ISO New England Overview and Regional Update

Rhode Island Senate Committee on Environment and Agriculture

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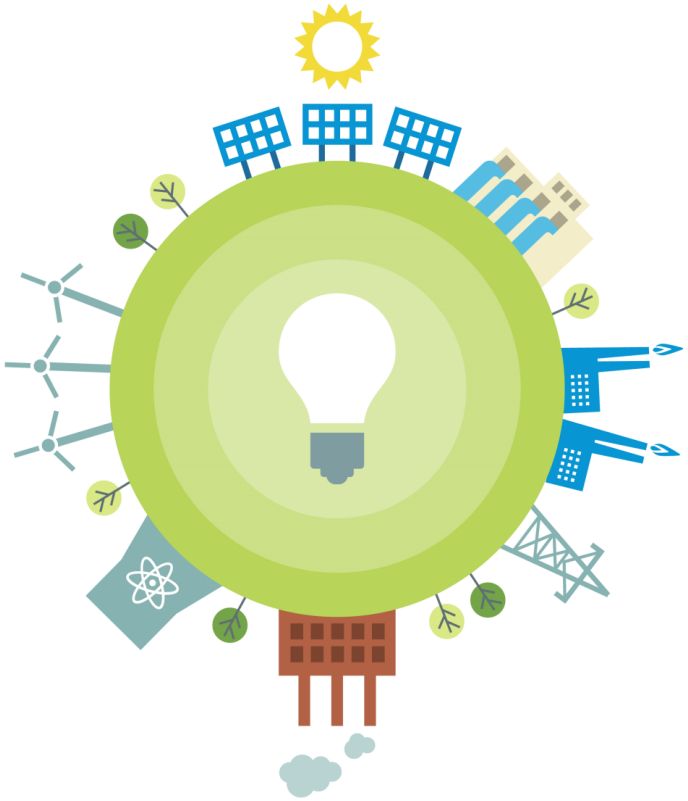
EXTERNAL AFFAIRS REPRESENTATIVE

Overview of Presentation

- About ISO New England
- Major Responsibilities
- Electric Grid at a Glance
- Strategic Planning Initiatives
- Renewable Energy Development and Integration
- Closing Thoughts
- Appendix: Background Information



What Are Independent System Operators and How Did We Get Here?

- New England's electric power industry has **changed dramatically** over the past few decades
- The industry once consisted of **vertically-integrated utilities** that handled every aspect of supplying electricity: generating it, transmitting it, distributing it to retail customers, and planning for future reliability
- Orders by the **Federal Energy Regulatory Commission** (FERC) paved the way for electric restructuring
- Soon after, **Independent System Operators** (ISOs) were created to establish competitive wholesale electricity markets and ensure reliable power system operations

Note: The Federal Energy Regulatory Commission (FERC) is an independent agency that regulates the interstate transmission of natural gas, oil, and electricity.

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 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

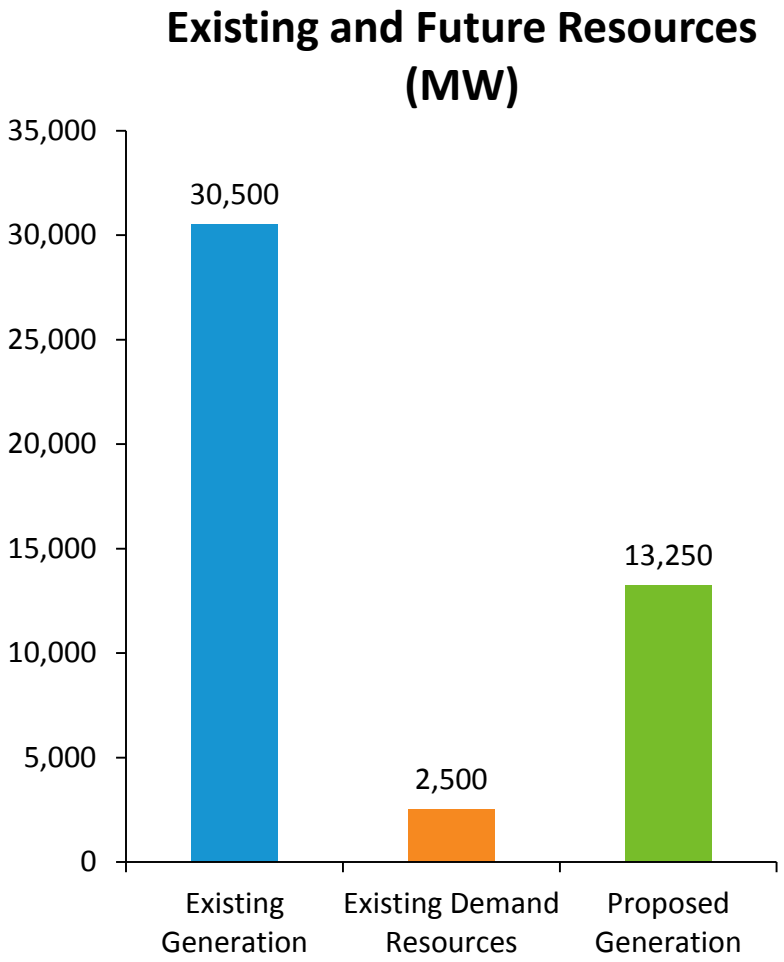
Overseeing the day-to-day operation of New England's electric power generation and transmission system

Managing comprehensive regional power system planning

Developing and administering the region's competitive wholesale electricity markets

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

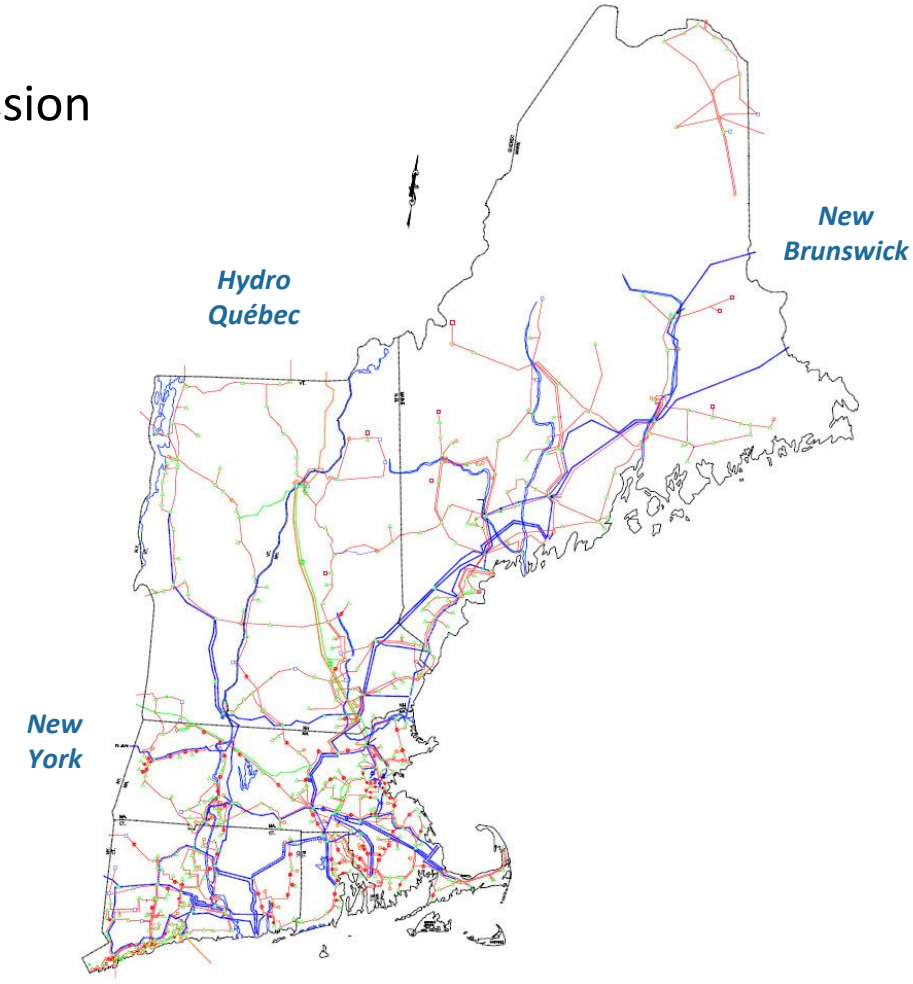
- **350** generators in the region
- **30,500 MW** of generating capacity
- **13,250 MW** of proposed generation in the ISO Queue
  - Mostly natural gas and wind
- **4,200 MW** of generation has retired or will retire in the next five years
- **600 MW** of active demand response and **1,900 MW** of energy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



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

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



ISO New England Administers Fair and Efficient Wholesale Electricity Markets

Energy Market

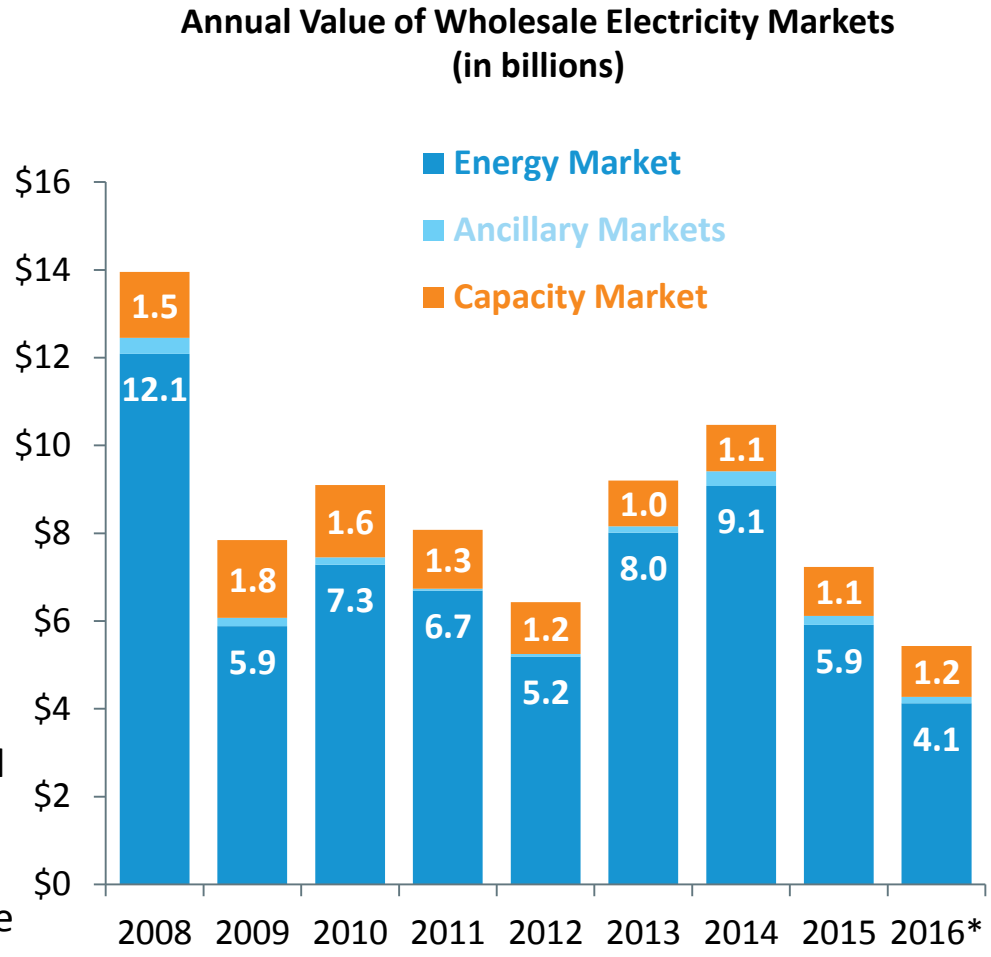
Daily market for wholesale customers to buy and sell electric "energy"

Forward Capacity Market

ISO determines capacity needs three years into the future and resources compete to sell capacity to the system through annual forward capacity auctions

Ancillary Markets

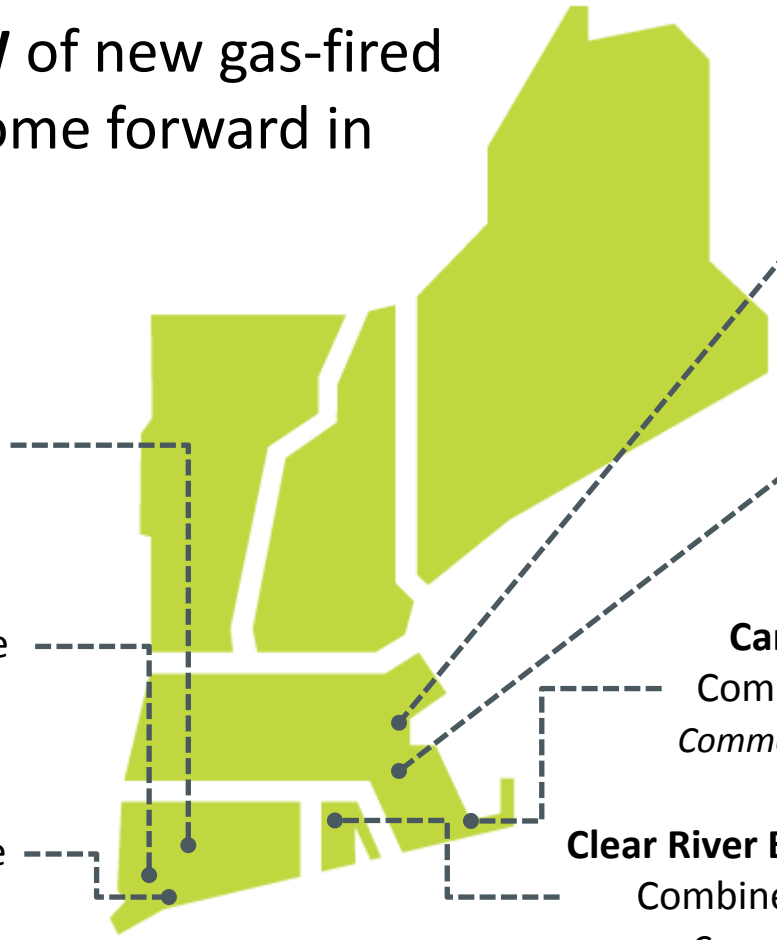
Resources are compensated for providing regulation services and reserves to ensure reliability in real time



