The Transformation of the New England Electric Grid and the Importance of Situational Awareness Tools

North American SynchroPhasor Initiative

NASPI Work Group Meeting

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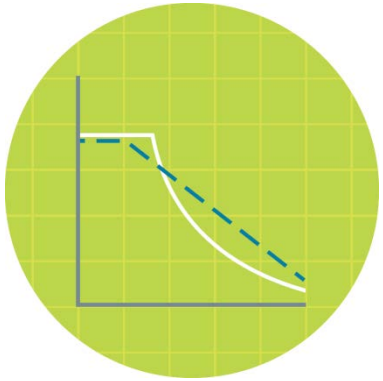
ISO New England Performs Three Critical Roles to Ensure Reliable Electricity at Competitive Prices

Grid Operation

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

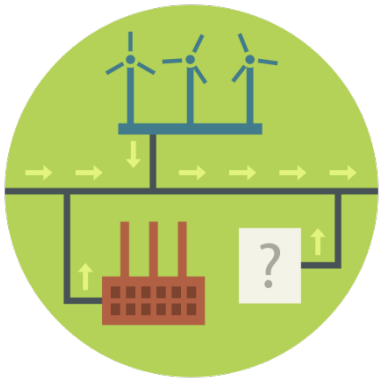
Market Administration

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



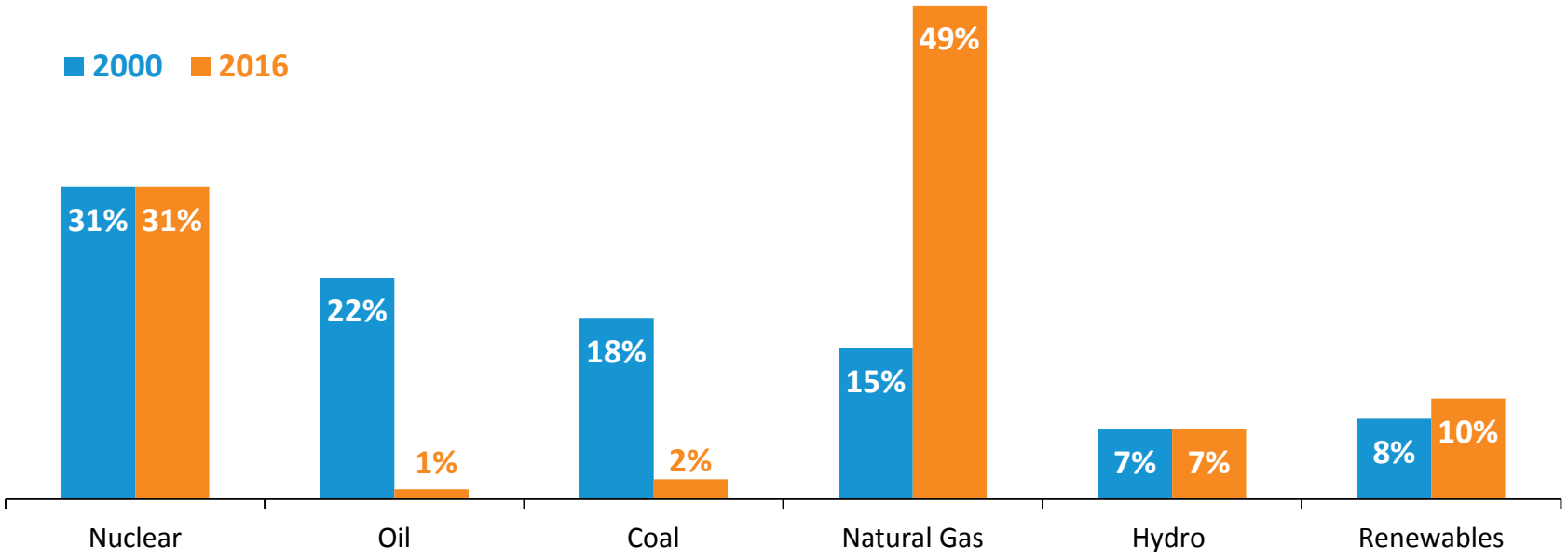
Power System Planning

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



New England Has Seen Dramatic Changes in the Energy Mix: *From Coal and Oil to Natural Gas*

Percent of Total **Electric Energy** Production by Fuel Type
(2000 vs. 2016)



