POWER ADVISORY

Energy Storage Policy and Practices: A Nova Scotia Perspective

Net Zero Atlantic

June 2, 2022

Overview

- Power Advisory was retained by Net-Zero Atlantic (NZA) to prepare a comprehensive report examining the current landscape and evaluating the development of a grid-scale energy storage policy and practices for Nova Scotia (NS).
- This report covers the following tasks:
  1. Value Stack of Grid-Scale Energy Storage;
  2. Energy Storage Ownership Model
  3. Energy Storage Policy and Practices Scan
  4. Nova Scotia Legislation and Regulations Affecting Energy Storage
  5. Stakeholder Engagement
  6. Summary of Findings – Options for Nova Scotia
- Drawing upon research, analysis, and discussions throughout the tasks, Power Advisory will summarize options for grid-scale energy storage policies and practices for Nova Scotia.

Contents

POWER ADVISORY

Executive Summary

Executive Summary

- Power Advisory was retained by Net Zero Atlantic (NZA) to prepare a comprehensive report examining the current landscape and evaluating options for the development of grid-scale energy storage policies and practices for Nova Scotia.
- The changing supply mix in Nova Scotia provides the opportunity to examine how energy storage can support the transition to cleaner energy supply in a reliable and cost-effective manner.
- Power Advisory reviewed and evaluated the services and benefits that energy storage can offer to the power grid such as shifting surplus wind energy and providing capacity, operating reserve, and other ancillary services.
- Power Advisory assessed a number of policies and practices most relevant to Nova Scotia, outlining takeaways for the province. The current legislation and regulations affecting energy storage in Nova Scotia were also reviewed.
- The project relied on stakeholder interviews to get input from companies and organizations with experience in the Nova Scotia electricity sector, as well as global storage developers and equipment suppliers that have considered energy storage deployment in the province.
- The following are some of the conclusions reached based on the structure of Nova Scotia's electricity sector and learnings from other jurisdictions.

Summary of Findings

1. Legislative – Regulatory and Structural Barriers

- There are no real legislative barriers to energy storage deployment in Nova Scotia. The government has the authority to direct programs for the research, development and testing of energy storage assets (Electricity Act S. 4D).

- There are barriers to private investment in energy storage projects outside of procurement by NS Power. The electricity sector structure does not provide energy storage operators with a price signal to guide charging/discharging decisions or offer compensation for the value of services provided, whether they be energy, ancillary services or capacity. In the current vertically-integrated electricity market structure, NS Power or various municipal utilities are the only purchasers of electricity or services from grid-scale energy storage projects. In this environment, developers must collaborate with NS Power or the municipal utilities, which represent a small share of the market, to develop grid scale energy storage projects.

Summary of Findings

1. Legislative – Regulatory and Structural Barriers

- NS Power has proposed to develop four 50 MW / 4-hour duration energy storage projects in its current IRP update and GRA as a means of renewables integration and supporting the coal phase out.
  - As the penetration of energy storage increases, the value offered by each subsequent MW typically declines. This is true for virtually all resources, but particularly for energy limited resources. This notion of diminishing returns is reflected in the results of the Effective Load Carrying Capability (ELCC) approach used in NS Power's IRP process to assess the capacity contribution of energy storage.

- Power Advisory recognizes that NS Power will be re-evaluating the role of energy storage target in the ongoing update to its IRP. With a more limited role for natural gas under the Clean Electricity Standard, Power Advisory expects that the IRP Update will recommend increased volumes of energy storage. This is unlikely to change our findings. In fact, as discussed it may strengthen the case for some of the alternatives identified.

Summary of Findings

2. Pathways - Ownership and Development Models

- NS Power is responsible for long-term resource planning for the vast majority of the province's electricity requirements. This includes evaluating the cost-effectiveness of energy storage in its IRP and utilizing energy storage to address resource adequacy. NS Power is planning to deploy four 50 MW four-hour duration energy storage projects to support the phase out of coal and integrate additional wind.

- The two main options for ownership of energy storage asset are either NS Power or private developers.

- Nova Scotia's electricity system doesn't have price signals that would allow independent storage developers to evaluate the economics of making a merchant investment in an energy storage project and make operating decisions regarding the provision of the various services that it could provide. The level of effort required to develop such a market structure is significant and equally important such a market structure is unlikely to induce private sector investment given NS Power's market dominant position. Therefore, Power Advisory believes that third-party investment in energy storage is only likely to occur if there is a contract with NS Power that allows it to direct the operation of the project.

Summary of Findings

2. Pathways - Ownership and Development Models

- Such a contract would likely be in the form of a tolling agreement and would have to anticipate all of the operating parameters and system conditions that would affect dispatch. Designing such a contract will require significant effort given that it will need to reflect the anticipated performance of the energy storage asset and the impact on the performance of the asset of various operating conditions. For example, lithium-ion batteries have a desired operating range to maintain their useful life. However, there may be system conditions (e.g., peak electricity demands and unavailability of various generating units) when it is otherwise economic or preferable to exceed these desired operating parameters. These complexities will need to be embedded within such a tolling agreement. Furthermore, it will be important that the tolling agreement be fully developed and be part of energy storage procurement process so that independent storage developers can properly price the services to be provided.

Summary of Findings

2. Pathways - Ownership and Development Models

- Independent storage development and ownership may offer benefits to Nova Scotia customers given the experience and potential economies that these parties can bring. These storage developers offer experience in the efficient operation and maintenance of energy storage and are motivated by maximizing the value and revenue from these storage assets.

- The development and construction of a storage asset by an independent developer may result in lower costs and lower overall risk than having NS Power develop and construct the storage assets itself. The benefits of an independent developer constructing a storage project are likely to be muted by the fact that both NS Power and the storage developers are likely to rely on third-party contractors for construction. We expect that independent storage developers may be better positioned to oversee and manage the contractor, but this is likely to vary depending on the independent developer's experience.

Summary of Findings

2. Pathways - Ownership and Development Models

- Given the uncertainty regarding the relative attractiveness of these two-storage development and construction models, Nova Scotia may wish to test the relative cost-effectiveness of each by conducting a competitive procurement where both development and construction models participate.
    - The importance of selecting the most cost-effective on a risk-adjusted basis model for energy storage development and operation in Nova Scotia depends in part on the amount of energy storage that Nova Scotia ultimately will require.

- However, it will be difficult for such a competitive procurement model to be able to properly assess the relative risk of the two models. The NS Power energy storage project will have a fundamentally different risk profile than a privately developed energy storage project NS Power energy storage projects are likely to be built and operated on a cost of service basis. This represents a very different risk profile than for a private developer project where cost recovery is likely to be more performance based. A tolling agreement would reflect performance assumptions (e.g., round trip efficiency and the potential for performance degradation over time). To the degree that the project didn't achieve these performance assumptions the developers returns would be lower.

Summary of Findings

2. Pathways - Ownership and Development Models

- Discerning the differences between these two risk profiles and value propositions would be difficult if this was to be done as part of the procurement process. The procurement administrator would need to be able to discern the differences in the relative risks posed by the two ownership and operation models and based on these risk differences determine what's an appropriate cost/price differential for each.

- An alternative model would be to allow both NS Power and independent developer storage projects to be developed and constructed and to assess the performance of each over time, with a third-party audit of the performance and effective cost of each.
    - Given the anticipated volume of energy storage that Nova Scotia is likely to ultimately require to achieve the province's clean energy and carbon reduction goals, assessing the relative merits of these two approaches is likely to be a valuable endeavor.

Summary of Findings

3. Metering and Interconnection Requirements

- There could be increased clarity as to whether and how existing interconnection rules and related documents, such as application forms and agreements, apply to customer-based energy storage systems. NS Power under its Generation Interconnection Procedures uses the Generator Interconnection Request Form and the Standard Generator Interconnection and Operating Agreement (GIA) for storage projects, even though the GIA makes no mention of energy storage within its terms. Nova Scotia could customize the interconnection process for energy storage by creating interconnection procedures specifically designed for energy storage.

- The generator interconnection procedure in Nova Scotia can require significant deposit fees to secure a position in the interconnection queue. Specifically, the System Impact Study Deposit and the Re-Study Deposit can total up to $450,000 for projects over 150 MW. Stakeholders reported that these fees in Nova Scotia were substantially higher than in other Canadian jurisdictions.
  - The Re-Study Deposit is designed to cover the costs of repeating studies for renewable generators that can cause system constraints if those projects do not move forward.

Summary of Findings

4. Energy Storage Assessment / Service Value Recognition

- Some US jurisdictions mandate that utilities specifically evaluate the benefits and costs of energy storage in their planning processes. NS Power included energy storage in its 2020 IRP. The IRP presents short and long-term scenarios that include energy storage. It also presents the results of the ELCC methodology that evaluates the contribution of storage toward meeting resource adequacy needs under a number of seasonal demand scenarios.

- Power Advisory expects that NS Power will present the business case for its energy storage investment in its Annual Capital Expenditure filing with the UARB. This should provide the foundation for future assessments and reporting on of the actual performance and value of storage assets, as experience is gained. The government or the UARB could require such reporting as part of the ongoing regulatory review processes to ensure that the value of the assets is maximized and the full value of potential benefits realized.

Summary of Findings

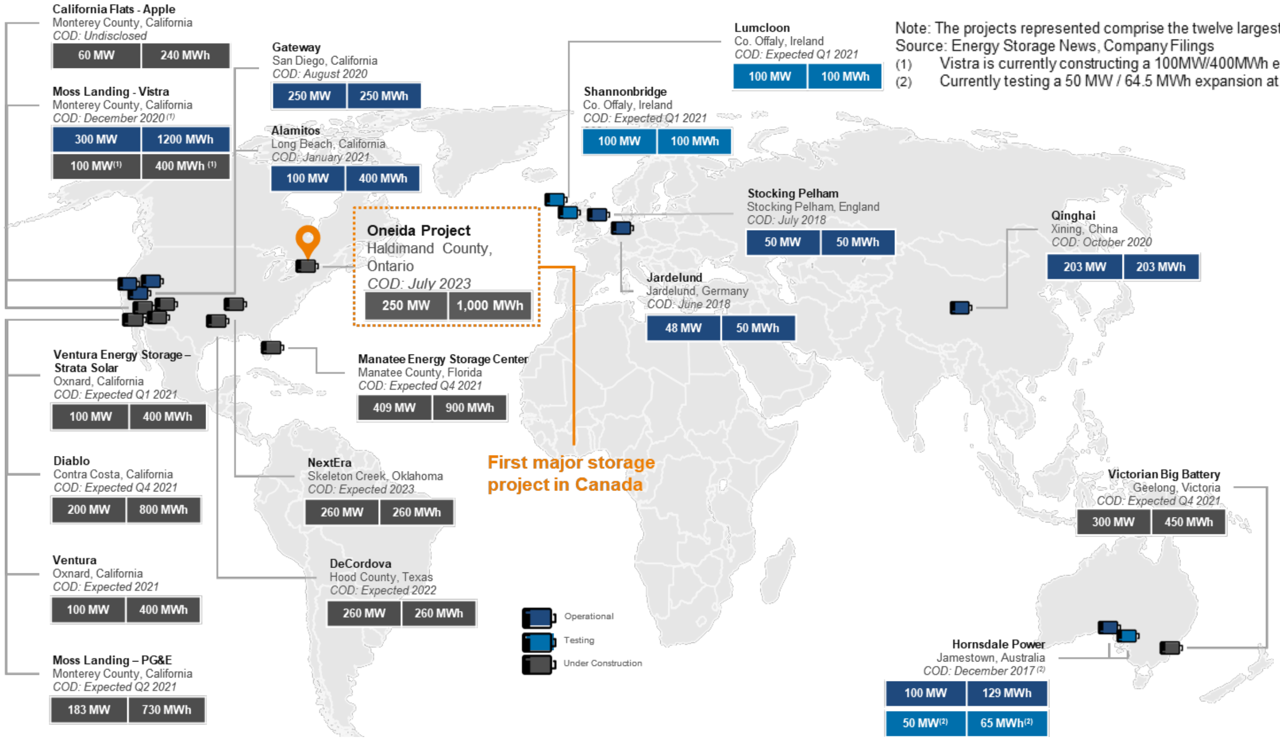
5. Customer-based Storage

- Customer-based storage is an extensive field itself and will present its own unique challenges.
- If there is a desire to promote customer-based storage, electricity rate design should better reflect the time-of-use value of electricity.
- Many jurisdictions are encouraging customer-based battery storage to produce cost savings and enhance reliability, as is NS Power through the Battery Storage Pilot Program for residential customers. Learnings from this pilot willallow NS Power to expand customer-based storage. This could include electric vehicle to grid (V2G) incentives that pay EV owners for delivering energy services to the power system.
- In the US, FERC Orders have resulted in utilities removing barriers to participation and allow Distributed Energy Resource (DER) aggregations to participate in competitive markets. This objective is being advanced in Nova Scotia through the pilot program and experience and control technologies will improve the value of these types of distributed resources on the Nova Scotia grid.

Introduction

Energy Storage Policy & Practice Introduction

- Worldwide, development of energy storage is advancing rapidly with declining costs along with its increasing value and flexibility that it can provide to electricity grids.