* 2016 wholesale electricity market values are preliminary and subject to reconciliation

The Forward Capacity Market Is Attracting Efficient and Fast-Starting Resources

- Roughly **3,000 MW** of new gas-fired generation have come forward in recent auctions



Footprint (674 MW)
Combined-Cycle Gas Turbine
Commercial: June 1, 2017

Medway (195 MW)
Combustion Turbine
Commercial: June 1, 2018

Canal (333 MW)
Combustion Turbine
Commercial: June 1, 2019

Clear River Energy Center (485 MW)
Combined-Cycle Gas Turbine
Commercial: June 1, 2019

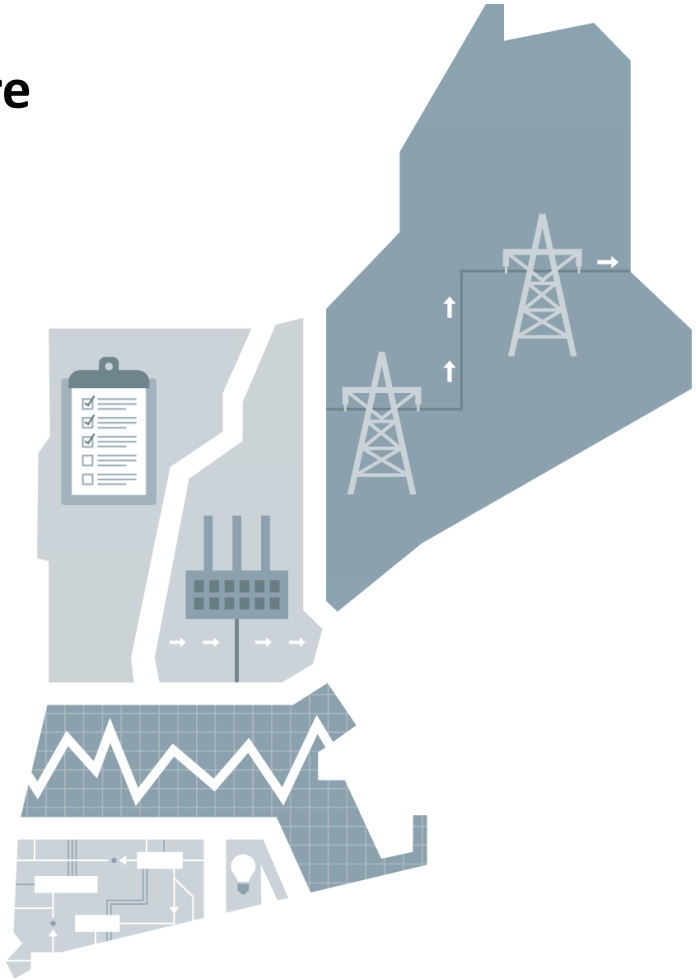
Wallingford (90 MW)
Combustion Turbines
Commercial: June 1, 2018

Towantic (725 MW)
Combined-Cycle Gas Turbine
Commercial: June 1, 2018

Bridgeport (484 MW)
Combined-Cycle Gas Turbine
Commercial: June 1, 2019

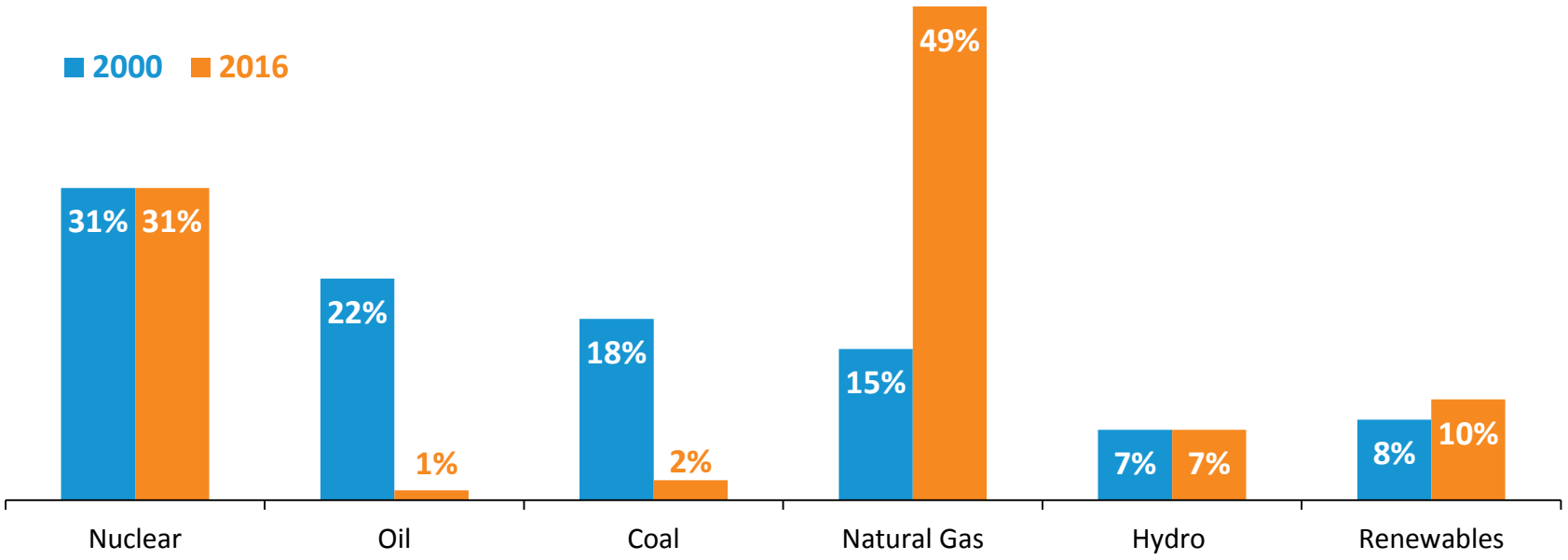
ISO New England Is Focused on Developing Solutions to the Region's Top Reliability Risks

- **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



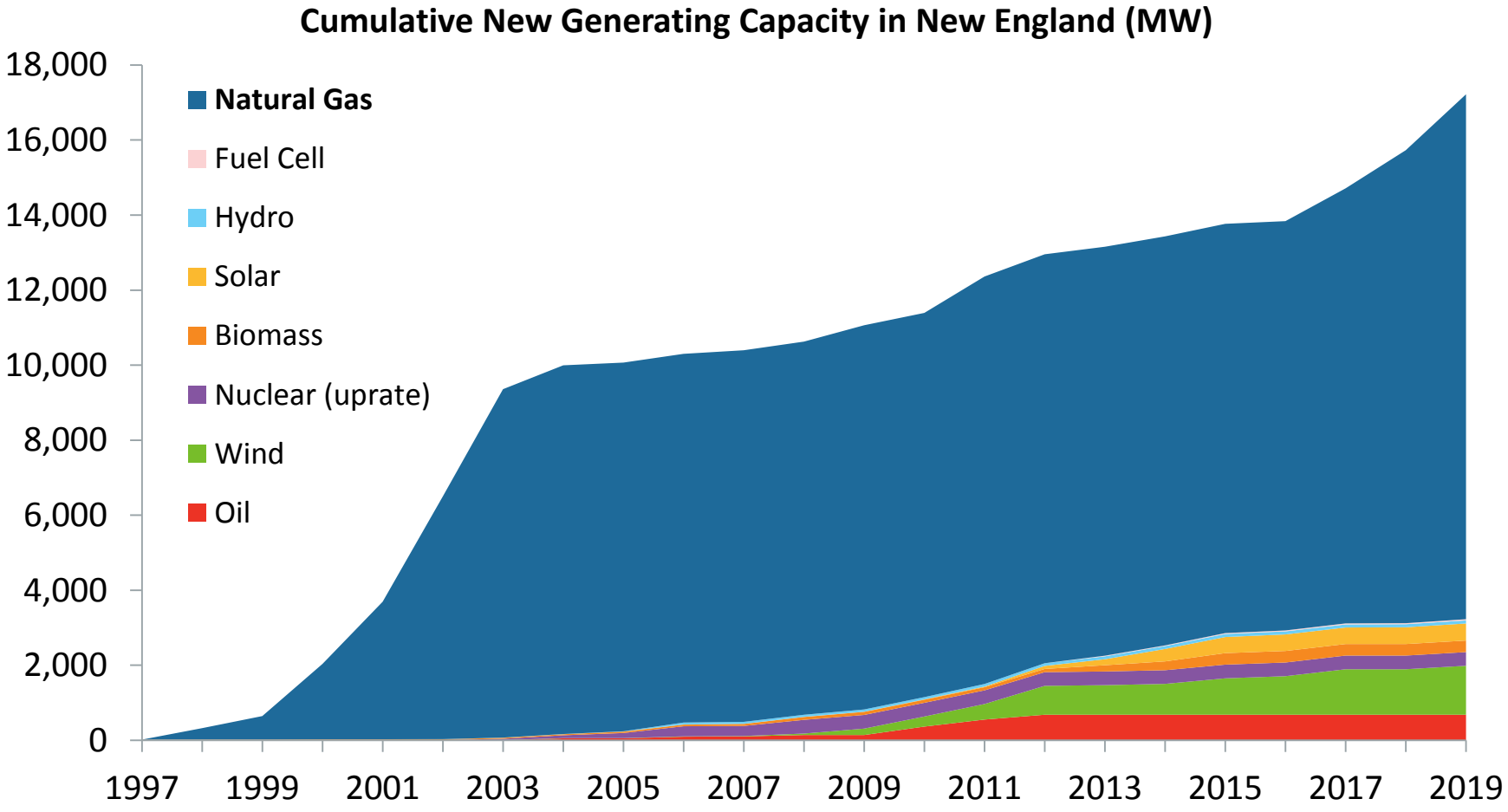
New England Has Seen Dramatic Changes in the Energy Mix: *From Coal and Oil to Natural Gas*

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

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

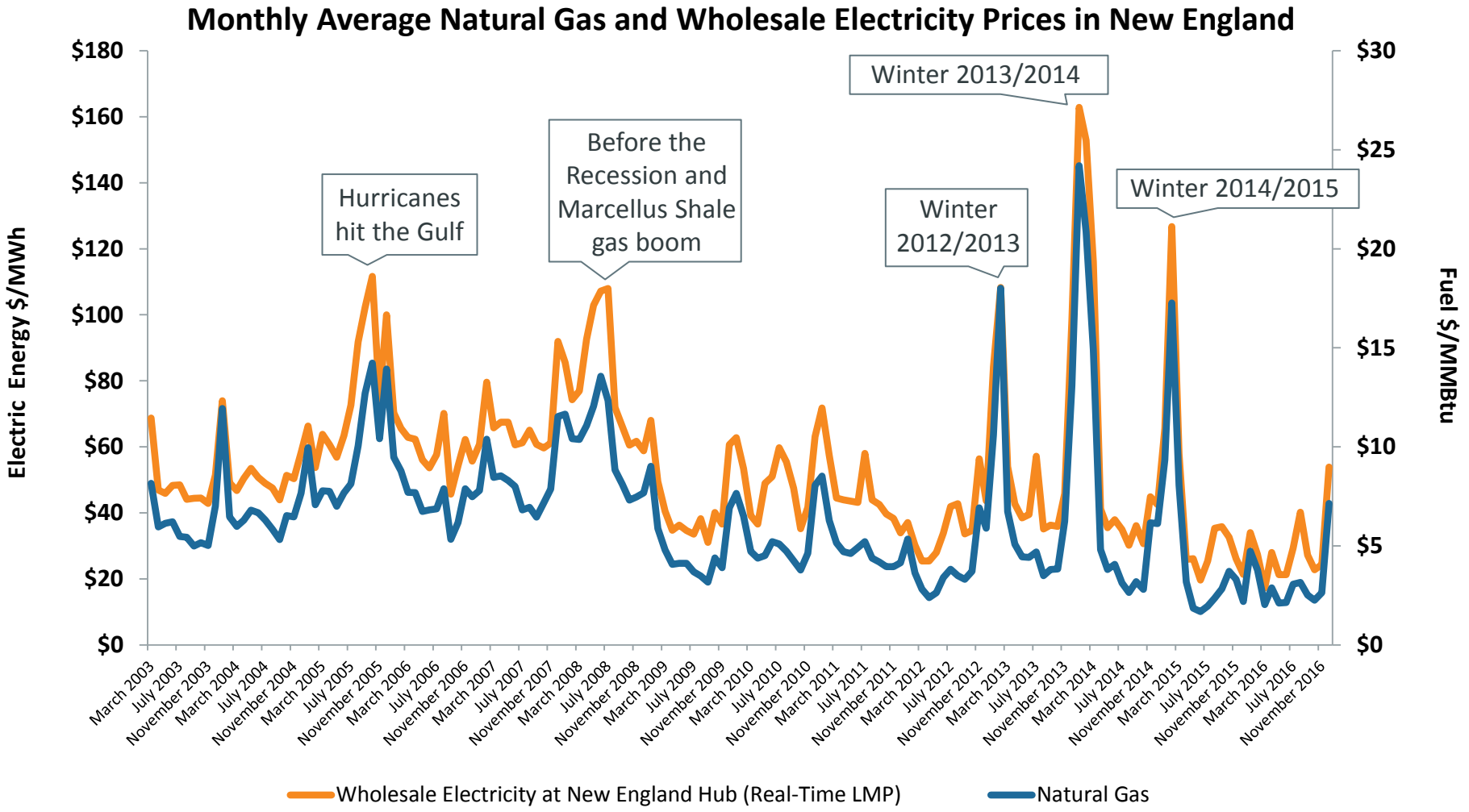


Note: New generating capacity for years 2016 – 2019 includes resources clearing in recent Forward Capacity Auctions.

