APRIL 18, 2018 | BOSTON, MA

The Expanding Role of Energy Storage in the Regional Power System

Energy Storage Association Annual Meeting

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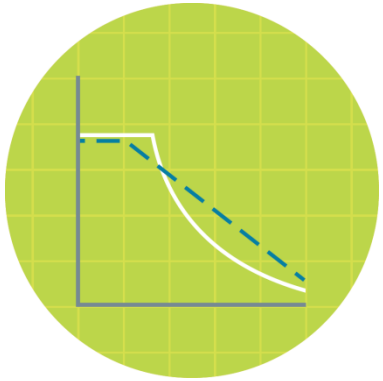
ISO New England Performs Three Critical Roles to Ensure Reliable Electricity at Competitive Prices

Grid Operation

Coordinate and direct the flow of electricity over the region's high-voltage transmission system

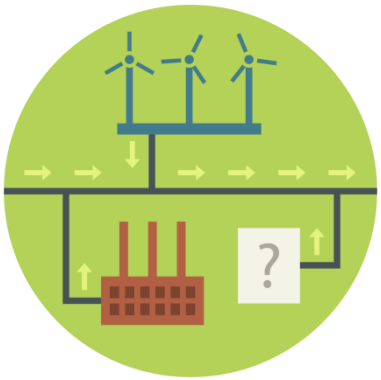
Market Administration

Design, run, and oversee the markets where wholesale electricity is bought and sold



Power System Planning

Study, analyze, and plan to make sure New England's electricity needs will be met over the next 10 years



Markets Select the Most Cost-Efficient Resources to Meet Current and Future Electricity Needs

Energy Market

Electric Energy: The Day-Ahead and Real-Time Energy Markets are forward and spot markets for trading **electric energy**. Energy prices **fluctuate** throughout the day and at different locations in New England, reflecting the amount of consumer demand, constraints on the system, and the price of fuel that resources use to generate electricity.