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 Policy & Practice Introduction

- Historic and future continued cost reduction has drawn the attention of utilities, regulators and governments. This has triggered a closer look at the policies and practices surrounding the treatment of energy storage as both an electrical load and electricity generator.

- Policies to address climate change are resulting in reductions in fossil generation and increasing amounts of variable, low-cost renewable generation. The integration of these variable output resources and resulting system operation requires new tools and approaches to manage this energy transition, while maintaining reliable supplies of energy at reasonable prices for customers.

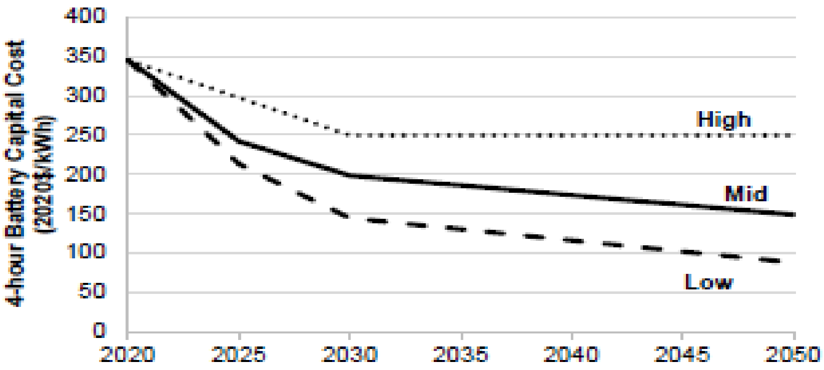


Figure ES-2. Battery cost projections for 4-hour lithium ion systems.

Source: NREL Cost Projections for Utility Scale Battery Storage: June 2021 Update

Storage Cost Declines

- In the past, energy storage has not been developed partly due to the technology being uneconomic compared to traditional resources. However, technological advancements and significant price reductions in the past decade have made energy storage a valuable and cost-effective option in many jurisdictions. Declining storage costs are causing NS Power to consider energy storage as a resource option for Nova Scotia.

- The National Renewable Energy Laboratory (NREL) found the price of lithium-ion batteries has fallen by about 80% from 2015 to 2020. The energy capacity-weighted average installed cost of large-scale 2 hour+ batteries fell from $2,102/kWh in 2015 to $589/kWh in 2019, a 72% decrease.

- The effects of these price reductions are seen in energy storage uptake. The IEA reported that annual battery storage capacity additions in 2020 rose to a record high 5 GW. This is compared to about 0.75 GW of added capacity in 2015.

- However, recent supply chain disruptions and other economic dislocations are impacting the energy storage market. Cost reductions of lithium-ion battery storage systems have been offset in the last year by supply chain issues, material cost increases, and increased competition for battery cells. A change of pace in installations is yet to be seen and planned new storage capacity by developers through 2023 is projected to surpass recent years.

Four Phases of Energy Storage

- The National Renewable Energy Laboratory (NREL) uses a 4-phase framework for explaining the role of storage in the US power system. This framework helps explore the roles and opportunities for new cost-competitive energy storage. The four phases, which progress from shorter to longer duration, link the key metric of storage duration to possible future deployment opportunities, considering how the cost and value vary as a function of duration.
  - Phase 1, which began around 2011, is characterized by the deployment of storage with 1-hour or shorter duration and resulted from the emergence of restructured power markets and new technologies that allow for the provision of cost-competitive services, primarily operating reserves and regulation services.
  - Phase 2 is characterized by the deployment of storage with 2–6 hours of discharge duration to serve as peaking capacity. Phase 2 has begun in some regions (e.g., California), with lithium-ion batteries becoming cost-competitive where durations of 2–6 hours are sufficient to provide reliable peaking capacity. The primary services are capacity, energy time-shifting, and energy arbitrage.
  - Phase 3 is less distinct but is characterized by lower costs and technology improvements that enable storage to be cost-competitive while serving longer-duration (4–12 hour) peaks. Deployment in Phase 3 could include a variety of new technologies. The primary services are daily capacity and energy arbitrage.
  - Phase 4 is the most uncertain of the phases. It characterizes a possible future in which storage with durations from days to months is used to achieve very high levels of renewable energy in the power sector, or as part of multisector decarbonization. Technology options in this phase include production of liquid and gas fuels, which can be stored in large underground formations with a very low loss rate. The primary services are multiday to seasonal capacity and energy-time shifting.

POWER ADVISORY

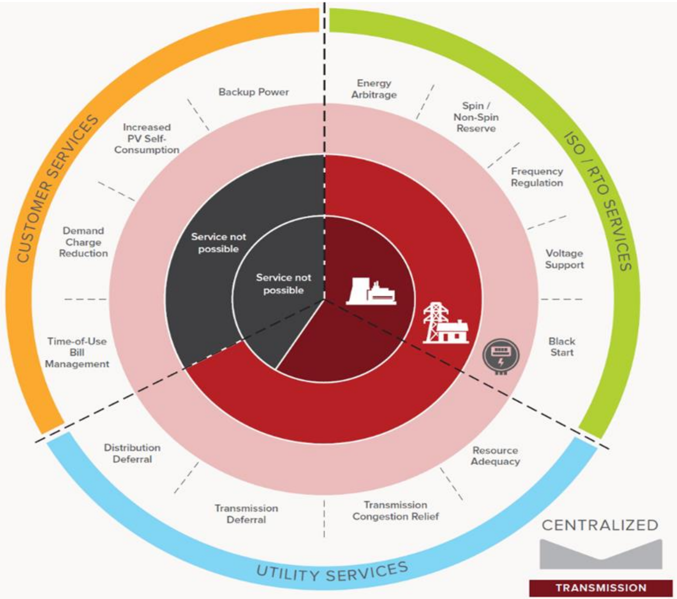
Four Phases of Energy Storage

- The table below summarizes NREL's characterization of the four phases of energy storage in terms of the distinguishing characteristics of duration, likely technology and the services that are provided for each.

NREL Phase	Duration	Technology	Services/Benefits
1	1 hour or shorter	Lithium-ion battery	Operating reserves, regulation, shifting surplus wind, fast-frequency response
2	2 to 6 hours	Lithium-ion battery	Capacity, energy arbitrage, shifting surplus wind, operating reserve.
3	4 to 12 hours	Longer duration battery chemistries	Daily capacity, energy time-shifting, energy arbitrage, shifting surplus wind, transmission deferral
4	Days to months	Liquid and gas fuels (stored in underground formations with low loss rates)	Multiday to seasonal capacity, energy-time shifting, seasonal shifting of surplus wind

Value Stack of Grid-Scale Energy Storage Applications

Energy Storage Value Stacking Opportunities



Fitzgerald, Garrett, James Mandel, Jesse Morris, and Hervé Touati. The Economics of Battery Energy Storage: How multi-use, customer-sited batteries deliver the most services and value to customers and the grid. Rocky Mountain Institute, September 2015. Retrieved from: http://www.rmi.org/electricity_battery_value

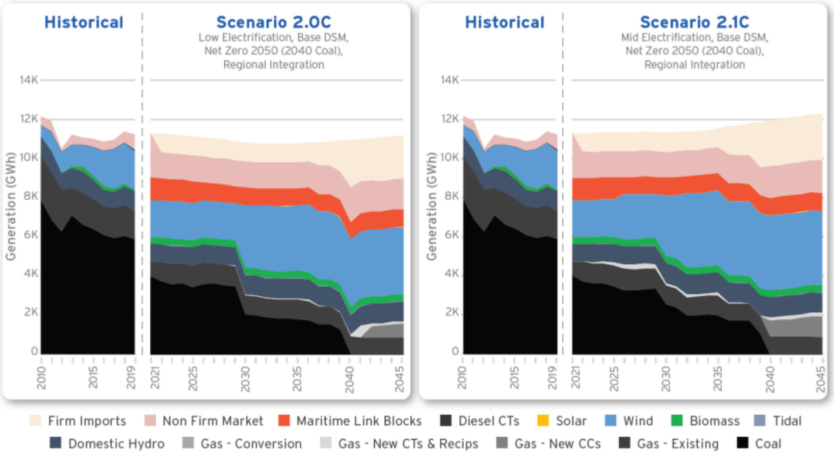
- The electricity supply mix is changing in response to climate change policy objectives and technology advancement
- In addition, demand patterns are changing with the adoption of innovative technologies and electrification
- Grid operators will require new resources and tools to maintain safety, reliability and affordability goals
- Energy storage resources offer versatility and a variety of services to grid operators and customers
- Energy storage resources can increase the utilization of existing assets and improve the efficiency of electricity market activities

Primary Grid-Scale Energy Storage Value Stacking Opportunities in Nova Scotia

Service	Description
Real-Time Energy Arbitrage (RTEA)	• Shifting low-cost energy output to constrained or high-priced hours • In Nova Scotia, RTEA would primarily target shifting surplus wind generation output to peak load hours and for GHG emissions reduction
Capacity (CA)	• Resource adequacy needs require investment in new capacity to be available during peak demand hours • Energy storage can defer or avoid new fossil fuel capacity additions
Operating Reserve (OR)	• Operating reserves are maintained to ensure there are resources available to maintain power system stability during outage events (e.g., a forced outage at a generation unit or transmission circuit outage) • Energy storage can provide OR during both charging and discharging and thus are a low-cost source of OR supply
Fast-Frequency Response (FFR)	• During outage events, system frequency can change rapidly and risks system stability • FFR limits the initial rate of change of frequency to provide time for other resources to bring energy and demand back into balance • Energy storage technologies that are inverter-based can provide FFR
Regulation Capacity (RC)	• Regulation capacity maintains system supply-demand balance between dispatch intervals of generation resources • Energy storage resources can offer RC and follow Automatic Generation Control (AGC) signals used to maintain system frequency and balance
Transmission Congestion Reduction (TCR)	• The transmission system can become congested when existing transfer capability cannot allow low-cost energy output to be delivered to load centers resulting in curtailment and higher cost energy dispatch • Energy storage can reduce congestion within the Nova Scotia power system through optimal siting and operation

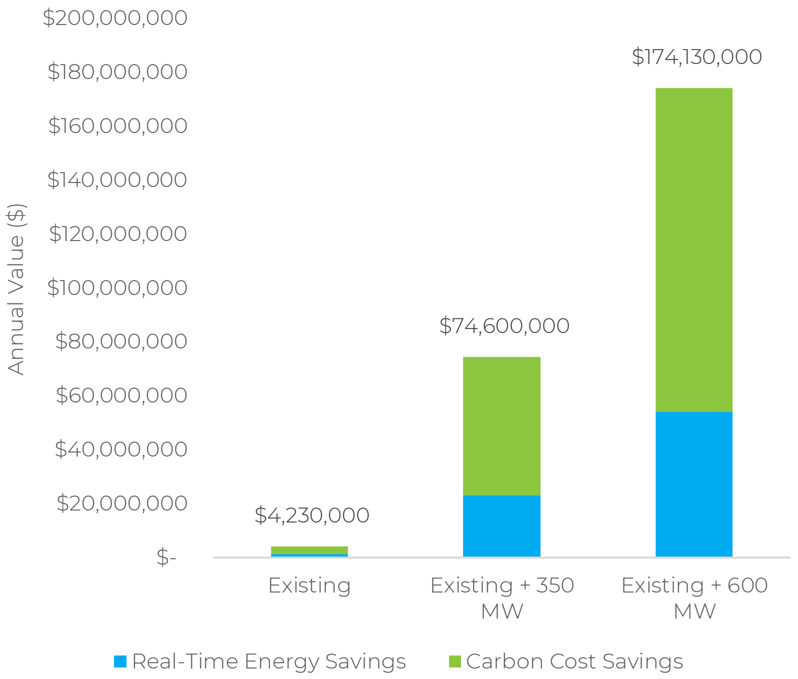
Real-Time Energy Value from Shifting Surplus Wind

- Nova Scotia's Integrated Resource Plan (IRP), published in 2020, expects new wind generation to be developed to meet future energy needs and support decarbonization of the electricity grid
- Increasing wind capacity could lead to periods where there is surplus wind generation; energy storage resources can store surplus wind generation and reinject into the Nova Scotia grid when it is more highly valued
- There are three primary benefits of energy storage's ability to shift surplus wind generation
    - Avoid wasting low-cost energy from spilling wind energy production
    - Reduce energy costs by displacing high-cost fossil fuel energy production
    - Reduce GHG emissions from fossil fuel energy production



Value Potential of Shifting Surplus Wind

- With existing demand and supply, there is little surplus wind energy to shift; however, as additional wind generation is planned (e.g., up to 600 MW with two upcoming RFPs) the amount of surplus wind available for shifting increases
- Power Advisory considered three different scenarios:
  - Existing wind generation of 616 MW
  - Increase of 350 MW of wind generation to 996 MW
  - Increase of 600 MW of wind generation to 1,216 MW
- Annual value for avoided energy costs and GHG emissions savings are shown in chart to right
  - Energy savings are determined by reduced coal-fired generation from shifting surplus wind
  - Carbon cost savings are based on a carbon price of $170/tonne. The carbon values can be scaled to different carbon price assumptions



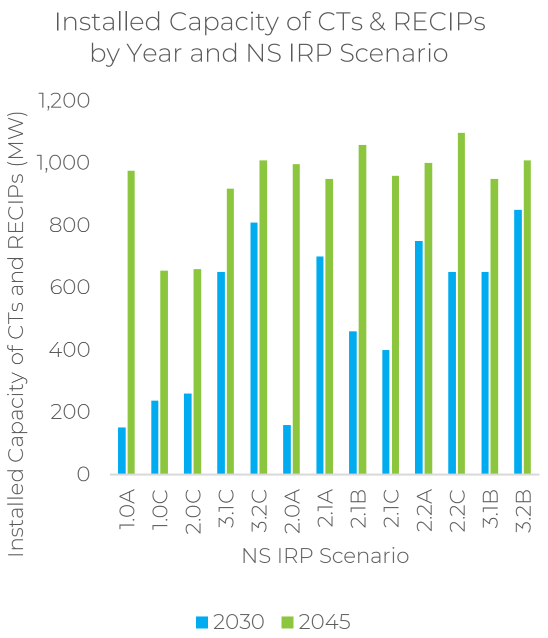
POWER ADVISORY

Shifting Surplus Wind Constraints

- Surplus wind generation may not necessarily be "spilled" and therefore the value of shifting surplus wind generation may be reduced.
    - In some instances, the surplus wind generation can be exported to neighbouring jurisdictions such as New Brunswick/New England or Newfoundland & Labrador.
- Further, surplus wind conditions can occur in short spikes that can exceed the capabilities of the energy storage resources; that is the maximum charging capacity of a given energy storage resource.
    - Future hourly demand profiles as well as an estimate of the diversity of wind generation is required to refine the surplus wind generation shifting value for energy storage resources.
- Wind is one resource being added as part of the decarbonization effort which is variable, intermittent, or limited in how it dispatches. Dispatch-limited resources limit them from operating continuously at full capacity to meet demand.

