



State of the Grid: 2017

ISO on Background

Gordon van Welie

PRESIDENT & CEO, ISO NEW ENGLAND INC.



About the *ISO on Background Series*

- Informal opportunity for media to learn more about trends affecting New England's electricity industry
- Hosted by ISO New England senior management
- **Content is on the record**
- Please hold questions until the Q&A session at the end of the presentation
- Presentation and remarks will be posted at www.iso-ne.com>About Us>News and Media>Press Releases



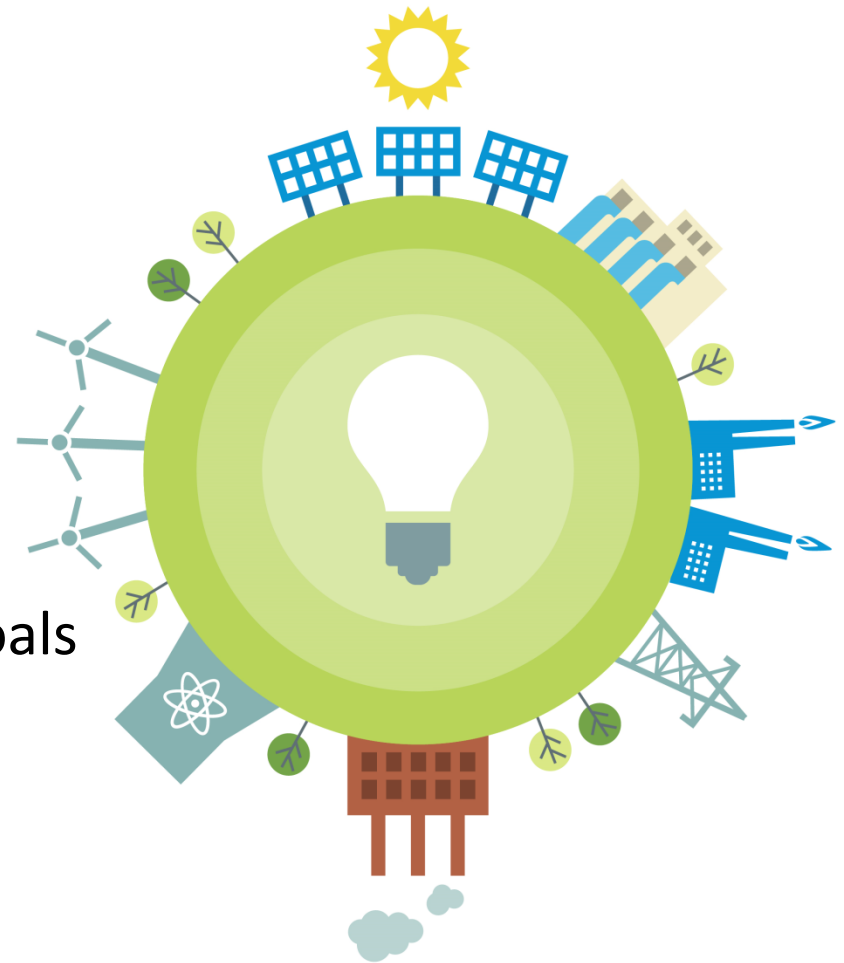
Agenda

- 11 to 11:10 a.m. **Welcome**
Ellen Foley, director, Corporate Communications
- 11:10 to 11:45 p.m. **State of the Grid: 2016**
Gordon van Welie, president and CEO
- 11:45 to 12:15 p.m. **Question-and-Answer Session**



Overview of Presentation

- State of the Grid
 - New England’s Power System Today
 - Winter
 - The Future Grid
 - Harmonizing Competitive Markets and Clean Energy Goals
 - Conclusions
- Q & A
- Appendix

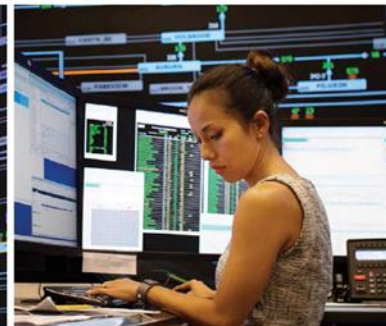


STATE OF THE GRID: NEW ENGLAND'S POWER SYSTEM TODAY



State of the Grid 2017: Key Takeaways

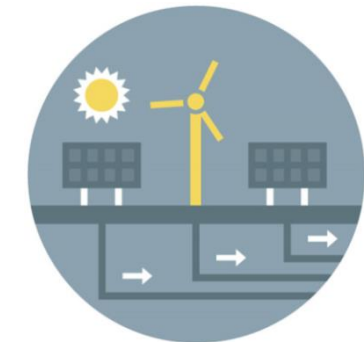
- **What's working:**
 - **Markets and planning:** 20 years of competitive markets & transmission planning have significantly enhanced reliability
 - **Resource adequacy:** New England has the resource base & transmission system needed to meet consumer demand for power
 - **Transformation of the grid:** System is evolving to a cleaner, hybrid grid