New England Has Relatively Few Interstate Natural Gas Pipelines and Few Delivery Points for LNG

Natural Gas and Wholesale Electricity Prices Are Linked

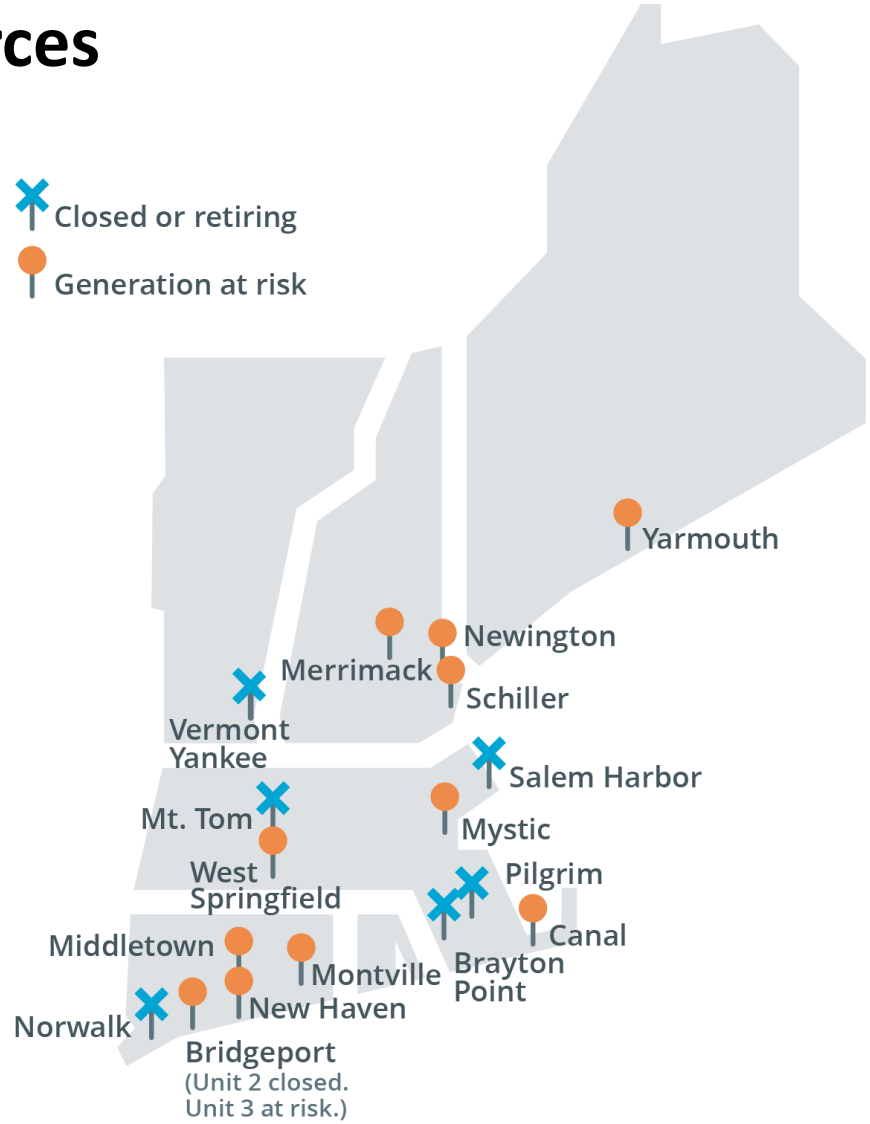
A large portion of the region's fleet uses natural gas for power generation; natural gas typically sets the price for wholesale electricity



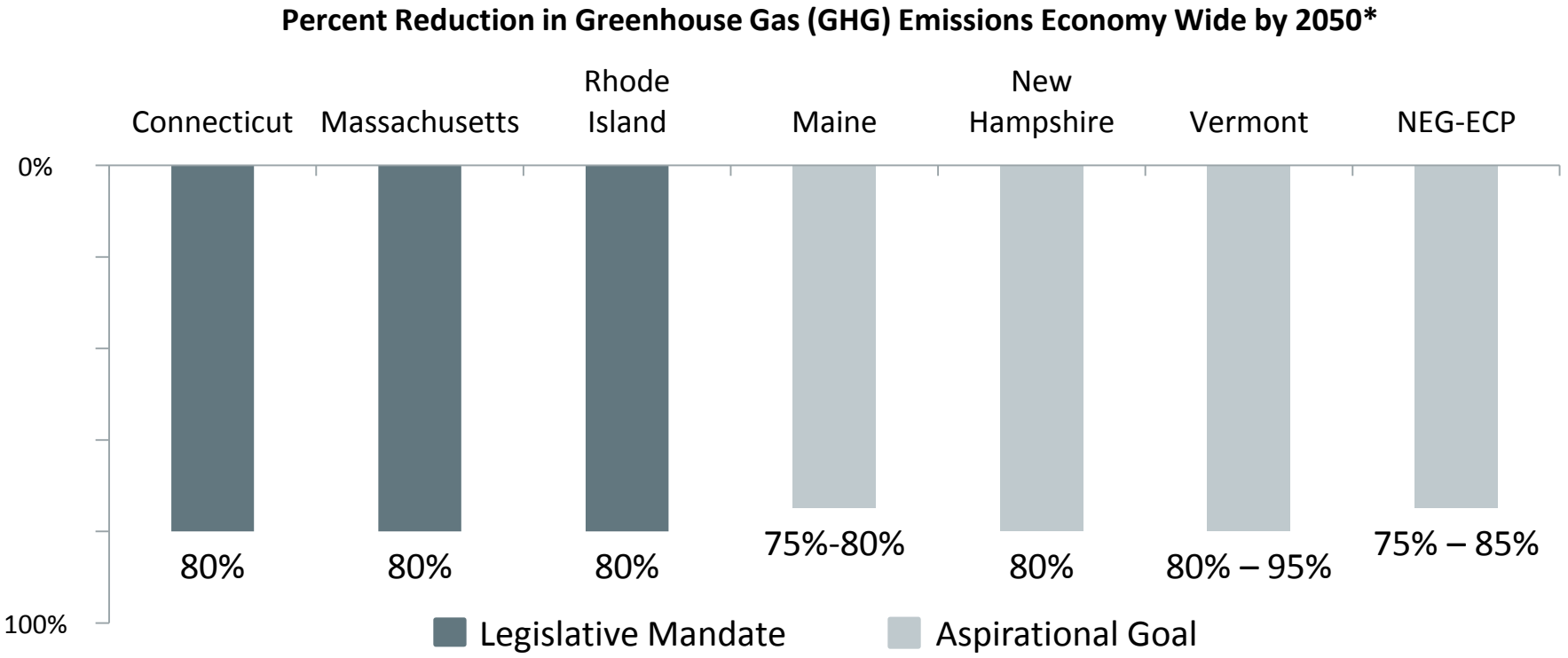
The Region Has Lost—*and Is at Risk of Losing*—Substantial Non-Gas Resources

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*



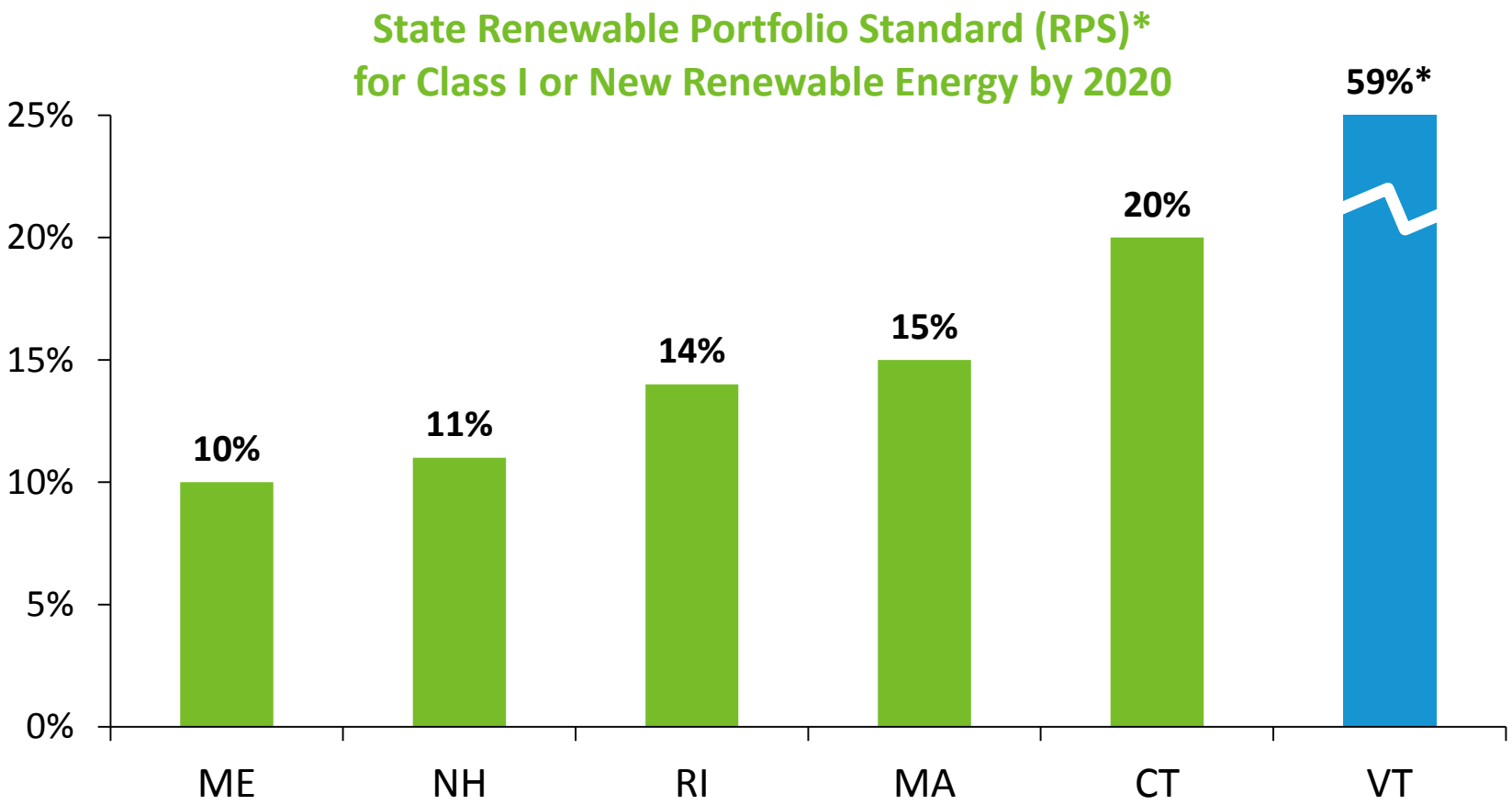
States Have Set Goals for Reductions in Greenhouse Gas Emissions: *Some Mandated, Some Aspirational*



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).

* MA, RI, NH, and VT use a 1990 baseline year for emissions reductions. CT and the NEG-ECP use a 2001 baseline. ME specifies reductions below 2003 levels that *may* be required "in the long term." For more information, see the following ISO Newswire article: http://isonewswire.com/updates/2017/3/1/the-new-england-states-have-an-ongoing-framework-for-reducin.html.

State Policy Requirements Drive Proposals for Renewable Energy

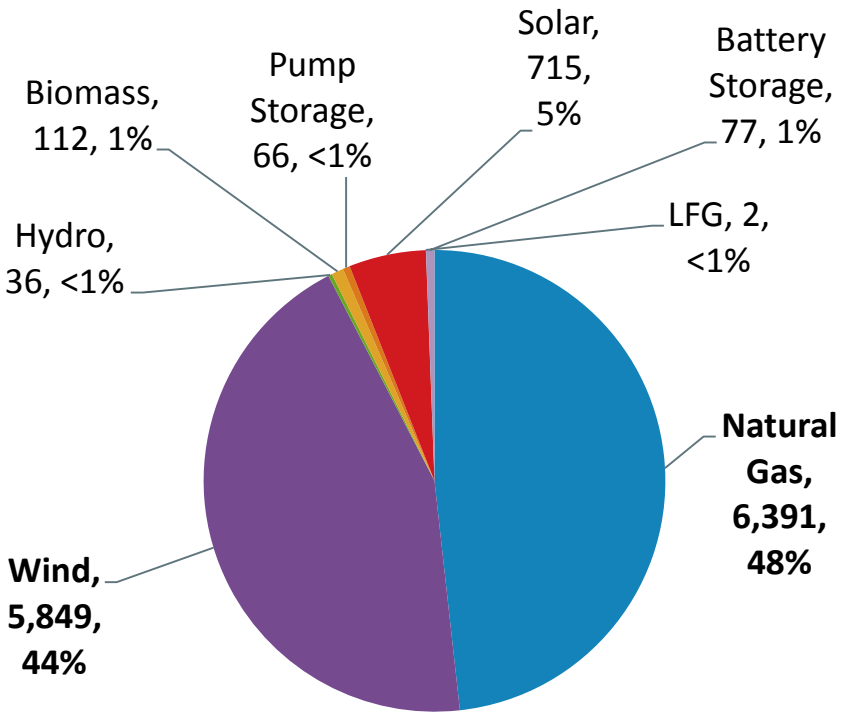


* State Renewable Portfolio Standards (RPS) promote the development of renewable energy resources by requiring electricity providers (electric distribution companies and competitive suppliers) to serve a minimum percentage of their retail load using renewable energy. Vermont's Renewable Energy Standard 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.