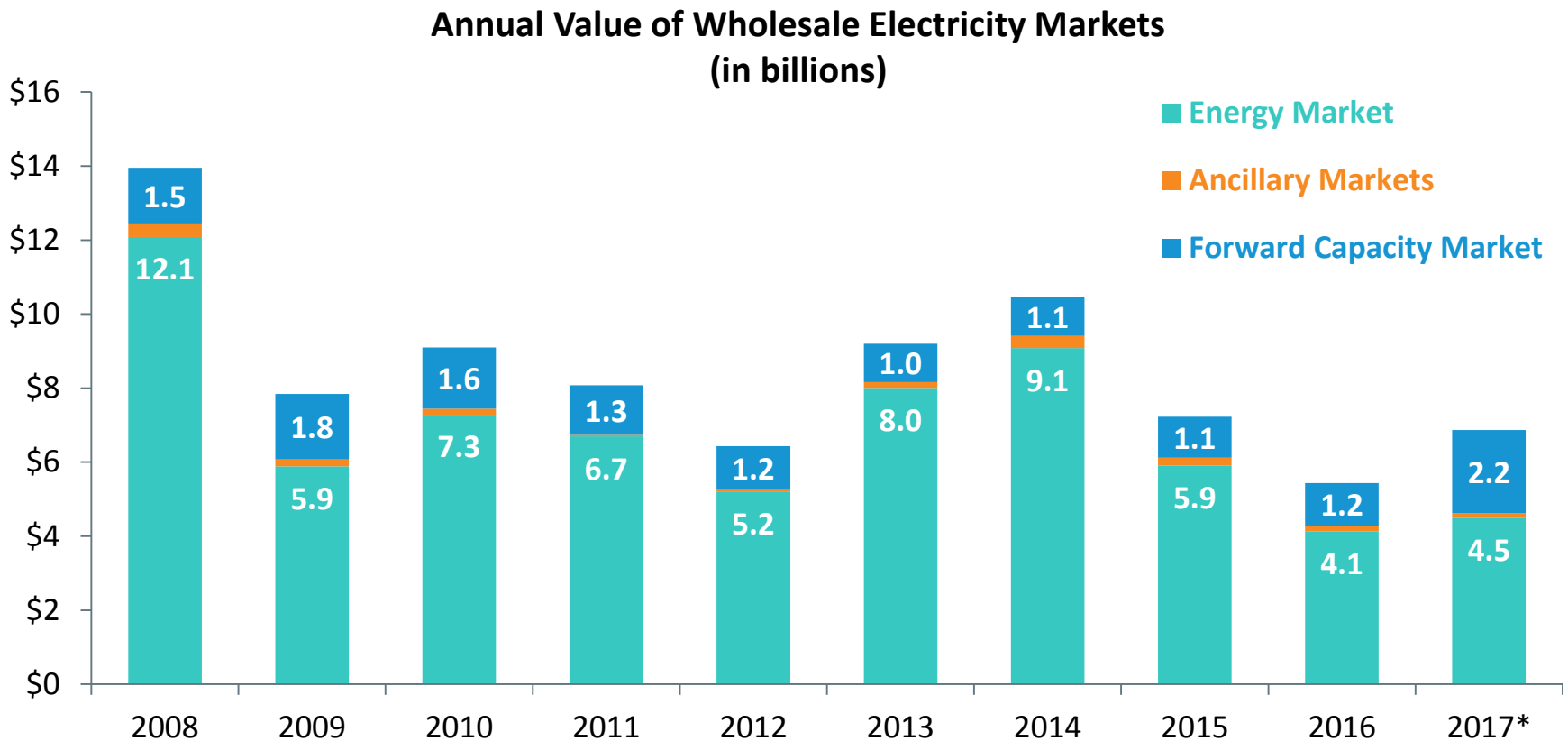
Ancillary Markets

Short-Term Reliability Services: Resources compete in the ancillary markets to provide backup electricity as well as services needed to support the physical operation of the system, such as frequency regulation and voltage support. These services are **critical** during periods of heavy demand or system emergencies.

Forward Capacity Market

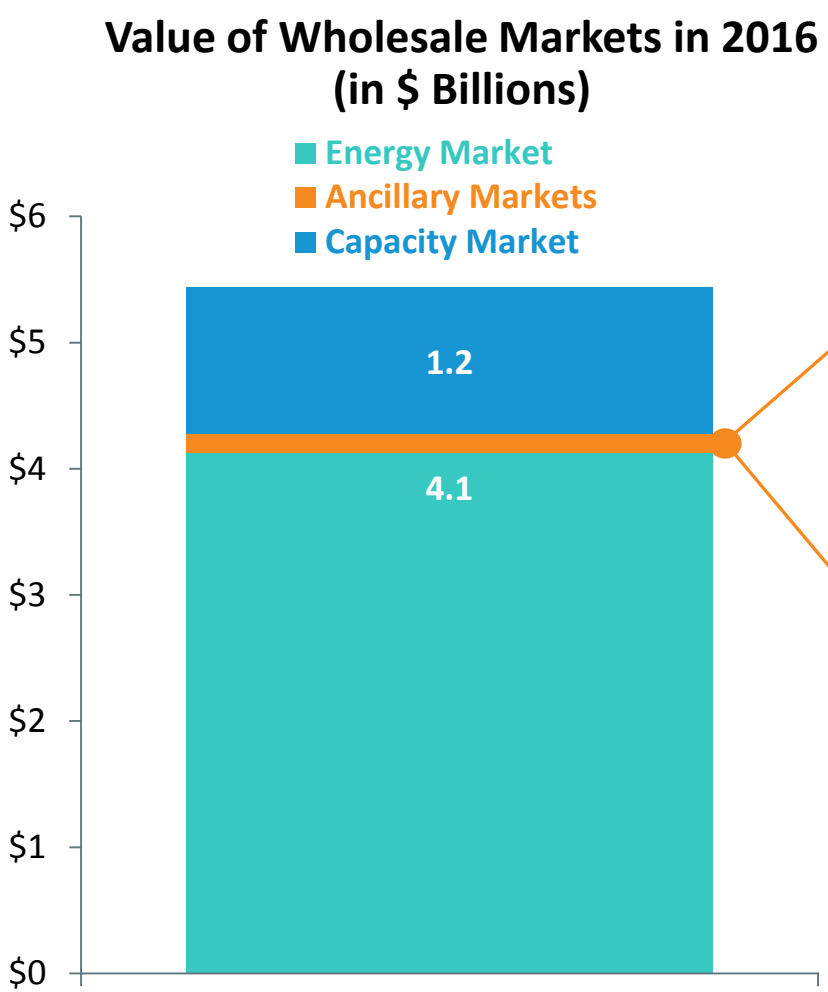
Long-Term Reliability Services: Resources compete to sell **capacity** to the system in three years' time through annual Forward Capacity Auctions. The Forward Capacity Market works in tandem with the Energy Markets to **attract** and **sustain** needed power resources today and into the future.