State of the Grid 2017: Key Takeaways *(continued)*

- **What's challenging:**

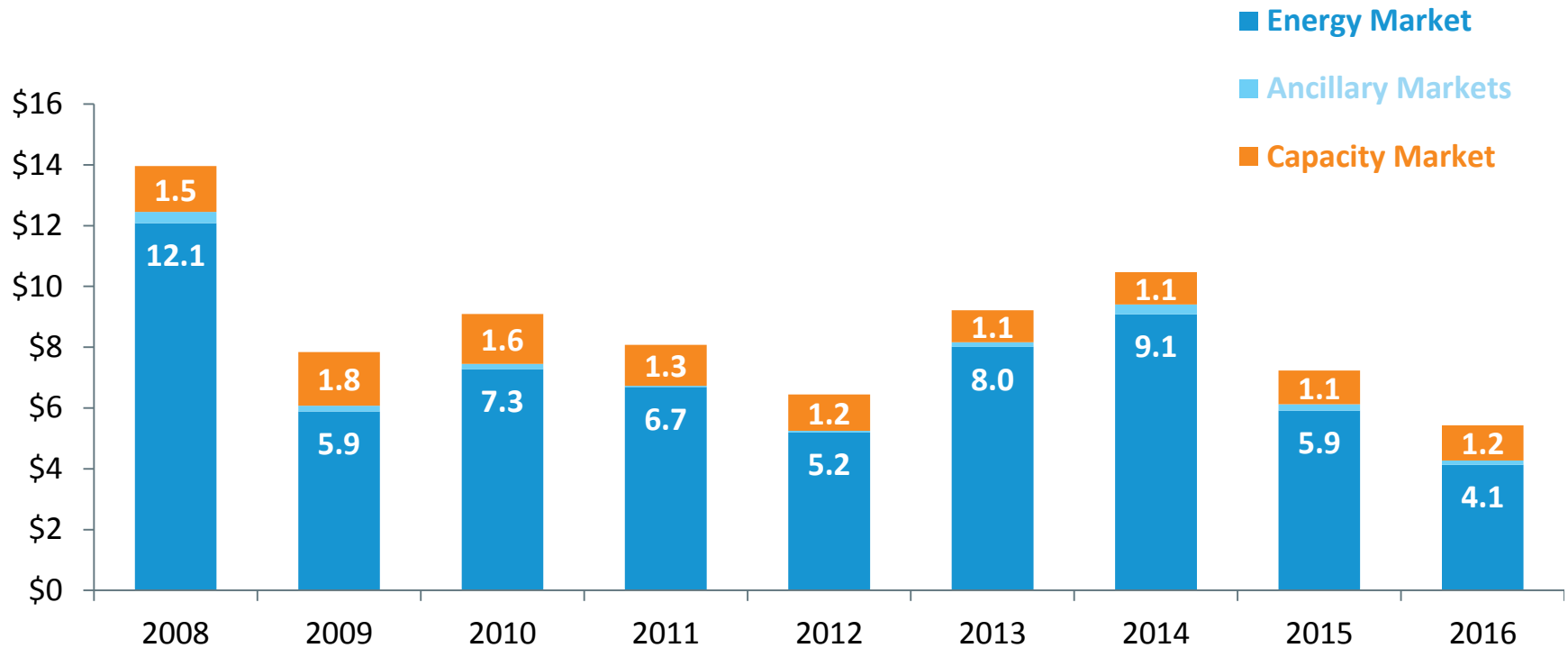
- **Fuel security:** Ensuring sufficient fuel to generate electricity needed for peak demand
 - Limited fuel infrastructure: pipeline constraints & limited liquefied natural gas storage
 - Emissions restrictions: increasingly difficult to obtain permits for dual-fuel generators that can use oil when they can't get natural gas
- **Retirements:** Nuclear, oil- and coal-fired generators retiring; they are being replaced by natural-gas-fired power plants
- **Renewable integration:** More transmission required to connect Canadian hydro & wind in northern New England to population centers
- **Incorporating clean energy goals:** Competitive markets are working, but are vulnerable



2016: The Lowest Wholesale Prices Since 2003

Competitive markets produce low prices when fuel infrastructure is unconstrained, and transmission investments provide access to the lowest-cost resources