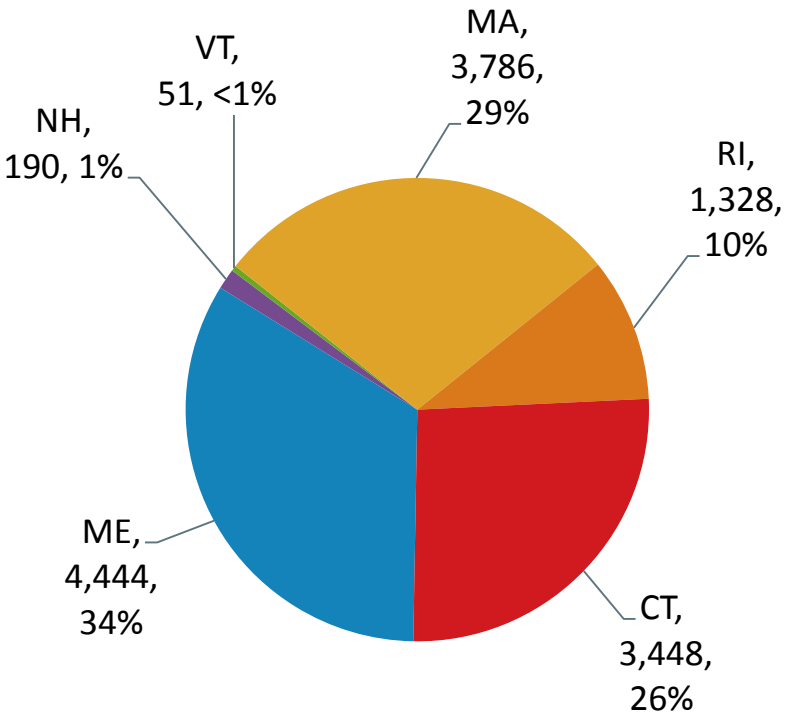
Natural Gas and Wind Power Dominate New Resource Proposals in the ISO Queue

Approximately 13,250 MW

By Type



By State

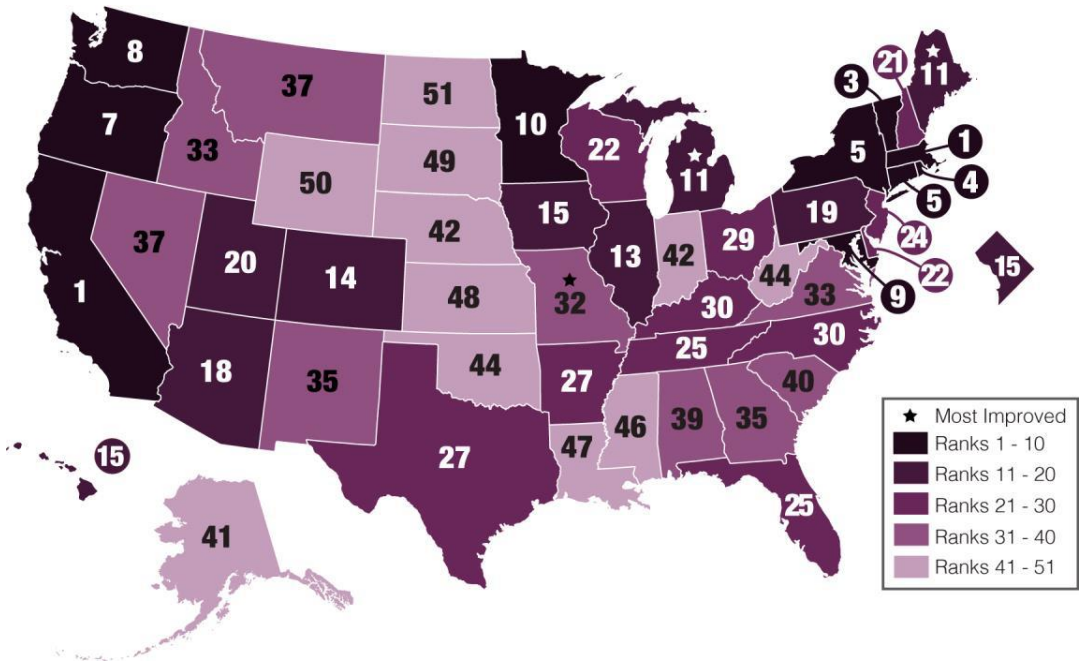


Note: Some natural gas proposals include dual-fuel units (oil); megawatts represent nameplate capacity ratings

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

Energy Efficiency Is a Priority for State Policymakers

2016 State Energy-Efficiency Scorecard



Source: American Council for an Energy-Efficient Economy

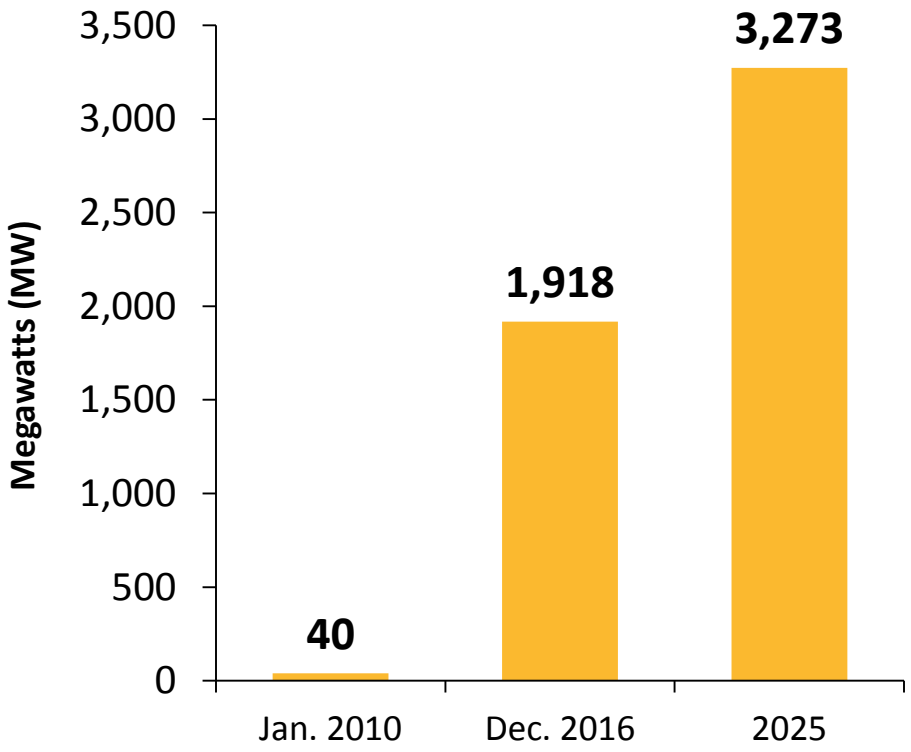
Ranking of state EE efforts by the *American Council for an Energy-Efficient Economy*:

- 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

ISO New England Forecasts Strong Growth in Solar PV

Cumulative Growth in Solar PV through 2025 (MW_{ac})

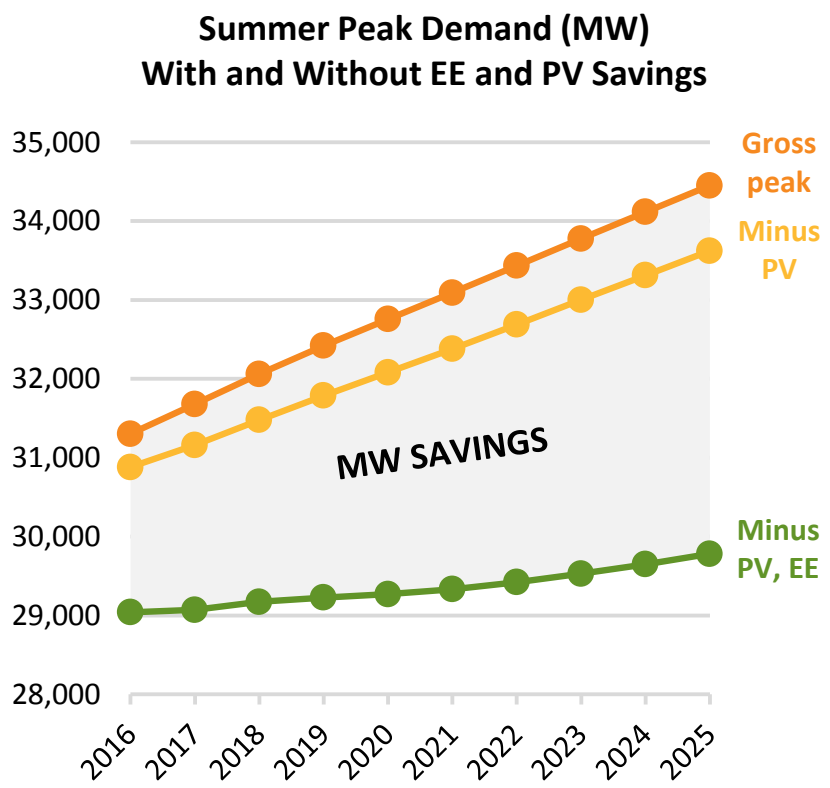


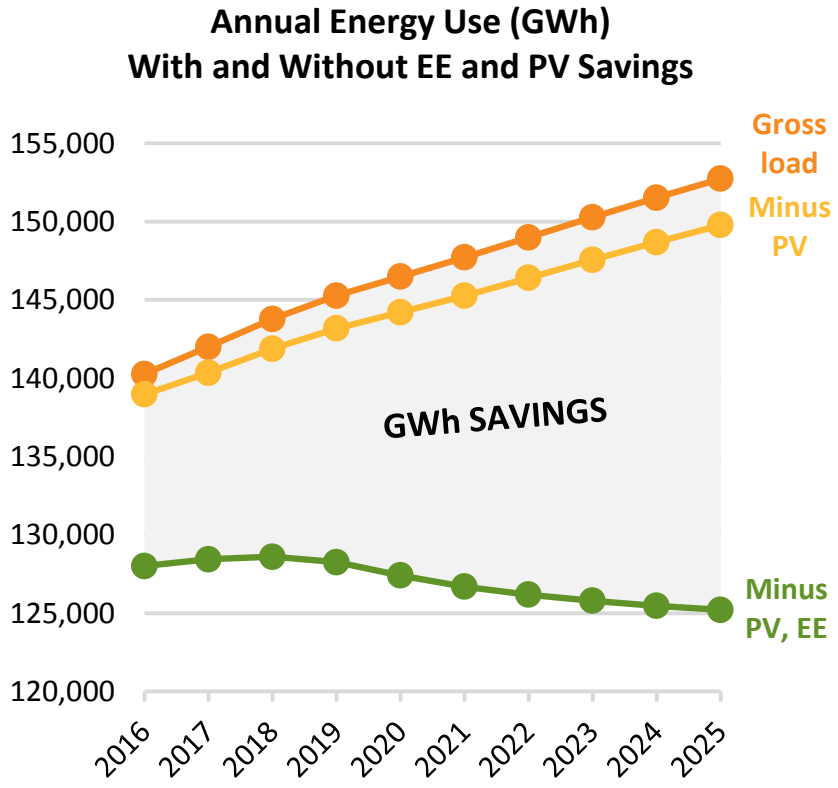
December 2016 Solar PV Installed Capacity (MW_{ac})

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**

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

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



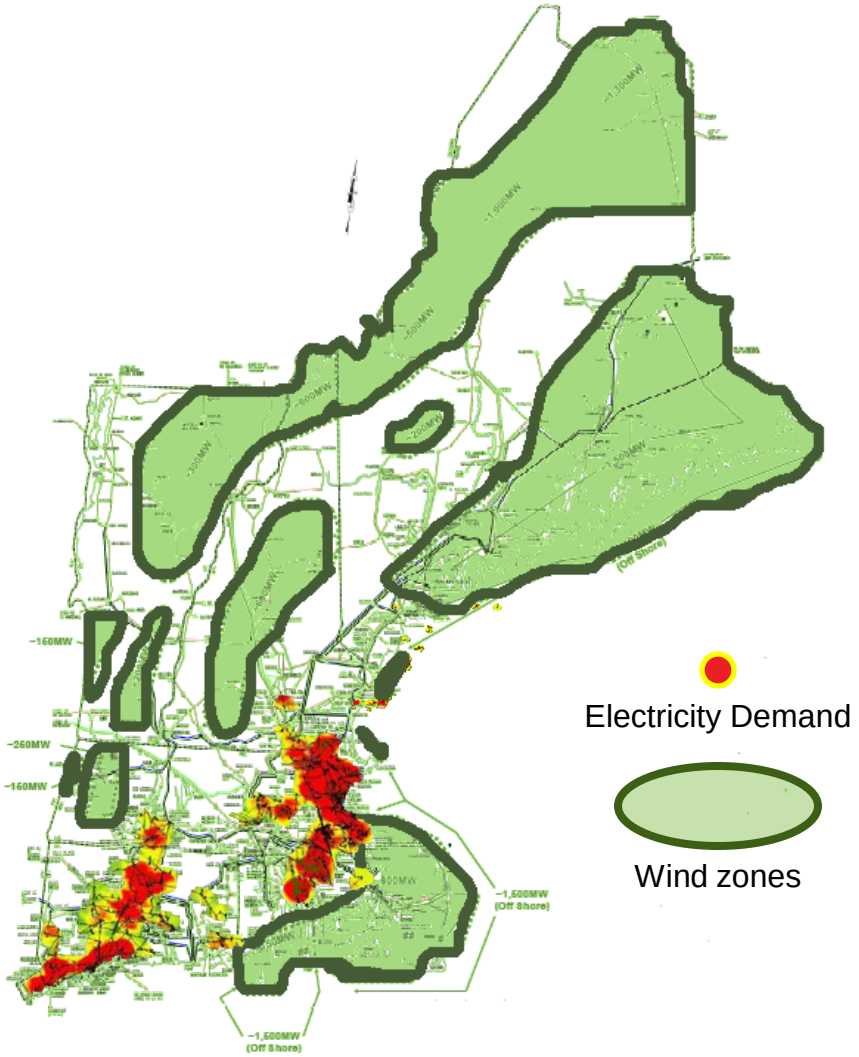


- The gross peak and load forecast
- The gross peak and load forecast minus forecasted "behind-the-meter" (BTM) solar PV resources
- The gross peak and load forecast minus forecasted BTM solar PV, minus energy-efficiency (EE) resources in the Forward Capacity Market 2016-2019 and forecasted EE 2020-2025

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)