Potential Capacity Value of Energy Storage

- The NS Power IRP has assessed capacity need for several scenarios primarily through the deployment of new combustion turbines (CTs) and reciprocating engines (RECIPs) for peaking capacity.
    - Energy storage could defer or avoid deployment of CTs and RECIPs assuming duration of operating hours do not exceed the energy capability of the energy storage resource.
- Depending on the future scenario and cost of new CTs and RECIPs, **the value of deferred capacity could range from $330-million to $560-million between today and 2030;** this estimate does not assume any payment to the energy storage resource for replacement capacity.
- The capacity value is based on the full replacement cost of CTs and RECIPs and doesn't reflect any energy cost reductions or ancillary service value that they may offer, which is likely to be negligible. The actual value of energy storage resources may be lower. Capacity payments are typically on a net CONE basis with a deduction for expected real-time and ancillary service revenues from the fixed capital and operating costs.
- Under a net-zero future, CTs and RECIPs may not be an appropriate comparison; in such a future a firm non-emitting resource should be used (e.g., PV + storage).



Operating Reserve Value Proposition

- Energy storage resources can provide OR when both charging and discharging
  - During charging, the energy storage resource can stop consumption when called upon to provide operating reserve and assist the power system in returning to stable conditions
  - When the energy storage asset has enough charge it can act like a generator on stand-by mode and be capable of injecting energy when required for OR services
- Given the low operating and opportunity cost of energy storage resources when participating as a load during low-price hours, Power Advisory expects there would opportunities to reduce the cost of OR in Nova Scotia
- Nova Scotia does not have an Operating Reserve market for pricing; therefore, Power Advisory reviewed three neighbouring jurisdictions to estimate an OR value to project potential cost savings. The annual average price of 10-minute spinning reserve operating reserve in Ontario, NYISO and ISO-NE ranges from $4/MWh to $10/MWh; for supplemental operating reserve the annual average price ranges from $3/MWh to $6/MWh
- Assuming 50 MW of OR offered for 200 cycles a year, **the value of OR from energy storage could range from $835,000 ($16.7/kW-year) to $950,000 ($19/kW-year) per year**
  - As with other ancillary services, OR is a thin market where the requirements are established relative to the size of the largest generation unit within the electricity system.

POWER ADVISORY

Fast-Frequency Response vs. Inertia

- Inertial Response is traditionally provided by conventional synchronous generators using the stored kinetic energy of the total rotating mass directly coupled to the AC grid
  - Synchronous generators release their stored kinetic energy into the grid, reducing the initial rate of change of frequency following an outage, allowing slower governor actions (e.g., regulation capacity) to catch up and contribute to frequency stabilization
  - If frequency drops below a certain threshold, the power system is forced to shed load to avoid the risk of cascading blackouts
- FFR is technologically and physically distinct from synchronous inertia from traditional generators
  - FFR differs from synchronous inertia given the short delay while frequency change is detected, and the response initiated; these should be considered as two different services, with different technical characteristics that interact differently with the power system
  - FFR provides rapid active power injection (in 1-2 seconds or less) to arrest the frequency decline following an outage event
- FFR type service from inverter-connected devices (e.g., energy storage) can reduce the amount of synchronous inertia required to maintain system frequency

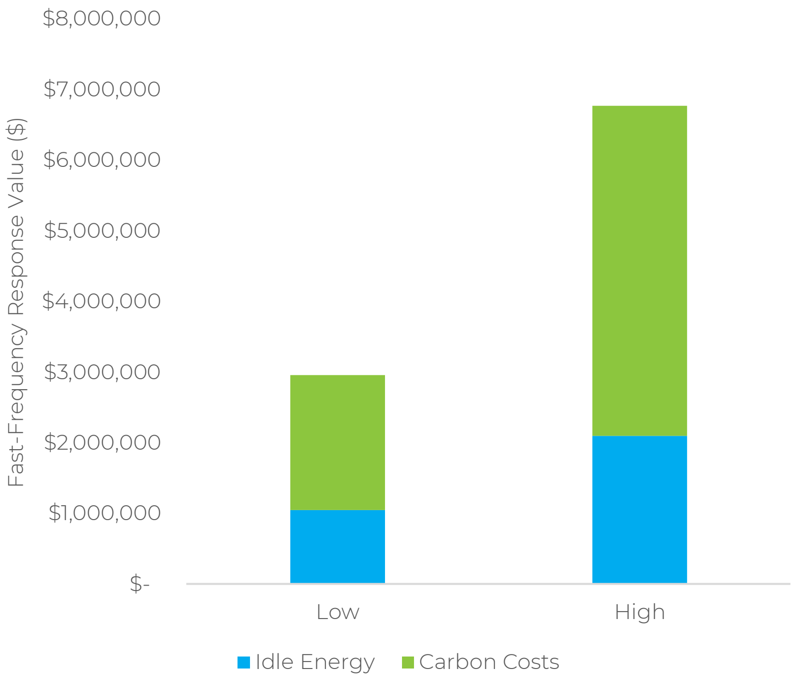
FFR Value Proposition

- In Nova Scotia, coal-fired generation is the primary generation resource for providing inertia; under certain system conditions (i.e., low load and high wind), Nova Scotia must maintain a minimum thermal generation output to ensure adequate inertia in the system

- Under these conditions coal units operate at minimum loads so they are available to respond to provide inertia in the event of a loss of the NB-NS tie when Nova Scotia is importing

- Energy storage can reduce the need for coal-fired generation to idle by providing FFR, in turn offering cost savings through lower fuel costs and GHG emissions
  - FFR can also be provided by wind generation

- Power Advisory estimated the inertia constraints could occur in 250 to 500 hours a year for a 50 MW minimum block for coal-fired generation; FFR value estimates for avoided idling energy and carbon costs are provided in the figure to the right



Regulation Capacity Value Proposition

- Regulation capacity in Nova Scotia is provided by generation units responding to an Automatic Generation Control (AGC) signal that adjusts to maintain system balance every 2 to 4 seconds
- Energy storage resources can provide effective regulation capacity due to their fast-response and accurate output capabilities
    - Energy storage resources are fast becoming the major contributor of regulation capacity in many markets
- For Regulation Capacity, Power Advisory relied on the average cost annual costs ($/MW) from the ISO-NE, NYISO, PJM and Ontario electricity markets
- Assuming 30 MW of Regulation Capacity from energy storage, the potential value could range from $4.4-million ($147/kW-year) to $7.2-million ($240/kW-year) annually
    - This assumes that the capacity of the energy storage device dedicated to providing regulation service wouldn't be available to capture other elements of the value stack
        - Specifically, given the small size of this market only a portion of the project's capacity is likely to be dedicated to it.

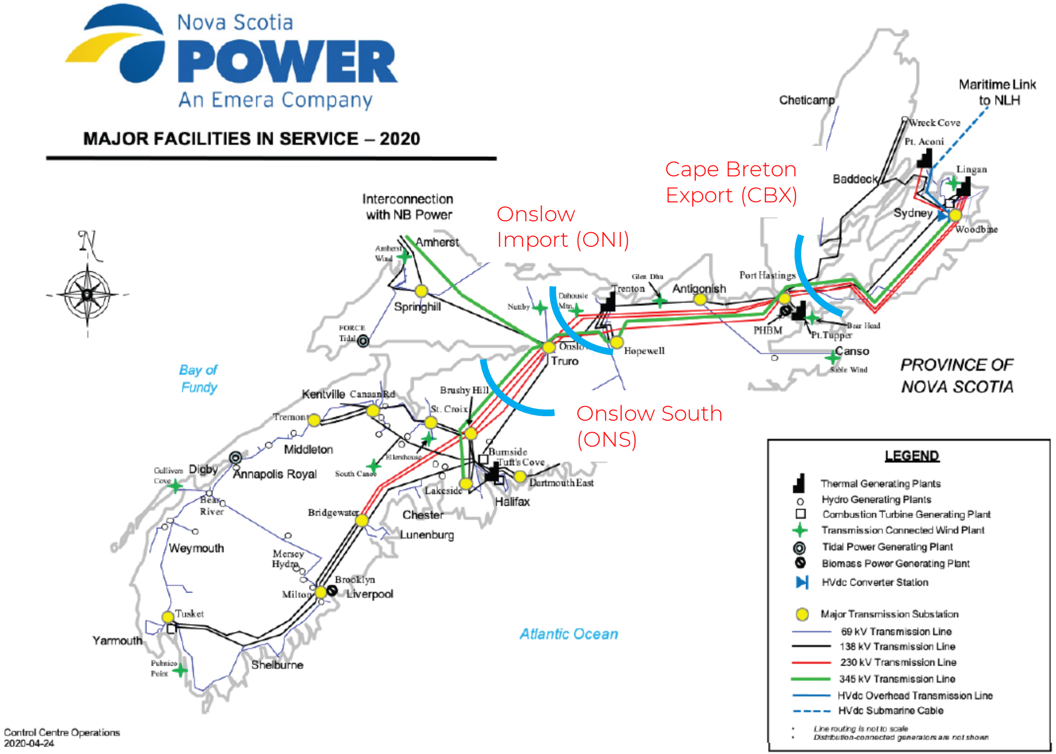
Limitations for Ancillary Service Provision

- FFR, OR and Regulation Capacity are all ancillary services required to maintain balance and stability in the electricity system
    - The ancillary service market is relatively small compared to real-time energy and capacity; therefore the opportunity for energy storage is limited
- These services are currently provided by existing generation assets owned and operated by NS Power; there is no open market for the provision of these services
- If new resources are to used to provide these services, then the cost savings relative to having existing resources provide the services must be considered. If these cost savings are greater the cost of the new facility then the project should be deemed to be economic.

Limitations for Ancillary Service Provision

- A possible consideration for investing in new energy storage resources offering ancillary services is the potential to strand existing assets
    - Careful examination of alternative uses for existing assets displaced by energy storage should be completed to determine what other services they can provide
    - In particular, capacity that requires limited operating hours may be appropriate since run-times will be lower leading to lower emissions and variable costs
- A barrier for energy storage resources is the provision of ancillary services requires close communication and coordination with the system operator and utility
    - There are many options for ownership and operational control that can be explored to determine the optimal arrangement for energy storage to provide ancillary services

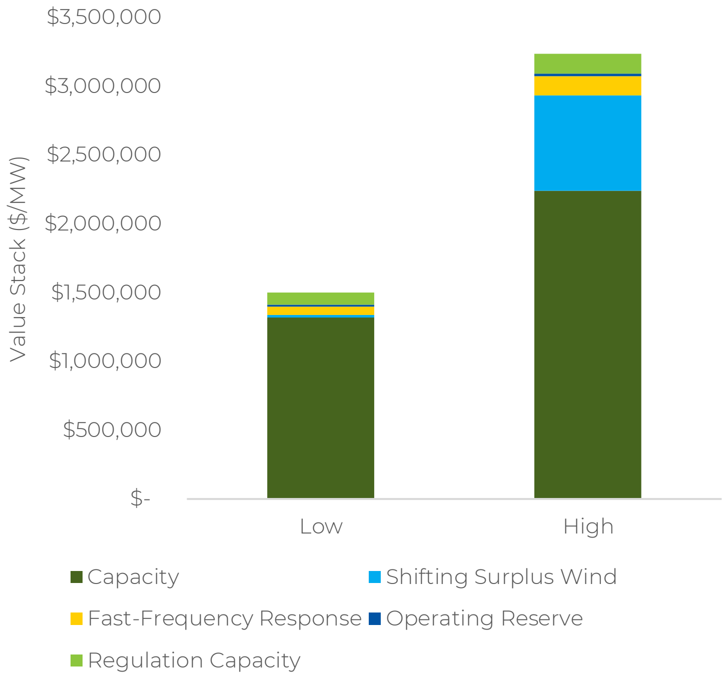
Transmission Congestion Potential Value



- Deployment of energy storage resources in select locations could reduce the potential for congestion within the NS Power system
- Locating energy storage resources at each major interface can provide an option for system operators to store excess low-cost energy that might otherwise be curtailed during real-time energy operation
- Reducing congestion increases the efficiency of the NS Power system

Summary of Energy Storage Value Stacking

- A high-level summary of energy storage value stacking on a $/MW basis is shown in the chart to the right. The analysis doesn't consider the constraints associated with realizing this full value given the potential for temporal overlaps for the provision of these services. It is important to note that the composition of value stacking will change over time.
- The value of capacity dominates the stack; which is expected as new peaking capacity generation to meet future supply needs is needed in the near-term. With the increased penetration of energy storage longer durations of sustained output are required as the peak is flattened.
- The differences between the low and high estimate for ancillary services reflect the small market size relative to the energy storage project sizes.
- A key value for energy storage is shifting surplus wind generation which is expected to grow following the planned renewable procurements
    - Nova Scotia has announced RFPs that could procure up to 600 MW of additional wind in the next four to five years.