**Annual Value of Wholesale Electricity Markets
(in billions)**



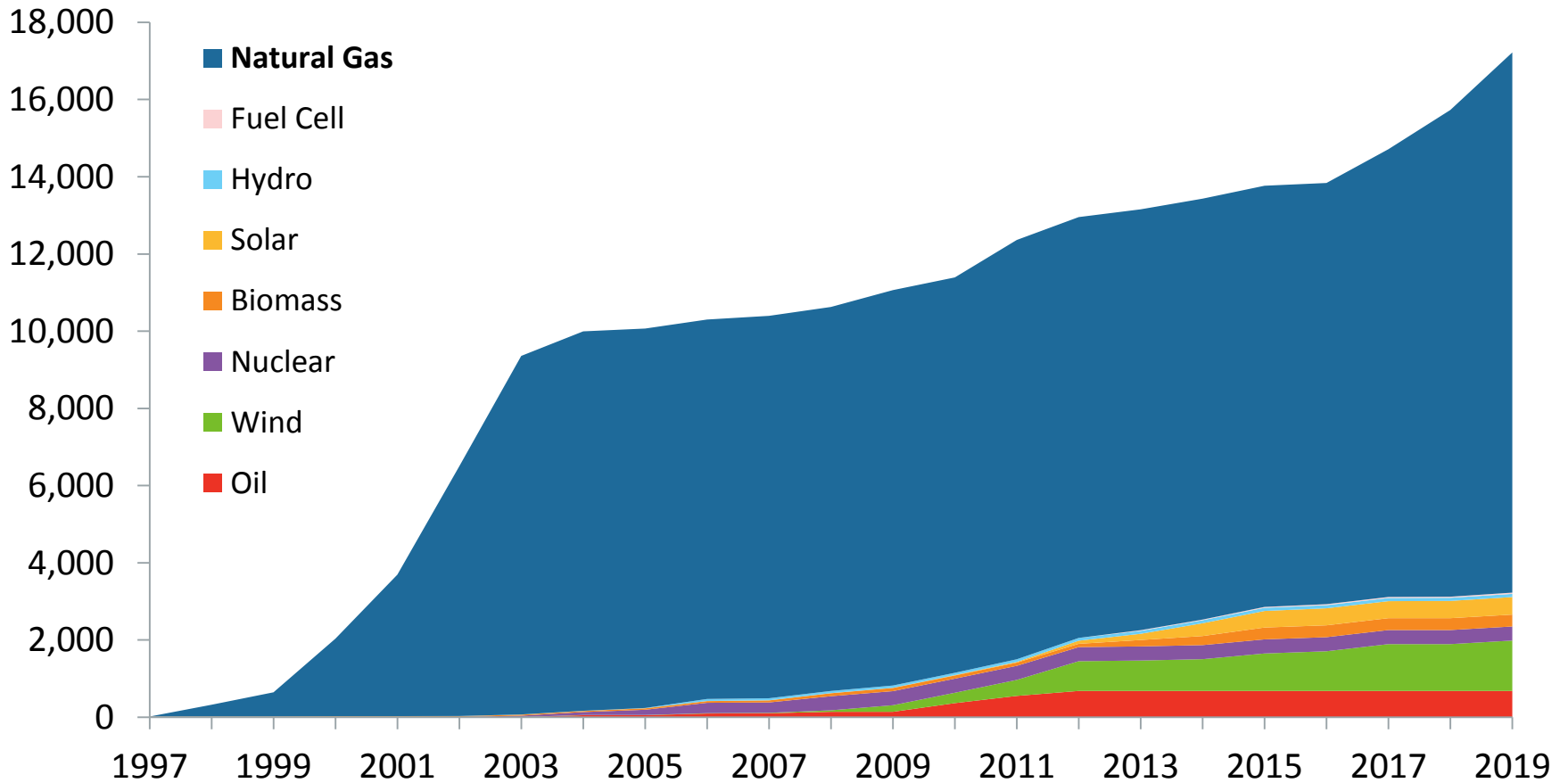
Source: [2015 Report of the Consumer Liaison Group](#); 2016 wholesale electricity market values are preliminary and subject to reconciliation



Billions Invested in Power Plants Since 1999

Natural gas is the dominant fuel source for new generating capacity

Cumulative New Generating Capacity in New England (MW)

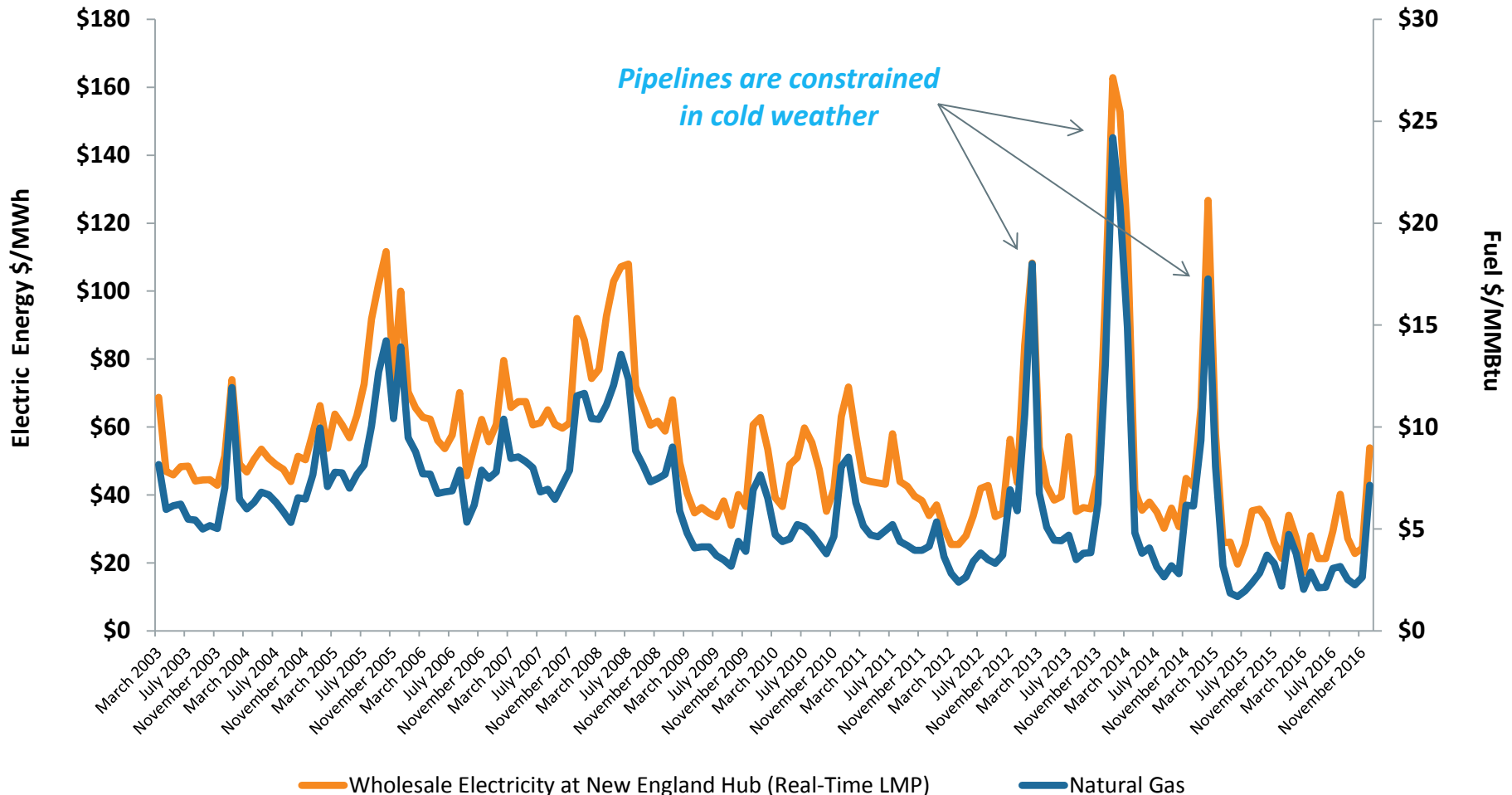


Note: New generating capacity for years 2016 – 2019 includes resources clearing in recent Forward Capacity Auctions.