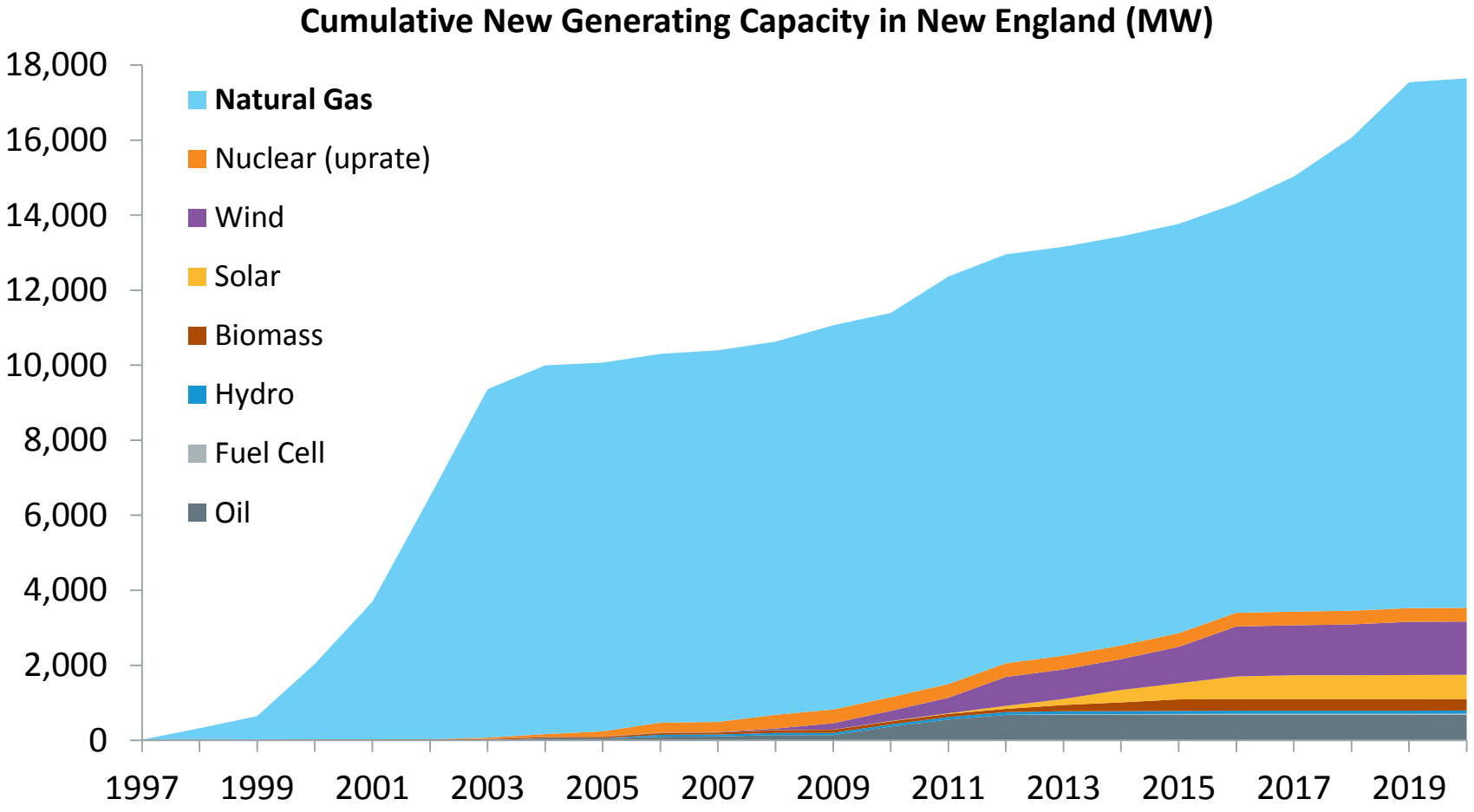
Source: ISO New England Net Energy and Peak Load by Source
Renewables include landfill gas, biomass, other biomass gas, wind, solar, municipal solid waste, and miscellaneous fuels

The Region Has Lost—*and Is at Risk of Losing*—Substantial Non-Gas Resources

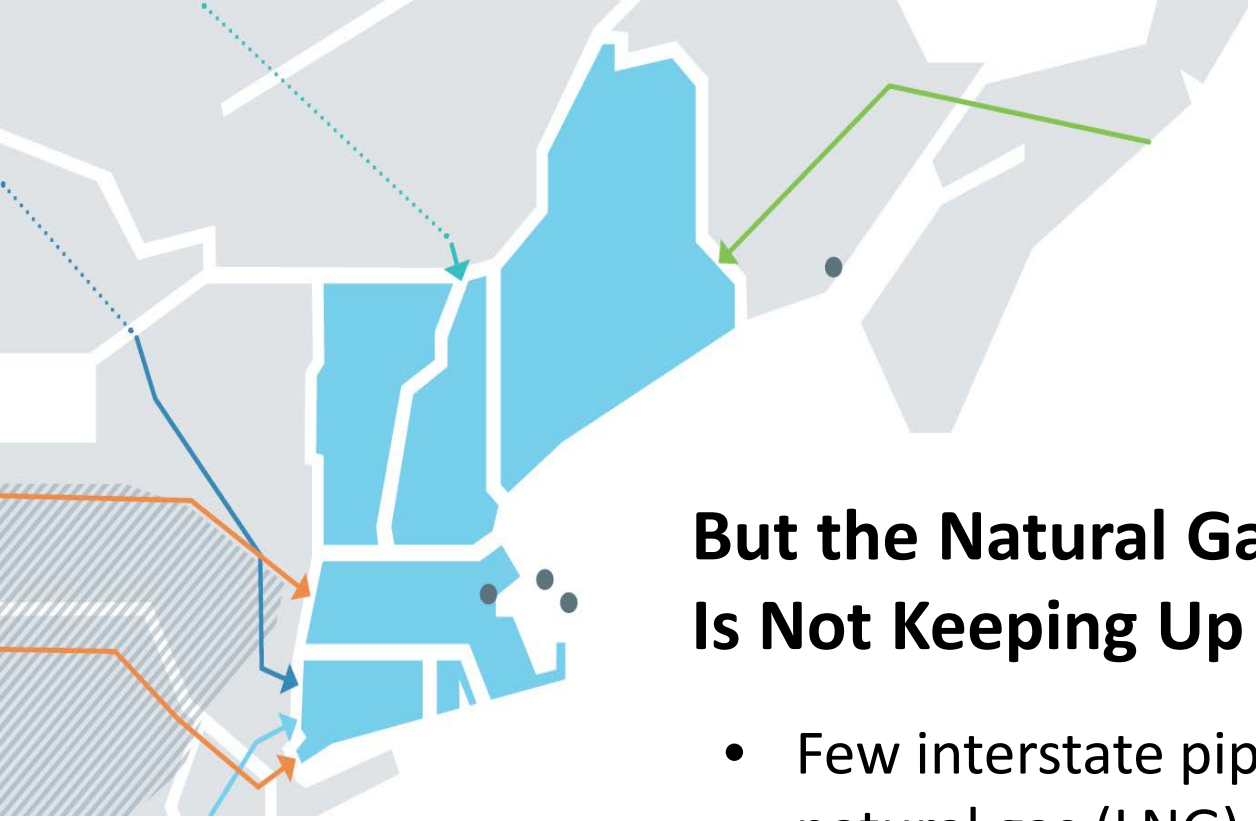
Major Generator Retirements:

- **Salem Harbor Station (749 MW)**
  - 4 units (coal & oil)
- **Norwalk Harbor Station (342 MW)**
  - 3 units (oil)
- **Mount Tom Station (143 MW)**
  - 1 unit (coal)
- **Vermont Yankee Station (604 MW)**
  - 1 unit (nuclear)
- **Brayton Point Station (1,535 MW)**
  - 4 units (coal & oil)
- **Pilgrim Nuclear Power Station (677 MW)**
  - 1 unit (nuclear)
- **Bridgeport Harbor Station (564 MW)**
  - 2 units (coal & oil)
- *Additional retirements are looming*

Natural Gas Has Been the Dominant Fuel Source for New Generating Capacity in New England



Note: New generating capacity for years 2017 – 2020 includes resources clearing in recent Forward Capacity Auctions.



Pipelines

LNG facilities

Marcellus shale

Source: ISO New England

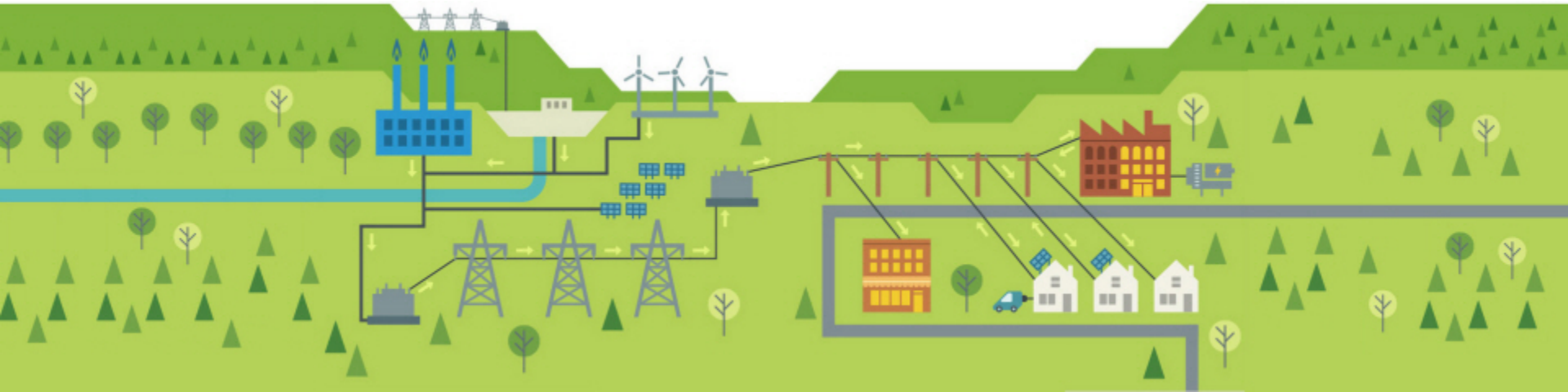
But the Natural Gas Delivery System Is Not Keeping Up with Demand

- Few interstate pipelines and liquefied natural gas (LNG) delivery points
- Regional pipelines are:
  - Built to serve heating demand, not power generation
  - Running at or near maximum capacity during winter