Energy Storage Ownership Models

Energy Storage Ownership Models

Energy Storage Value Optimization

- As discussed in the previous section, energy storage technologies can provide multiple services to the electricity grid with significant value to customers. The changing supply mix in Nova Scotia provides the opportunity to examine how new energy storage can support the transition to cleaner energy supply in a reliable and cost-effective manner. However, for the full value offered by energy storage to be realized by customers, projects must employ ownership and operating models that are efficient and allow and incent operators to maximize value.

- Energy storage is a domestic resource that increases energy security in Nova Scotia.

- NS Power serves the vast majority of Nova Scotia and resource deployment is heavily influenced by its Integrated Resource Planning process. Private sector participants have few options for introducing innovative new energy storage projects or technologies, other than behind the customer meter. Clearly, energy storage ownership and operation configurations need to recognize this context to ensure full value extraction and optimal operation of energy storage assets.

- While this engagement focuses on grid-scale energy storage policies and practices, distributed customer-based energy storage policies and practices will be touched on as well.

Context: No Wholesale Market Competition

Nova Scotia Context – Nova Scotia Power (NS Power) is a vertically integrated electricity distributor, transmitter, and retail service provider and the dominant generator in Nova Scotia.

- In many North American competitive wholesale markets, grid services are procured through market mechanisms, allowing energy storage resources to be owned and operated by independent energy storage developers, competing to deliver services to the highest value market so as to maximize the value of their investment.

- However, in Nova Scotia there is no competitive wholesale electricity market or price signals for the provision of grid services (or energy). Therefore, there are no price signals for energy storage owners to utilize to optimize the dispatch of an energy storage project. If there were to be third-party ownership of energy storage projects in Nova Scotia, the provision of grid services or energy would be prescribed through bilateral agreements with NS Power, likely the NS Power System Operator.

- An important element of Nova Scotia's electricity market is the respective roles of the NS Power System Operator and the Marketing Desk in determining the generation dispatch. Understanding this context is important when considering who should control the dispatch of energy storage facilities in Nova Scotia.
    - The energy arbitrage value of storing energy in low-cost hours and running during higher cost hours would presumably be scheduled based on direction by NS Power's Marketing Desk, the group responsible for NS Power's day ahead plan.

Context: Role of System Operator & Marketing Desk

- NS Power has a System Operator (NS Power System Operator) who is responsible for the safe, reliable, and efficient operation of Nova Scotia's bulk power system. It functions independently from other NS Power operations under the Open Access Transmission Tariff (OATT) Standards of Conduct. The NS Power System Operator manages real-time operation of NS Power's generation fleet. The NS Power System Operator is also responsible for administering NS Power's OATT and maintaining compliance with international grid reliability standards.

- NS Power's Fuels Energy and Risk Management (FERM or Marketing Desk) group is responsible for the purchasing of fuel and power, and for development and commitment of dispatch schedules for its generation fleet. NS Power's Marketing Desk establishes the optimized day ahead dispatch schedules which are then manually adjusted by the System Operator as required to consider real-time conditions. As more variable output energy resources are added to the system it will be more appropriate for the System Operator to conduct the optimization of the system in real time.

Context: Role of System Operator & Marketing Desk

- The Marketing Desk produces a Day-Ahead dispatch schedule that is sent to the System Operator. The System Operator adjusts this dispatch schedule as necessary to reflect Real Time conditions. The following factors can require adjustments to the dispatch schedule: (a) actual system load varies from the forecast used to create the Day-Ahead schedule; (b) a transmission constraint prevents the implementation of planned dispatch; (c) voltage support or reactive power requirements require re-dispatch; (d) a generating facility suffers a forced outage or otherwise fails to fulfill its schedule; (e) the actual output of Intermittent Generating Facilities varies from the scheduled output; (f) accumulated inadvertent energy flows on the interconnection with New Brunswick; or (g) the New Brunswick Power System Operator activates operating reserves, or either utility requests emergency support in accordance with the interconnection agreement between Nova Scotia Power Inc. and the New Brunswick Power.

- A recent study* noted that "intra-hour net load changes (load after the impacts of variable output resources such as wind are considered) have increased to a degree that the day-ahead market's hourly schedules do not align with the real-time load curve; this results in a need for the Real-Time market to make up for granularity differences and uncertainty." (p. 56) This study* recommended increasing the system optimization capabilities available to the System Operator: "This increased complexity of the dispatch in Real Time indicates the Control Center should acquire independent analytical capabilities to re-optimize the dispatch solution within the Real Time market." (p. 12)

- A central tenet of this study is that the System Operator requires additional capabilities and IT tools to assist it in managing system operations.

* 2018-2019: FAM Dispatch Study, February 10, 2022

Energy Storage Ownership Models

- Grid-scale energy storage technologies can benefit grid operations; however, they increase the complexity of the power system.
- There are two structural considerations that will have a bearing on the province's ability realize the value of energy storage:

  (1) Who should **Own** grid-scale energy storage resources in Nova Scotia?

  (2) Who should **Operate** grid-scale energy storage resources in Nova Scotia?
- These questions are addressed in the following slides and examine the two main options available to Nova Scotia:
  - Private energy storage developer owning and/or operating energy storage assets, or
  - Nova Scotia Power owning and/or operating energy storage assets.

Energy Storage Ownership Models

Nova Scotia Context – **Ownership** of grid-scale energy storage resources

Energy storage developers could own storage assets and deliver grid services.

- In the Nova Scotia power sector, grid services would likely be subject to an agreement between NS Power System Operator (the "offtaker") and the energy storage developer. Such agreements in other markets are contracted under:
  - a tolling agreement whereby the energy storage project developer receives a fixed capacity charge (e.g., $/kW-month) and a variable energy charge. Under this structure, the offtaker typically makes decisions regarding when to charge and discharge the energy storage device, subject to its operating limitations and dispatch parameters. In addition, the offtaker would pay for all charging energy from the grid to the energy storage device and acts as "scheduling coordinator" or "market participant" for the battery in managing its scheduling arrangements.
  - a capacity sales agreement, which is a variant of the energy storage tolling agreement, where the offtaker contracts for capacity attributes. Under a capacity sales agreement, only the capacity and capacity attributes of the battery storage project are sold to the offtaker. The project owner is entitled to sell all of the battery's other products, including energy, ancillary services, to third parties or on a merchant basis. No such market exists in Nova Scotia thus this approach is incompatible (since there is no ancillary services market) and would require greater certainty in the value if these market services to the storage developer which is effectively a tolling agreement.
  - a hybrid contract structure where the project owner participates in the various available electricity product markets including energy, capacity and various ancillary services. The project owner would be incented to maximize the value offered by these markets. However, because of the lack of market price signal, or certainty around the expected value of ancillary services, owners would need to contract for a number of years to justify any investment, again, effectively under a tolling agreement.
- While the energy storage developer could own the storage asset, the agreements or services contracts would have to anticipate the operating parameters and system conditions that would affect dispatch. The service agreement with the storage asset owner would have to document anticipated operating conditions with specific terms and conditions dictating operation and compensation. This would be very challenging given the complexity of grid operations and the dynamic and complex nature of power system operation.

Energy Storage Ownership Models

Nova Scotia Context – **Operation** of grid-scale energy storage resources

Energy storage developers could own and operate storage assets and deliver grid services.

- Services delivery would be under contract to NS Power System Operator, however:
  - NS Power System Operator would dictate dispatch, and
  - the services contract would have to anticipate the operating parameters and system conditions that would affect dispatch, which would be challenging to operationalize.

- Ultimately, the vertically integrated nature of the Nova Scotia power market, even with an energy storage developer owning and operating the asset, NS Power would be responsible for directing asset operation for both day ahead coordination and scheduling and real time dispatch. There are no market price signals. The power grid is complex and is expected to become increasingly more complex with the significant addition of variable renewable generation. The 2018-2019 FAM Dispatch Study identified this increasing complexity and recommended the introduction of an IT Platform to ensure real time optimization of all grid assets to minimize costs to customers. To maximize the storage asset benefit, the system operator would need operational control to dispatch the storage assets in conjunction with the rest of the power system and interties. An example would be the desired operating range of lithium-ion batteries to maintain their useful life. There may be system conditions (e.g., peak electricity demands and unavailability of various generating units) when it is otherwise economic or preferable to exceed these desired operating parameters. These complexities will need to be embedded within such a tolling agreement.

Energy Storage Ownership Models

Nova Scotia Context – **Operation** of grid-scale energy storage resources

- An example of a market that had developed a form of tolling agreement that could be relevant to the Nova Scotia context is the Public Service Company of Colorado (PSCo). The actual PPA was not available for review, however stakeholders recommended PSCo's approach as being a relevant precedent for Nova Scotia.

- Power Advisory was able to obtain a publicly available example of an Energy Storage Tolling Agreement * between San Diego Gas & Electric (SD&G) and a potential developer. This may provide a template for Nova Scotia to form a tolling agreement.

* https://www.sdge.com/sites/default/files/ES_Proforma_Agreement.docx

POWER ADVISORY

Energy Storage Ownership Models

Pros and Cons of energy storage ownership and operation: energy storage developer vs. NSP ownership

Ownership Option	Pros	Cons
Energy Storage Developer	Motivated to maximize revenue	No market signal to optimize dispatch, therefore would require tolling or capacity agreements
	More experience with optimizing dispatch of multiple storage services	Negotiating agreements for storage services would have to anticipate all system conditions affecting dispatch, challenging
	Expect lower installed cost	
Nova Scotia Power (NSP)	Able to coordinate dispatch with system operations, ancillary services, capacity and energy balancing	NSP likely to rely more heavily on vendors and EPC firms; may result in higher installed costs given less experience. But development and construction is distinct from ownership and operation
	Can more easily optimize generator operation scheduling with storage operation schedules	Storage dispatch and grid optimization is becoming increasingly complex, however NSP is expected to invest in an IT Platform to optimize system performance
	Can optimize impact of battery cycling on life cycle through centralized dispatch algorithm	An NS Power led RFI or RFQ could identify creative solutions best suited to Nova Scotia

Development and construction is distinct from storage asset operation so energy storage developer could construct the asset and transfer to NS Power upon completion.

POWER ADVISORY

Energy Storage Ownership Models

Storage Asset Development and Construction

- There is significant global experience in development and construction of energy storage assets and system operators often use competitive procurement approaches to select storage developers, such as the IESO in Ontario and the AESO in Alberta. It is common for the procurement to specify the geographic area for storage installations to address system needs.

- A competitive tendering process for design, development and construction of storage assets is expected to yield lowest capital cost and could be followed by an NSP partnership agreement or asset acquisition at completion as part of the RFP.
    - An RFP could be administered by NS Power or by a government appointed procurement administrator (coordinated with NS Power to ensure optimal design and location). Any RFP would have to clearly specify the services being procured and performance requirements.

- This approach is expected to result in lower cost and lower risk than having NSP develop and construct storage assets itself, given its limited experience with the design and build of grid-scale energy storage projects.

- For the reasons already cited, an RFP for the development and construction of the energy storage asset, followed by a partnership agreement or asset transfer at completion is likely most appropriate for Nova Scotia.

- It would be impractical to run an RFP for energy storage services without an ultimate asset transfer to or partnership with NS Power, given that the lack of price signal and uncertainty around potential revenue streams for the storage developer.