Natural Gas and Wholesale Electricity Prices Are Linked

A large portion of the region's fleet uses low-priced natural gas; competitive markets use the lowest-priced resources to meet demand

Monthly Average Natural Gas and Wholesale Electricity Prices in New England



— Wholesale Electricity at New England Hub (Real-Time LMP)

— Natural Gas

Transmission Investments Provide Benefits

Upgrades for reliability: \$8 billion 2002-2016; \$4.1 billion estimated through 2020

- Reliability benefits:
 - Strengthens weak areas
 - Removes bottlenecks; power can flow where needed, when needed
 - Lowers risk of dangerous, costly blackouts
- Economic benefits:
 - Enhances competition among resources: lower-cost power plants can compete across region
 - Lowers congestion costs
 - Lowers special payments to generators that wouldn't otherwise be used
 - Enables retirement of older, less efficient power plants
- Environmental benefits:
 - Emissions with greater use of more efficient power plants
 - Builds the transmission backbone required to move to the next stage in the evolution toward a hybrid grid

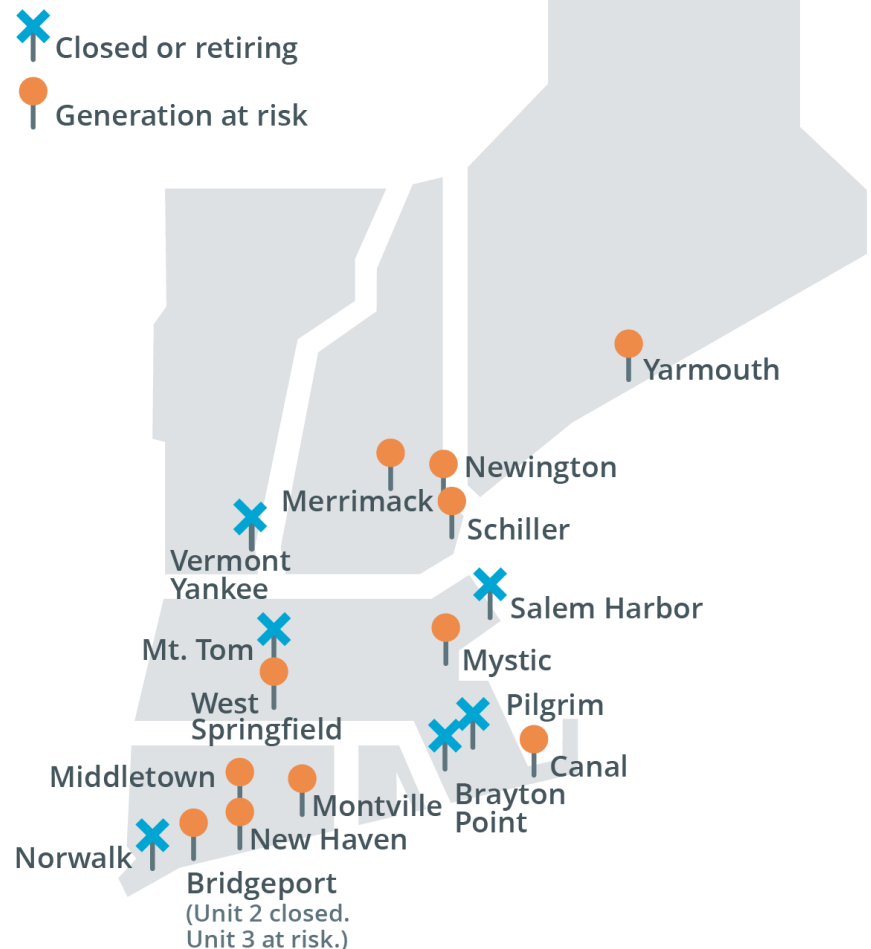


The Region Has Lost—and Is at Risk of Losing—Substantial Non-Gas Resources

4,200 MW retired since 2013; 6,000 MW at risk

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)



Power Plant Emissions Have Declined with a Changing Fuel Mix and Transmission Upgrades

CO₂ emissions rose in 2015 after Vermont Yankee's retirement in December 2014

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%

Source: [2015 ISO New England Electric Generator Air Emissions Report](#), January 2017