New England Has Significant Wind Potential

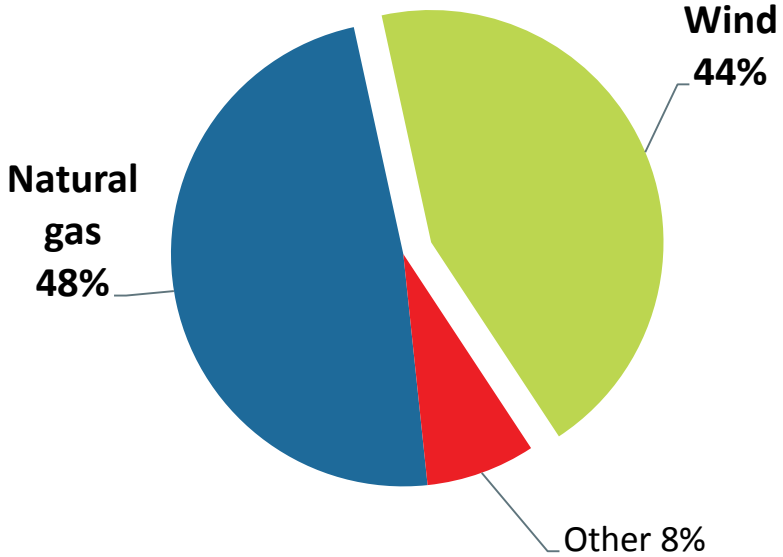
- Population and electric demand are concentrated along the coast in central and southern New England
- 12,000 MW of onshore and offshore wind potential
  - Preliminary screening eliminated wind sites near urban areas and sensitive geographic locations (e.g., Appalachian Trail)
- Transmission will be required to connect potential wind resources to load centers in New England



Infrastructure Will Be Needed to Deliver Energy from Proposed Resources

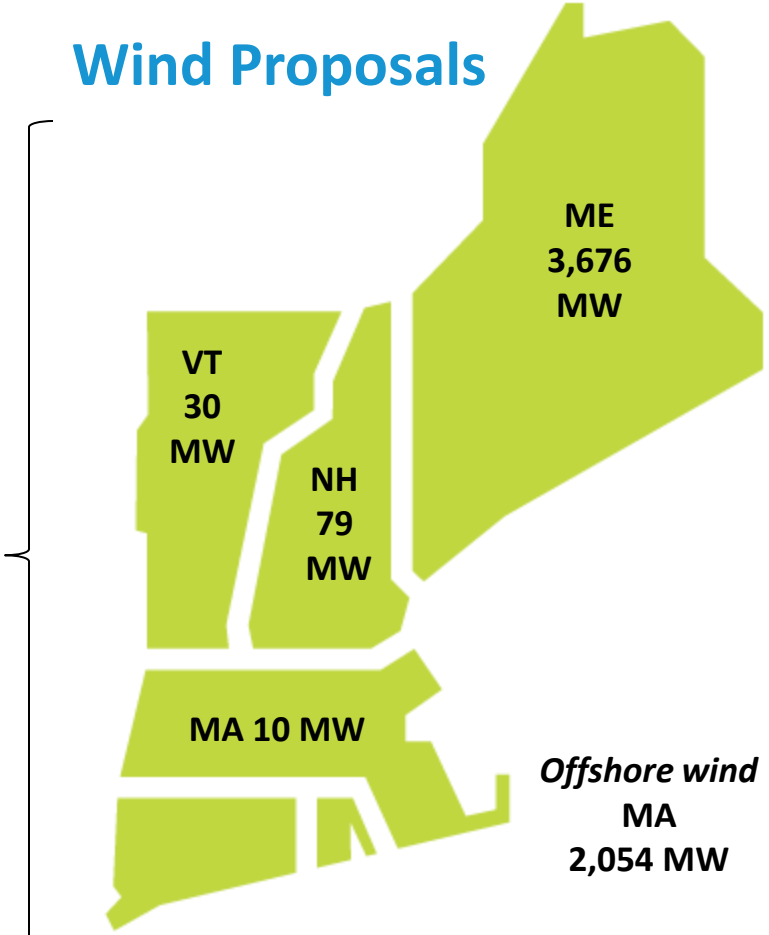
All Proposed Generation

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; Nameplate Capacity Ratings

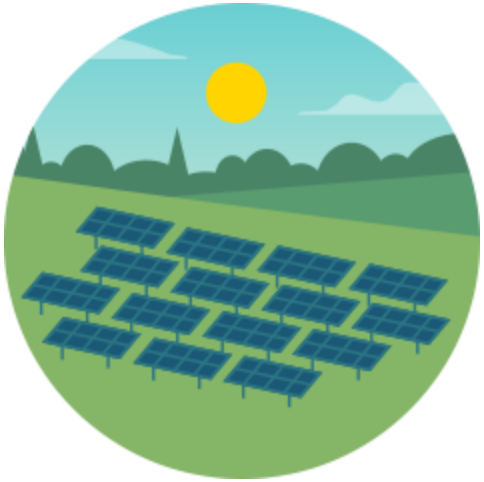
Wind Proposals



Source: ISO Generator Interconnection Queue (January 2017)
FERC Jurisdictional Proposals; Nameplate Capacity Ratings

Closing Thoughts…

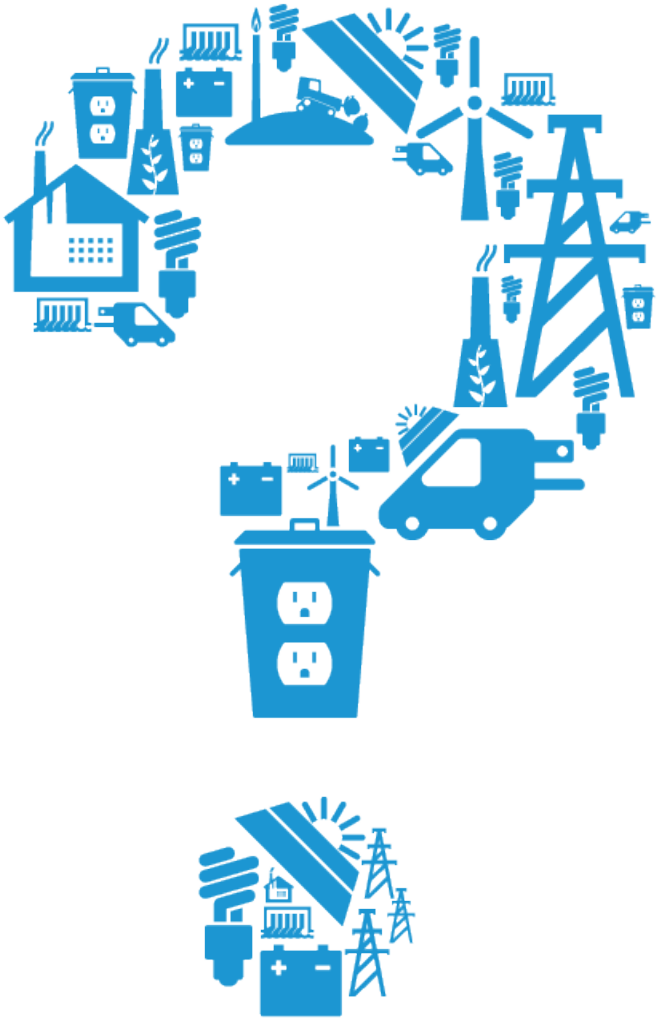
- New England's generation fleet is **changing rapidly** as older coal, oil and nuclear power plants retire
- Region's investments in energy efficiency and solar resources are having a **significant impact** on system planning and operations
- **Infrastructure needs** continue to be an area of focus for decision makers in New England



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



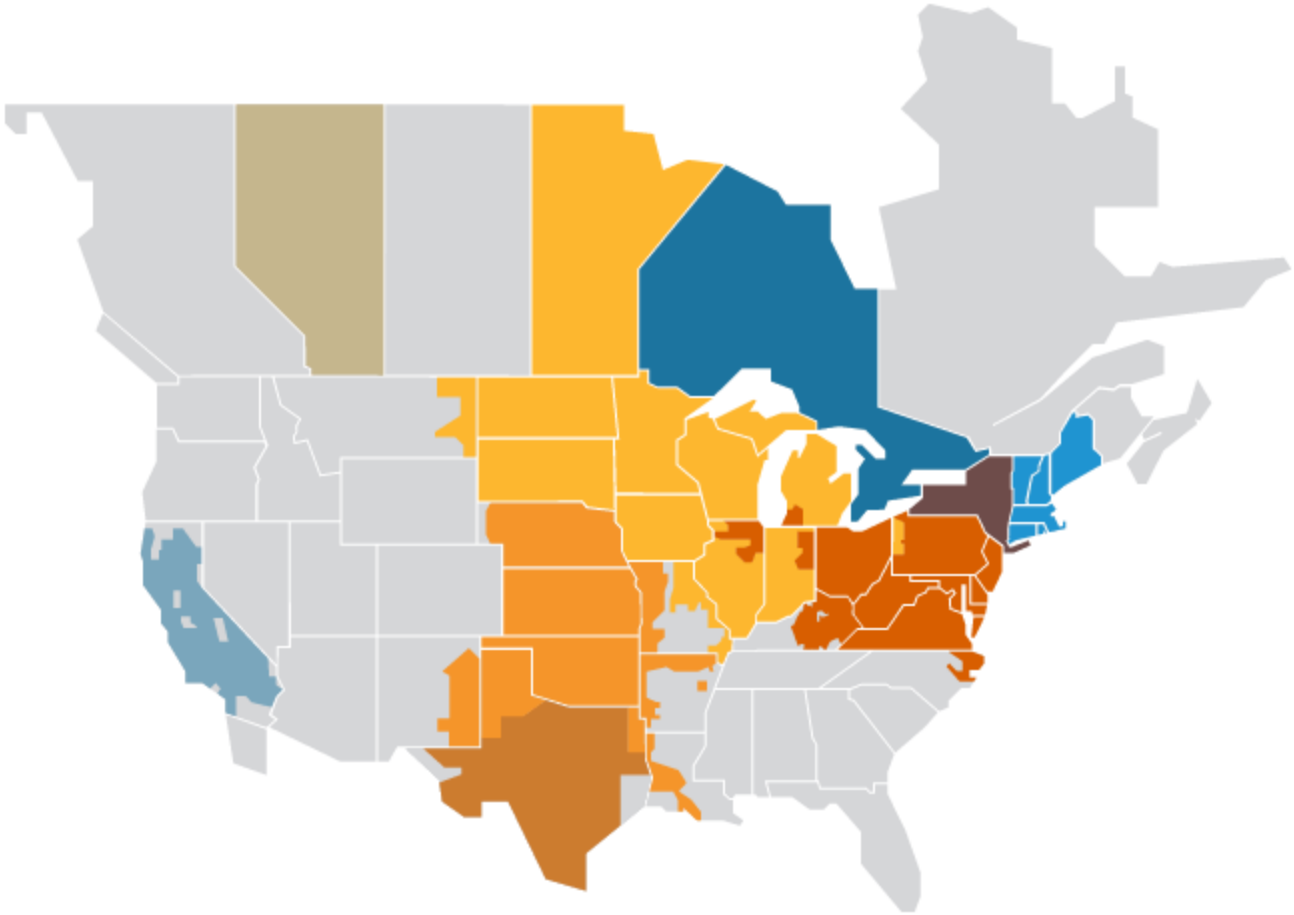
APPENDIX: BACKGROUND INFORMATION

There Are Nine ISOs and RTOs in North America

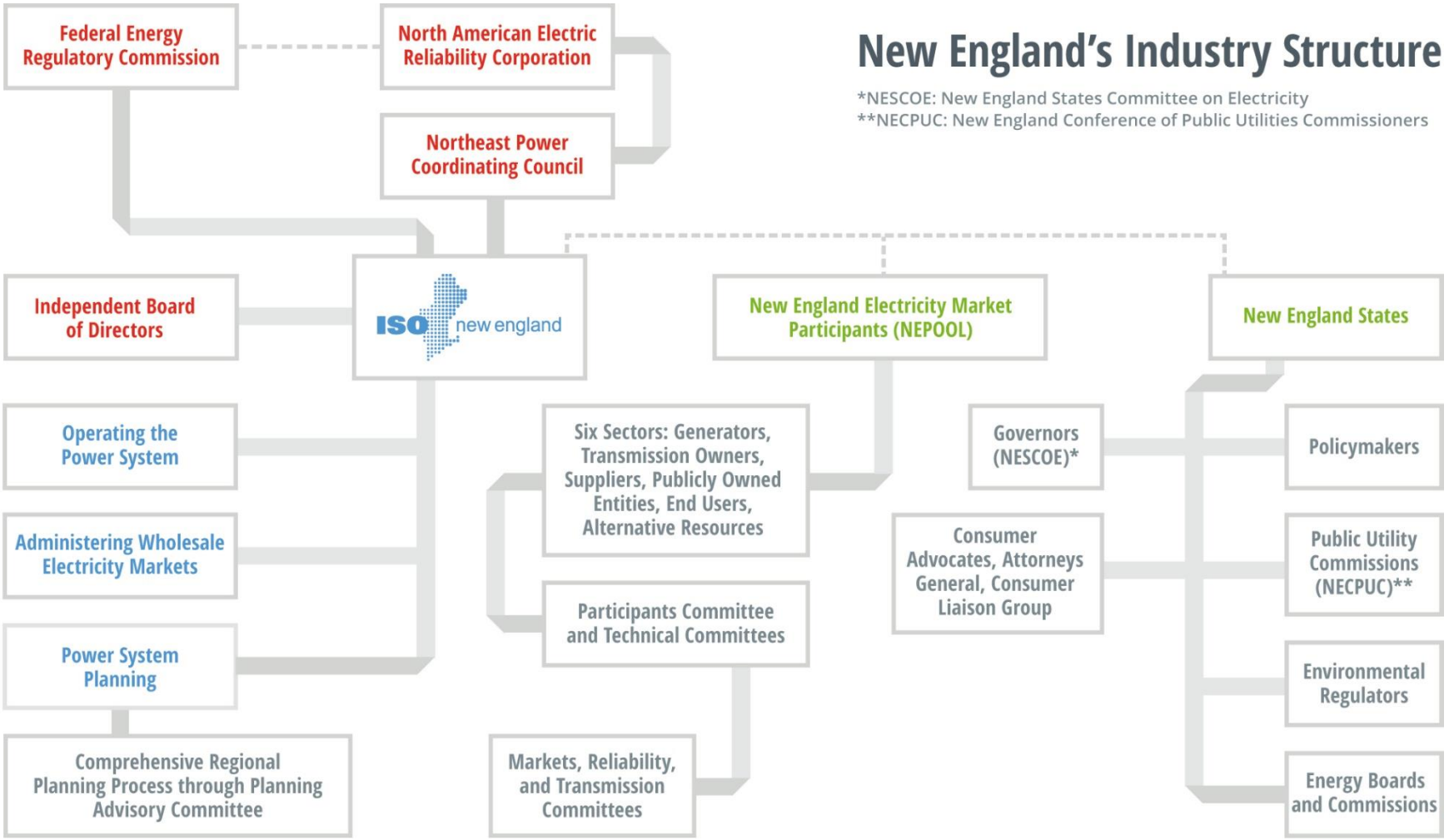
There Are Nine ISOs and RTOs in North America

ISO New England covers the six states of Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont.