Energy Storage Ownership Models

Grid-scale Storage vs. Customer-based Storage

- This analysis has focused on grid-scale energy storage projects offering services to the NS Power grid.
- As the costs of energy storage decline, interest in customer-based storage is expected to grow and customers may install on-site energy storage for a variety of reasons:
    - Increased reliability, address power quality issues; and reduce peak demand charges.
- In order to benefit these customers and take full advantage of the value of energy storage, policy makers should ensure alignment between customer interests and the power system needs.
- For example, Nova Scotia customers should benefit from shifting their power usage to lower demand periods of the day and reducing their demands during the highest system peak demand periods of the year. This is an electricity rate design policy that can be reviewed to ensure that the operational flexibility of customer-based storage is incented to operate to benefit both customers and the power system. Smart meters and time varying rates will incent such behaviour.
- NS Power has taken steps in this direction through the Battery Storage Pilot Program for residential customers. Learnings from this pilot will allow NS Power to expand customer-based storage through evolving electric vehicle to grid (V2G) incentives that pay EV owners for delivering capacity or other energy services to the power system.
- At the customer level, there is no need for NS Power to own energy storage assets. Customers or energy storage developers should own the behind the meter assets, however they should be incented to operate in manner which can benefit the system, both at the individual customer level and for aggregations of customers.

Customer-Based Storage Ownership Models

Grid-scale Storage vs. Customer-based Storage (Continued)

- In US markets, energy storage developers are empowered to aggregate storage resources and deliver the aggregated capacity or services into the wholesale market and receive compensation for the value of these services.
- This aggregation model allows resources as small as 100 kW to participate and earn revenue through the provision of grid services to the system operator while benefiting from the on-site storage deployed.
- As Nova Scotia gains familiarity with energy storage operation and dispatch and quantifies the value of the services provided by energy storage to the grid, this value should be extended down to customers or customer aggregators to reduce costs while ensuring reliability.
- At this time, Nova Scotia should focus on grid-scale energy storage policies to ensure timely deployment in the system planning processes, and once experience is gained and storage values are quantified, then consider extending policies to customer-based storage or generation. Increasing customer participation in system operation further supports investments by the NS Power System Operator in IT Platforms that can manage and integrate greater customer participation.

Energy Storage Policy and Practices Scan

Energy Storage Policy & Practice Introduction

- This section of the report will look at a number of policy and practice areas most relevant to Nova Scotia.
- The energy storage policy and practice areas most applicable to Nova Scotia fall under the following categories:
  - Planning – Based;
  - Technical Barriers; and
  - Customer – Based.
- Within each of these categories, we review relevant state and provincial policies, and note their applicability to Nova Scotia.
- We also review Nova Scotia specific barriers and energy storage policy and practice lessons learned.

Energy Storage Policy and Practice Applicable to Nova Scotia

Energy Storage Policy and Practice

Planning - Based

<u>Resource Planning</u>

- Arizona Corporation Commission Moratorium
- California SB 338
- Colorado HB 1270
- Washington SB 5116

<u>Services – Value Recognition</u>

- California AB 2514
- Nevada SB 204
- New Jersey A3723
- Washington UTC Policy Statement

Technical Barriers

<u>Metering Requirements</u>

- Germany Renewable Energy Source Act
- UK Connection and Use of System Code CMP 281

<u>Interconnection Requirements</u>

- UK Nationally Significant Infrastructure Project Legislation
- 2020 Ofgem Energy White Paper
- FERC Order No. 841
- Ontario's 2017 Long-Term Energy Plan
- Arizona Rule for Interconnection of Distributed Renewable Energy
- California Rule 21 Interconnection – Rulemaking

Customer - Based

- FERC direction informs ISO level policies
- Arizona Corporation Commission (ACC) storage amendment
- FERC directs states to recognize DERs
- Colorado SB 9
- FERC Order No. 2222

- The three categories shown above are most applicable to Nova Scotia. Under each category, we have detailed the types of policies and example policies we will review on the following slides.

- We focus on planning-based policies and practices due to the Nova Scotia electricity sector structure, however learnings from competitive wholesale markets are applied in the provincial context. Customer-based energy storage policies are reviewed in Appendix A as they are not the focus of this energy storage policy and practice scan but are indicative of current trends, primarily in US markets .

POWER ADVISORY

Planning - Based

Planning - Based Policies & Practices Considered

- Under Planning - based policies and practices, we consider two distinct types: 1) Resource Planning; and 2) Service Value Recognition.

1. Resource Planning: Give due consideration to energy storage in resource planning frameworks when evaluating generation, transmission or other system investments. Two different approaches are commonly used in the US.
    1. Public utility commission develops rules or targets for integrating energy storage, often to support increased renewable penetration as an alternative to coal-fired generation or displace or reduce the need for natural gas peaking generation. This may follow an independent study or report that investigates the benefits that energy storage can provide to the jurisdiction and its ratepayers.
    2. Utilities are mandated to consider energy storage in their resource planning efforts. In a similar process, commissions may direct utilities to evaluate energy storage by addressing the costs and benefits of integrating energy storage.
2. Service Value Recognition: Governments, regulators, and utilities are starting to recognize and monetize the value that energy storage can provide. Energy storage offers a variety of services, as described in the first section of the report. It is essential for utilities and system operators to monetize the value of the various services provided by energy storage resources when undertaking power system planning. In competitive power markets, this value recognition is enabled through wholesale market prices for these services. In regulated markets the alternative is to ensure that the value of all services are attributed to the energy storage asset when evaluating alternatives.

POWER ADVISORY

Resource Planning Policy and Practice

- **Arizona Corporation Commission (ACC) Moratorium:** Instituted in 2018, ACC placed a moratorium on utilities procuring capacity from new gas plants over 150 MW for 2018 through 2019. Utilities were required to conduct an independent analysis of "alternative energy storage options" costs. The ACC issued several orders imposing additional requirements on planning processes, including requiring utilities to analyze projected costs of future energy storage technologies in their IRPs.

- **California SB 338:** Required California PUC and publicly owned utility governing boards to consider how energy storage, energy efficiency strategies, and DERs can help utilities meet peak demand while reducing the need for new generation and transmission facilities. California utilities are now legally obligated to plan how carbon-free resources can help address the solar "duck curve" and consider energy storage in their IRP process.

- **Washington SB 5116**: Utilities must consider energy storage in their resource planning. When utilities make new investments, they are mandated to consider acquisition of resources, including energy storage.

Resource Planning Policy and Practice cont.

- **<u>Colorado HB 1270</u>:** Directed Colorado PUC (CPUC) to develop rules for integrating energy storage resources into utility planning process. CPUC must establish mechanisms for the procurement of energy storage systems by IOUs based on an analysis of costs/benefits, grid reliability, and reduced need for additional peak generation capacity. The Rules Regulating Electric Utilities was amended so that when considering adding additional resources to the grid, utilities must consider the benefits energy storage may provide for increasing integration of intermittent resources and improving reliability.

Nova Scotia Take Away

Guidelines similar to Colorado's HB 1270 for NS Power to evaluate and integrate energy storage in their IRP would formalize the consideration of energy storage resources. However, given that energy storage is already evaluated in NS Power's IRPs there is less need for legislative action.

Service Value Recognition Policy and Practice

- **California AB 2514:** Requires California PUC to determine appropriate targets for each large investor-owned utility (IOU) to procure viable and cost-effective energy storage systems (2010). The bill also required the governing board of each local municipally-owned electric utility to determine appropriate targets. Local municipally-owned electric utilities in California were required to evaluate if energy storage is appropriate, viable, and cost-effective and release a report every 3 years.

- **Nevada SB 204:** Directs Public Utilities Commission of Nevada (PUCN) to investigate whether it was in the public interest for electric utilities to procure energy storage systems and eventually establish biennial energy storage procurement targets for certain utilities (2017). PUCN was required under the bill to consider whether energy storage systems will catalyze the integration of renewable energy resources, improve the reliability of the electric grid, and help reduce the emissions of greenhouse gases. In response to SB 204, the Nevada's Office of Energy commissioned a study which determined that it is in the public interest to proceed with establishing energy storage procurements.

Nova Scotia Take Away

To date, there has not been a public review in Nova Scotia to determine whether energy storage is in the public interest, however the energy storage investments proposed by NS Power are being reviewed by the Nova Scotia Utility and Review Board (UARB) as part of such an assessment.

Service Value Recognition Policy and Practice cont.

- **New Jersey A3723:** (2018) required that the NJ Board of Public Utilities (BPU) conduct an energy storage analysis and submit a written report to the governor within one year of enactment. The law required BPU to consult with PJM and other stakeholders in preparing the energy storage analysis. In conducting the analysis, the board would consider how energy storage systems may benefit ratepayers and whether they promote the use of electric vehicles in the state. Ultimately, the report was to summarize the analysis and recommend ways to increase opportunities for energy storage.

- **Washington Utilities and Transportation Commission (UTC) draft policy statement:** Recognized in 2017 that energy storage is a “key enabling technology” for decarbonizing the Washington grid. Washington’s IOUs were directed to use an IRP process to analyze energy storage options before committing to other resources, like gas-fired peakers. The policy requires that all factors (transmission, generation, and distribution) should be included when evaluating energy storage so that all value streams can be analyzed. The UTC policy statement also made clear that it would apply ordinary cost recovery mechanisms to IOU acquisition of energy storage resources.

Nova Scotia Take Away

Currently, NS Power has proposed four 50 MW energy storage assets. The UARB is expected to review and assess the various value streams that these investments will deliver while enabling the phase out of coal and supporting increased penetration of renewable energy. Ongoing monitoring and performance reporting will ensure value is being extracted from these investments.

Technical Barriers

POWER ADVISORY

Technical Barriers Policies and Practices

- Other jurisdictions are examining any technical barriers or obstacles preventing the interconnection of energy storage under reasonable operating assumptions and requirements that are not appropriate for energy storage projects. These policies and practices look to change the classification of energy storage and promote rules that optimize the discharge capabilities of storage.

- Metering Requirements and Charge Determination: In general, since energy storage works differently than generating resources (charging during low demand and discharging during peak hours) normal metering and billing requirements can be unfairly applied to storage systems. Enabling policies can prevent "double-charging" energy storage systems for both purchasing and selling electricity or exempt storage from grid levies and tariffs.

- Interconnection Requirements: Currently, many interconnection policies hinder the development of energy storage. There is a general lack of clarity as to whether and how existing interconnection rules and related documents, such as application forms and agreements apply to storage systems. Developers often face similar approval and interconnection processes as traditional generating resources that were not designed for energy storage projects. In addition, the screening or study process in which utilities evaluate energy storage often make worst case operating assumptions and do not consider non- and limited-export systems.

Common approaches to removing these barriers include defining energy storage and clearly stating which procedures apply to the interconnection of new energy storage. Interconnection procedures should be updated to identify a list of acceptable methods so that there is a standard for the facility owner and utility to rely upon. Standards that describe the scheduling of energy storage operations, specifically time-specific import and export limitations, should be developed.*

** https://irecusa.org/programs/batries-storage-interconnection/*

Technical Barriers Policies and Practices

- Defining Energy Storage: Legislation, regulations and market rules and the regulatory treatment of energy storage is starting to be differentiated from current definitions for electricity generation and electricity loads to reflect its unique characteristics.

  - By way of example, in Alberta, Bill 86 was tabled in fall 2021 that included proposed amendments to the Alberta Utilities Commission Act, the Electric Utilities Act, and the Hydro and Electric Energy Act.

  - The Bill included definitions for "energy storage facility" and "energy storage resource" and amended several clauses by adding "energy storage resource" after a reference to "generating unit". The draft legislation was designed to be technology agnostic

  For example, under Alberta's draft legislation, one definition would include:

  - energy storage facility: "a facility that uses any technology or process that is capable of using electric energy as an input, storing the energy for a period of time and then discharging electric energy as an output."

Technical Barriers Policies and Practices

- Interconnection Requirements: The interconnection process presents different types of barriers which have been identified within the NS market.
  - In the Nova Scotia electricity market, there is no path to selling services from energy storage facilities to the NS grid, so energy storage will only be developed by NS Power as part of its system planning or through a competitive process where storage developers sell services through a form of tolling agreement or PPA.
  - Interconnection financial barriers: Stakeholders have reported that the NS Generator Interconnection Procedure requires deposit fees to maintain a position in the interconnection queue, much higher than other jurisdictions. These include the System Impact Study Deposit and the Re-Study Deposit, which can total up to $450,000 for projects over the size of 150 MW.
  - Interconnection methodology barriers: Interconnection studies should take into account the unique operating characteristics and technology benefits of energy storage. Connection processes may have been developed to assess renewable generation and use worst-case scenarios for system constraints. NS Power has reviewed its interconnection study process to take into account the ability of the energy storage facilities to relieve system limitations, and NS Power reports that it assumes less than full rated capacity when performing interconnection studies based on expected demand and supply conditions.
  - NS Power under its Generation Interconnection Procedures uses the Generator Interconnection Request Form and the Standard Generator Interconnection and Operating Agreement (GIA) for storage projects, even though the GIA has no mention of energy storage within its terms.

Metering Requirements

- **Germany's Renewable Energy Source Act:** Incentivizes the development of electric storage facilities by giving them exemptions to levies and grid tariffs, but only if the stored energy is fed back into the grid i.e. targeting grid-connected batteries in front of the meter. The German Federal Energy Industry Act (EnWG) similarly exempts storage facilities from the duty to pay network tariffs for a period of 20 years when withdrawing electricity from the distribution or transmission system for storage purposes. The exemption only applies if the electricity is re-fed with a delay into the same distribution or transmission system.

