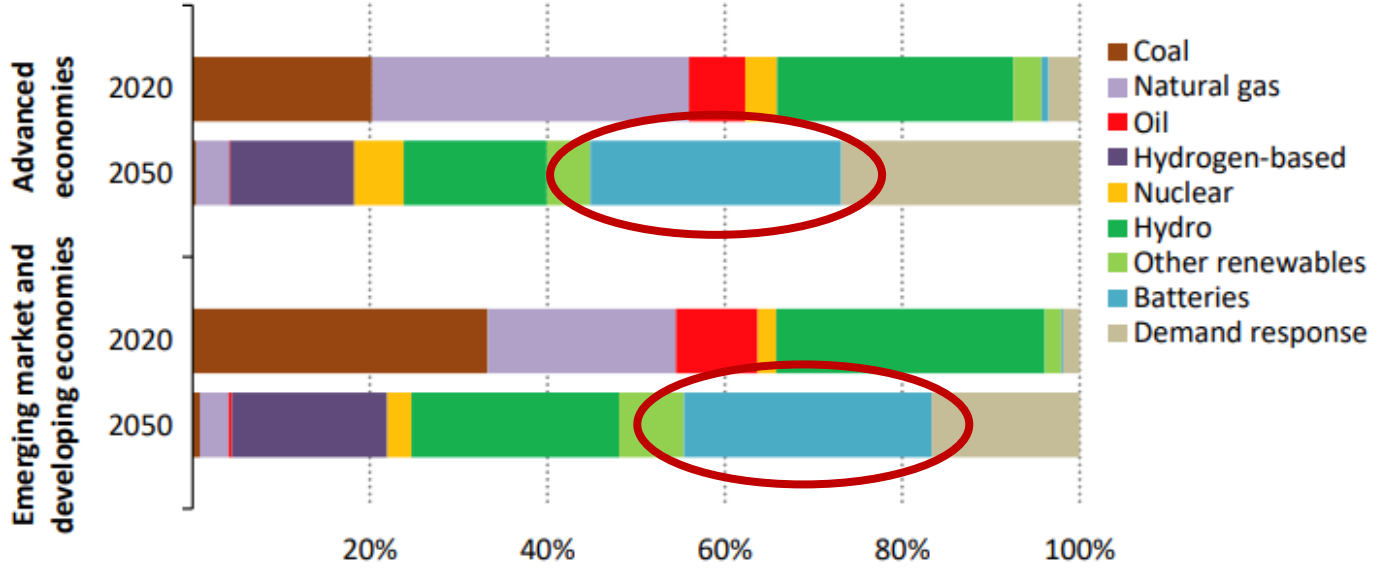


Note: The projects represented comprise the twelve largest battery projects underway globally
Source: Energy Storage News, Company Filings
(1) Vistra is currently constructing a 100MW/400MWh expansion at Moss Landing expected to be operational August 2021
(2) Currently testing a 50 MW / 64.5 MWh expansion at Hornsdale Power

Energy Storage & Climate Action

- Energy Storage deployment is imperative to achieve our global decarbonization objectives
- The International Energy Agency (IEA) has modeled that Energy Storage is a key piece for overall grid stability and phase out of fossil fuels
- The Net Zero Emissions by 2050 modelling is essential to reach our 'less than 2-degrees' global climate target

Figure 4.18 ▷ Electricity system flexibility by source in the NZE



To meet four-times the amount of hour-to-hour flexibility needs, batteries and demand response step up to become the primary sources of flexibility

Questions?

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