- California ISO
- Alberta Electric System Operator
- Electricity Reliability Council of Texas
- Southwest Power Pool
- Midcontinent ISO
- Ontario Independent Electricity System Operator
- PJM Interconnection
- New York ISO
- ISO New England



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

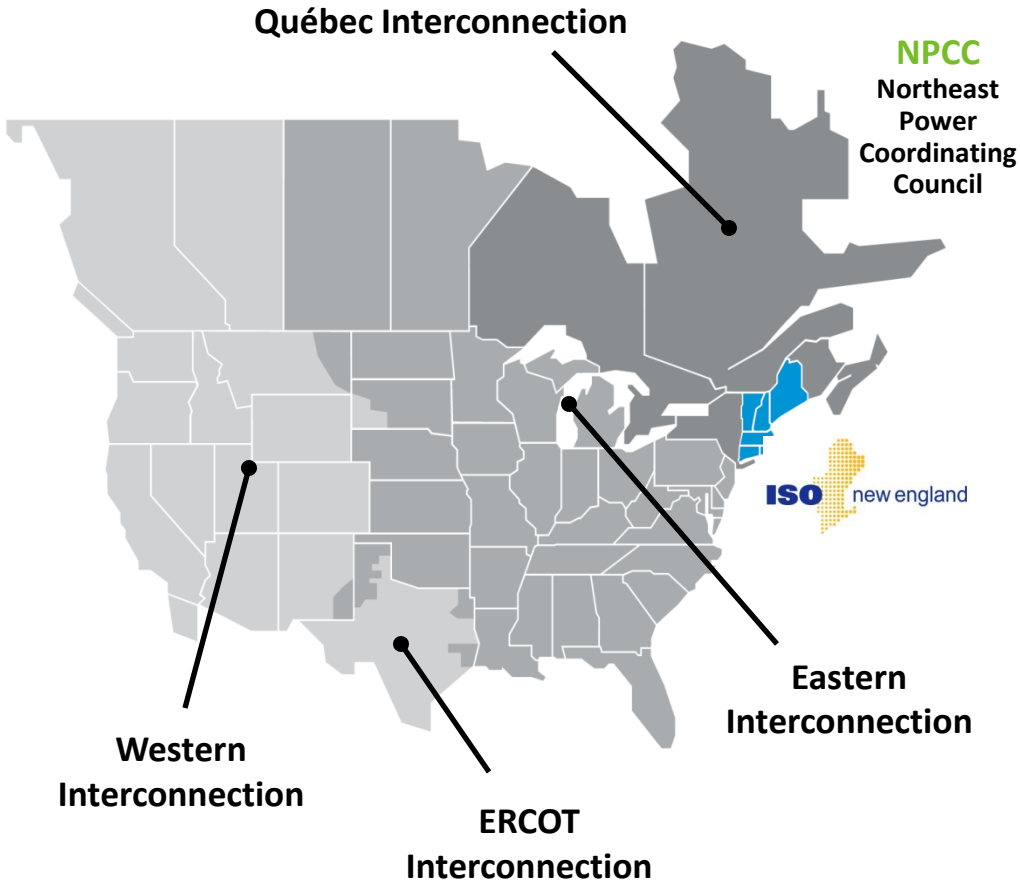


ISO New England Is Part of a Larger Electric Power System

- 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

NERC

North American Electric Reliability Corporation

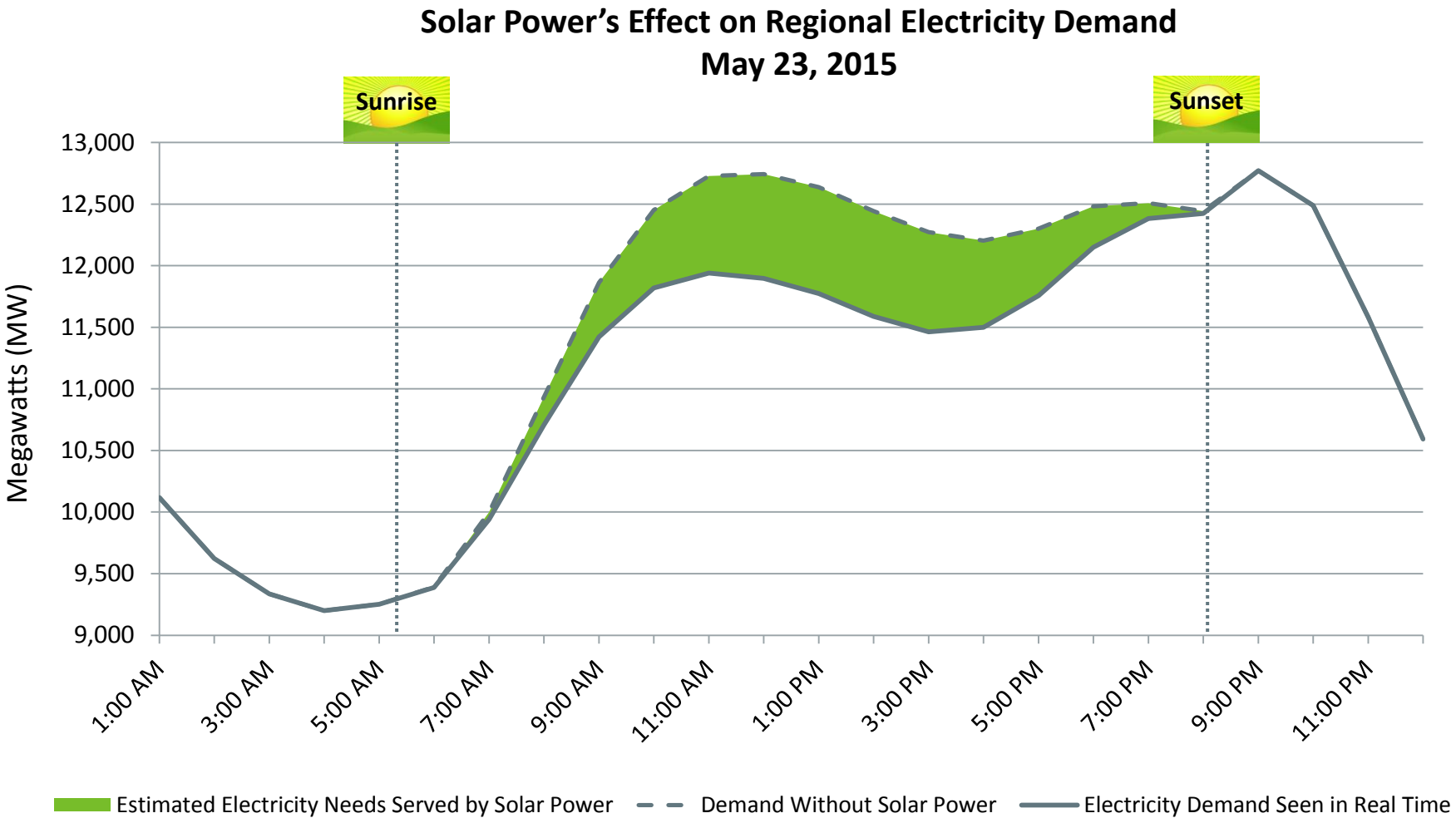


Overall Electricity Demand Is Flattening Due to Energy Efficiency and Behind-the-Meter Solar

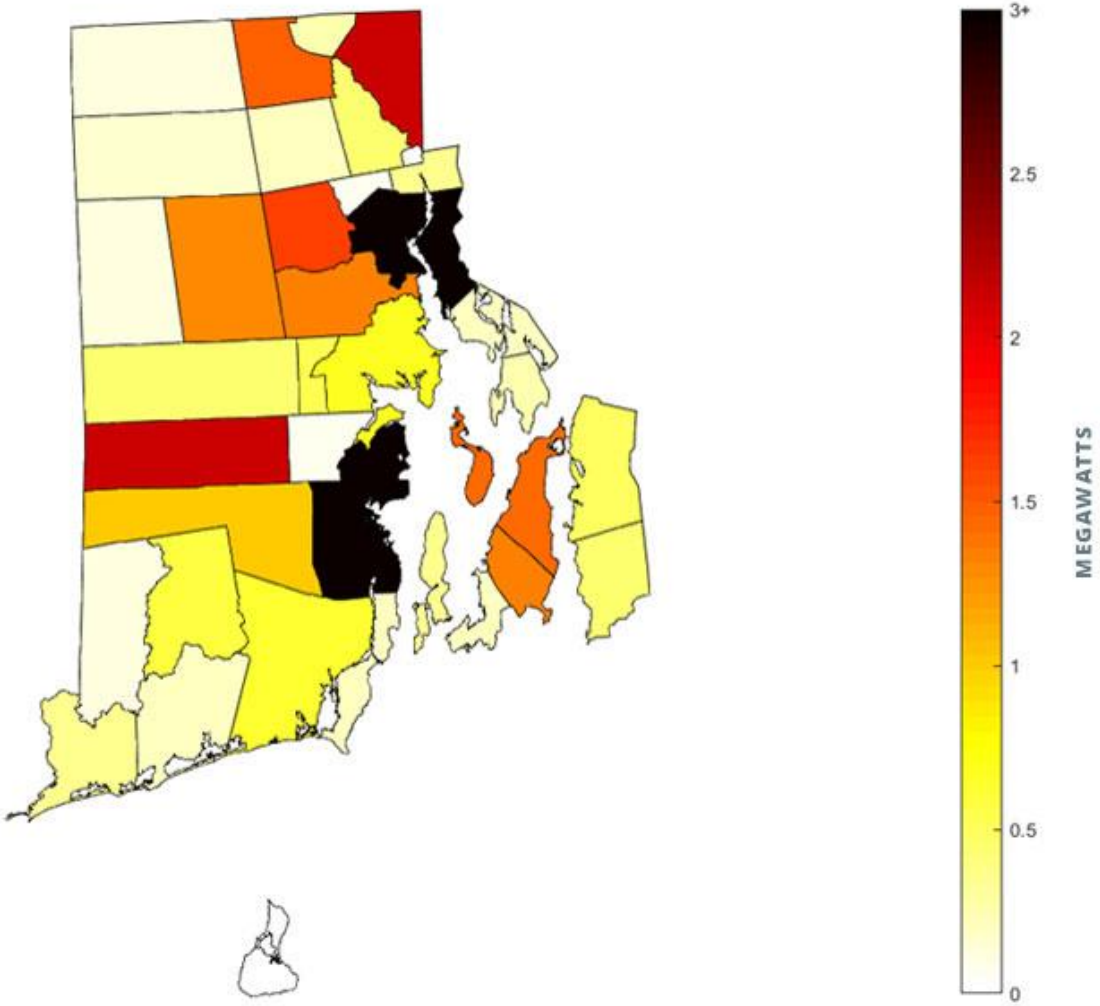
- **7.1 million** retail electricity customers drive the demand for electricity in New England (14.7 million population)
- Region's all-time summer peak demand set on August 2, 2006 at **28,130 MW**
- Region's all-time winter peak demand set on January 15, 2004 at **22,818 MW**
- Energy efficiency and 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.