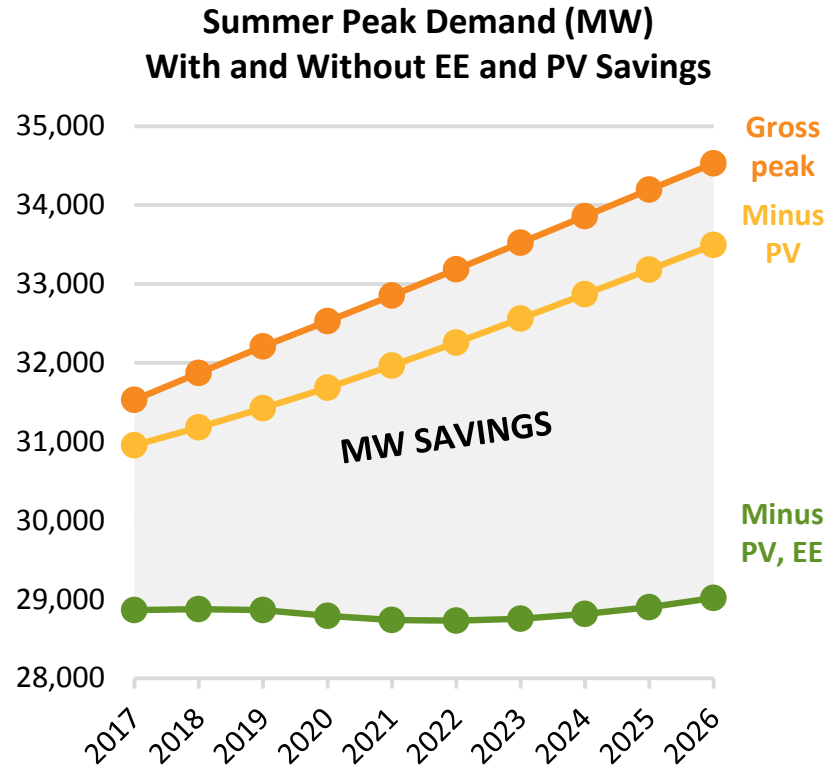
A “Hybrid Grid” Is Emerging

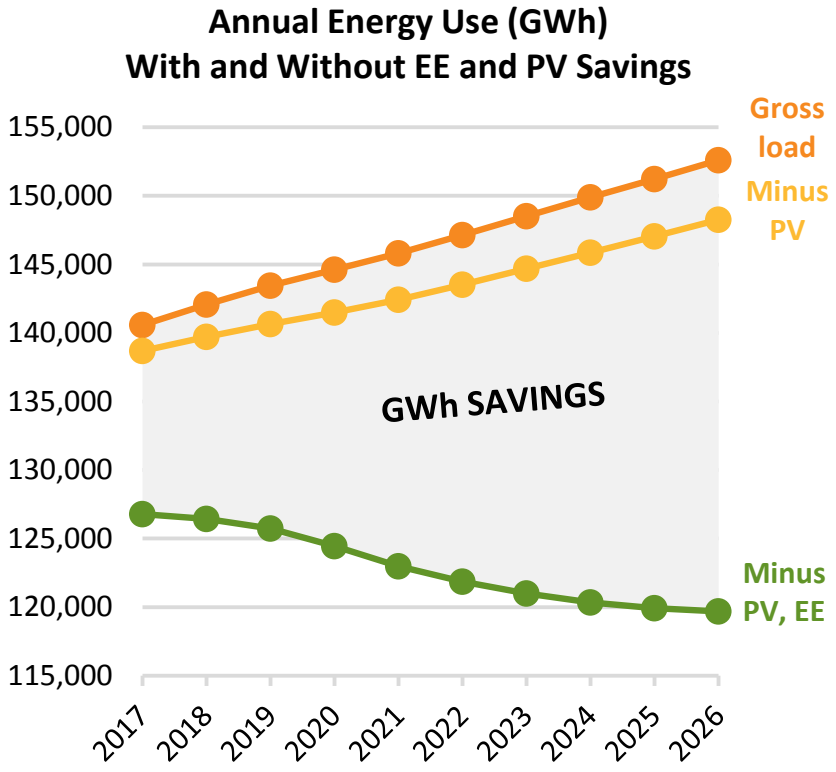
The region is changing how it generates, delivers, and uses electricity

- Large grid-connected power resources + thousands of small “behind-the-meter” resources
- Changes in how much grid energy people use and when they use it
- Significant amounts of variable generation and some battery storage
- Two-way grid communications



Energy Efficiency and Behind-the-Meter Solar Impact Peak Demand and Annual Energy Use





- **The gross peak and load forecast**
- **The gross peak and load forecast minus forecasted "behind-the-meter" (BTM) solar PV resources**
- **The gross peak and load forecast minus forecasted BTM solar PV, minus energy-efficiency (EE) resources in the Forward Capacity Market 2017-2020 and forecasted EE 2021-2026**

