ISO New England Overview and Regional Update

Vermont House Committee on Energy and Technology

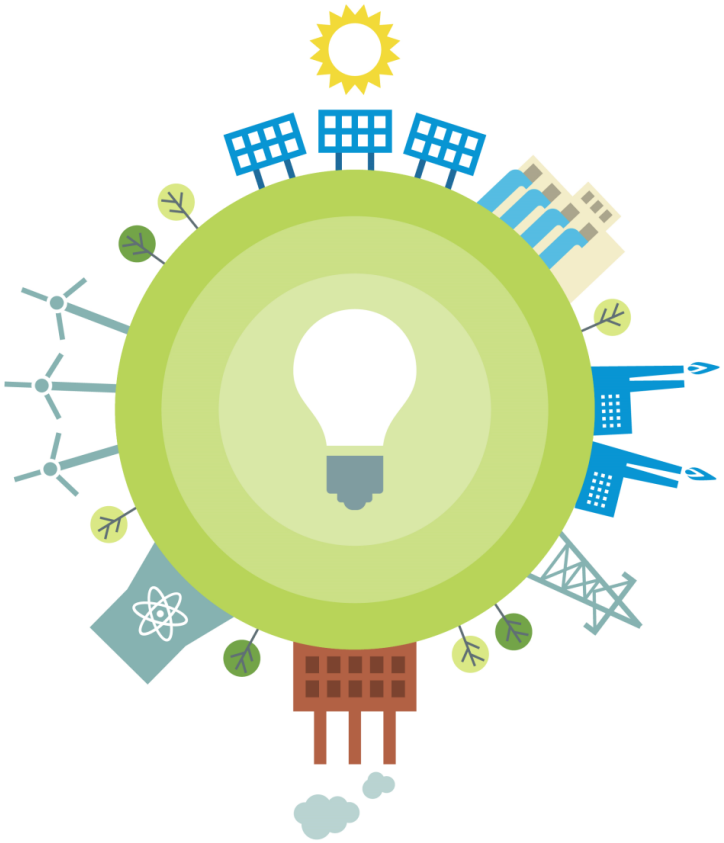
Vermont Senate Committee on Natural Resources and Energy

Eric Johnson and Molly Connors

EXTERNAL AFFAIRS

Overview of Presentation

- About ISO New England
- Electric Grid At-a-Glance
- Strategic Planning
- Resource Developments
- Transmission Developments



ISO New England (ISO) Has Two Decades of Experience Overseeing the Region's Restructured Electric Power System

- **Regulated by** the Federal Energy Regulatory Commission
- **Reliability and Planning Coordinator** for New England under the North American Electric Reliability Corporation
- **Independent** of companies in the marketplace and neutral on technology

Reliability Is the Core of ISO New England's Mission

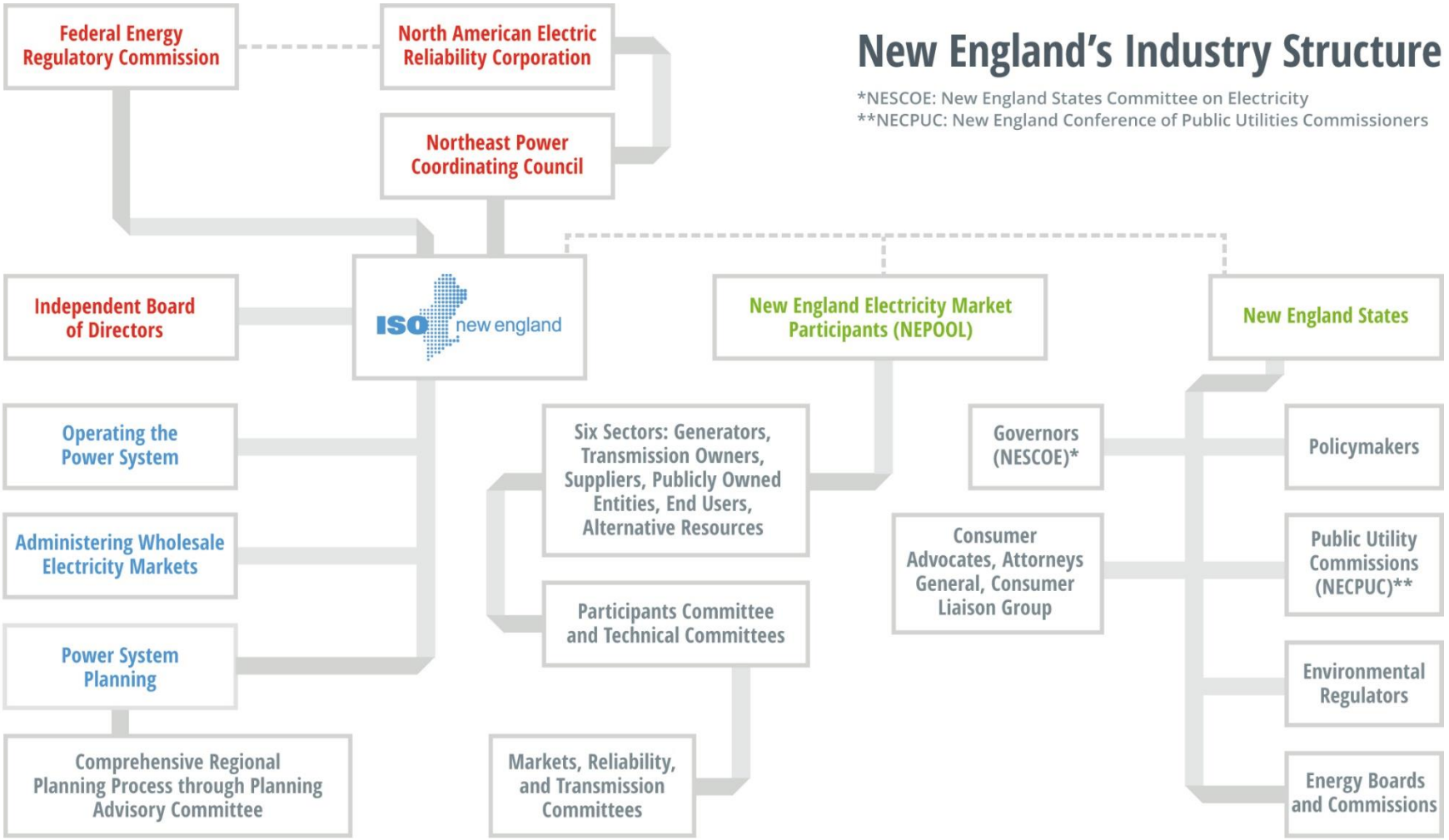
Fulfilled by three interconnected and interdependent responsibilities

Overseeing the day-to-day operation of New England's electric power generation and transmission system

Managing comprehensive regional power system planning

Developing and administering the region's competitive wholesale electricity markets

Numerous Entities Including an Independent Board Provide Oversight of and Input on ISO's Responsibilities

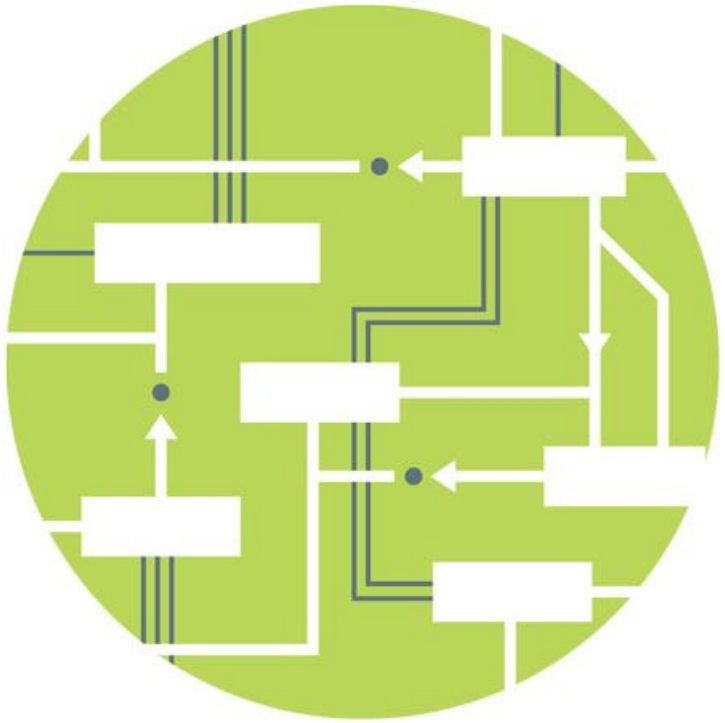


Ensuring Reliable Power System Operations Is a Major Responsibility

- Maintain minute-to-minute reliable operation of region's generation and transmission system
- Perform centralized dispatch of the lowest-priced resources
- Coordinate and schedule maintenance outages
- Coordinate operations with neighboring power systems

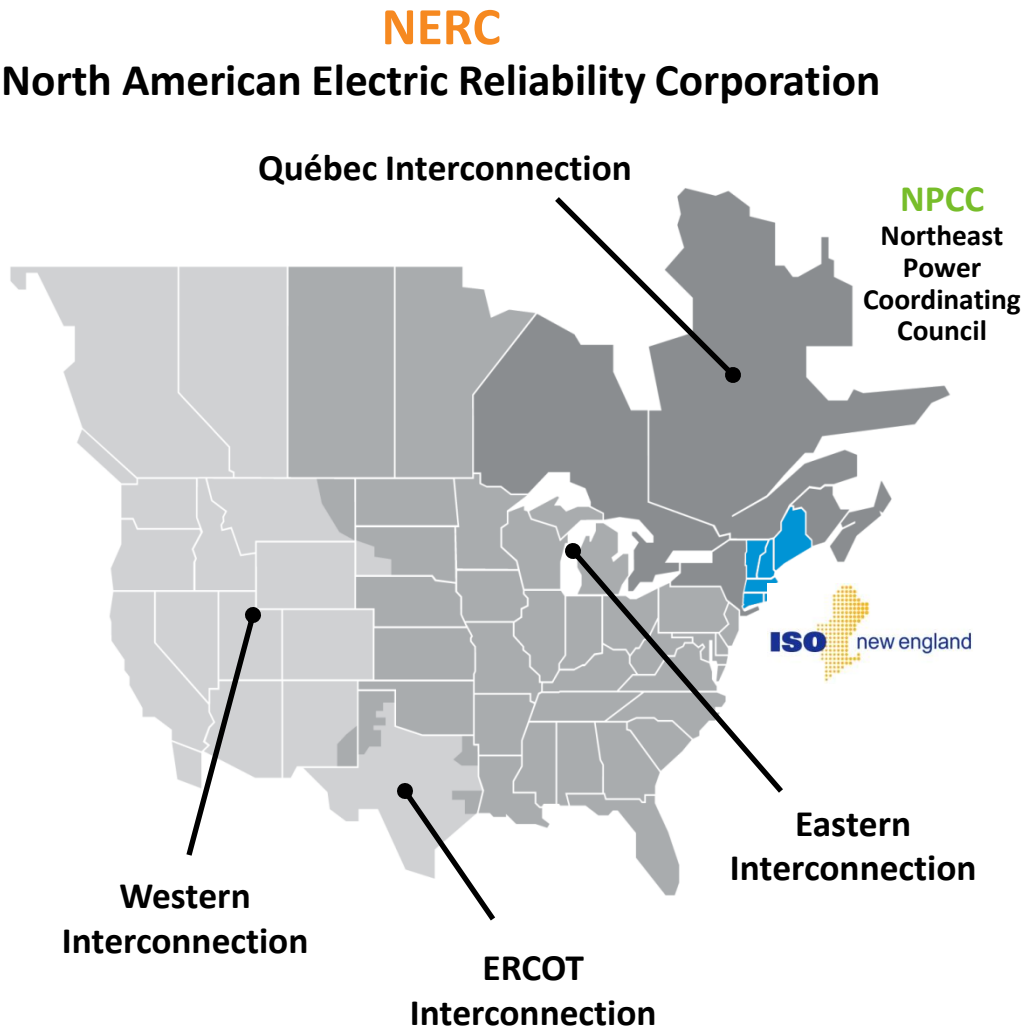
Managing Comprehensive Regional Power System Planning Is a Major Responsibility