Solar Power Has a Significant Impact on New England's Electricity Demand



Rhode Island Installed Solar PV “Heat Map”



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

Power Plant Emissions Have Declined with a Changing Fuel Mix

Reduction in Aggregate Emissions (kilotons/year)

Year	NO_x	SO_2	CO_2
2001	59.73	200.01	52,991
2014	20.49	11.68	39,317
2015	18.86	9.11	40,312
% Reduction 2001–2015	**⬇ 68%**	**⬇ 95%**	**⬇ 24%**
% Change 2014–2015	**⬇ 8%**	**⬇ 22%**	**⬆ 2.5%**

CO_2 emissions rose in 2015 after Vermont Yankee Nuclear Power Station retired in December 2014

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

Forward Capacity Market Overview

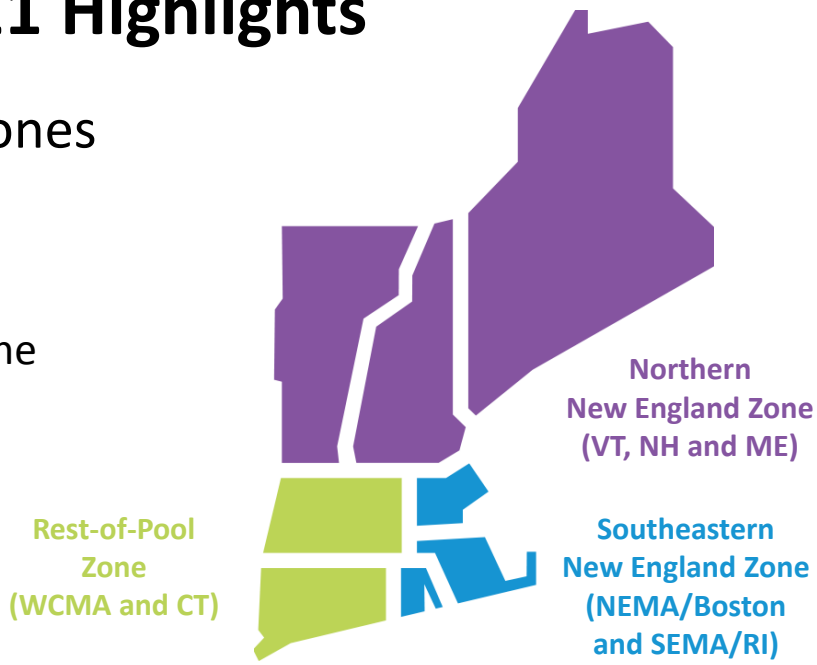
- Procures resources to meet New England's forecasted capacity needs three years in the future
- Allows **new capacity projects** to compete in the market and set the price for capacity in the region
- Selects a portfolio of **supply** and **demand** resources through a competitive Forward Capacity Auction (FCA) process
  - Resources must be pre-qualified to participate in the auction
  - Resources must participate and clear in the auction to be paid for capacity during the capacity commitment period
- Provides a long-term (up to 7-year) commitment to new supply and demand resources to encourage **investment**

Last Month, ISO New England Conducted the Eleventh Forward Capacity Auction (FCA #11)

- FCA #11 was held on February 6, 2017 to procure the capacity resources needed to meet electricity demand in New England during the **2020-2021 Capacity Commitment Period**
- The auction concluded systemwide after six rounds of competitive bidding, with a clearing price of **$5.30/kW-month**, lower than the $7.03/kW-month clearing price in the previous auction (FCA #10)
  - The $5.30/kW-month clearing price will be paid to new and existing resources in all three capacity zones, with the exception of imports from New Brunswick
- At $5.30/kW-month, the total value of the capacity market in 2020-2021 will be approximately **$2.4 billion**
  - Down from the estimated $3 billion for the 2019-2020 capacity commitment period (FCA #10)

Forward Capacity Auction #11 Highlights

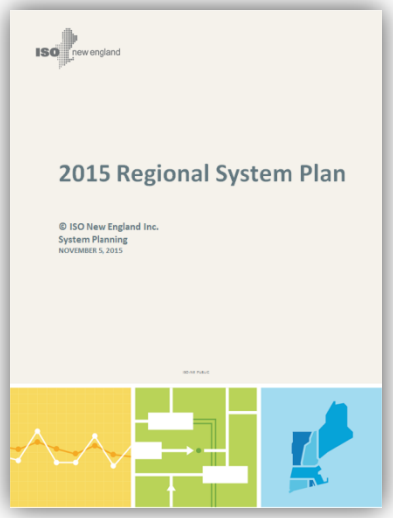
- The ISO modeled **three** capacity zones in the auction
  - Northern New England Capacity Zone
  - Southeastern New England Capacity Zone
  - Rest-of-Pool Capacity Zone
- The auction concluded with commitments from **35,835 MW** to be available in 2020-2021



- The net installed capacity target to be procured in the auction was **34,075 MW**
- No new large generators cleared in the auction, but **640 MW** of new energy-efficiency and demand-reduction measures—the equivalent of a large power plant—cleared and will be available in the 2020-2021 timeframe

Overview of Transmission Planning

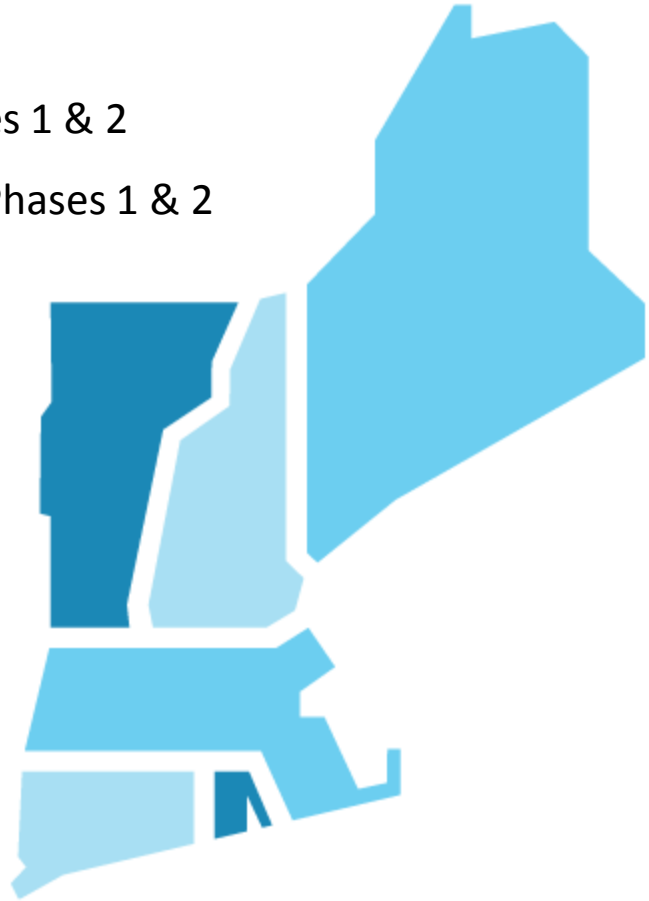
- As the **Regional Transmission Organization**, the ISO is required to identify transmission infrastructure solutions that are essential for maintaining power system reliability in New England
- Through an **open stakeholder process**, the ISO is responsible for the development of long-range plans to address future system needs over the ten-year planning horizon
  - Summarized in a **Regional System Plan (RSP)**
- The transmission planning process is governed by a **FERC-approved tariff**
- The transmission planning process has been revised to comply with the Federal Energy Regulatory Commission's (FERC) **Order 1000**



Transmission Projects to Maintain Reliability Have Progressed throughout New England

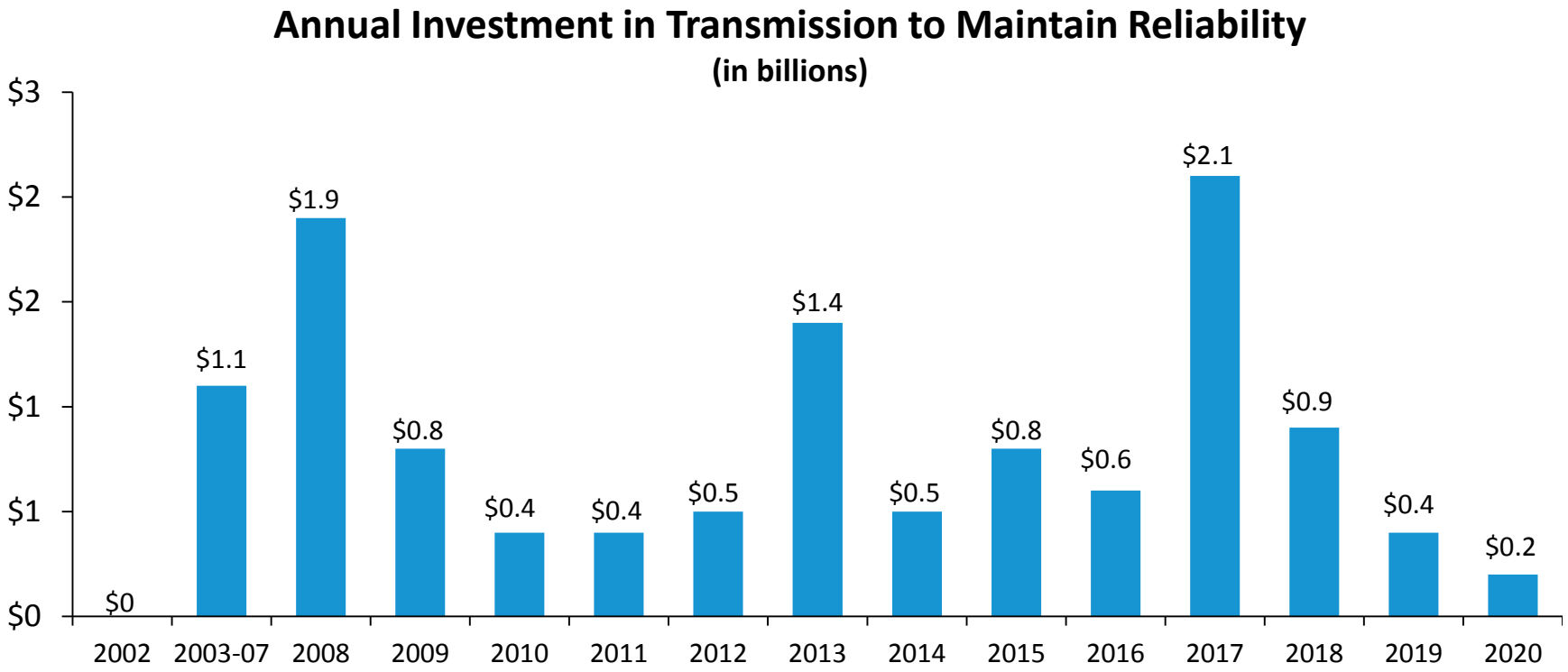
Major 345 kV Projects

- Southwest Connecticut Reliability Project, Phases 1 & 2
- Boston 345 kV Transmission Reliability Project, Phases 1 & 2
- Northwest Vermont Reliability Project, and Vermont Southern Loop Project
- New England East-West Solution
  - Greater Springfield Reliability Project
  - Rhode Island Reliability Project
  - Interstate Reliability Project
- Southeast Massachusetts
  - Short-term Lower SEMA Upgrades
  - Long-term Lower SEMA Project
- Maine Power Reliability Program
- Greater Boston Project



Source: RSP Transmission Project List, October 2016; RSP Transmission Project List also includes 115kV projects

Region Has Made Major Investments in Transmission Infrastructure to Ensure a Reliable Electric Grid

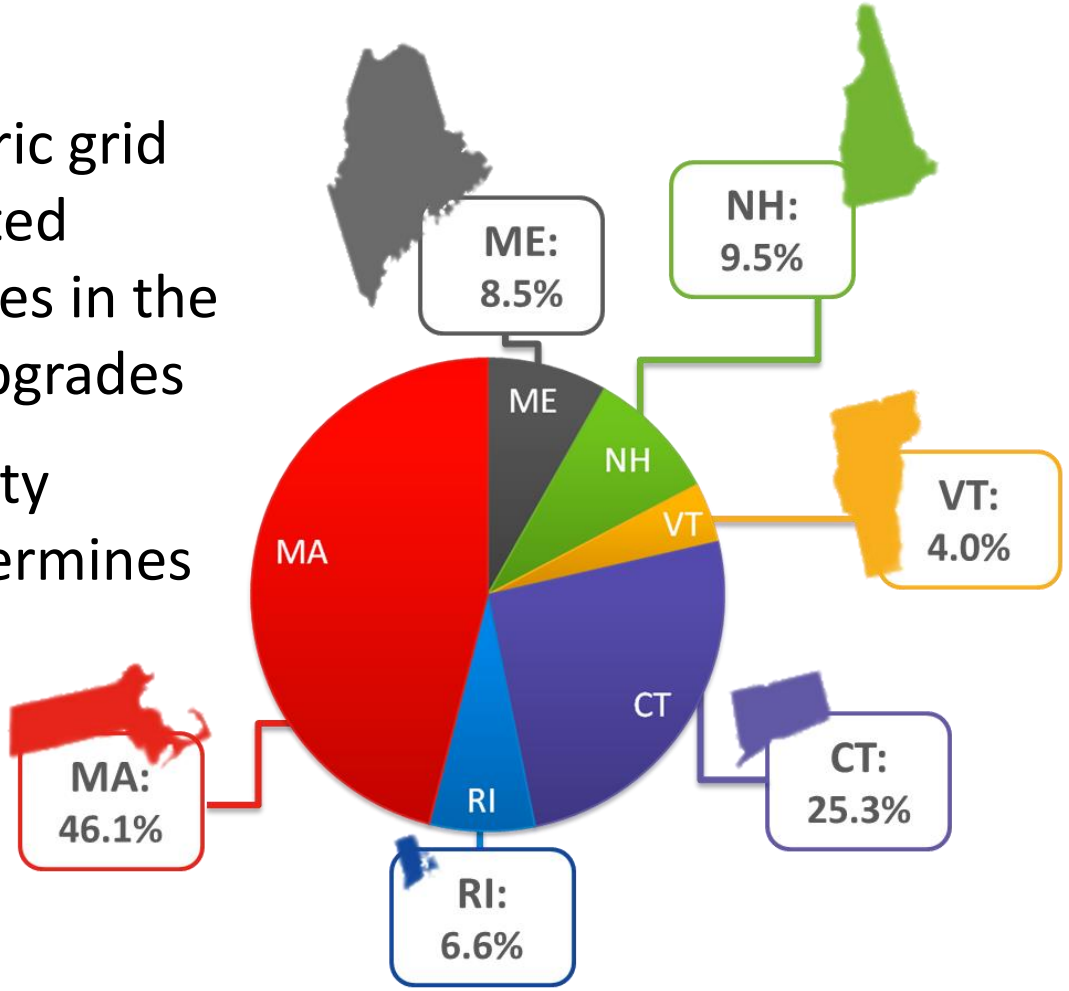


Cumulative Investment through October 2016	$8.02 billion
Estimated Future Investment through 2020	$4.07 billion

Source: ISO New England RSP Transmission Project Listing, October 2016
Estimated future investment includes projects under construction, planned and proposed

How Are Transmission Costs Allocated?