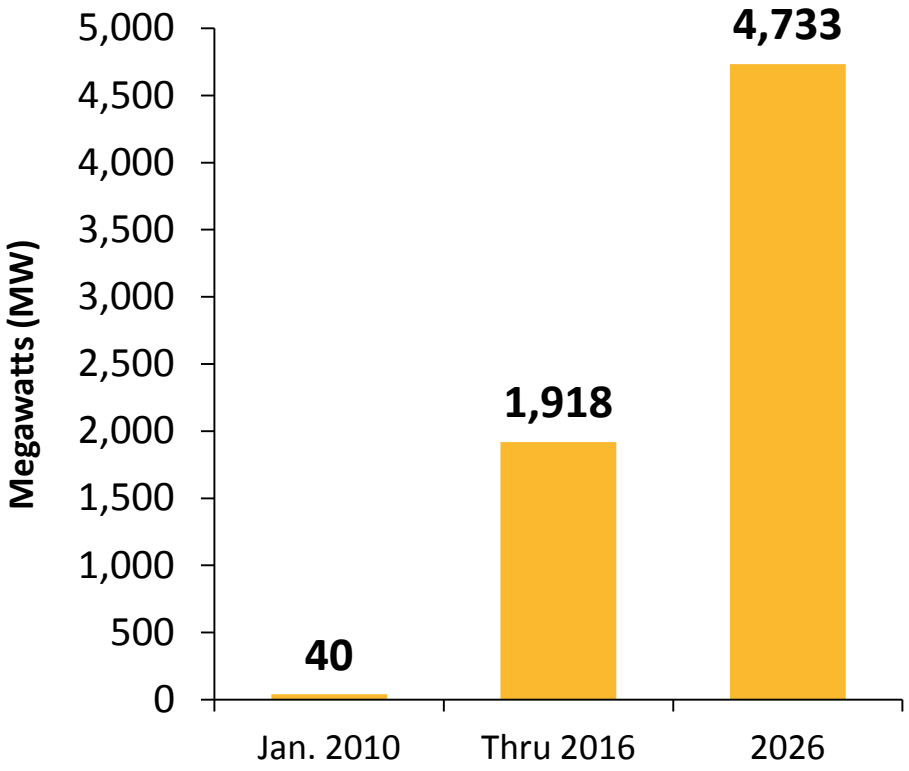
Note: Summer peak demand is based on the "90/10" forecast, which accounts for the possibility of extreme summer weather (temperatures of about 94° F).
Source: Final 2017 Solar PV Forecast (April 2017) and Final ISO New England Energy-Efficiency Forecast 2021-2026 (May 2017)

ISO New England Forecasts Strong Growth in Solar PV

December 2016 Solar PV Installed Capacity (MW_{ac})

State	Installed Capacity (MW_{ac})	No. of Installations
Connecticut	281.55	23,544
Massachusetts	1,324.77	65,883
Maine	22.14	2,745
New Hampshire	54.30	5,873
Rhode Island	36.81	2,202
Vermont	198.39	7,612
New England	**1,917.96**	**107,859**

Cumulative Growth in Solar PV through 2026 (MW_{ac})

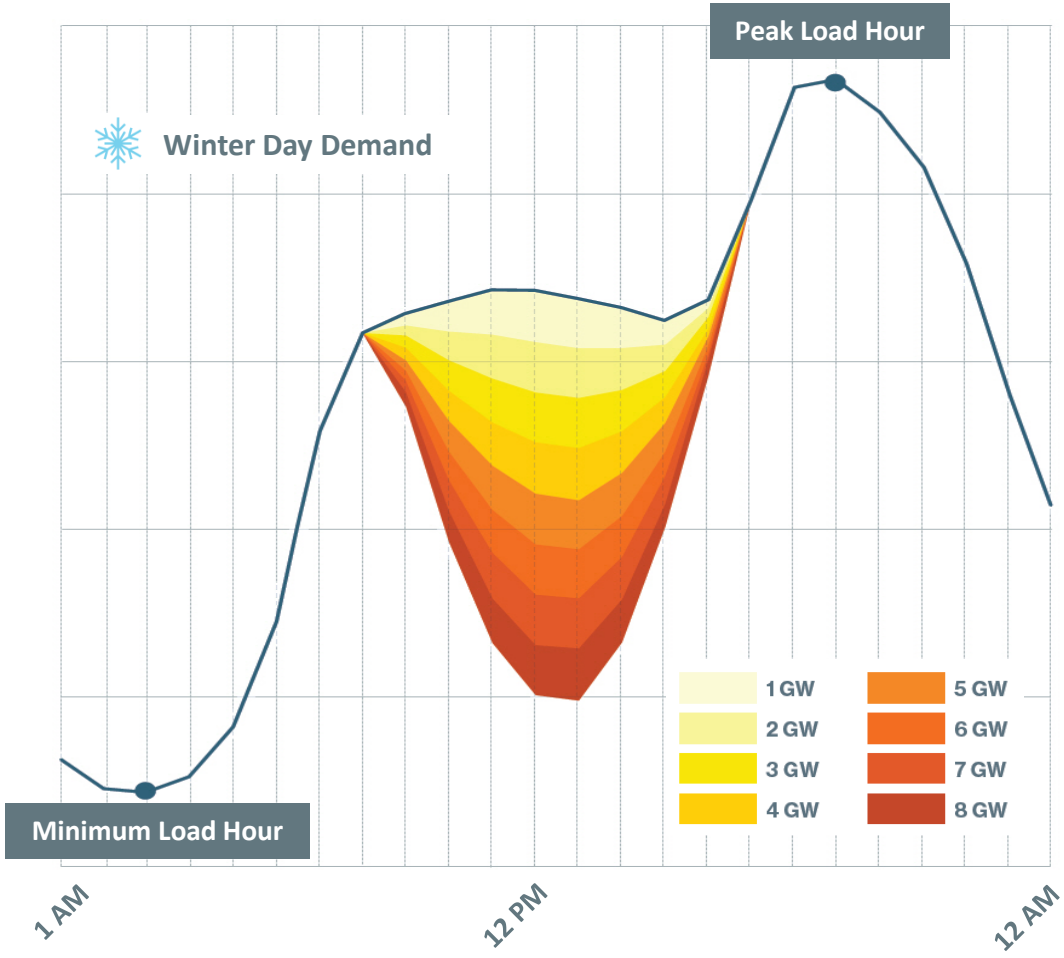


Note: The bar chart reflects the ISO's projections for nameplate capacity from PV resources participating in the region's wholesale electricity markets, as well as those connected "behind the meter." Source: Final 2017 PV Forecast (April 2017); MW values are AC nameplate.