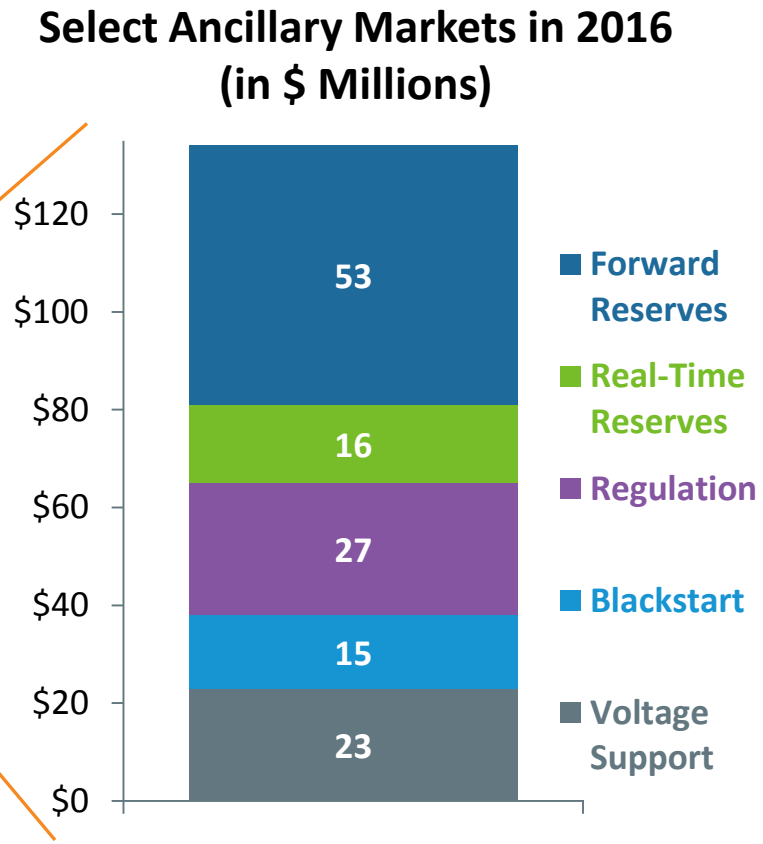
Energy Market Values Vary with Fuel Prices While Capacity Market Values Vary with Changes in Supply and Demand



Source: 2016 Report of the Consumer Liaison Group; *2017 data is preliminary and subject to resettlement
Note: Forward Capacity Market values shown are based on auctions held roughly three years prior to each calendar year.

Ancillary Services Are a Relatively Small Part of the Wholesale Electricity Markets