- The New England electric grid is a tightly interconnected system; each state shares in the benefits of reliability upgrades
- The amount of electricity demand in an area determines its share of the cost of new or upgraded transmission facilities needed for reliability

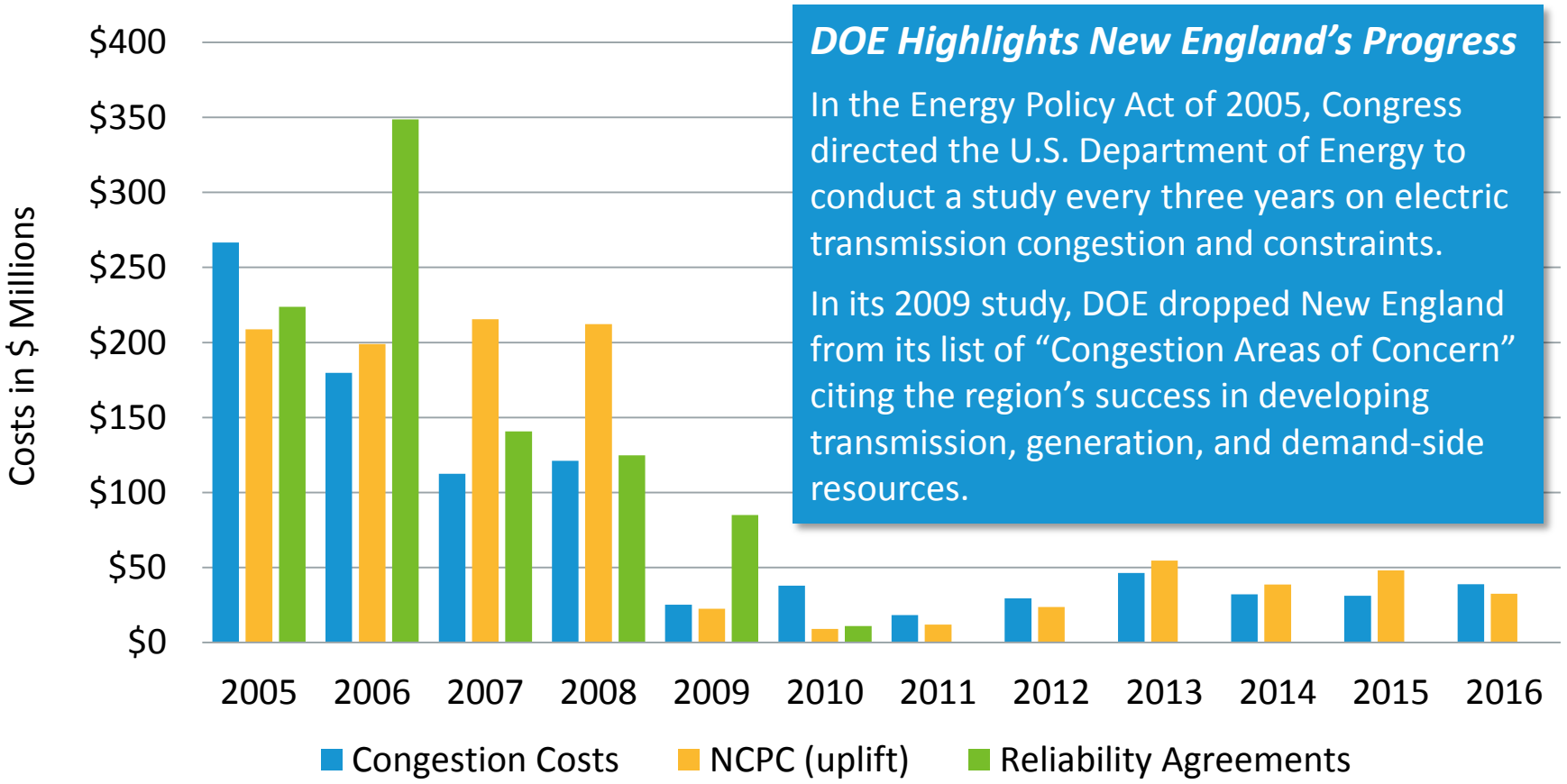


Source: 2015 Network Load by State

Transmission Provides Benefits Beyond Reliability

- **Transmission has reduced or eliminated out-of-market costs:**
  - Reliability agreements with certain generators that were needed to provide transmission support in weak areas of the electric grid
    - These often were older, less-efficient generating resources
  - Uplift charges to run specific generators to meet local reliability needs
- **The markets are increasingly competitive:** Easing transmission constraints into import-constrained areas has enabled the ISO to dispatch the most economic resources throughout the region to meet customer demands for electricity
- **Transmission congestion has been nearly eliminated**
- **Transmission facilitates resource transformation:** Transmission upgrades have allowed older, less-efficient resources to retire, which helps the states achieve their environmental objectives

Transmission and Resource Developments Have Reduced Energy and Reliability Costs



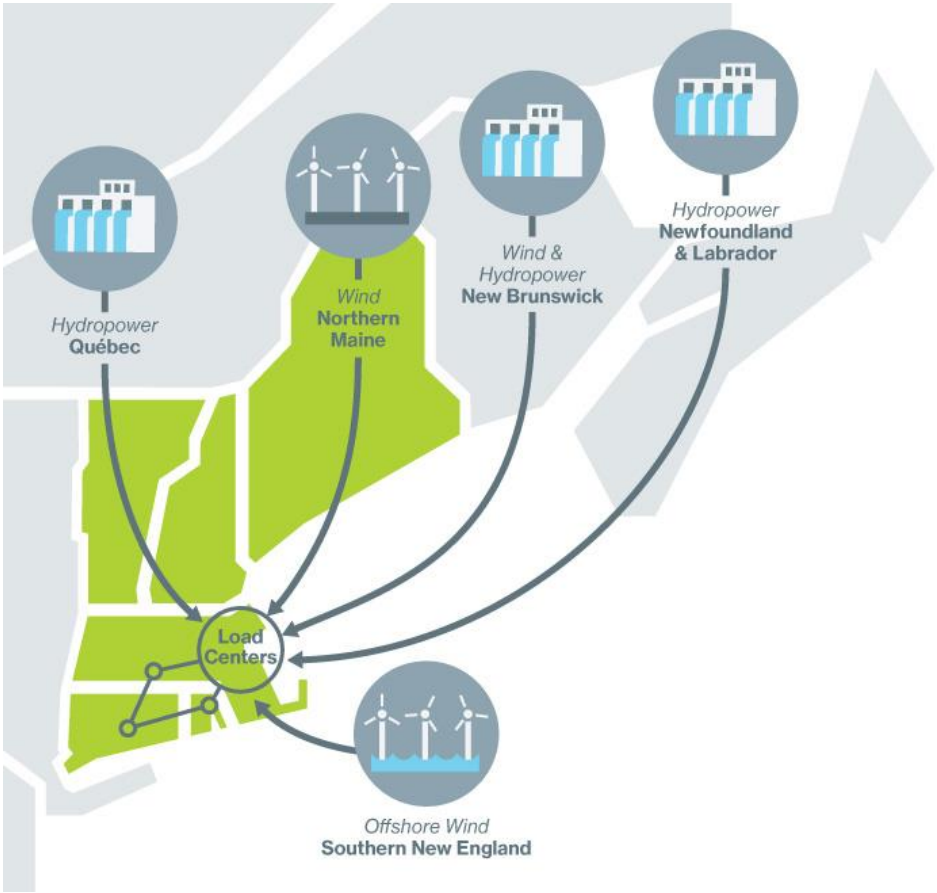
DOE Highlights New England's Progress

In the Energy Policy Act of 2005, Congress directed the U.S. Department of Energy to conduct a study every three years on electric transmission congestion and constraints.

In its 2009 study, DOE dropped New England from its list of "Congestion Areas of Concern" citing the region's success in developing transmission, generation, and demand-side resources.

Note: Congestion is a condition that arises on the transmission system when one or more restrictions prevents the economic dispatch of electric energy from serving load. Net Commitment-Period Compensation is a payment to an eligible resource that operated out of merit and did not fully recover its costs in the energy market. Reliability Agreements are special reliability contracts between the ISO and an approved generator whereby the generator continues to operate, even when it is not economical to do so, to ensure transmission system reliability. Sources: Regional System Plans, ISO-NE Annual Markets Reports

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



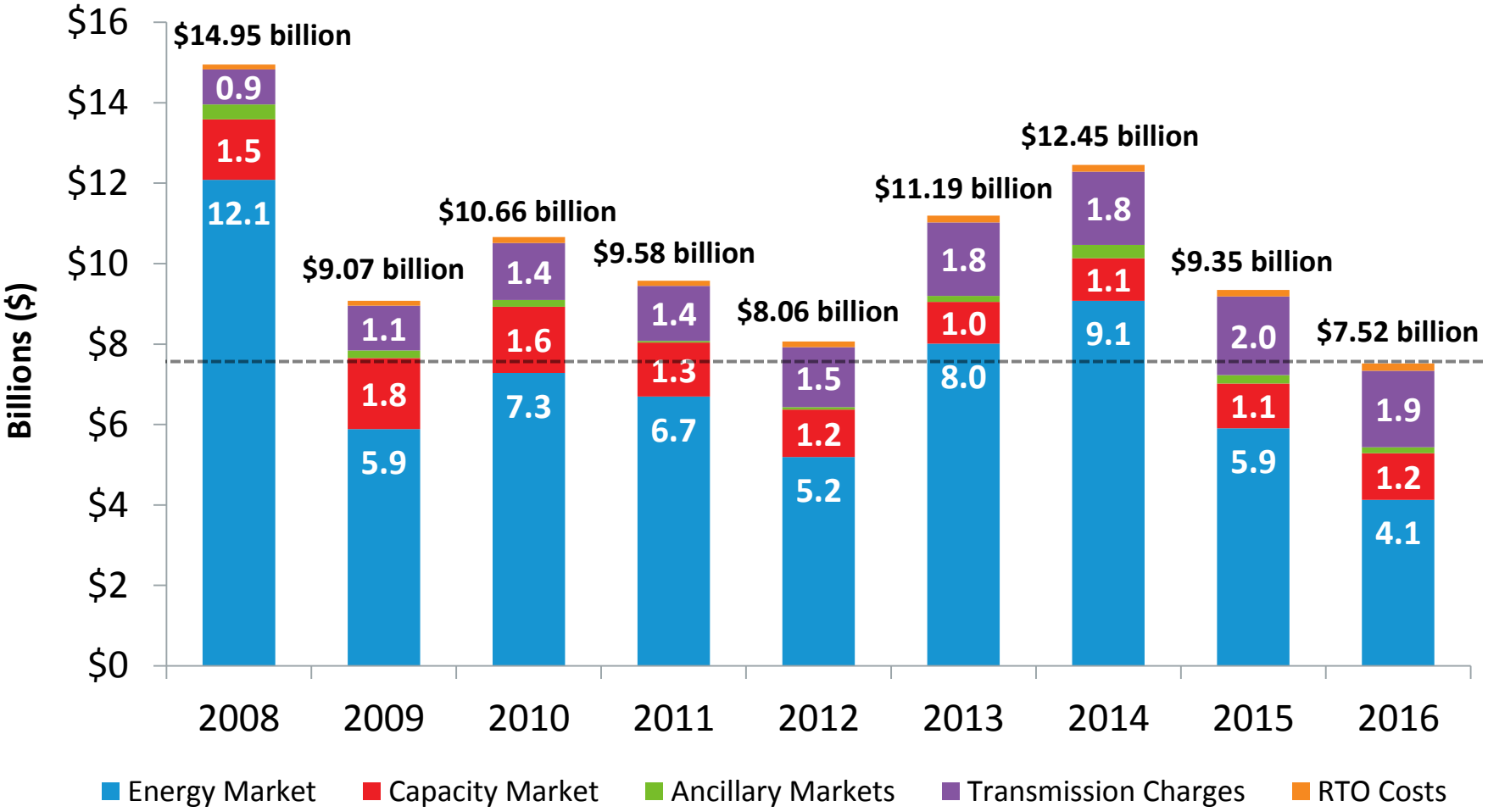
Map is representative of the types of projects announced for the region in recent years

- 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 Wholesale Electricity Costs

Annual wholesale electricity costs have ranged from $7.5 billion to $15 billion



Source: *2016 Report of the Consumer Liaison Group*; 2016 wholesale electricity costs are preliminary and subject to reconciliation

New England Wholesale Electricity Costs[a]

	2012		2013		2014		2015		2016[b]	
	$ Mil.	¢/kWh	$ Mil.	¢/kWh	$ Mil.	¢/kWh	$ Mil.	¢/kWh	$ Mil.	¢/kWh
Wholesale Market Costs										
Energy (LMPs)[c]	$5,193	3.9	$8,009	6.0	$9,079	6.9	$5,910	4.5	$4,127	3.2
Ancillaries[d]	$56	0.0	$152	0.1	$331	0.3	$210	0.2	$146	0.1
Capacity[e]	$1,182	0.9	$1,039	0.8	$1,056	0.8	$1,110	0.8	$1,161	0.9
Subtotal	*$6,431*	*4.8*	*$9,200*	*6.9*	*$10,466*	*8.0*	*$7,229*	*5.5*	*$5,433*	*4.2*
Transmission Charges[f]	$1,494	1.1	$1,823	1.4	$1,822	1.4	$1,954	1.5	$1,902	1.5
RTO Costs[g]	$139	0.1	$167	0.1	$165	0.1	$165	0.1	$180	0.1
Total	**$8,064**	**6.0**	**$11,190**	**8.4**	**$12,453**	**9.5**	**$9,348**	**7.1**	**$7,515**	**5.8**

(a) Average annual costs are based on the 12 months beginning January 1 and ending December 31. Costs in millions = the dollar value of the costs to New England wholesale market load servers for ISO-administered services. Cents/kWh = the value derived by dividing the dollar value (indicated above) by the real-time load obligation. These values are presented for illustrative purposes only and do not reflect actual charge methodologies.

(b) **The wholesale values for 2016 are preliminary and subject to reconciliation.**

(c) Energy values are derived from wholesale market pricing, and represent the results of the Day-Ahead Energy Market plus deviations from the Day-Ahead Energy Market reflected in the Real-Time Energy Market.

(d) Ancillaries include first- and second-contingency Net Commitment-Period Compensation (NCPC), forward reserves, real-time reserves, regulation service, and a reduction for the Marginal Loss Revenue Fund.

(e) Capacity charges are those associated with the transitional Installed Capacity (ICAP) Market through May 2010 and the Forward Capacity Market (FCM) from June 2010 forward.

(f) Transmission charges reflect the collection of transmission owners' revenue requirements and tariff-based reliability services, including black-start capability and voltage support. FCM reliability totals are not included in this value. In 2016, the cost of payments made to these generators for reliability services under the ISO's tariff was $37.5 million.

(g) RTO costs are the costs to run and operate ISO New England and are based on actual collections, as determined under Section IV of the *ISO New England Inc. Transmission, Markets, and Services Tariff*.