- Manage regional power system planning in accordance with mandatory reliability standards
- Administer requests for interconnection of generation, and regional transmission system access
- Conduct transmission system needs assessments
- Plan regional transmission system to provide regional network service
- Develop Regional System Plan (RSP) with a ten-year planning horizon



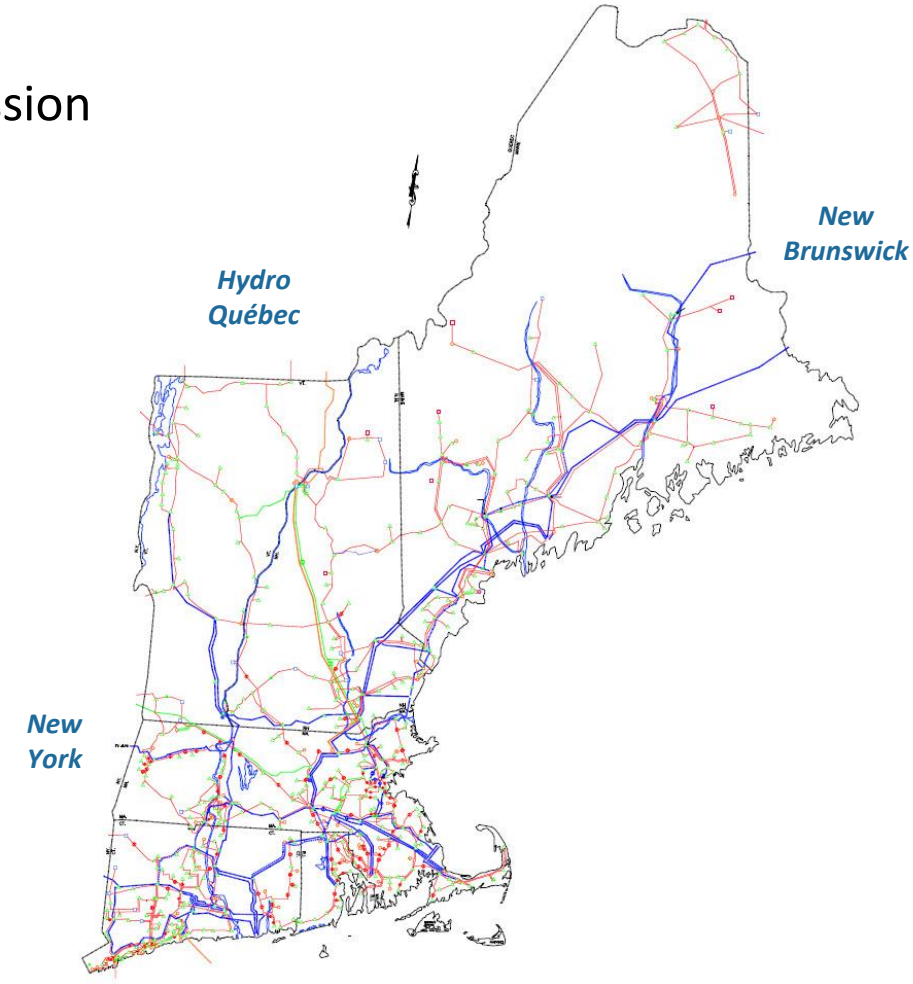
ISO New England Is Part of a Larger Electric Power System

- Eastern Interconnection spans from Rocky Mountains to East Coast and Canadian Maritimes
  - Primarily alternating-current (AC) transmission
  - New England linked to rest of Eastern Interconnection via transmission ties to New York and New Brunswick
- Tied to Québec only through direct-current (DC) transmission
- 2003 Blackout ushered in wide-area monitoring and mandatory reliability standards



New England's Transmission Grid Is the Interstate Highway System for Electricity

- **9,000 miles** of high-voltage transmission lines (115 kV and above)
- **13 transmission interconnections** to power systems in New York and Eastern Canada
- **17%** of region's energy needs met by imports in 2016
- **$8 billion** invested to strengthen transmission system reliability since 2002; **$4 billion** planned
- Developers have proposed multiple transmission projects to access non-carbon-emitting resources



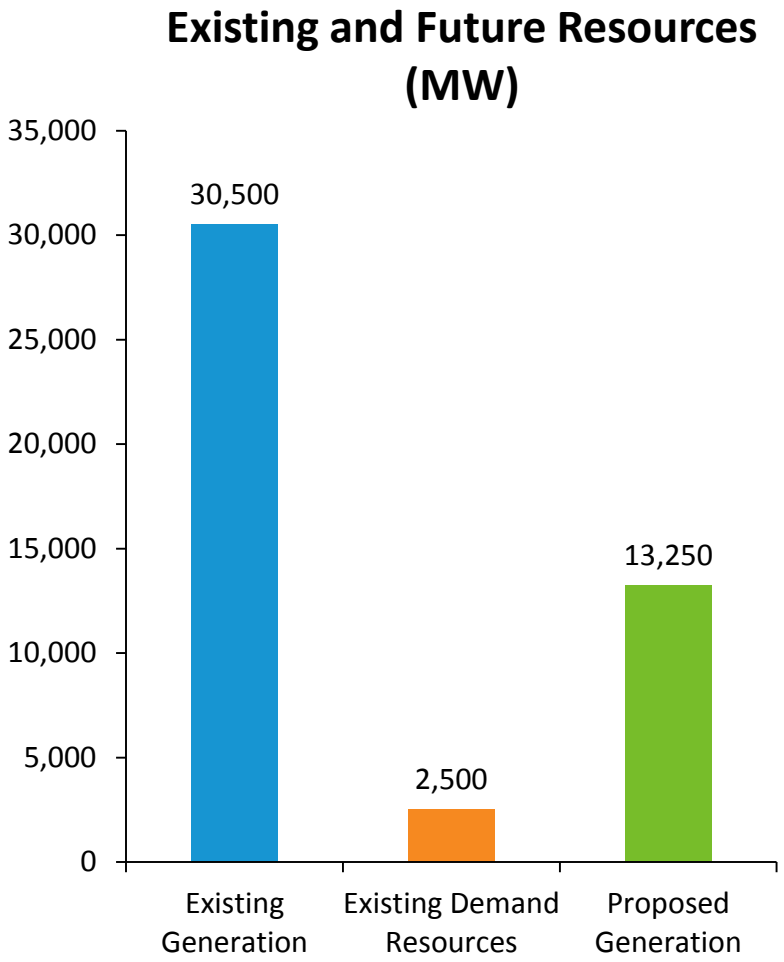
Overall Electricity Demand Is Flattening Due to Energy Efficiency and Behind-the-Meter Solar

- **7.1 million** retail electricity customers drive the demand for electricity in New England (14.7 million population)
- Region's all-time summer peak demand set on August 2, 2006 at **28,130 MW**
- Region's all-time winter peak demand set on January 15, 2004 at **22,818 MW**
- Energy efficiency and behind-the-meter solar slow the growth in summer *peak* demand to **0.3%** annually and flatten the growth in *overall* electricity demand to **-0.2%** annually

Note: Without energy efficiency and solar, the region's peak demand is forecasted to grow 1.1% annually and the region's overall electricity demand is forecasted to grow 1.0% annually. Summer peak demand is based on the "90/10" forecast for extreme summer weather.

A Range of Generation and Demand Resources Are Used to Meet New England's Energy Needs