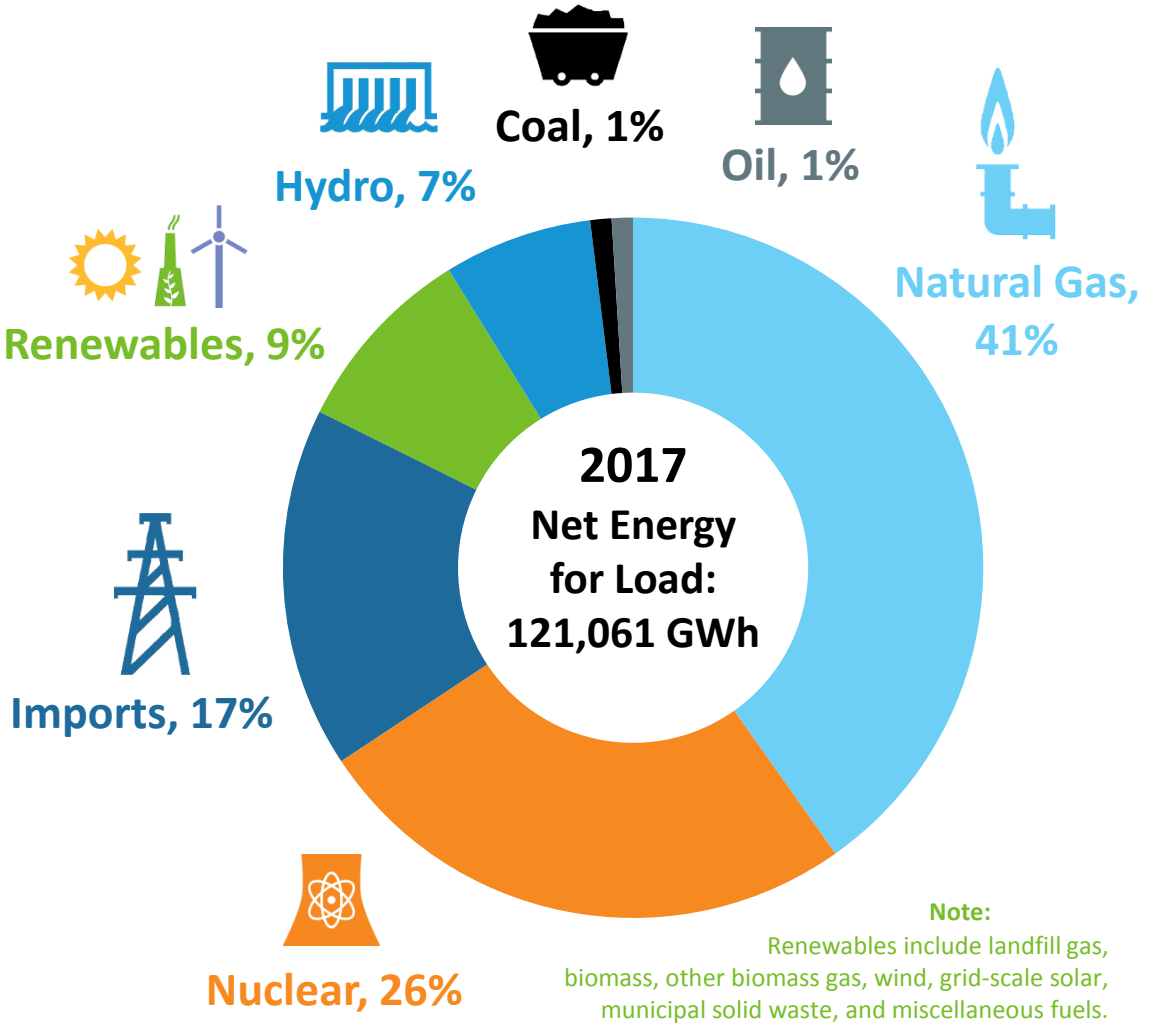




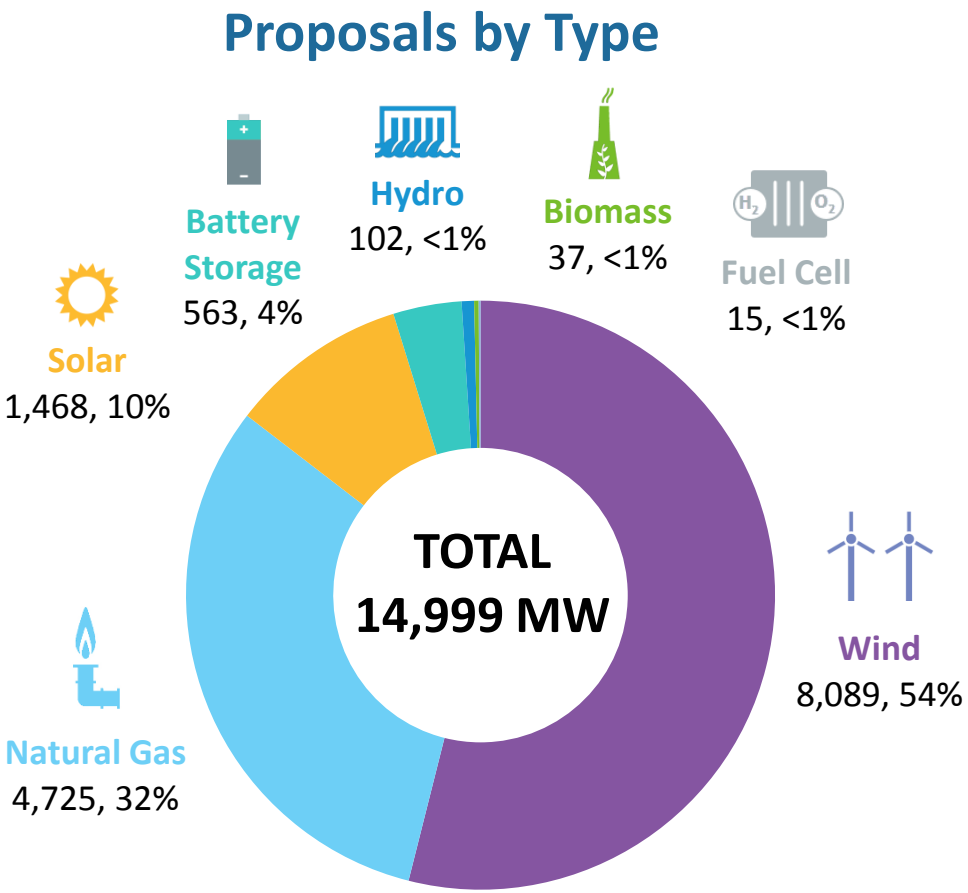
Note: Figures based on ISO New England's Internal Market Monitor 2016 Annual Markets Report

Lower-Emitting Sources of Energy Supply Most of New England's Electricity

- In 2017, most of the region's energy needs were met by