Solar PV Is Changing the Load Profile

PV additions:

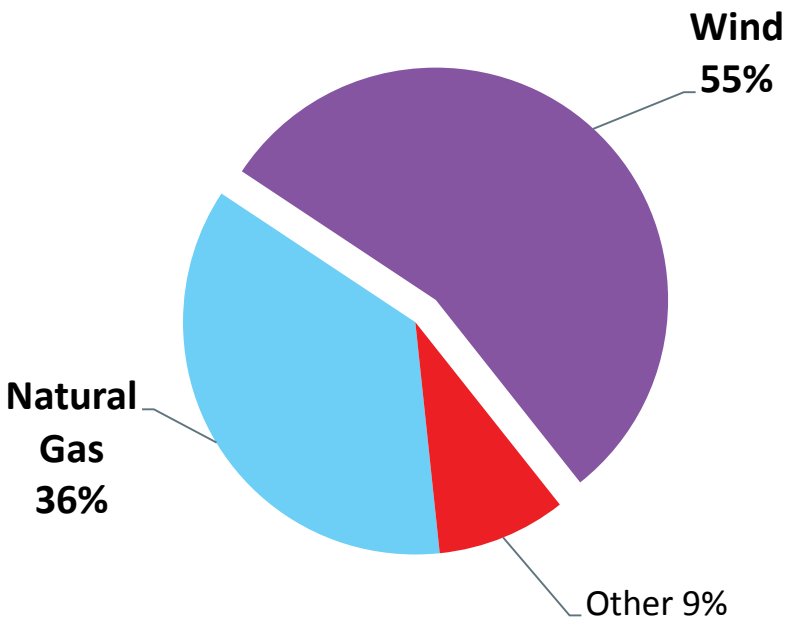
- Increasingly reduce mid-day demand
- Add to the need for fast, flexible generation (e.g., gas generators and storage)
- Will *not* help with the peak during winter or shoulder seasons



Wind Power Dominates New Resource Proposals, But Infrastructure Will Be Needed for Delivery

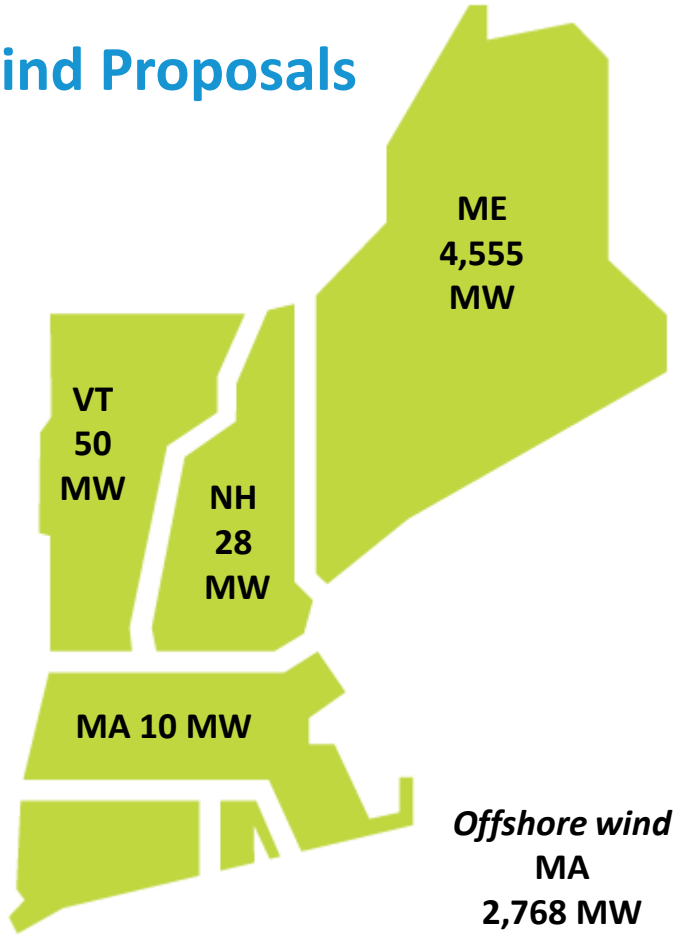
All Proposed Generation

Developers are proposing to build roughly 13,400 MW of generation, including nearly 4,800 MW of gas-fired generation and more than 7,400 MW of wind