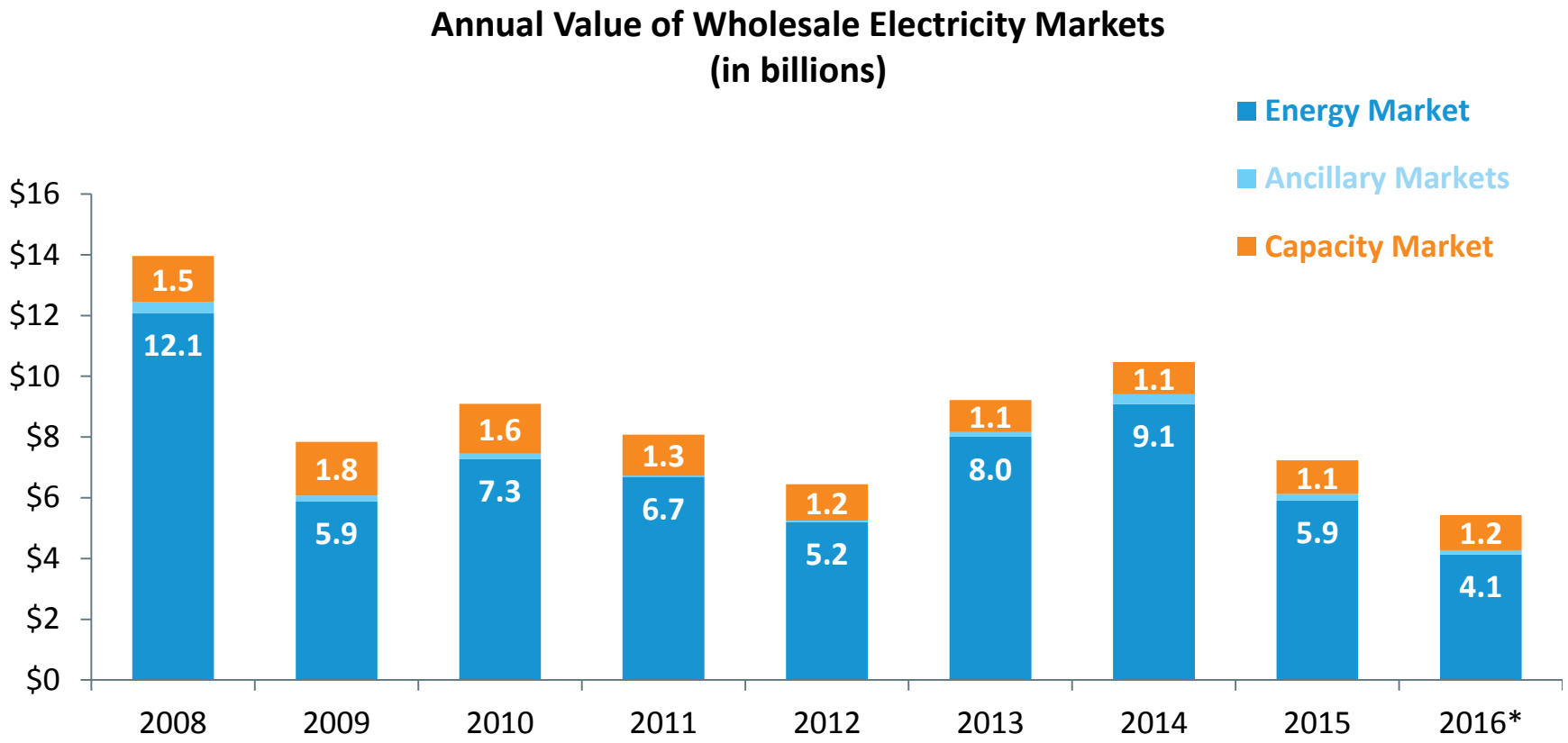
- **350** generators in the region
- **30,500 MW** of generating capacity
- **13,250 MW** of proposed generation in the ISO Queue
  - Mostly natural gas and wind
- **4,200 MW** of generation has retired or will retire in the next five years
- **600 MW** of active demand response and **1,900 MW** of energy efficiency with Capacity Supply Obligations in the Forward Capacity Market (FCM)*



* In the FCM, demand-reduction resources are treated as capacity resources.

Annual Value of Wholesale Electricity Markets Varies with Changes in Fuel Prices

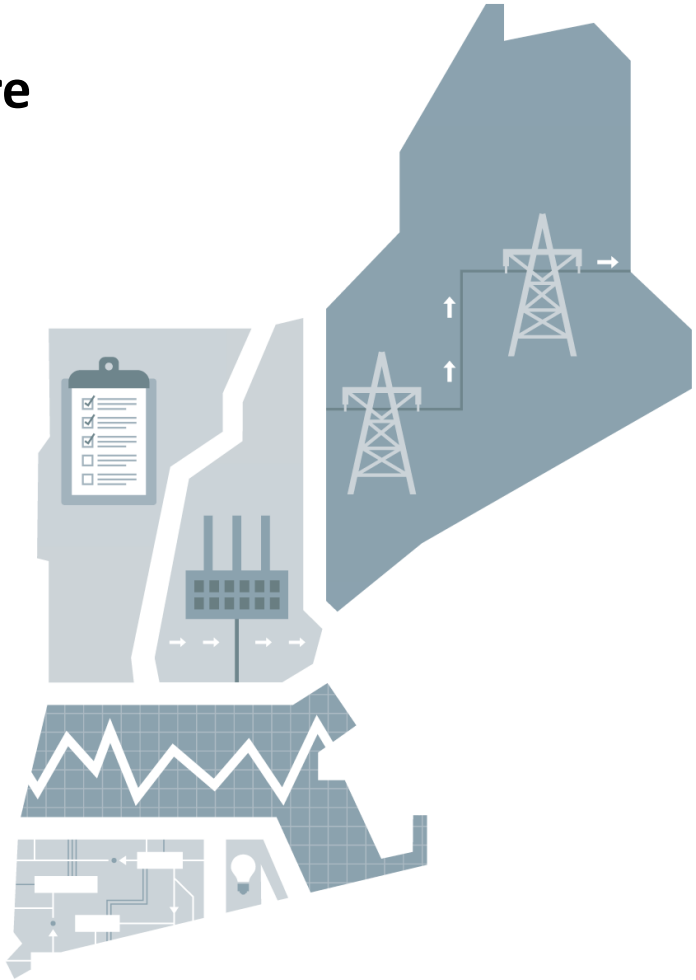
A robust transmission system allows the region to access the most economic resources



Source: 2015 Report of the Consumer Liaison Group; 2016 wholesale electricity market values are preliminary and subject to reconciliation

ISO New England Is Focused on Developing Solutions to the Region's Top Reliability Risks

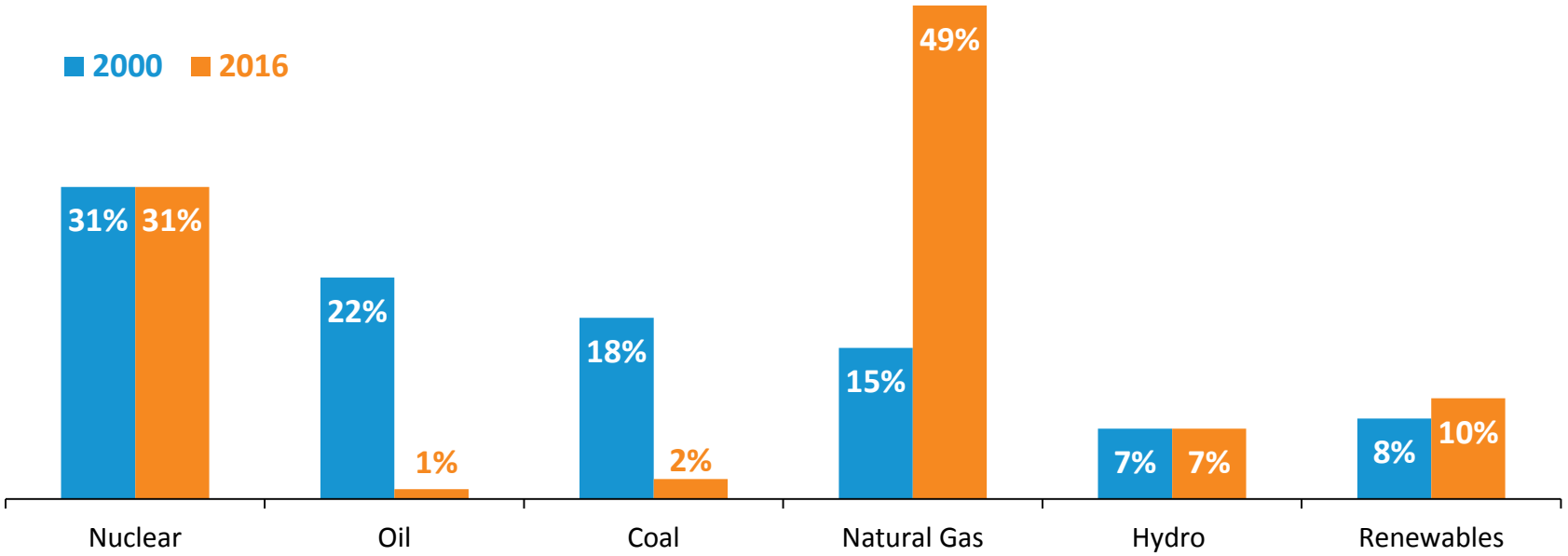
- **Inadequate Natural Gas Infrastructure**
  - New England is challenged to meet electricity demands with existing natural gas infrastructure, particularly during the winter
- **Power Plant Retirements**
  - New England will need new ways to meet peak demand as aging plants close
- **Renewable Resource Integration**
  - Maintaining reliability as increasing levels of distributed generation and intermittent resources come online



New England Has Seen Dramatic Changes in the Energy Mix

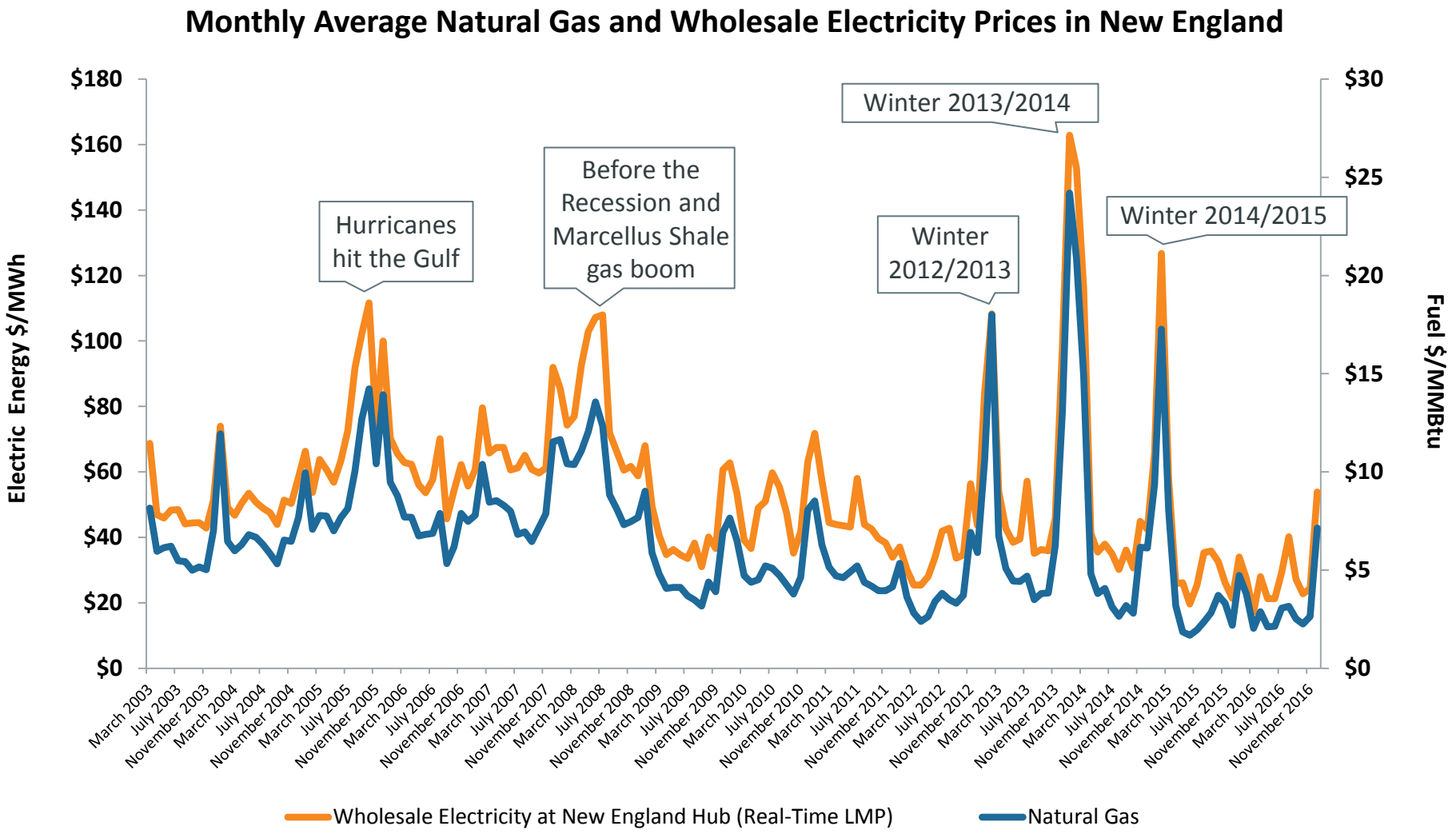
The fuels used to produce the region's electric energy have shifted as a result of economic and environmental factors