natural gas, nuclear, imported electricity (mostly hydropower from Eastern Canada), renewables, and other low- or non-carbon-emitting resources
- Region is transitioning away from older coal and oil resources



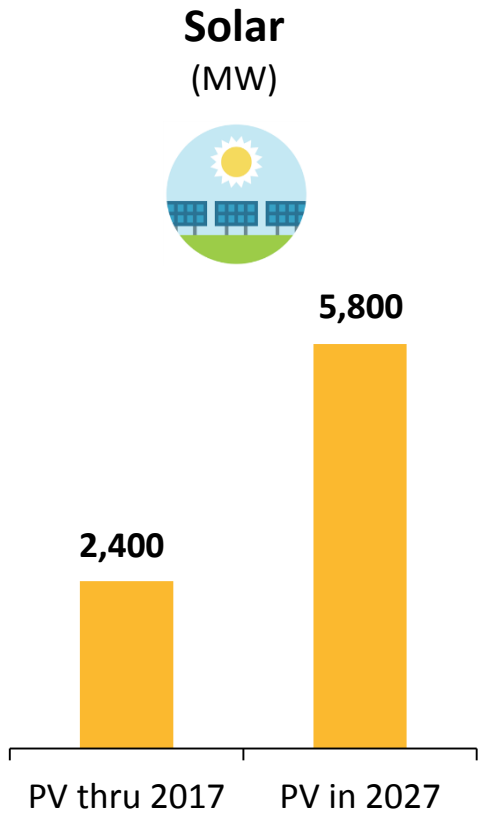
Battery Storage Is Emerging in the ISO Interconnection Queue