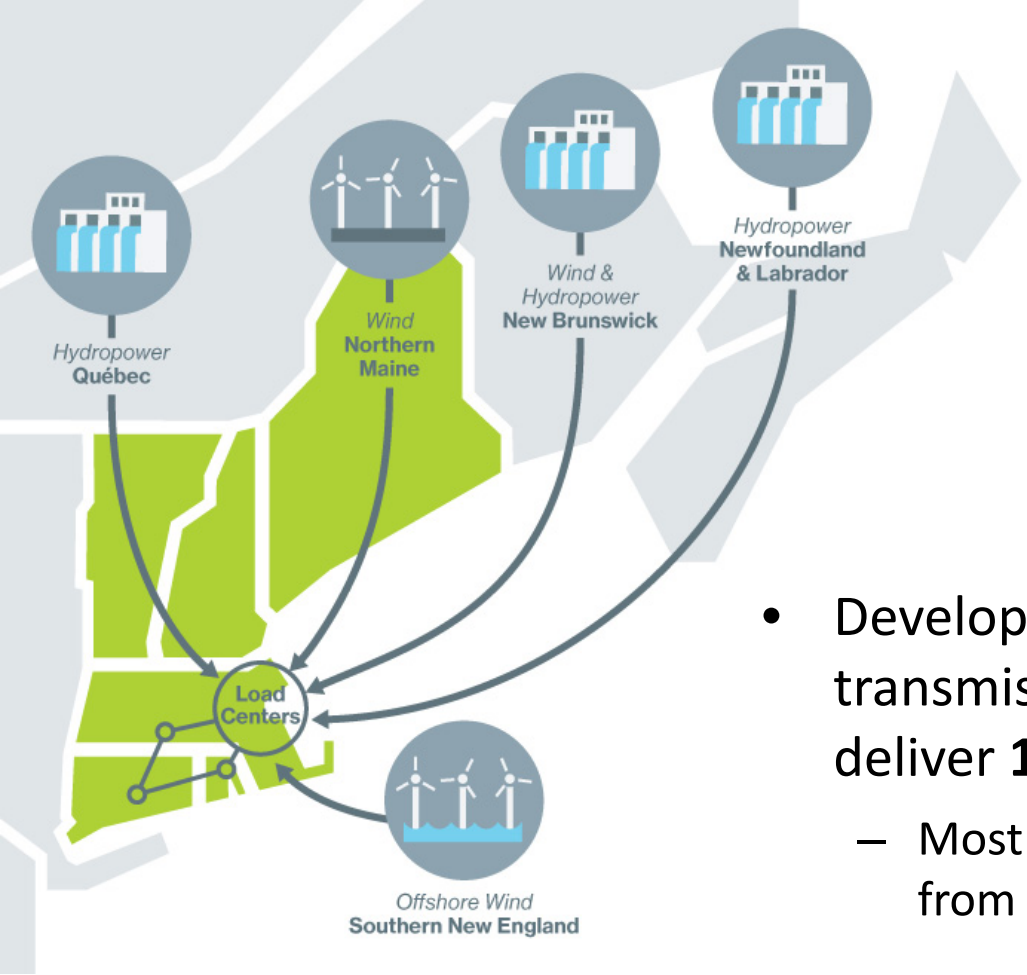
Source: ISO Generator Interconnection Queue (September 19, 2017)
FERC Jurisdictional Proposals Only; Nameplate Capacity Ratings

Wind Proposals



Note: Some wind proposals include battery storage.

Developers Are Proposing Large-Scale Transmission Projects to Help Deliver Clean Energy to Load Centers



Map is representative of the types of projects announced for the region in recent years

- Developers are proposing **23** elective transmission upgrades (ETUs) to help deliver **16,000+ MW** of clean energy
  - Mostly Canadian hydro and onshore wind from northern New England
- Wind projects make up **55%** of proposed new power resources, but most are remote
- Massachusetts has plans to contract for **1,600 MW** of offshore wind

Source: ISO Interconnection Queue (as of September 19, 2017)

States Are Supporting the Development of Clean Energy Resources to Meet Their Public Policy Goals

- Growing provision of out-of-market revenues through long-term contracts
- Legislative initiatives vary by state

State(s)	Recent State Resource Procurement Initiatives	Expected Resources	Target MW (nameplate*)
MA, CT, RI	2016 Multi-State Clean Energy RFP	Solar, wind	460
MA	2016 Energy Diversity Act	Clean energy, incl. hydro import	Approx. 1200
MA	2016 Energy Diversity Act	Off-Shore Wind	Up to 1600

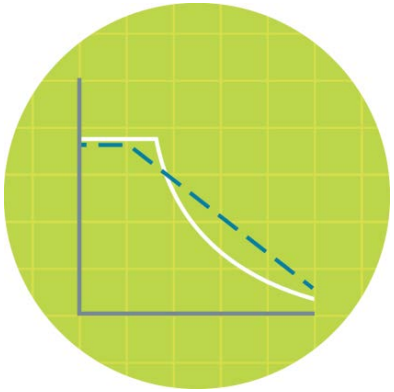
*Note: Nameplate MW may be higher than qualified Forward Capacity Market capacity MW

Integrating Markets and Public Policy (IMAPP) Discussions Continue Among Regional Stakeholders

- Last year, NEPOOL launched a formal stakeholder process to discuss potential market rule changes to **integrate** the region's wholesale electricity markets with the public policy goals of the New England states
- Through that process, ISO New England has offered a **conceptual approach** that could be implemented in the near term, involving enhancements to the Forward Capacity Market
  - The proposal is called *Competitive Auctions with Sponsored Policy Resources* or *"CASPR"*