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

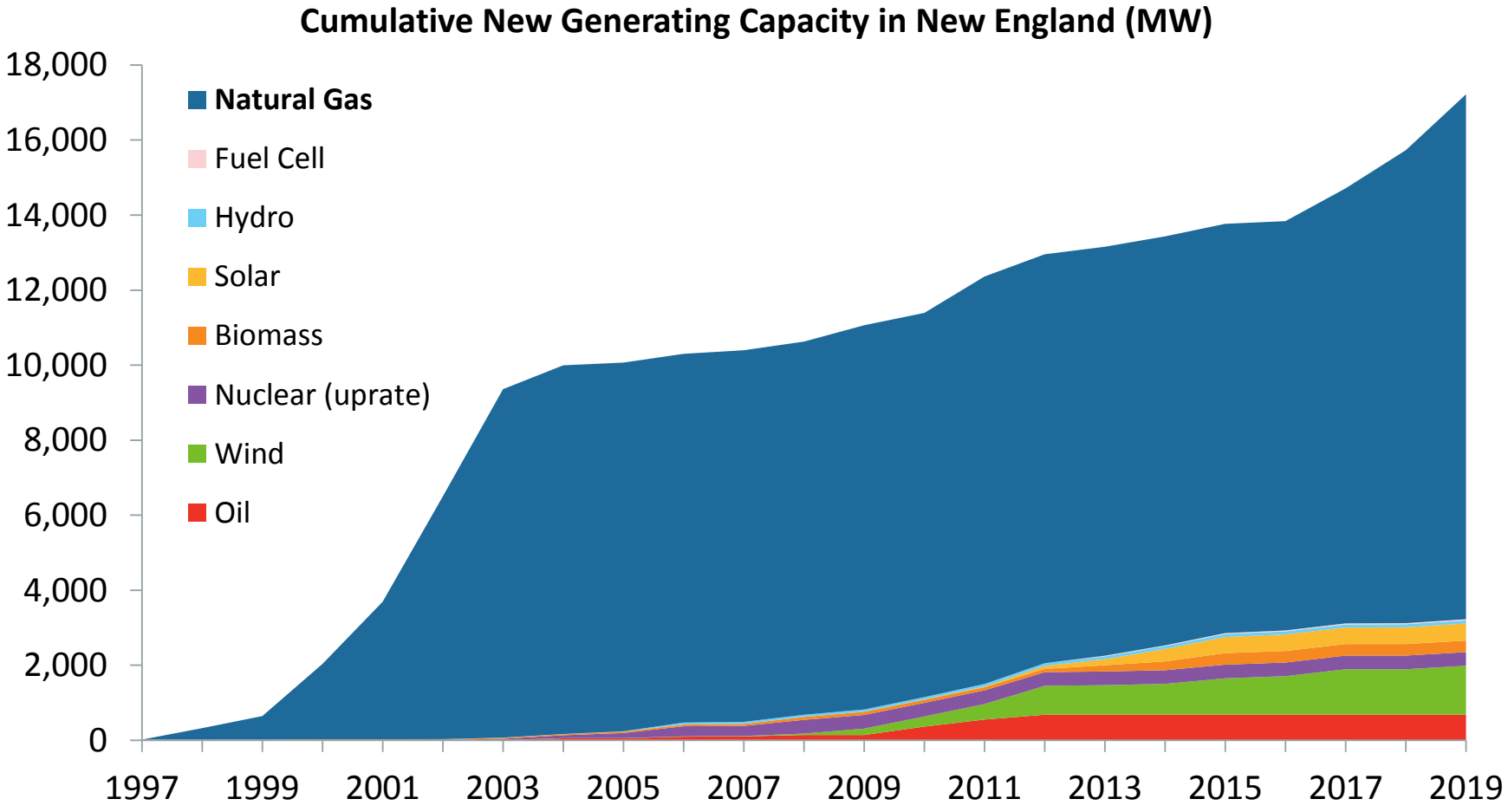


Source: ISO New England Net Energy and Peak Load by Source
Renewables include landfill gas, biomass, other biomass gas, wind, solar, municipal solid waste, and miscellaneous fuels

Natural Gas and Wholesale Electricity Prices Are Linked



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

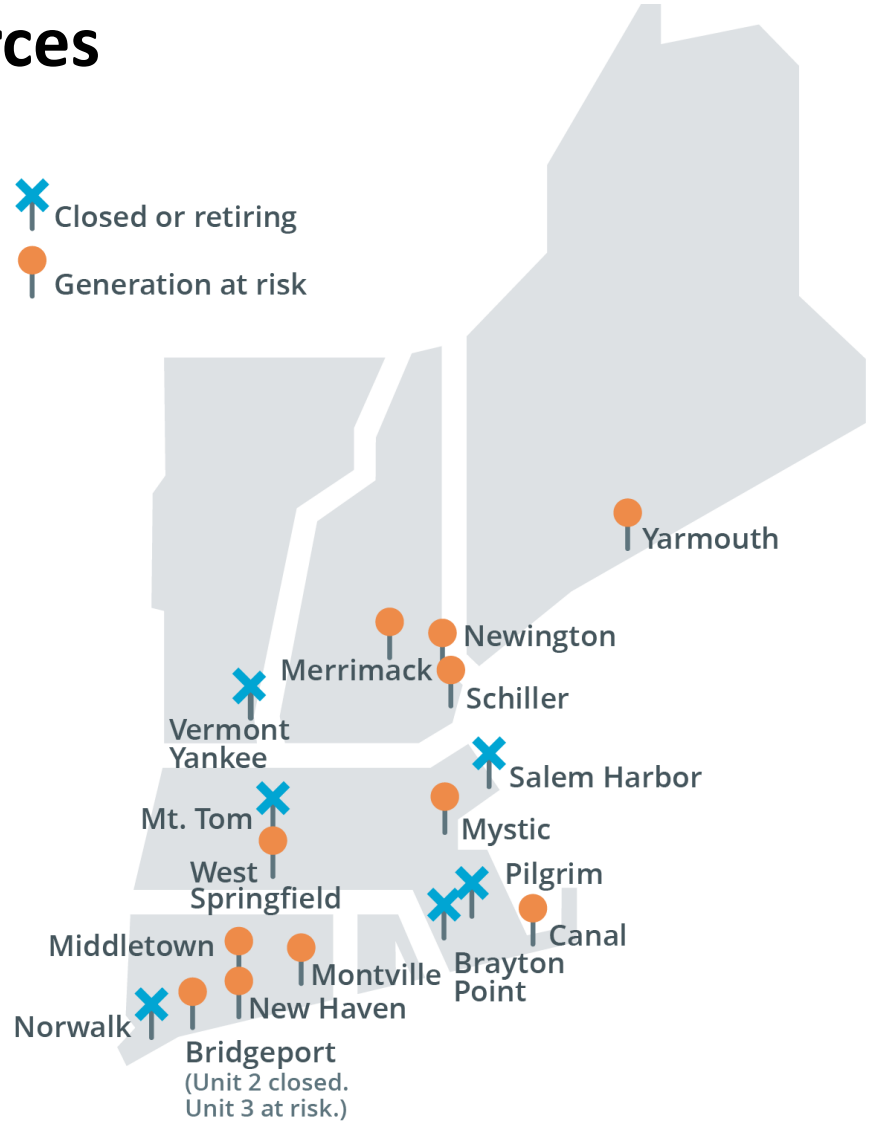


Note: New generating capacity for years 2016 – 2019 includes resources clearing in recent Forward Capacity Auctions.

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



Power Plant Emissions Have Declined with Changes in the Fuel Mix

Reduction in Aggregate Emissions (ktons/yr)

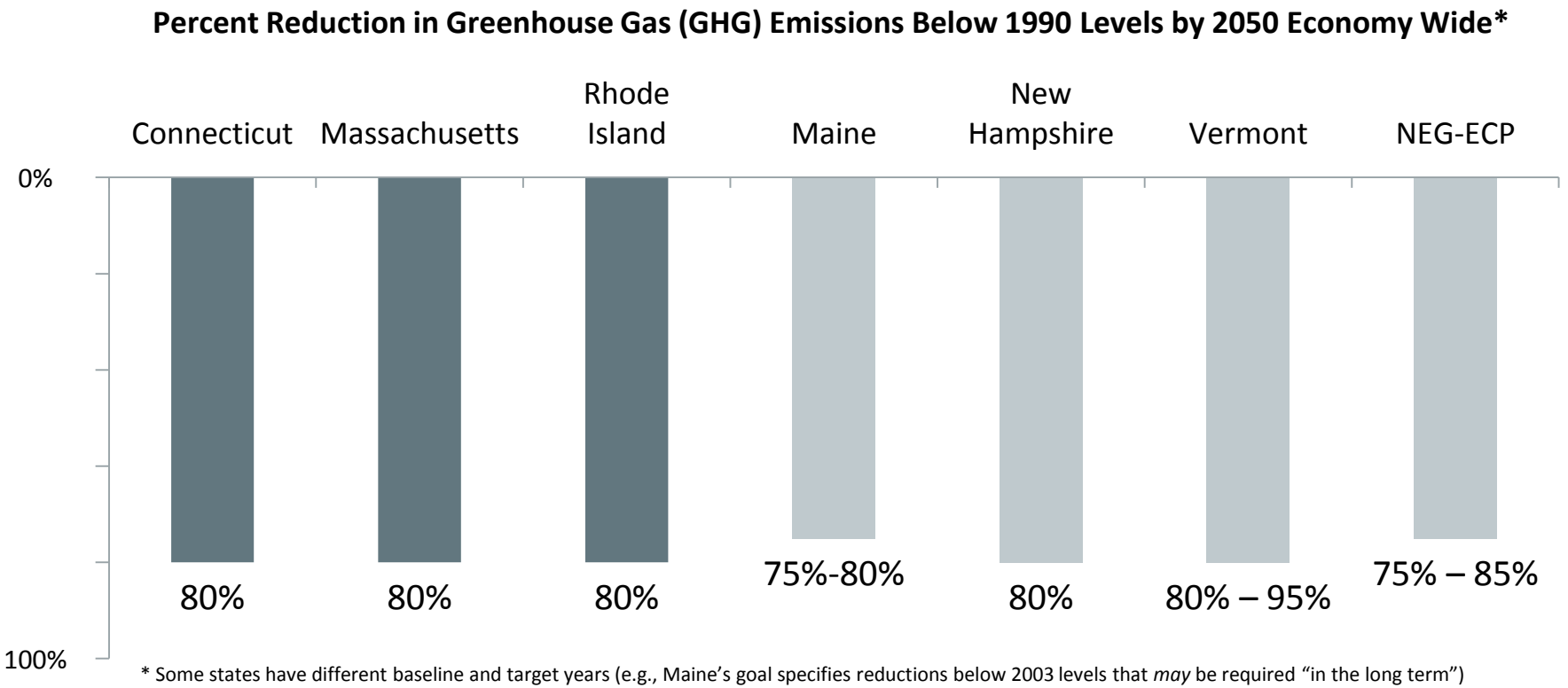
Year	NO_x	SO_2	CO_2
2001	59.73	200.01	52,991
2015	18.86	9.11	40,312
% Reduction, 2001–2015	**⬇ 68%**	**⬇ 95%**	**⬇ 24%**