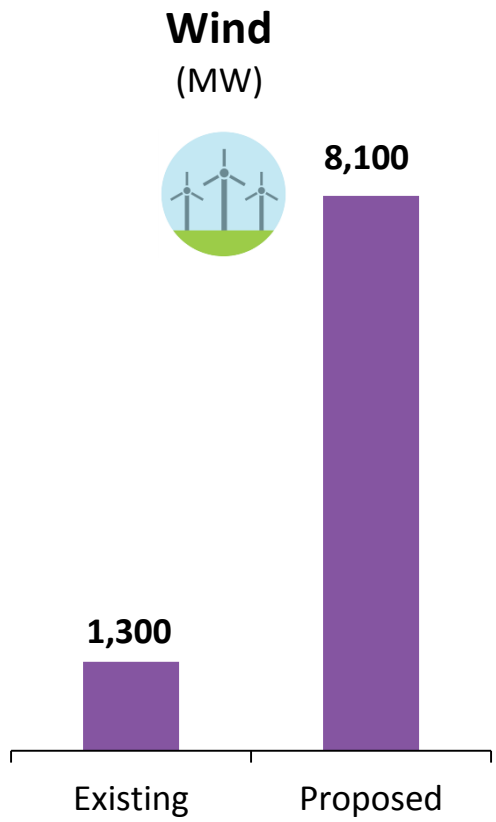
Note: Some natural gas proposals include dual-fuel units (oil); some wind and solar proposals include battery storage; megawatts represent nameplate capacity ratings; megawatts have been rounded for each proposal; data as of April 12, 2018.

The ISO Works with Developers to Help Integrate a Variety of Technologies into the Markets

- ISO New England's markets are **technology-neutral**
- These markets are designed to **incentivize flexibility and performance**
- **Flexible resources** will be needed to balance increasing levels of variable generation

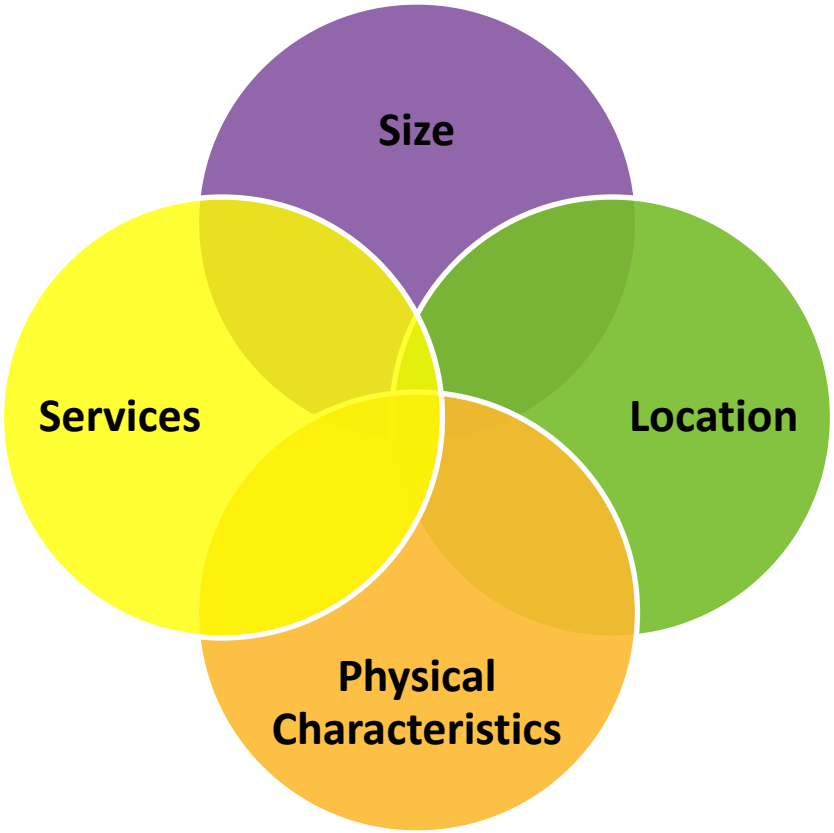


Final 2018 ISO-NE PV Forecast, AC nameplate capacity from PV resources participating in the region's wholesale electricity markets, as well as those connected "behind the meter."