STATE OF THE GRID: WINTER



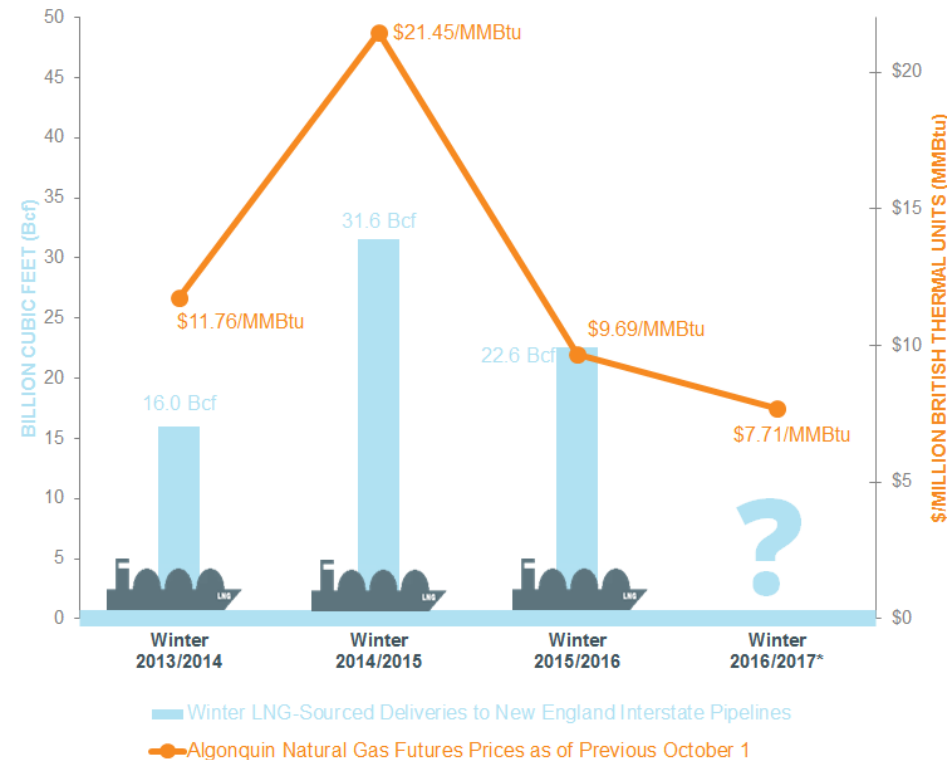
New England Has Relatively Few Interstate Natural Gas Pipelines and LNG Delivery Points



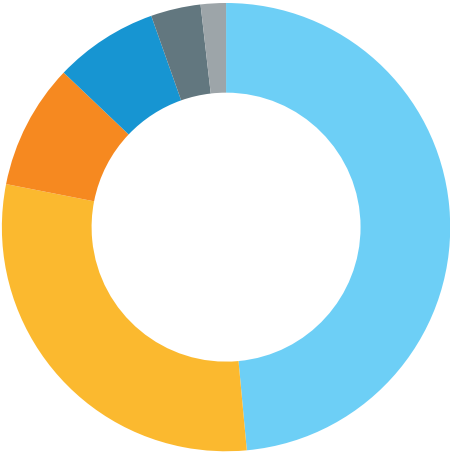
Will Imported Liquefied Natural Gas (LNG) Fill the Gap?

- Demand for natural gas is rising
 - Retiring non-gas generators are being replaced by natural gas generators
 - Gas distribution companies will rely on LNG when pipelines cannot be built
 - LNG is a global commodity; without firm contracts, spot LNG goes where the prices are highest

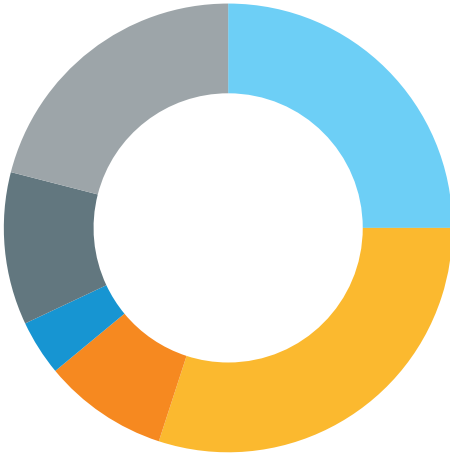
LNG Tanker Deliveries to New England During Winter and Natural Gas Futures-Market Prices



Non-Gas Resources Are Needed for Reliability in Winter



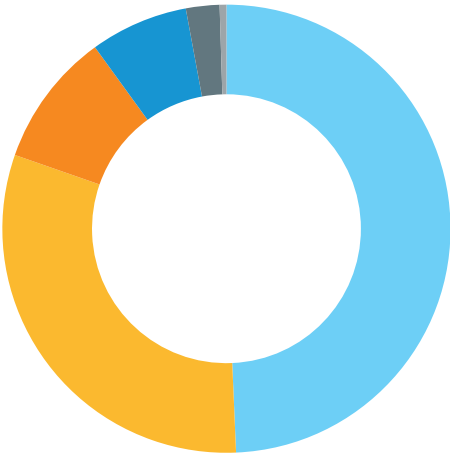
2015 Annual Fuel Mix



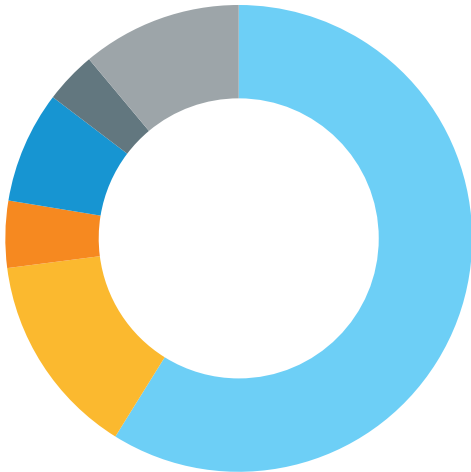
February 25, 2015
12:00-1:00 PM
30°F

● Natural Gas	49%	25%
● Nuclear	30%	30%
● Renewables	9%	9%
● Hydro	7%	4%
● Coal	4%	11%
● Oil	2%	21%

Non-Gas Resources Are *Also* Needed for Reliability in Summer



2016 Annual Fuel Mix



August 12, 2016
Peak hour: 2:00-3:00 PM
93°F

● Natural Gas	49%	59%
● Nuclear	31%	14%
● Renewables	10%	5%
● Hydro	7%	8%
● Coal	2%	4%
● Oil	1%	11%

What Is the Outlook for Fuel Security?