Reduction in Average Emission Rates (lb/MWh)

Year	NO_x	SO_2	CO_2
1999	1.36	4.52	1,009
2015	0.35	0.17	747
% Reduction, 1999–2015	**⬇74%**	**⬇ 96%**	**⬇ 26%**

Source: 2015 ISO New England Electric Generator Air Emissions Report, January 2017

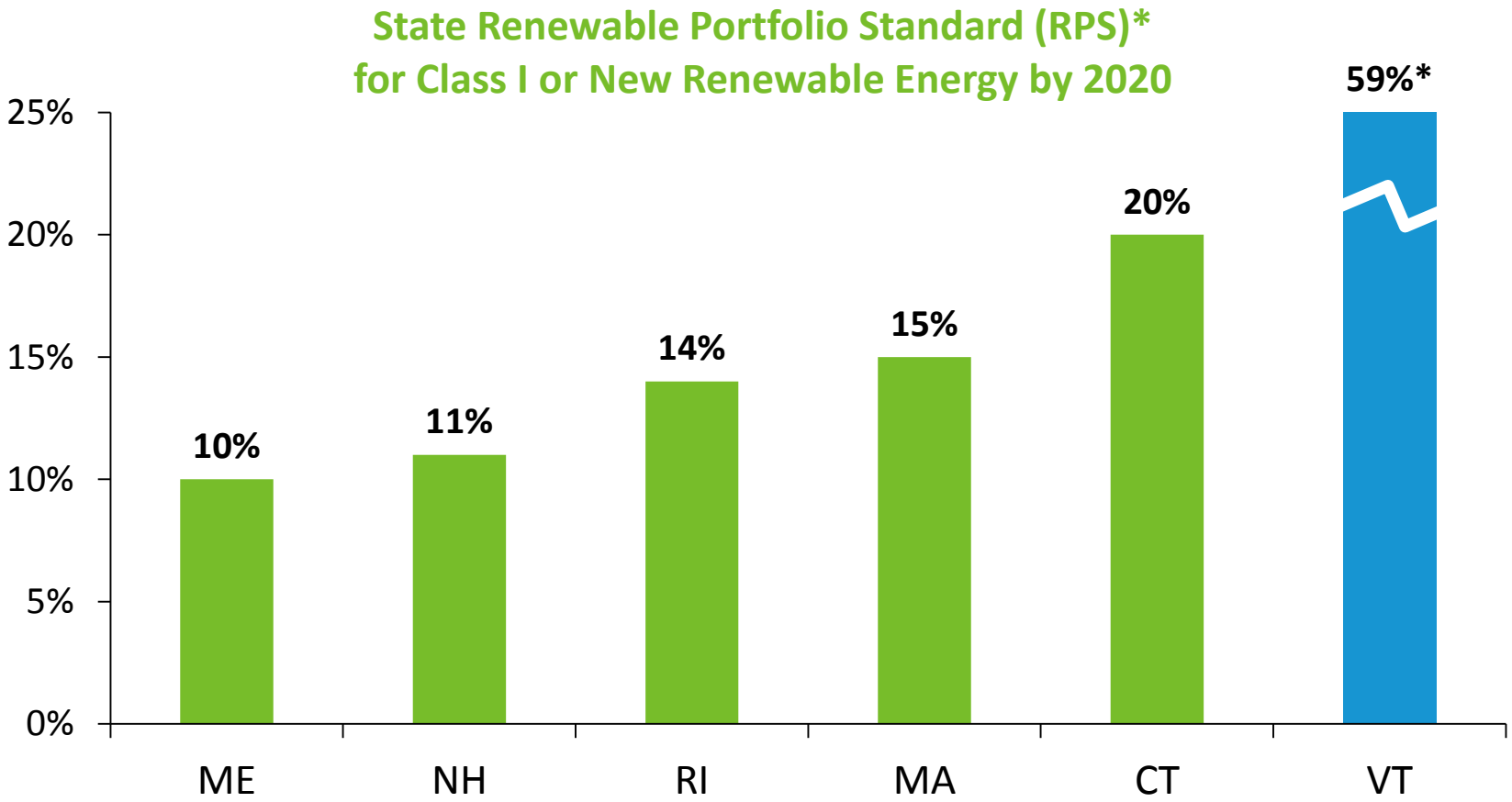
States Have Set Goals for Significant Reductions in Greenhouse Gas Emissions



* Some states have different baseline and target years (e.g., Maine's goal specifies reductions below 2003 levels that *may* be required "in the long term")

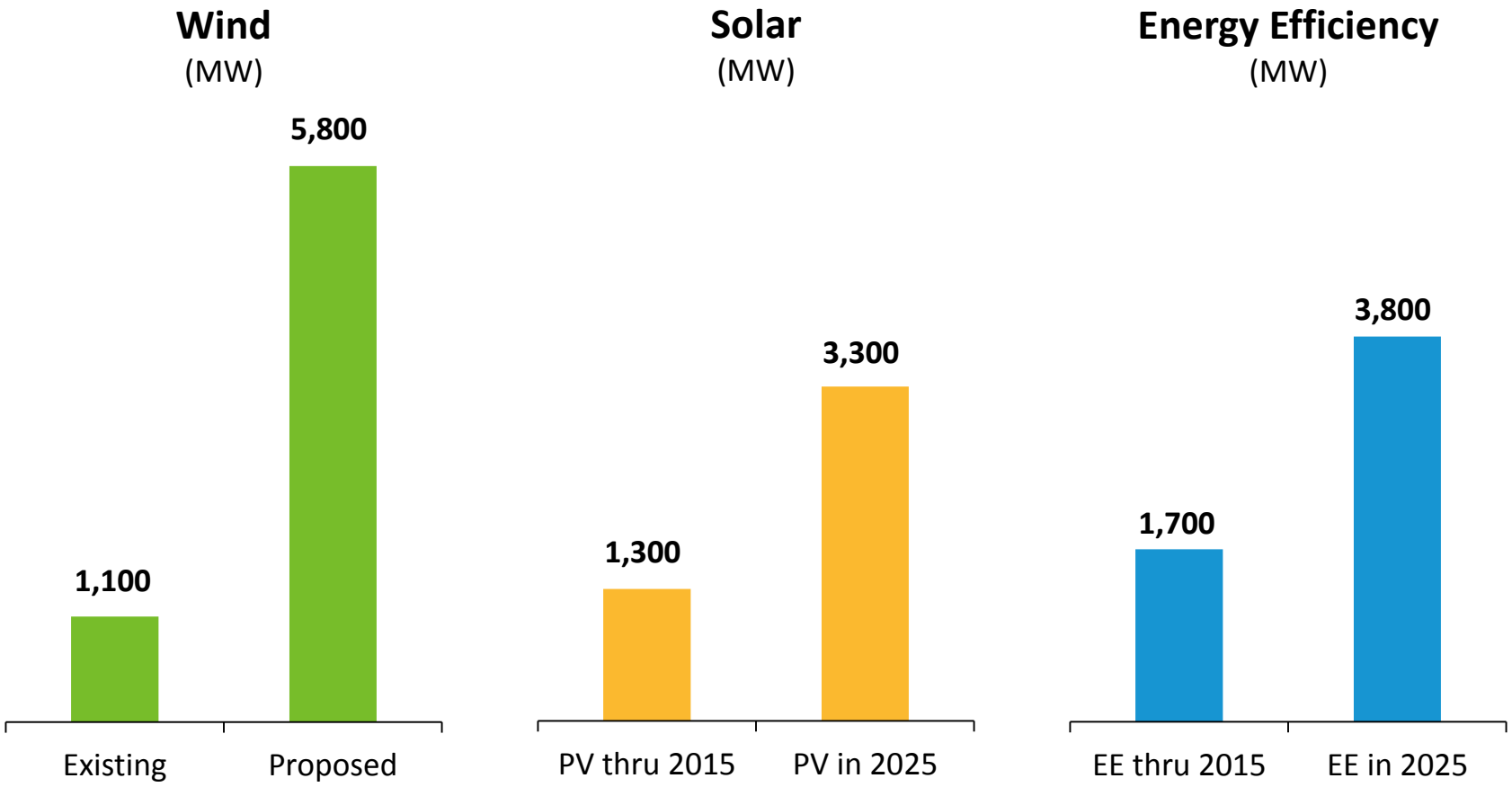
The New England states are promoting GHG reductions on a state-by-state basis, and at the regional level, through a combination of legislative mandates (e.g., CT, MA, RI) and aspirational, non-binding goals (e.g., ME, NH, VT and the New England Governors and Eastern Canadian Premiers).

State Policy Requirements Drive Proposals for Renewable Energy



* State Renewable Portfolio Standards (RPS) promote the development of renewable energy resources by requiring electricity providers (electric distribution companies and competitive suppliers) to serve a minimum percentage of their retail load using renewable energy. Vermont's Renewable Energy Standard has a 'total renewable energy' requirement (reflected above), which recognizes all forms of new and existing renewable energy, and is unique in classifying large-scale hydropower as renewable.