Nameplate capacity of existing wind resources and proposals in the ISO-NE Generator Interconnection Queue; some wind proposals include battery storage.

Participation of Storage Is a Function of Many Factors Including the Size and Location of the Resource



- **Larger storage resources (> 5 MW)** generally participate directly in the wholesale markets and provide most of the services

- **Smaller storage resources** can participate in different ways, including aggregating with other resources

Different Technologies Have Different Characteristics

Pumped Storage

- Two large facilities built in **the 1970s**
- Can supply nearly **1,800 MW for more than five hours**
- Can provide or consume energy within **15 minutes**
- Modeling was enhanced in 2017

Battery Storage

- Two resources installed **since 2017**
- Can supply nearly **20 MW for 30 minutes**
- Can provide or consume electricity on a **near-instantaneous basis**
- Modeling enhancements expected early 2019

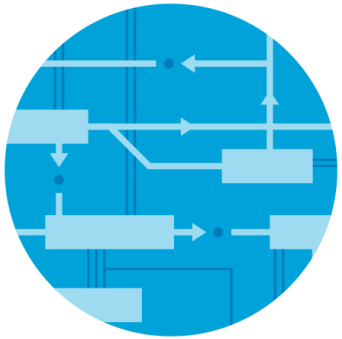
BATTERY STORAGE IN NEW ENGLAND

An Evolving Marketplace

The ISO Has Been Revising Its Rules To Enhance Battery Storage Participation

- The existing framework allows batteries to participate **in all markets,** but does not enable them to be deployed to their full technical capability
- To address this, the ISO **enhanced its rules in 2016** for directly metered battery storage in the Resource Dispatchability changes (ER17-68-000)
- This enhancement, once implemented, will enable battery storage to **fully participate** in all markets
  - Additional discussion on conforming changes are occurring with New England stakeholders at the NEPOOL Markets Committee

New Modeling Will Enable Full Market Participation for Battery Storage



- Can participate in the **Capacity Market** as supply
- Can participate in the **Energy Market** as dispatchable supply and dispatchable demand
  - Eligible to set price as supply and demand
  - Receive the nodal LMP for its supply and demand
  - Eligible for uplift payments (Net Commitment Period Compensation) as supply and demand
- Can participate in the **Forward Reserve Market** and will be counted as **Ten-Minute Spinning Reserve** in real-time
- Can participate in the **Regulation Market**
  - Can manage its *state of charge* using the energy-neutral signal
  - Any capability not taken in the regulation market can be offered into the energy market

New Modeling Also Provides Other Enhancements for Battery Storage Participation

- "Available energy" and "available storage" will now be telemetered **in real time**, which allows:
  - The resource to manage its *state of charge* (combined with bids/offers)
  - The ISO to calculate **dispatch limits** for use in real-time markets and reserve capability
- The ISO can determine a single "net" dispatch instruction
  - Avoid conflicting dispatch instructions
- Will apply current cost-allocation treatment for pumped storage hydro to battery storage (i.e., when resources are consuming power from the grid)

The ISO Is Well Along the Way to Fulfill FERC's Objectives in Order 841

- On February 15, 2018, FERC issued **Order 841** to facilitate the participation of electric storage resources in wholesale markets
- A two-step process will be followed for compliance:
  1. Conforming changes for early 2019 implementation (Filing: Jul-2018)
  2. Propose any additional compliance changes (Filing: Dec-2018)
- The ISO is evaluating Order 841 and will discuss further potential changes at the NEPOOL Markets Committee