- The lights stay on during extremely cold periods with a combination of these fuels: nuclear, coal, oil and LNG
 - Very little pipeline gas is available to support gas generators under these conditions
- Nuclear, coal- and oil-fired generation are declining rapidly, LNG deliveries are uncertain, and more natural gas generation is being added
 - Renewable resources are valuable, but limited, offsets to natural gas consumption (on average) *However, these resources may not be available during extreme weather conditions or able to respond to emergencies on the system*
- Further coal and oil generator retirements expected post-2019 due to generally low natural gas prices, renewable energy additions, & pending environmental regulations
- Environmental permitting for dual-fuel capability is becoming more difficult and, when permitted, run-times on oil are restricted, as is the case for the existing oil fleet
- Operating conditions are precarious during winter
- ISO-NE is focused on ensuring that reliability can be sustained during extreme cold conditions beyond 2019

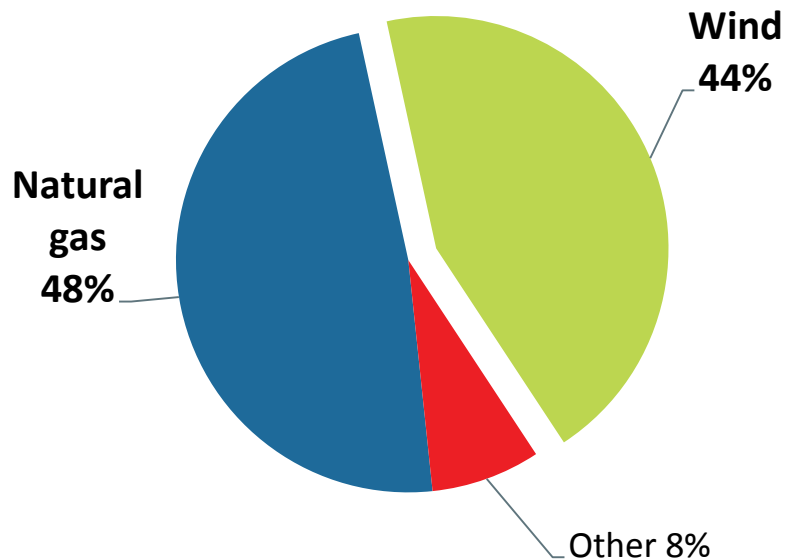
STATE OF THE GRID: THE FUTURE GRID



Infrastructure Will Be Needed to Deliver Energy from Proposed Resources

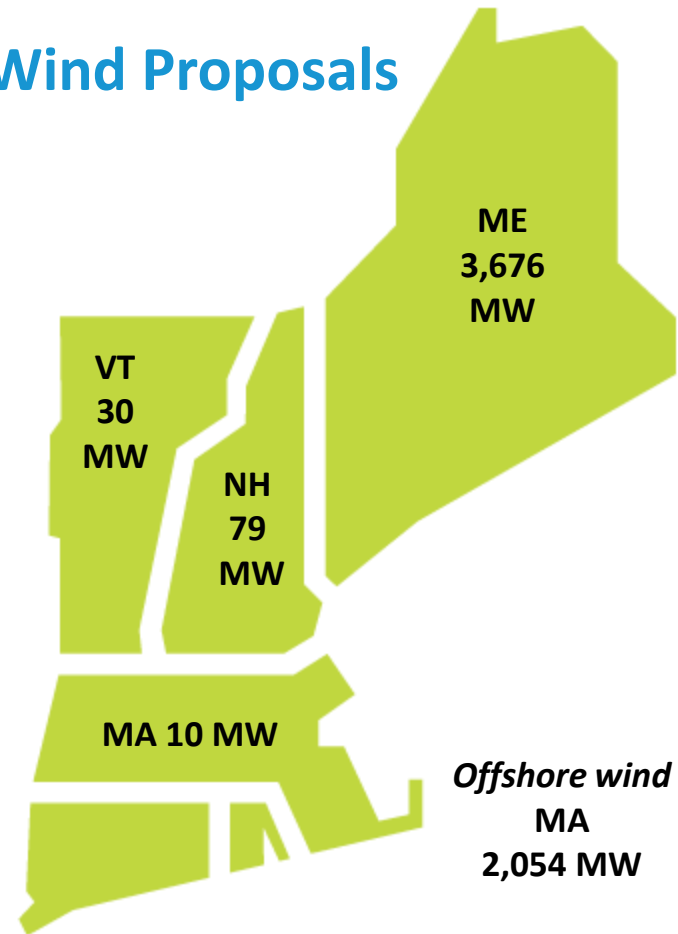
All Proposed Generation

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

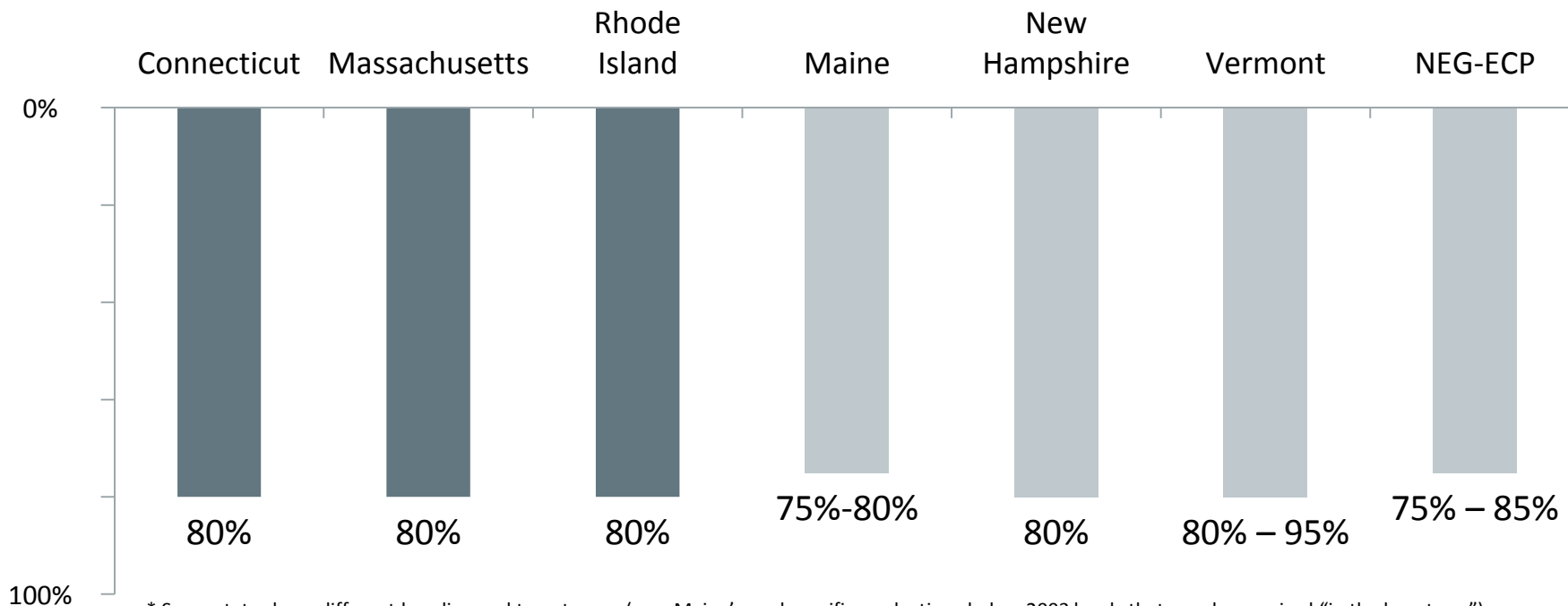
Wind Proposals



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

States Have Set Goals for Significant Reductions in Greenhouse Gas Emissions

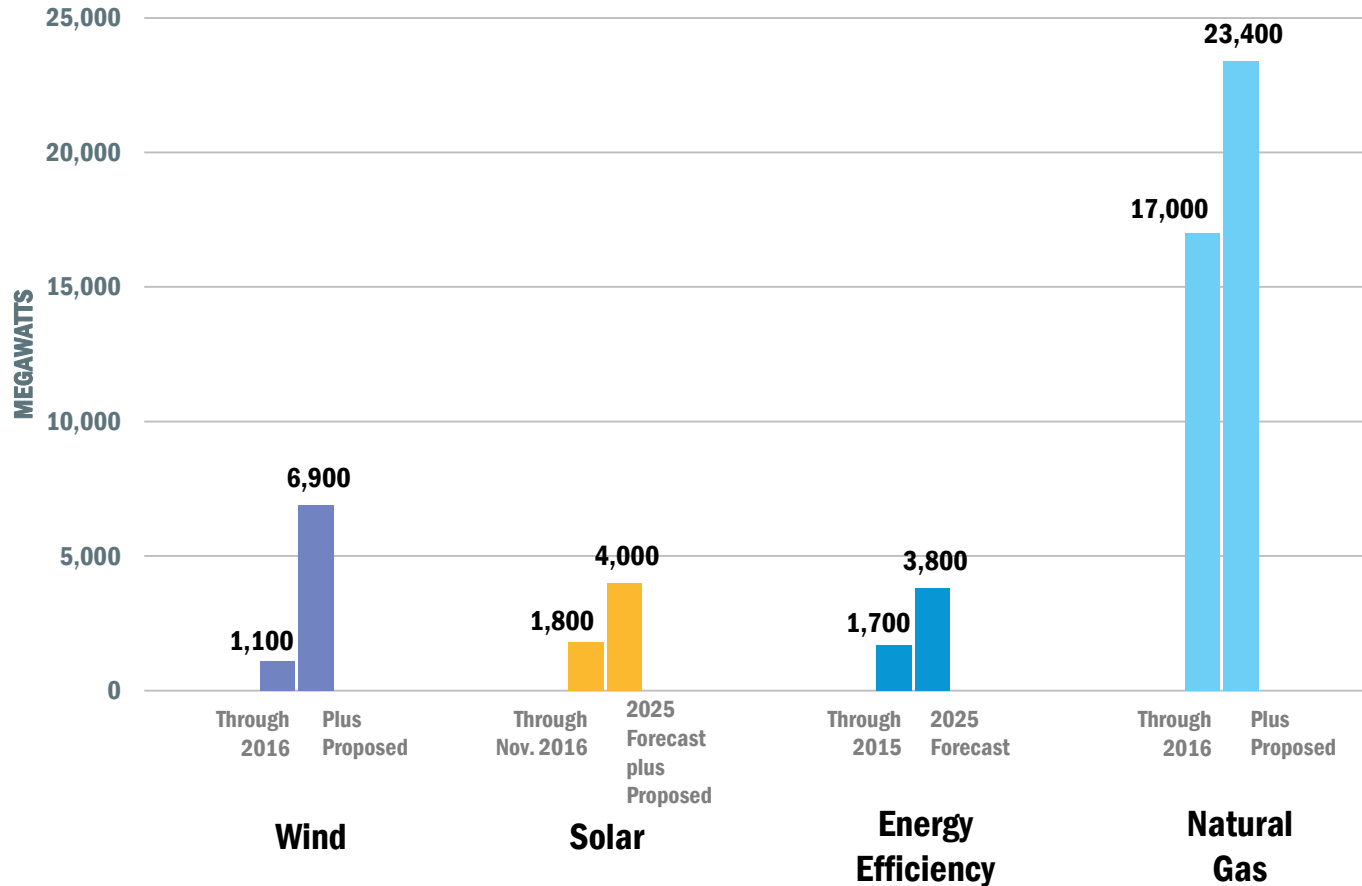
Percent Reduction in Greenhouse Gas (GHG) Emissions Below 1990 Levels by 2050 Economy Wide*