Renewable and EE Resources Are Trending Up



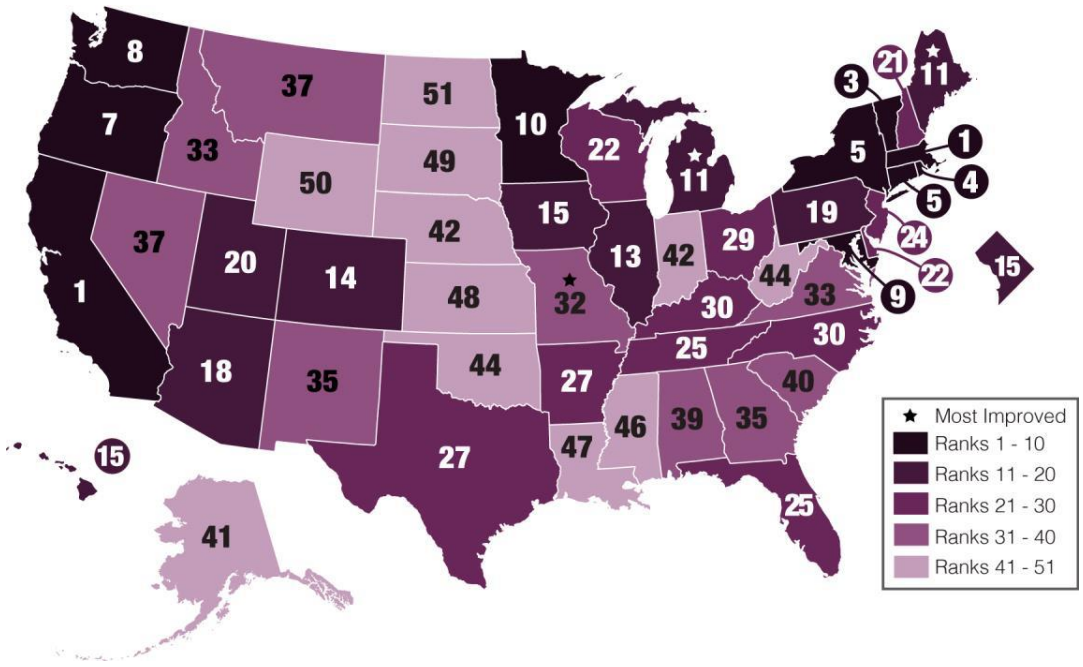
Nameplate capacity of existing wind resources and proposals in the ISO-NE Generator Interconnection Queue; megawatts (MW).

Final 2016 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."

2016 CELT Report, EE through 2015 includes EE resources participating in the Forward Capacity Market (FCM). EE in 2025 includes an ISO-NE forecast of incremental EE beyond the FCM.

Energy Efficiency Is a Priority for State Policymakers

2016 State Energy-Efficiency Scorecard



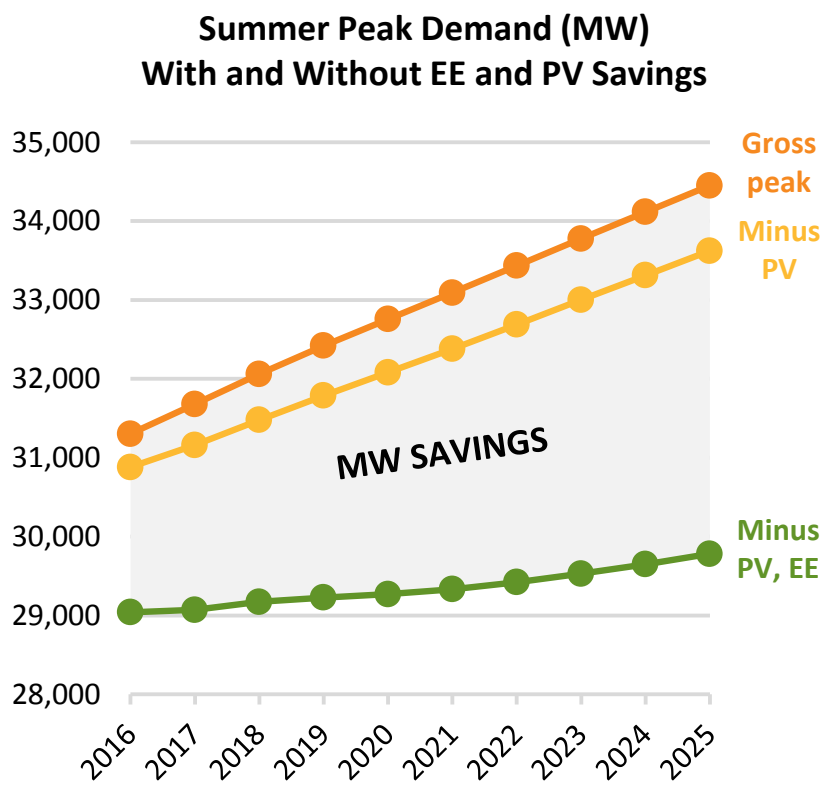
Source: American Council for an Energy-Efficient Economy

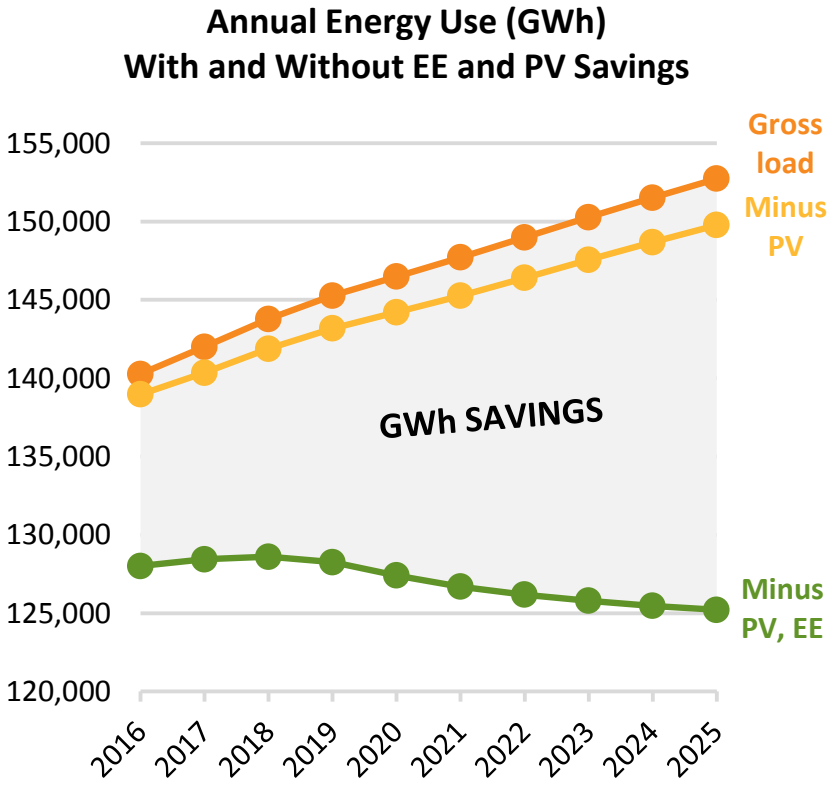
Ranking of state EE efforts by the *American Council for an Energy-Efficient Economy*:

- Massachusetts 1
- Vermont 3
- Rhode Island 4
- Connecticut 5
- Maine 11
- New Hampshire 21

- Billions spent over the past few years and more on the horizon
  - Nearly $4 billion invested from 2009 to 2014
  - ISO estimates $6.6 billion to be invested in EE from 2020 to 2025

Energy Efficiency and Solar PV Are Slowing Peak Demand Growth and Flattening Energy Use

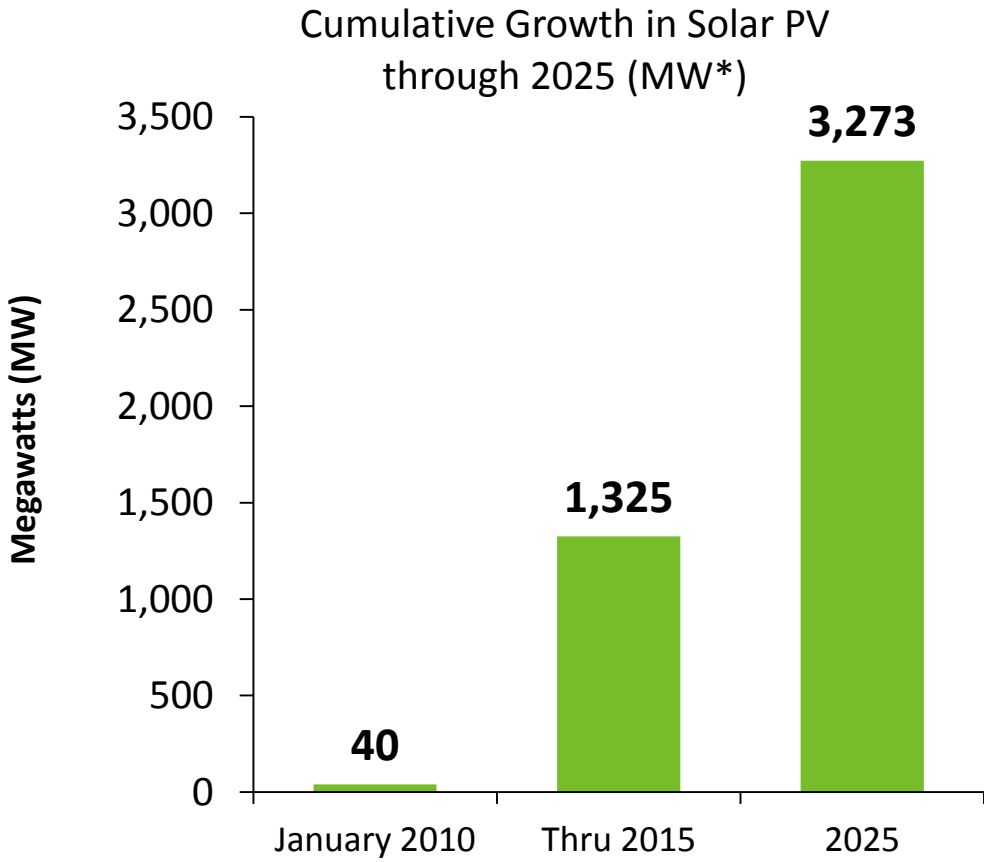




- **The gross peak and load forecast**
- **The gross peak and load forecast minus forecasted "behind-the-meter" (BTM) solar PV resources**
- **The gross peak and load forecast minus forecasted BTM solar PV, minus energy-efficiency (EE) resources in the Forward Capacity Market 2016-2019 and forecasted EE 2020-2025**

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 ISO New England Energy-Efficiency Forecast 2020-2025 and Final 2016 Solar PV Forecast Details (May 2016)

ISO New England Forecasts Strong Growth in Solar PV



Note: This 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 2016 ISO-NE PV Forecast (April 2016); MW values are AC nameplate.