Summary of ISO New England's Design Approach

- The ISO's capacity market design approach:
  - **Accommodates** sponsored policy resources into the Forward Capacity Market over time, and
  - **Preserves** competitively based capacity pricing for other resources



- **Key idea:** Coordinate, through a new *substitution auction*, the entry of new state-sponsored (i.e., clean energy) resources with the exit of existing capacity resources

- Likely to help the New England states achieve their renewable energy and greenhouse gas reduction goals as older, higher-emitting (traditional) units are likely to retire sooner

Note: Additional materials can be found on the ISO's Wholesale Markets and State Public Policy Initiative website and NEPOOL's Integrating Markets and Public Policy website.

ISO New England Is Conducting a Study of Fuel Security Challenges

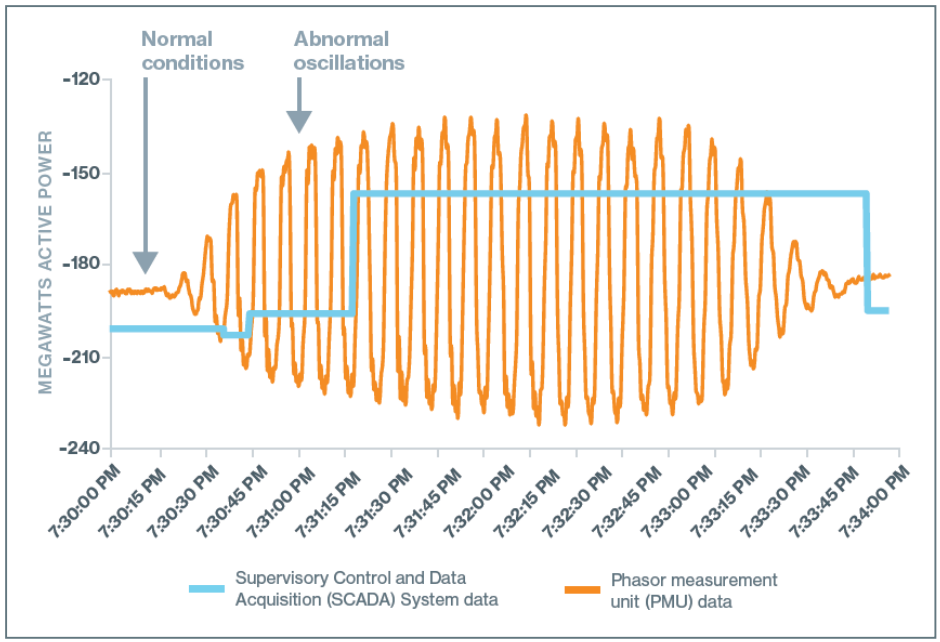
- Fuel security refers to the ability of power plants to have or obtain the fuel required to generate electricity, especially during the **winter peak season**
- The study is examining more than 20 cases of generating resource and fuel-mix combinations during the 2024-2025 winter, and will quantify each case's **fuel security risk**
  - *i.e.,* the number and duration of energy shortfalls that could occur and that would require implementation of emergency procedures to maintain reliability
- The preliminary results will be presented to regional stakeholders next month for full discussion and input
- The ISO will work with stakeholders to determine whether further **operational** or **market design measures** will be needed

As Operations Grow Increasingly Complex, Situational Awareness Tools Become Ever More Important

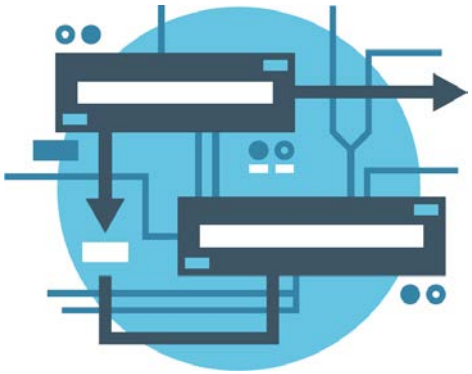
- 40+ phasor measurement units (PMUs or synchrophasors) and associated computer systems for collecting and analyzing power system data were installed in 2013 (primarily on the 345 kV network)
- A new ISO initiative will install additional PMUs, including at all new generators 100 MW or more
- PMUs improve detection of abnormal oscillations and the observability of other undesirable power system conditions

PMUs Allow the ISO to Monitor System Dynamics More Closely Than Ever Before

- The region's new PMUs measure grid conditions **30 times per second**, providing a much more accurate picture of what is happening on the power system (traditional SCADA systems measure grid conditions every 2 to 10 seconds)
- Real-time alerts enable the ISO to respond more quickly to **abnormal oscillations**, which can cause potentially dangerous fluctuations of power flows on the grid without corrective action
- PMUs also improve post-disturbance analysis



Conclusions



- New England faces key grid challenges relating to fuel security and the integration of greater levels of intermittent and distributed energy resources
- As New England moves toward a more complex electric grid, the ISO must work to improve its situational awareness tools to ensure reliable power system operations
- PMUs provide critical real-time data that improve operator awareness and help system planners prepare for the grid of the future

Questions