- **Connection and Use of System Code (CUSC) CMP281:** In the United Kingdom, Ofgem released modifications removing the Balancing Service Use of System (BSUoS) charges from energy taken from the National Grid system by storage facilities. Eligible storage facilities will be exempt from the BSUoS charges on their imported electricity volumes and will only be charged for their exports, eliminating double-charging.

Nova Scotia Take Away

NS Power does not charge generator customers for injections onto the grid and only charges customers for consumption thus the current rate treatment does not result in double-charging that is being addressed in other markets.

Interconnection Requirements

- **<u>United Kingdom Infrastructure Planning (Electricity Storage Facilities) Order 2020:</u>** Removed obstacles for development of large battery storage projects by exempting electricity storage from nationally significant infrastructure project (NSIP) regime, which requires pre-consultation, submission, and examination for a consent order. The NSIP policy is aimed at large infrastructure projects and is a time and labor-intensive process.

Nova Scotia Take Away

The Nova Scotia government can analyze building and permit requirements for generating facilities and judge their appropriateness for energy storage facilities.

- **<u>2020 Ofgem Energy White Paper:</u>** Defined energy storage and provided clarification to investors. A growing number of larger projects were needing licenses which depend on resource classification and investors were seeking greater regulatory certainty.

Nova Scotia Take Away

For developers and investors to undertake energy storage projects, clarity on the regulations that apply to energy storage is critical to gauge risk and complexity.

Interconnection Requirements

- **FERC Order No. 841:** Seeks to remove barriers for energy storage participation in wholesale capacity, energy, and ancillary services markets in RTOs/ISOs. The order directed RTOs/ISOs to revise their tariffs to develop a participation model that better incorporates energy storage into the market, including implementing processes that accommodate the physical and operational characteristics of energy storage.

Nova Scotia Take Away

This FERC order is intended for market-based jurisdictions with RTOs/ISOs. However, NS Power can ensure their tariffs similarly remove obstacles and optimize the benefits energy storage provides to the grid.

- **Ontario's 2017 Long-Term Energy Plan (LTEP):** Established initiatives to reduce market and regulatory barriers to deploy energy storage. As a result, the IESO established the Energy Storage Advisory Group in April 2018 to identify potential obstacles to fair competition for energy storage and address related market issues and opportunities.

Interconnection Requirements

- **ACC's New Rule for Interconnection of Distributed Renewable Energy:** provides an update to the interconnection rules of Arizona, making the interconnection of distributed generation and distributed storage more streamlined and less costly. It establishes an Expedited Interconnection Process for non-exporting energy storage facilities and addresses the technical and safety standards for energy storage systems.

- **California Rule 21 Interconnection - Rulemaking:** California's Electric Rule 21, the tariff that describes the interconnection and metering requirements for facilities has been updated multiple times to improve the guidelines. In 2016, a decision enhanced the behind-the-meter storage interconnection process with clarifications regarding the treatment of load from energy storage and modifying the interconnection application and agreement. Rulemaking in 2017 worked to streamline interconnection of storage facilities by establishing methods for optimal location on the grid.

Nova Scotia Take Away

Nova Scotia can learn from these examples of updating rules that are designed for generating resources and forming new ones specific to storage facilities. By establishing expedited processes and forming interconnection policy geared to energy storage, Nova Scotia will be taking steps to implement a FERC compliant approach to storage.

Customer - Based

POWER ADVISORY

Customer-Based Storage Policies and Practices

- To increase the uptake of energy storage by customers, jurisdictions can implement policies that break down barriers for customer-owned storage to participate in the market or create incentives for customers to build energy storage systems on their property. Time varying electricity rates is under review in Nova Scotia and can support the deployment of customer-based storage.
- In the US, FERC issued Order No. 2222 directed RTOs/ISOs to remove barriers to participation and allow Distributed Energy Resource (DER) aggregations to participate as a type of market participant. The order requires that proper coordination is taken with DERs to maximize their value by being able to deliver and be compensated for grid services. These DERs include energy storage and are generally customer-owned and customer-based.
- US states also have been taking initiatives to increase customer-based storage deployment. Some jurisdictions require utilities to submit programs and tariffs that incentivize customers to purchase distributed storage or establish the right of customer-based storage to interconnect to the grid without unnecessary restrictions. Practices include programs for customer-based storage by developers and quantifying and providing compensation for the value stack of storage services and benefits.
- Since the focus of this report is grid-scale energy storage and customer-based storage is an extensive field itself, the policies and practice related to customer-based storage in other markets are provided in the Appendix A.

Nova Scotia Specific Barriers and Energy Storage Policy and Practice Lessons Learned

Nova Scotia Specific Barriers to Energy Storage

1. Undervalued Grid Benefits: In the past, governments, regulators, and utilities have failed to recognize the value that energy storage can provide through capital deferral, load shifting and peak load shaving, improving grid reliability with cost-effective grid services. This is due in part to the lack of energy storage consideration in resource planning processes and lack of opportunity to realize value streams.

2. Technical Barriers:
    1. Interconnection Policy: There should be a distinction between energy storage and generation in the connection assessment process. Stand-alone storage has historically gone through the same planning, approval processes, and tariffs as generation facilities. This policy can deter the development of energy storage systems and delay projects.
    2. Metering Policy: The lack of distinction between generating resources and energy storage systems may also create metering issues. Standards that describe the scheduling of energy storage operations (charging/discharging) are necessary. "Double-charging" for importing and exporting electricity to/from energy storage facilities is not a concern for Nova Scotia, as NS Power does not have a rate for exporting electricity to the grid.

3. Policy Direction: Many jurisdictions that have strong uptake of energy storage are ones with a number of policies and legislation that mitigate the discussed barriers and provide guidance to utilities and stakeholders. Clarity and certainty in policy will provide guidance and initiative for commissions, utilities, stakeholders, and customers to take action.

Nova Scotia Energy Storage Metric Overview

The Metric Overview below is adapted from the 2019 Sandia Energy Storage Policy Summaries and provides a snapshot of the areas where Nova Scotia has already made progress in advancing energy storage policy.

Does Nova Scotia have a renewables mandate?	Yes 80% by 2030
Does Nova Scotia have a state mandate or target for storage?	No, but initial 200 MW planned
Does Nova Scotia offer financial incentives for energy storage development?	A smart grid pilot
Does Nova Scotia have a policy for the strategic deployment of Non-Wires Alternatives or Distributed Energy Resources to defer, mitigate, or obviate the need for certain T&D investments?	The IRP process
Does Nova Scotia have a policy addressing multiple use applications for storage?	Expected through the IRP and 200 MW of storage projects
Does Nova Scotia have a policy on utility ownership of storage assets?	The IRP process
Does Nova Scotia allow or mandate the inclusion of energy storage in utility IRPs?	Yes
Has Nova Scotia modified its permitting requirements specific to energy storage?	No
Does Nova Scotia allow customer-sited storage to be eligible for net metering compensation?	Yes
Has Nova Scotia revised its rate structures to drive adoption of behind-the-meter storage?	In process - Time Varying Prices
Approximate development of storage capacity in Nova Scotia.	2-3 pilots at the distribution level

Lesson Learned for Nova Scotia

- A major hurdle in the development of energy storage is utilities and other industry players failing to realize the full value of benefits. Service value recognition is the first step that many jurisdictions take to begin the process of enabling energy storage. The analyses and studies allow utilities and regulatory bodies to decide whether energy storage is cost-effective and appropriate and provide insight on the best way to develop the technology.

- Resource planning is another important step in implementing energy storage. Many utility commissions are requiring their state and local utilities to include energy storage in their IRP process. This does not force the utilities to develop energy storage, but it compels them to evaluate the benefits and costs it provides in a transparent manner. NS Power has taken this step in their most recent planning documents.

- Technical barriers are hurdles that energy storage systems face because the facility is a unique type of resource. It acts differently than other generating resources in response to the grid's needs. By defining energy storage clearly and changing regulations to optimize its benefits, energy storage becomes easier to build and connect to the grid. This catalyzes the development of energy storage when it is in the public interest.

Nova Scotia’s Current Legislation and Regulations Affecting Energy Storage

Legislative, Regulatory and Planning Framework for Energy Storage in Nova Scotia

The Nova Scotia electricity sector is governed by specific legislation, regulations and planning practices that impact the potential deployment of grid-scale energy storage.

- The Electricity Act establishes the authority of the Minister of Energy with the general supervision and management of the Act and authority to establish policies, programs, objectives, directives and approval processes among other things.
- The Act sets out NS Power's obligations to file applications for Board approval
- The Act authorizes the government to make regulations for establishing programs for the research, development and testing of energy storage. (S. 4D)
    - Regulations must establish program limits based on energy production capacity, energy output or ratepayer impacts.
    - Costs for programs under this regulation can be recovered through rates approved by the Board (S. 4E(3))

Legislative, Regulatory and Planning Framework for Energy Storage in NS

- The Public Utilities Act establishes the authority of the Board to regulate the electricity sector in Nova Scotia, including:
  - Requirements for NS Power to submit capital expenditure plans for Board approval (S 35)
  - Authority of the Board to approve rates, tolls and charges (S 64)

Legislative, Regulatory and Planning Framework for Energy Storage in NS

- To assist in evaluating necessary resource investments and provide an analytical foundation for such investments NS Power has developed an Integrated Resource Planning process (IRP). In this plan, NS Power evaluates a wide range of scenarios that assist in planning a power system that is safe, reliable and affordable for customers.

- NS Power's 2020 IRP discusses energy storage as an important element in the future planning of the grid. The IRP portrays energy storage (battery storage specifically) as a potential supply resource that can offer a range of services with differing values that is limited by the cost and duration of stored energy. NS Power notes that battery storage provides capacity for only limited durations, while in contrast, fossil fuel-based generators can provide on-demand capacity for unlimited durations. NS Power specifies that battery storage can provide on-demand and firm capacity, ancillary services, and enables the integration of wind.

- The IRP includes energy storage in all of its near-term scenarios in varying amounts, with 30-60 MW by 2025 and up to 120 MW of storage by 2045 in several plans.

- The IRP also evaluated options to enable the integration of additional wind. First, it confirmed that an incremental 100 MW of wind could be added without system enhancements and that an additional 400 MW of wind could be added with a 200 MVA synchronous condenser and 200 MW grid-scale battery.

Legislative, Regulatory and Planning Framework for Energy Storage in NS

- When evaluating resource options, the IRP presents battery storage as a technology that can provide on-demand capacity and grid services on a limited basis. NS Power indicated to Power Advisory that the storage capability of its Wreck Cove hydroelectric facility provides many of the services that a short duration battery can provide, which diminishes the business case for short-term duration batteries.

- While acknowledging the services energy storage can provide, NS Power states that as a dispatch-limited resource, energy storage adds complexity to reliability planning because it has constraints that limit it from operating continuously at full capacity to meet demand, particularly in extended cold weather periods with high demand for electric space heating.

- The IRP asserts that wind capacity can be installed and supported with battery storage, but energy storage is limited in its ability to store low-carbon energy during high production and low demand hours.

Legislative, Regulatory and Planning Framework for Energy Storage in NS

- NS Power states in its IRP that it plans to monitor the two conditions that are limiting energy storage development: cost and duration.
  - The IRP expects a large decrease in battery costs as the technology matures. NS Power will “continue to track the installed costs of wind, solar, and energy storage to look for variations from the trajectories established in the IRP.”
  - The IRP assumes that 1-hour duration batteries are the only cost competitive options available. With the expected decrease in levelized capacity cost, 4-hour batteries may become more realistic for NS Power’s future planning. This would change the assumptions for capacity and wind integration services.
- The IRP does present the battery storage costs by system duration and cost assumptions for power (“capacity”) and energy (“duration”). It also includes lower wind and battery costs in a sensitivity analysis.
- Within its System Impact Study (SIS), NS Power considers two aspects to energy storage. The first is transmission planning; NS Power uses the nameplate capacity of energy storage facilities in its interconnection studies and discharge/charge expectations. It uses mean peak capacity for winter capacity forecasts. The second aspect is future resource planning; NS Power utilizes a prorated capacity when considering energy storage projects using an Effective Load Carrying Capability (ELCC) approach. The details of this method is presented on the next slide.

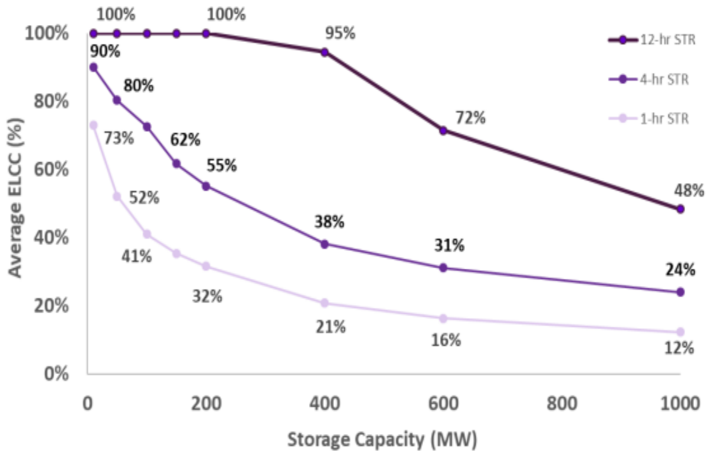
Legislative, Regulatory and Planning Framework for Energy Storage in NS

- As part of its resource planning process, NS Power considers storage in its "pre-IRP" work by examining the potential contribution of the resource toward resource adequacy needs. The ELCC method was selected as the best practice for estimating the contribution of dispatch-limited resources, including storage.