2016 Solar Photovoltaic Forecast

Cumulative Nameplate, MW_{ac}

States	Cumulative Total MW (AC nameplate rating)										
	Thru 2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
CT	188.0	273.5	378.0	459.0	540.0	621.0	676.9	731.2	776.2	821.1	866.1
MA	947.1	1241.5	1364.2	1433.9	1472.6	1511.3	1550.1	1588.8	1627.6	1666.3	1705.0
ME	15.3	20.0	24.6	29.1	33.5	37.9	42.1	46.1	50.0	53.9	57.9
NH	26.4	39.7	47.3	51.3	55.3	59.3	63.3	67.3	71.3	75.3	79.3
RI	23.6	45.2	83.9	119.9	155.9	181.8	190.9	197.5	204.1	210.7	217.2
VT	124.6	154.8	178.5	201.0	223.5	246.0	267.3	287.3	307.3	327.3	347.3
Regional - Cumulative (MW)	**1325.0**	**1774.7**	**2076.5**	**2294.2**	**2480.9**	**2657.4**	**2790.6**	**2918.1**	**3036.3**	**3154.6**	**3272.8**

Notes:

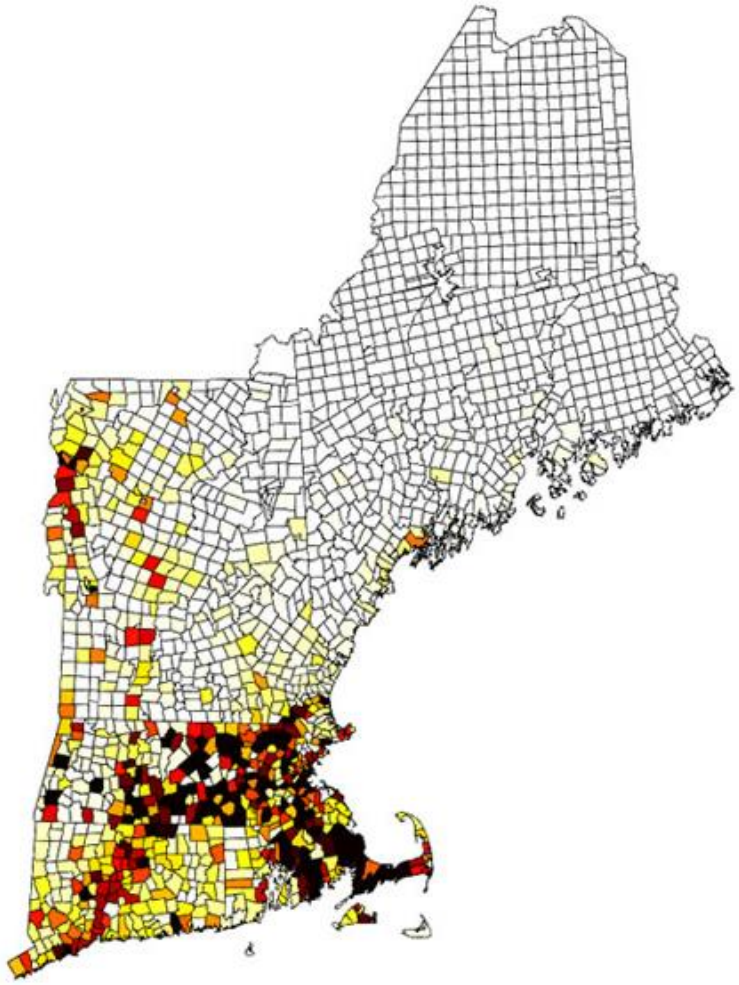
(1) Forecast values include FCM Resources, non-FCM Energy Only Generators, and behind-the-meter PV resources

(2) The forecast reflects discount factors to account for uncertainty in meeting state policy goals

(3) All values represent end-of-year installed capacities

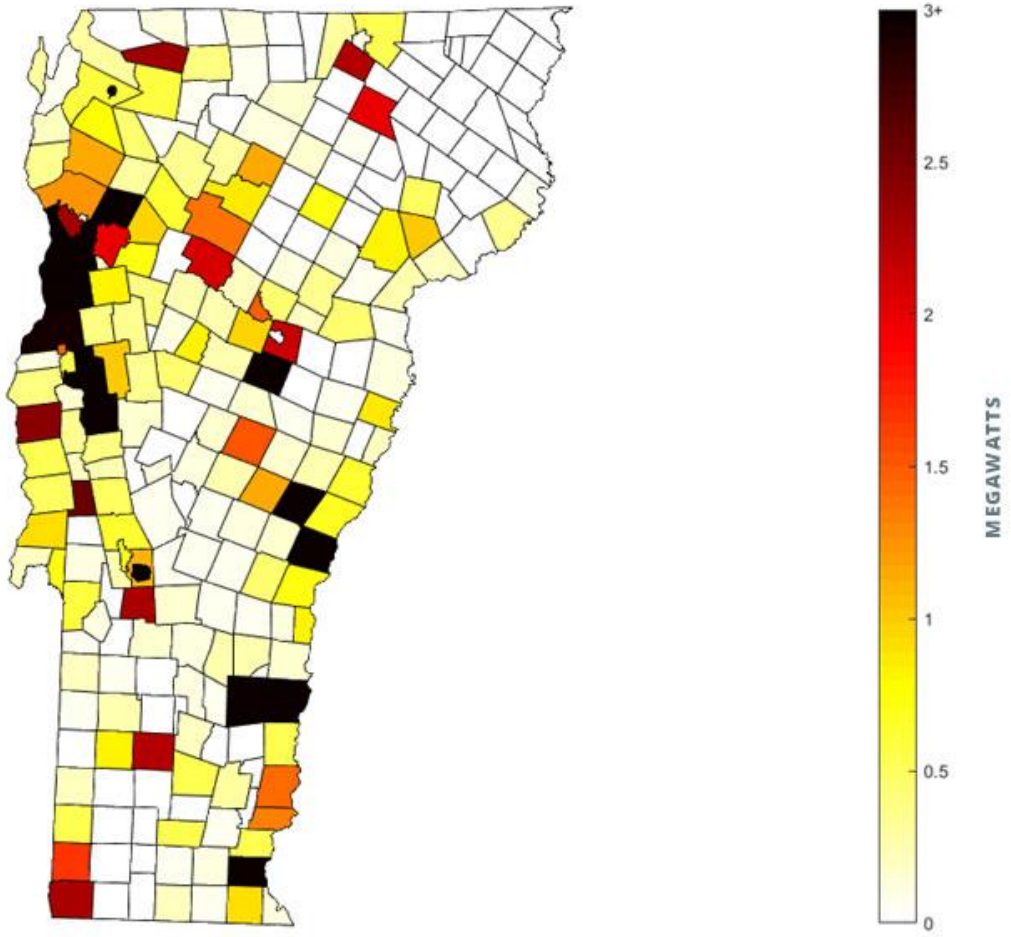
State Installed Solar PV "Heat Maps"

- Understanding the **spatial distribution** of existing solar PV resources will be critical to the ISO's ongoing integration activities within both System Planning and System Operations
- Based on the data provided by distribution owners, the ISO has aggregated the installed nameplate capacity by town within each state, and generated heat maps showing the results



Note: Heat map reflects solar PV installed through August 31, 2016.

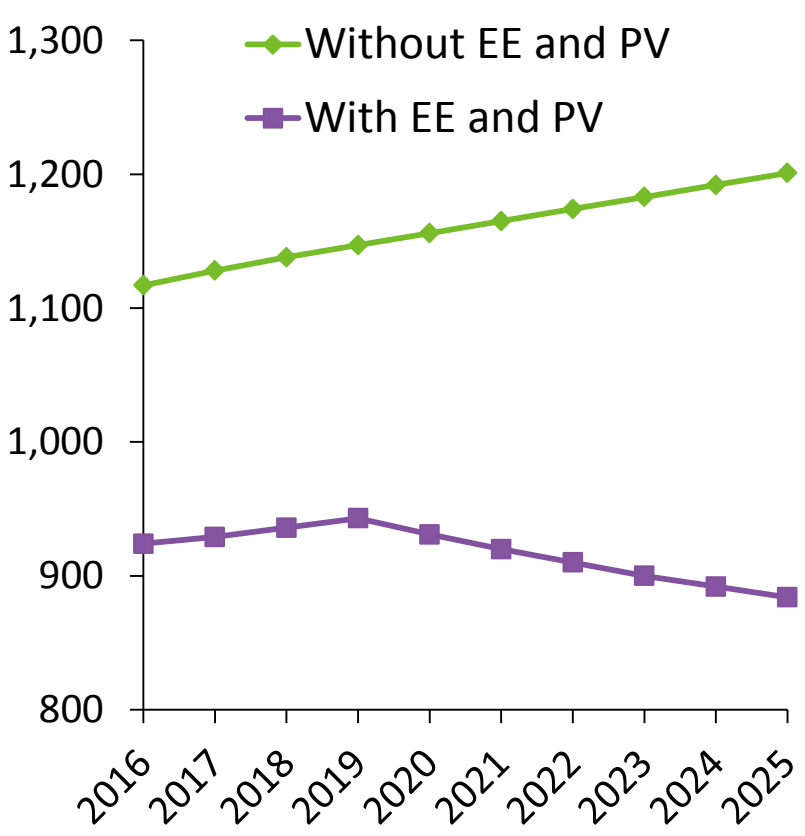
Vermont Installed Solar PV “Heat Map”



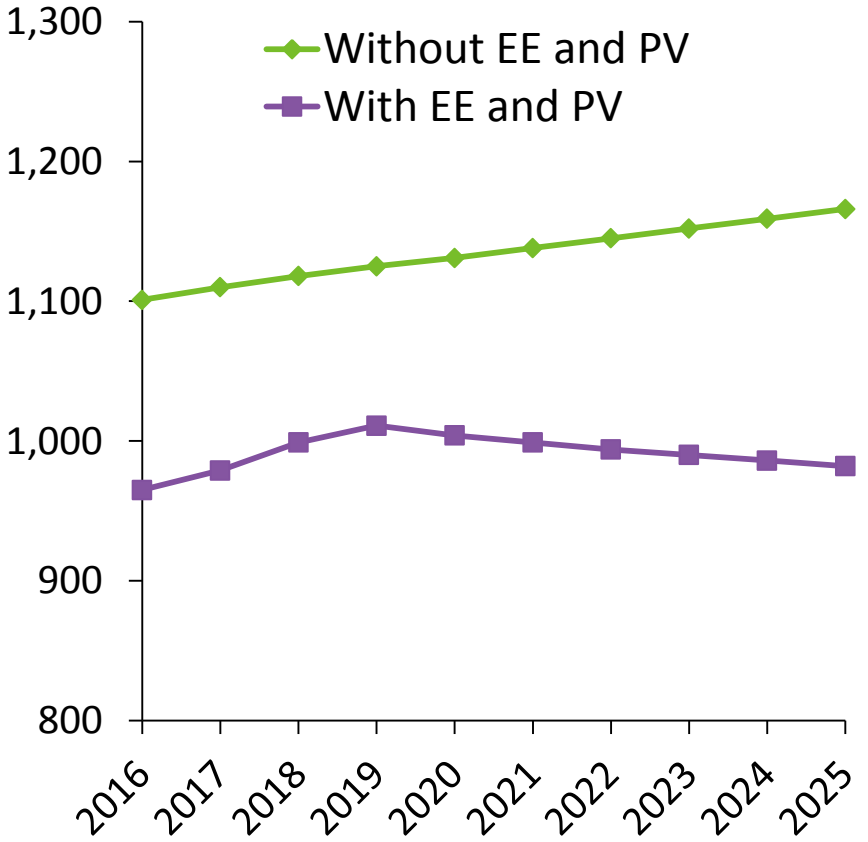
Note: Heat map reflects solar PV installed through August 31, 2016.