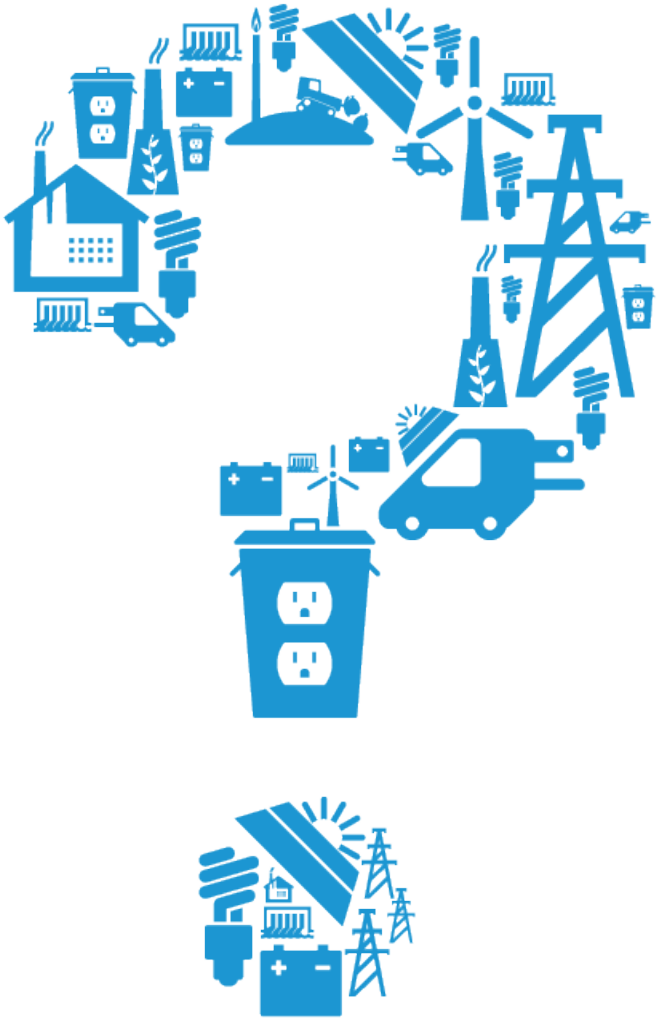
The ISO Continually Evaluates Opportunities to Enhance the Market Design to Enable New Technologies

- Storage can participate in the markets **today**
- The ISO recently made **rule changes** to better integrate storage and other technologies into the markets
- The ISO is looking **at further enhancements** to better incorporate technologies into the markets and value reliability services
- The region will need **flexible resources** to help balance the quantities of wind and solar being added to the system

For More Information…

- Subscribe to the ***ISO Newswire***
  - *ISO Newswire* is your source for regular news about ISO New England and the wholesale electricity industry within the six-state region
- Log on to **ISO Express**
  - ISO Express provides real-time data on New England's wholesale electricity markets and power system operations
- Follow the ISO on **Twitter**
  - @isonewengland
- Download the **ISO to Go App**
  - ISO to Go is a free mobile application that puts real-time wholesale electricity pricing and power grid information in the palm of your hand

Questions



States Are Taking Steps to Further Advance Storage

Examples include:

Massachusetts	Set a **200 MWh energy storage target and committed $20 million** for energy storage demonstration projects
Connecticut	Allowed **energy storage projects to compete** in recent clean energy and grid-modernization RFPs
Maine	Hosts **two**, **utility-scale** battery storage projects
Rhode Island	A 2017 Power Sector Transformation Report contemplates using energy storage **to shave peak demand**
Vermont	Allows its **Clean Energy Development Fund** to support energy storage projects
New Hampshire	The 2017 Grid Modernization Working Group report said energy storage could **optimize demand, bolster reliability, and enable customer engagement and empowerment**

Dispatchable Storage Participation Rules

Category	Description
Pumped Storage	• Used by directly metered pumped storage hydro • Allows for the provision of capacity, energy, reserves and regulation as dispatchable supply and dispatchable demand
Battery Storage*	• Used by directly metered battery storage and other similar technologies • Allows for the provision of capacity, energy, reserves and regulation as dispatchable supply and dispatchable demand
Regulation Focused	• Used by battery storage and other similar technologies • Allows for the provision of regulation (including aggregation) • Larger facilities may have non-dispatchable supply which would allow for the provision of capacity and energy
Demand Response**	• Used by behind-the-end-use meter storage technologies • Allows for the provision of capacity, energy and reserves as dispatchable demand response (including aggregation)

* Battery Storage rules will be implemented in Q1-2019

** Demand Response will be fully integrated into the energy and reserve market on June 1, 2018.