- NS Power's IRP indicates that storage exhibits diminishing Effective Load Carrying Capability (ELCC) returns to additional capacity. The decline in storage ELCC occurs because after storage has clipped the original peak demand the peak period becomes longer.

- The study evaluates 3 durations of energy storage: 1-hr, 4-hr, and 12-hr. The results are shown to the right. Increasing the duration of storage increases the ELCC but reduces its cost-effectiveness.

Figure 32: Average Storage ELCC



Source: Nova Scotia Power 2019 Final Pre-IRP Report

Legislative, Regulatory and Planning Framework for Energy Storage in NS

- Power Advisory believes that NS Power's IRP selected relatively modest amounts of energy storage because it assumed that natural gas would be available to provide longer duration energy requirements. However, the Low-Emitting Generation requirement that is an element of the Clean Electricity Standard (CES) that is being implemented by the Federal government is likely to significantly constrain or effectively prohibit natural gas-fired generation after 2035.
  - The CES proposes a Low-Emitting Generation standard of 50 tonnes C02/GWh or less, which is based on carbon capture applied to natural gas-fired generation.

- NS Power's IRP Action Plan Update – January 2022 notes:
  - NS Power continues to evaluate options for CT deployment that are compliant with the evolving planning and policy landscape.
  - NS Power is studying a number of potential locations for CT deployment in Nova Scotia; this work includes evaluating and co-optimizing gas supply and transmission interconnection requirements and discussions with potential CT manufacturers to identify candidate units.
  - NS Power is prioritizing alternatives such as BESS and coal to gas conversions that may reduce the total CT resource requirements by 2030, however new CT resources are still expected to be required. "

- Power Advisory notes that this Action Plan Update was issued prior the release of the Federal government's Clean Electricity Standard Discussion Paper in March. This Discussion Paper appears to strengthen the rationale for BESS given the constraints on CTs.

Legislative, Regulatory and Planning Framework for Energy Storage in NS

- NS Power filed a 2022-2024 General Rates Application (GRA) in January 2022 seeking an increase to Nova Scotia customer electricity rates.

- The GRA references several changes to its capital investment and planning for meeting the 2030 coal phase out and 80% renewable energy obligations including;
    - increased interprovincial transmission capability,
    - Retirement or phase-out of existing coal-fired generation by 2030, including the conversion of existing coal generation to natural gas at Point Tupper GS, and
    - installation of four 50 MW grid scale battery sites providing firm capacity, ancillary services, and wind and solar integration

Legislative, Regulatory and Planning Framework for Energy Storage in NS

- As part of its 2022-2024 GRA, NS Power's capital plans includes a list of major projects the utility plans to undertake. It includes the installation of four 50 MW grid-scale battery sites which will provide "energy storage, firm capacity, and ancillary services for the reliable addition to further intermittent renewable resources" and contribute "to the decarbonization of NS Power's generation mix." The GRA also states that to fulfill the 2030 goals of phasing out coal-fired generation and achieving 80% renewable electricity, a portfolio of clean energy solutions including grid-scale storage is required.

- The GRA emphasizes the value of energy storage services reviewed in the 2020 IRP and makes clear that NS Power is planning to add energy storage to integrate additional wind energy.

- This investment presumably will be reviewed by the UARB as part of NS Power Annual Capital Expenditure Plan. It will be interesting to see whether the UARB will be satisfied by the fact that this investment was identified in the IRP as necessary if additional wind were to be added beyond 100 MW or whether further analysis from NS Power will be requested. This process may provide the foundation for future assessments and reporting on of the actual performance and value of storage assets, as experience is gained.

Legislative, Regulatory and Planning Framework for Energy Storage in NS

- The Nova Scotia government has the authority to require the deployment of energy storage under the Electricity Act, Section 4D:
  - *“establishing programs for the interconnection of any plant or equipment to the electrical grid of a public utility for the purpose of research, development and testing relating to*
    - *(a) energy storage;"*
- NS Power has increased its planning assumptions from the 2020 IRP where it stated it would deploy:
    - *"...Up to 120 MW of storage by 2045 is selected in the portfolios with deployments of 30-60 MW by 2025..."*
- To an increase noted in the GRA with:
    - *"Installation of four 50 MW grid-scale battery sites providing energy storage, firm capacity, and ancillary services required for the reliable addition of further intermittent renewable resources (e.g., wind & solar) and contributing to the decarbonization of NS Power’s generation mix."*
- Alternatively, the province could allow NS Power to proceed with its proposed approach, however that may not encourage private sector investment and innovation in storage technology deployment.

Legislative, Regulatory and Planning Framework for Energy Storage in NS

- The IRP review and the GRA processes should create an environment where the details around the planning assumptions and value of the services that are attributable to energy storage can be shared and reviewed with stakeholders in a collaborative manner.

- Energy storage is a relatively new technology whose costs are rapidly declining, and NS Power has made commitments to pursue the technology as a means of supporting the move to phase out coal, reduce emissions, and integrate additional wind energy resources.

- It will be key for NS Power to share its planning assumptions regarding the different services provided by energy storage assets, as a means of demonstrating transparency in planning and storage assest valuation and educating stakeholders about the benefits and challenges that energy storage faces in supporting the decarbonization of the Nova Scotia electricity system.

Stakeholder Engagement

POWER ADVISORY

Stakeholder Engagement

- Power Advisory reached out to a number of stakeholders to seek views on the opportunities and barriers to grid-scale energy storage in Nova Scotia, including the organizations listed below.
- Their comments and perspectives are presented in this section. These are stakeholder views, not Power Advisory's.

Organizations Interviewed	
Nova Scotia Power – System Planning	EDF Renewables
Nova Scotia Power – System Operator	Stem
Alternative Resource Energy Authority	NRStor Inc.
Dalhousie University	Siemens Energy Canada Ltd.
Canadian Renewable Energy Association	SunGrid Solutions
	Renewable Energy Systems (RES)

Stakeholder Feedback – Market Structure

- There is currently no price signal for energy storage asset owners to follow to guide operation and dispatch. This is a barrier to private investment.
- Customer electricity rate design should better reflect time of use value of electricity. With sufficiently high price signals (which might otherwise be unpopular) this would encourage the consideration of storage.
- NS Power ownership of storage may be most appropriate at first. Then once value attribution has been established, allow third parties to participate. Third-party development and operation is possible, but only with NS Power controlling dispatch. An NS Power and private developer partnership may deliver the most value given private developer experience and motivation to maximize utilization / revenue. [Power Advisory discussed earlier the challenges of efficiently structuring such a commercial relationship.]
  - Not all developers shared this view, as some strongly advocated the role for private storage ownership or shared ownership in partnership with NS Power to extract maximum value from storage assets.

POWER ADVISORY

Stakeholder Feedback – Market Structure

- It is impossible to advance storage projects without a revenue stream so those without a power purchase agreement cannot remain in the interconnection queue. Revenue streams could include payments for capacity, operating reserve, energy shifting value to provide a bundled revenue to a storage developer.

- PPA structure for storage is possible but complex. Thus, energy storage development through PPA's will take a couple of years to develop.

- The market will require increased transparency in value attribution to justify deployment of storage. It could allow or encourage private storage development but would require transparent pricing methodology and third-party validation of valuation for services such as energy (time differentiated), capacity, and ancillary services.

Stakeholder Feedback – Value Compensation

- NS Power and the UARB must determine the value for storage assets, locational differentiation, and disaggregate the value of storage services which will evolve over time. It is important to establish metrics and benchmarks to assess the asset performance and value of storage to maximize benefit to customers through UARB regulatory oversight.
- Developers need revenue certainty of 10 – 20 years to warrant investment in ownership and operation. NS Power is best positioned to operate assets and take full advantage of the range of services in the immediate term. Storage investment requires significant data disclosure for developers to have confidence in future revenue streams.
- Grid scale storage may or may not be economic for rate payers given the range of options to manage Nova Scotia grid. The IRP process needs to be more transparent and could have independent third parties performing economic assessment of energy storage investments.
- NS Power will be motivated to own storage assets as it increases its rate-base and revenues whereas purchasing storage services from private developers are expenses and do not benefit the utility financially.

Stakeholder Feedback – Planning

- Energy storage is a domestic resource that provides energy security to the province, in contrast to imports.
- When planning for storage and compared to natural gas generation, one must take into account the cost of gas storage for winter peak demands, not just capital cost of gas generation.
- If storage assets are owned by NS Power, the UARB should monitor energy storage asset utilization to ensure optimal use through independent studies or performance benchmarking. Privately-owned storage assets generally have strong incentives to maximize utilization, which helps ensure that these facilities are cost-effectively deployed.

Stakeholder Feedback – Technical

- The interconnection process can be a barrier, but it is not always an obstacle. System impact studies and process requirements must be clear for private developers of storage to support investment.
- The costs of interconnection studies in Nova Scotia are higher than other markets. For example, the interconnection deposit that was required for one project of $625k was more than 10 times what the comparable project interconnection deposit would be in Ontario.
- Getting storage equipment approved through standards organizations is time consuming and onerous. The Canadian Standards Association facility inspections can be inconsistent due to the lack of experience by inspectors.
- There is no standard form of customer-based storage services agreement with NS Power, so each project requires negotiation. This can be a barrier.
- The NS Power customer interface is not yet developed to take advantage of the distributed storage deployed under the current pilot programs. NS Power infrastructure is advancing but not yet fully prepared.

Summary of Findings – Options for Nova Scotia

POWER ADVISORY

Summary of Findings – Options for Nova Scotia

The following are some of the key research areas reviewed with options and considerations presented. `

1. Legislative – Regulatory and Structural Barriers
2. Pathways - Ownership and Development Models
3. Metering and Interconnection Requirements
4. Energy Storage Assessment / Service Value Recognition
5. Customer-based Storage

POWER ADVISORY

Summary of Findings

1. Legislative – Regulatory and Structural Barriers

- There are no real legislative barriers to energy storage deployment in Nova Scotia. The government has the authority to direct programs for the research, development and testing of energy storage assets (Electricity Act S. 4D).

- There are barriers to private investment in energy storage projects outside of procurement by NS Power. The electricity sector structure does not provide energy storage operators with a price signal to guide charging/discharging decisions or offer compensation for the value of services provided, whether they be energy, ancillary services or capacity. In the current vertically-integrated electricity market structure, NS Power or various municipal utilities are the only purchasers of electricity or services from grid-scale energy storage projects. In this environment, developers must collaborate with NS Power or the municipal utilities, which represent a small share of the market, to develop grid scale energy storage projects.

Summary of Findings

1. Legislative – Regulatory and Structural Barriers

- NS Power has proposed to develop four 50 MW / 4-hour duration energy storage projects in its current IRP update and GRA as a means of renewables integration and supporting the coal phase out.
  - As the penetration of energy storage increases, the value offered by each subsequent MW typically declines. This is true for virtually all resources, but particularly for energy limited resources. This notion of diminishing returns is reflected in the results of the Effective Load Carrying Capability (ELCC) approach used in NS Power's IRP process to assess the capacity contribution of energy storage.
- Power Advisory recognizes that NS Power will be re-evaluating the role of energy storage target in the ongoing update to its IRP. With a more limited role for natural gas under the Clean Electricity Standard, Power Advisory expects that the IRP Update will recommend increased volumes of energy storage. This is unlikely to change our findings. In fact, as discussed it may strengthen the case for some of the alternatives identified.

Summary of Findings

2. Pathways - Ownership and Development Models

- NS Power is responsible for long-term resource planning for the vast majority of the province's electricity requirements. This includes evaluating the cost-effectiveness of energy storage in its IRP and utilizing energy storage to address resource adequacy. NS Power is planning to deploy four 50 MW four-hour duration energy storage projects to support the phase out of coal and integrate additional wind.
- The two main options for ownership of energy storage asset are either NS Power or private developers.
- Nova Scotia's electricity system doesn't have price signals that would allow independent storage developers to evaluate the economics of making a merchant investment in an energy storage project and make operating decisions regarding the provision of the various services that it could provide. The level of effort required to develop such a market structure is significant and equally important such a market structure is unlikely to induce private sector investment given NS Power's market dominant position. Therefore, Power Advisory believes that third-party investment in energy storage is only likely to occur if there is a contract with NS Power that allows it to direct the operation of the project.

Summary of Findings

2. Pathways - Ownership and Development Models

- Such a contract would likely be in the form of a tolling agreement and would have to anticipate all of the operating parameters and system conditions that would affect dispatch. Designing such a contract will require significant effort given that it will need to reflect the anticipated performance of the energy storage asset and the impact on the performance of the asset of various operating conditions. For example, lithium-ion batteries have a desired operating range to maintain their useful life. However, there may be system conditions (e.g., peak electricity demands and unavailability of various generating units) when it is otherwise economic or preferable to exceed these desired operating parameters. These complexities will need to be embedded within such a tolling agreement. Furthermore, it will be important that the tolling agreement be fully developed and be part of energy storage procurement process so that independent storage developers can properly price the services to be provided.