Energy Efficiency and Solar PV Are Lowering Peak Demand Growth in Vermont

Forecasted Summer Peak (MW)



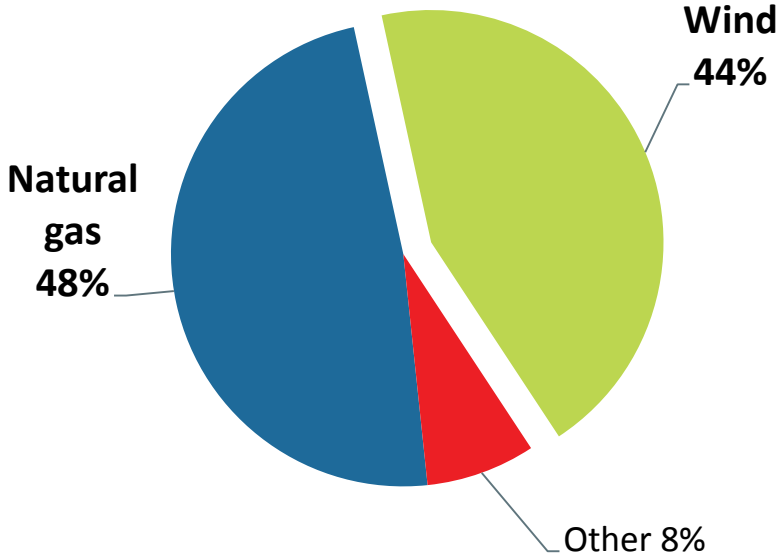
Forecasted Winter Peak (MW)



Infrastructure Will Be Needed to Deliver Energy from Proposed Resources

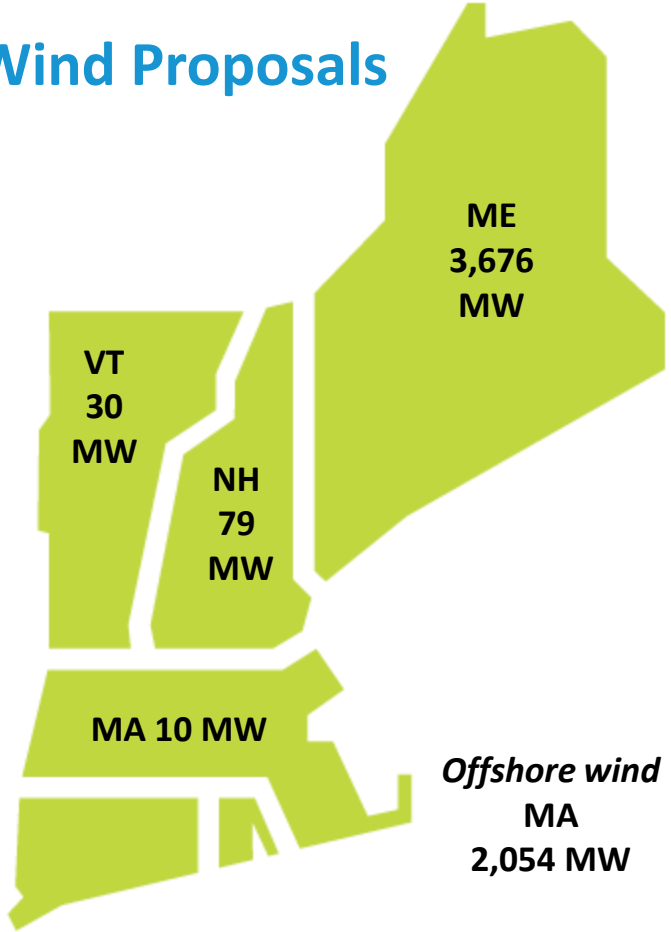
All Proposed Generation

Developers are proposing to build roughly 13,250 MW of generation, including nearly 6,400 MW of gas-fired generation and more than 5,800 MW of wind



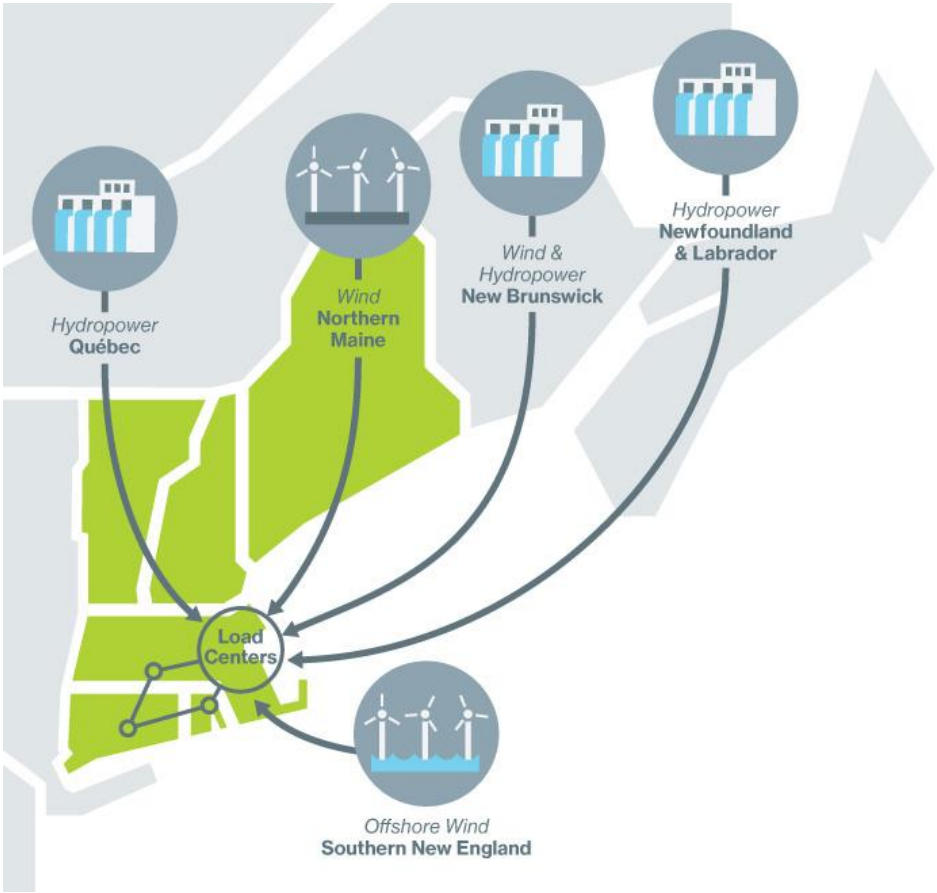
Source: ISO Generator Interconnection Queue (January 2017)
FERC Jurisdictional Proposals Only

Wind Proposals



Source: ISO Generator Interconnection Queue (January 2017)
FERC Jurisdictional Proposals

Developers Are Proposing to Move Renewable Energy to New England Load Centers



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

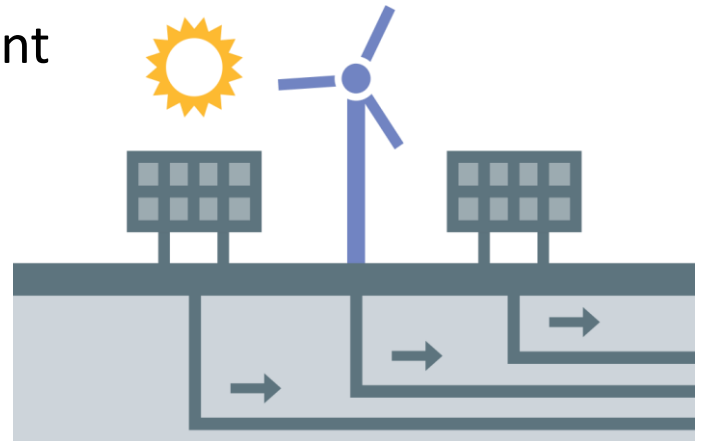
- As of **January 1, 2017**, seventeen elective transmission projects had been proposed in the ISO Interconnection Queue, totaling more than **10,000 MW** of potential transfer capability, including:
  - **Large-scale hydro** resources from eastern Canada, and
  - **Onshore wind** resources from northern New England
- Projects seek to address public policy goals, not reliability needs
- In addition, **offshore wind** resources are emerging in southern New England

Source: ISO Interconnection Queue (January 2017)

New England Is Moving Toward a "Hybrid" Grid

With grid-connected and distributed resources, and a continued shift toward natural gas and renewable energy

- The electric grid of the future will require renewable resources to meet policy goals for clean ***energy***, but also require adequate ***capacity*** as a backup when renewable resources cannot deliver energy to consumers
- The ***backup/capacity resources need to be flexible*** to reliably balance the variability of increasing renewable energy levels
- The capacity market will be an important ***revenue balancing mechanism to ensure resource adequacy*** as renewable resources drive down revenues in the energy market



ISO New England Follows Best Practices to Address Cybersecurity Risks

- Safeguarding physical and cyber security is a **top priority** for ISO New England
- The nine Independent System Operators and Regional Transmission Organizations (ISOs/RTOs) in North America are subject to **mandatory** NERC Critical Infrastructure Protection (CIP) reliability standards that address cybersecurity
- The ISO is actively engaged in NERC grid security exercises that test the readiness of the electricity subsector to respond to physical and cybersecurity threats (e.g., **GridEx III**)

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**
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  - 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