Summary of Findings

2. Pathways - Ownership and Development Models

- Independent storage development and ownership may offer benefits to Nova Scotia customers given the experience and potential economies that these parties can bring. These storage developers offer experience in the efficient operation and maintenance of energy storage and are motivated by maximizing the value and revenue from these storage assets.

- The development and construction of a storage asset by an independent developer may result in lower costs and lower overall risk than having NS Power develop and construct the storage assets itself. The benefits of an independent developer constructing a storage project are likely to be muted by the fact that both NS Power and the storage developers are likely to rely on third-party contractors for construction. We expect that independent storage developers may be better positioned to oversee and manage the contractor, but this is likely to vary depending on the independent developer's experience.

Summary of Findings

2. Pathways - Ownership and Development Models

- Given the uncertainty regarding the relative attractiveness of these two-storage development and construction models, Nova Scotia may wish to test the relative cost-effectiveness of each by conducting a competitive procurement where both development and construction models participate.
    - The importance of selecting the most cost-effective on a risk-adjusted basis model for energy storage development and operation in Nova Scotia depends in part on the amount of energy storage that Nova Scotia ultimately will require.

- However, it will be difficult for such a competitive procurement model to be able to properly assess the relative risk of the two models. The NS Power energy storage project will have a fundamentally different risk profile than a privately developed energy storage project NS Power energy storage projects are likely to be built and operated on a cost of service basis. This represents a very different risk profile than for a private developer project where cost recovery is likely to be more performance based. A tolling agreement would reflect performance assumptions (e.g., round trip efficiency and the potential for performance degradation over time). To the degree that the project didn't achieve these performance assumptions the developers returns would be lower.

Summary of Findings

2. Pathways - Ownership and Development Models

- Discerning the differences between these two risk profiles and value propositions would be difficult if this was to be done as part of the procurement process. The procurement administrator would need to be able to discern the differences in the relative risks posed by the two ownership and operation models and based on these risk differences determine what's an appropriate cost/price differential for each.

- An alternative model would be to allow both NS Power and independent developer storage projects to be developed and constructed and to assess the performance of each over time, with a third-party audit of the performance and effective cost of each.
    - Given the anticipated volume of energy storage that Nova Scotia is likely to ultimately require to achieve the province's clean energy and carbon reduction goals, assessing the relative merits of these two approaches is likely to be a valuable endeavor.

Summary of Findings

3. Metering and Interconnection Requirements

- There could be increased clarity as to whether and how existing interconnection rules and related documents, such as application forms and agreements, apply to customer-based energy storage systems. NS Power under its Generation Interconnection Procedures uses the Generator Interconnection Request Form and the Standard Generator Interconnection and Operating Agreement (GIA) for storage projects, even though the GIA makes no mention of energy storage within its terms. Nova Scotia could customize the interconnection process for energy storage by creating interconnection procedures specifically designed for energy storage.

- The generator interconnection procedure in Nova Scotia can require significant deposit fees to secure a position in the interconnection queue. Specifically, the System Impact Study Deposit and the Re-Study Deposit can total up to $450,000 for projects over 150 MW. Stakeholders reported that these fees in Nova Scotia were substantially higher than in other Canadian jurisdictions.
  - The Re-Study Deposit is designed to cover the costs of repeating studies for renewable generators that can cause system constraints if those projects do not move forward.

POWER ADVISORY

Summary of Findings

4. Energy Storage Assessment / Service Value Recognition

- Some US jurisdictions mandate that utilities specifically evaluate the benefits and costs of energy storage in their planning processes. NS Power included energy storage in its 2020 IRP. The IRP presents short and long-term scenarios that include energy storage. It also presents the results of the ELCC methodology that evaluates the contribution of storage toward meeting resource adequacy needs under a number of seasonal demand scenarios.

- Power Advisory expects that NS Power will present the business case for its energy storage investment in its Annual Capital Expenditure filing with the UARB. This should provide the foundation for future assessments and reporting on of the actual performance and value of storage assets, as experience is gained. The government or the UARB could require such reporting as part of the ongoing regulatory review processes to ensure that the value of the assets is maximized and the full value of potential benefits realized.

Summary of Findings

5. Customer-based Storage

- Customer-based storage is an extensive field itself and will present its own unique challenges.
- If there is a desire to promote customer-based storage, electricity rate design should better reflect the time-of-use value of electricity.
- Many jurisdictions are encouraging customer-based battery storage to produce cost savings and enhance reliability, as is NS Power through the Battery Storage Pilot Program for residential customers. Learnings from this pilot willallow NS Power to expand customer-based storage. This could include electric vehicle to grid (V2G) incentives that pay EV owners for delivering energy services to the power system.
- In the US, FERC Orders have resulted in utilities removing barriers to participation and allow Distributed Energy Resource (DER) aggregations to participate in competitive markets. This objective is being advanced in Nova Scotia through the pilot program and experience and control technologies will improve the value of these types of distributed resources on the Nova Scotia grid.

Appendix A: Customer-Based Energy Storage Policy and Practice

FERC Order No. 841

In the US, federal policy establishes the framework at the wholesale level for encouraging energy storage and opening up the market to Distributed Energy Resources(DER) participation. States and Regional Transmisson Organizations (RTOs) and Independent System Operators (ISO) then comply with the federal policy framework.

- In February 2018, FERC issued Order No. 841, which sought to remove barriers for energy storage participation in wholesale capacity, energy, and ancillary services markets in RTOs/ISOs. Order No. 841 directed RTOs/ISOs to revise their tariffs to develop a participation model that better incorporates energy storage into the market, including implementing processes that accommodate the physical and operational characteristics of ESRs. The revisions focus on eligibility to participate in all capacity, energy, and ancillary services markets, establish market clearing price as a wholesale seller or buyer, and set a minimum size requirement for storage resources' participation in the RTO/ISO markets of not more than 100 kW.

- FERC also determined that energy storage resources should pay the wholesale locational marginal price for electric energy that the resource buys from the RTOs/ISOs (presumably to charge the resource) that is then resold back into the RTOs/ISOs.

FERC Order No. 2222

- Order No. 2222 defines a DER broadly as “any resource located on the distribution system, any subsystem thereof or behind a customer meter.” The list of eligible resources includes electric storage resources. FERC seeks to foster a “technology-neutral” approach by prohibiting RTOs/ISOs from limiting the kinds of technologies (such as ESRs) that can join DER aggregations. In turn, RTOs/ISOs must remove barriers to participation and allow DER aggregations to participate as a type of market participant.

- Specifically, Order No. 2222 requires that DER aggregations meet a minimum size specified by the RTOs/ISOs rules, not to exceed 100 kW. FERC also provides flexibility in terms of the system location of DERs and DER aggregations, requiring RTOs/ISOs to propose locational requirements that are “as geographically broad as technically feasible.” The Order also directs the RTOs/ISOs to address market participation agreements and coordination with DER aggregations.

- In theory, Order No. 2222 should maximize the value of DERs based on evaluating price signals and the operational cost of delivering services. At the same time, it should benefit ratepayers through reduced prices and improved grid resiliency.

Distributed Energy Storage

- **Arizona Corporation Commission (ACC) storage amendment:** Required by December 2035 for installed energy storage systems with an aggregate capacity equal to or greater than five percent of an electric utility's 2020 peak demand, 40% of which must be customer-owned or leased distributed storage.
    - Utilities must submit tariffs and programs to incentivize customers to purchase or lease distributed storage in exchange for that customer's participation in a demand response or similar program, as well as to provide compensation to customers for the energy storage value stack.

- **California AB 2868:** requires PG&E, SCE, and San Diego Gas & Electric (SDG&E) to propose programs and investments for an additional 500 MW of distribution-connected or behind-the-meter ESRs with a useful life of at least 10 years. The state's IOUs were instructed by the PUC under the bill to hold at least two workshops to develop consistent standards for storage procurements.

- **Colorado Senate Bill 9:** Directed Colorado Public Utilities Commission to develop rules allowing the installation, interconnection, and use of energy storage systems by utility customers. Establishes that Colorado's electric consumers have a right to install, interconnect, and use energy storage systems without unnecessary restrictions or regulations and without discriminatory rates or fees.

- **Massachusetts S.1977:** Directs Massachusetts Department of Energy Resource (DOER) to establish an incentive program for additional deployment of energy storage systems in Massachusetts on customer premises.

Order No. 2222 Compliance Filings

- FERC's new rules under Order No. 2222 requires RTOs/ISOs to implement these reforms by proposing market rules and changes to their tariffs. CAISO and NYISO were the only ones to submit their proposals by the original deadline. The following summaries provide an overview of the changes proposed to be made in compliance filings.

CAISO Compliance Filing

- The proposed tariff revisions include: amending the definition of a DER to match the FERC definition; implementing a DER aggregation model that includes both technologies that supply energy to load and that curtail demand (demand response); creating a compliance obligation on the DER aggregation to avoid double-counting with retail programs and requiring the distribution company and CAISO to confer regarding double-counting issues; lowering the DER aggregation capacity requirement from 500 kW to 100 kW; requiring DER aggregators to notify the CAISO whenever their information changes due to the removal, addition, or modification of a DER within the DER aggregation.

NYISO Compliance Filing

- The proposed tariff revisions include: addressing the interconnection of DER for the exclusive purpose of participating in an aggregation; preventing the double-counting of DER services; revising the market participation agreement for DER aggregations and DER enrollment requirements; enhance coordination; requiring retail regulatory authorities to opt-in small utilities serving four million MWh or less per year to the DER program; revising the definition of aggregation to allow aggregations of a single resource.

POWER ADVISORY

Distributed Storage / Aggregation Practices

- The following states have implemented practices that encourage the development of distributed storage at the residential, business, and commercial level. The practices focus on making the market participation easier for distributed storage and aggregators and taking advantage of their benefits to the grid. These examples may provide ideas for Nova Scotia to utilize in the future when considering the development of distributed storage.

- **New York**: An aggregation of resources can participate as a single entity in NYISO's wholesale energy, ancillary services, and capacity markets with a minimum offer of 100 kW, provided each individual resource is electrically connected to the same transmission node. Under NYISO's rules, DERs benefit from a "dual participation" model in which they can simultaneously offer into the wholesale markets while also providing energy and services to local distribution utilities and host load. Including ESRs in an aggregation of resources and providing services in both the wholesale and retail markets open up new revenue streams for ESRs.

- **Arizona**: In 2020, the ACC approved a residential energy storage pilot program approved by Arizona Public Service (APS). APS is also required to submit a revised tariff to provide for aggregation of distributed energy storage resources to provide compensation for the value stack of benefits these resources will provide to the grid.

POWER ADVISORY

Distributed Storage / Aggregation Practices

- **California:** California's Community Choice Aggregators (CCAs) are beginning to procure storage, with East Bay Community Energy, Monterey Bay Community Power, Silicon Valley Clean Energy, and Marin Clean Energy all pursuing a variety of stand-alone storage or solar plus storage projects to provide capacity or defer distribution and transmission upgrades. Many of the RFOs coming from the California CCAs include a renewables plus storage component and focus on Resource Adequacy procurement.

- **Texas:** Texas projects have included utility-scale projects as well as microgrid and community storage developments. One example is Austin Energy's aggregated fleet of customer-sited energy storage, developed by Stem, a commercial-scale energy storage service company. Austin Energy offers its commercial customers energy storage options to help reduce energy costs while providing a reliable ESR for the grid. Austin Energy can call upon the systems provide instant and dispatchable grid stability.

Long-Term Energy Storage Agreement Structures

- Numerous energy storage projects (focused study of the US) have successfully entered long-term contracts for offtake of the energy storage resource. The contracts are most commonly referred to as energy storage PPAs, but several forms of agreements have been developed to take advantage of energy storage systems as both a generator and load discharge/charge.

- **Capacity Service Agreement (CSA):** the developer is responsible for developing, installing, and operating the energy storage system and charges the system at its own expense. The offtaker (usually a utility) pays a capacity charge for the system, subject to adjustment for availability, and uses the storage system's capacity attributes to satisfy the offtaker's resource adequacy (RA) requirements. The CSA typically allows the developer to market certain products from the energy storage system to third parties, as long as the delivery of such products does not interfere with the developer's obligation to deliver RA to the offtaker as and when required by the CSA.

Long-Term Energy Storage Agreement Structures

- **<u>Demand Response Energy Storage Agreement (DRESA):</u>** If a developer provides on-site, behind-the-meter storage to a number of customers, it may be able to aggregate the storage capabilities of those customers and enter into a DRESA. A DRESA between a local utility and an energy storage system developer allows utilities to compensate an energy storage system developer for providing the utility with energy storage system capacity and demand response energy storage ancillary services.

- Under customer agreements, each customer contractually allows the developer to make the storage systems available to reduce demand at the direction of the utility offtaker. The developer then enters into a long-term DRESA with a utility buyer under which the developer agrees to cause its customers to switch to energy storage as, and for the duration, requested by the utility. During this period, the developer's customers will rely on energy discharged from the storage system instead of electricity from the utility, thus reducing load on the grid.