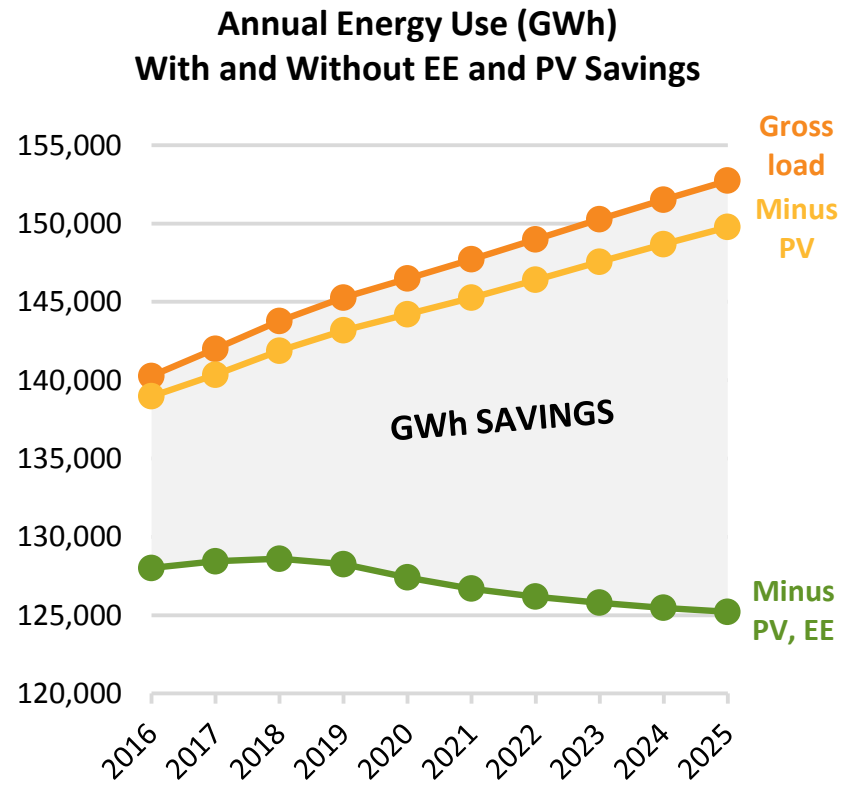
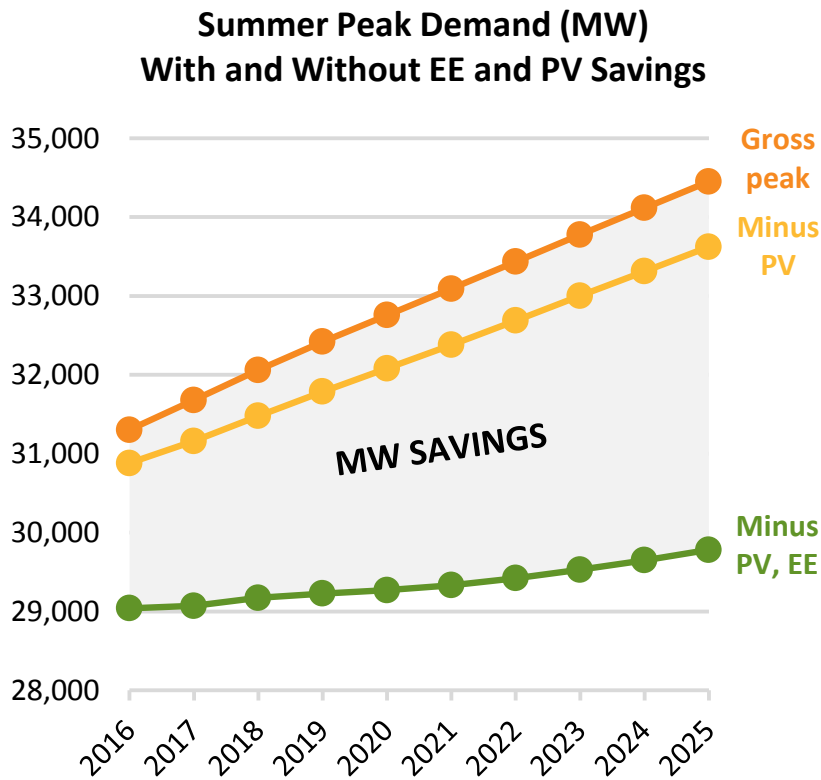
The New England states are promoting GHG reductions on a state-by-state basis, and at the regional level, through a combination of legislative mandates (e.g., CT, MA, RI) and aspirational, non-binding goals (e.g., ME, NH, VT and the New England Governors and Eastern Canadian Premiers).

Renewable and EE Resources Are Trending Up

But natural gas remains the predominant fuel for existing and new power plants



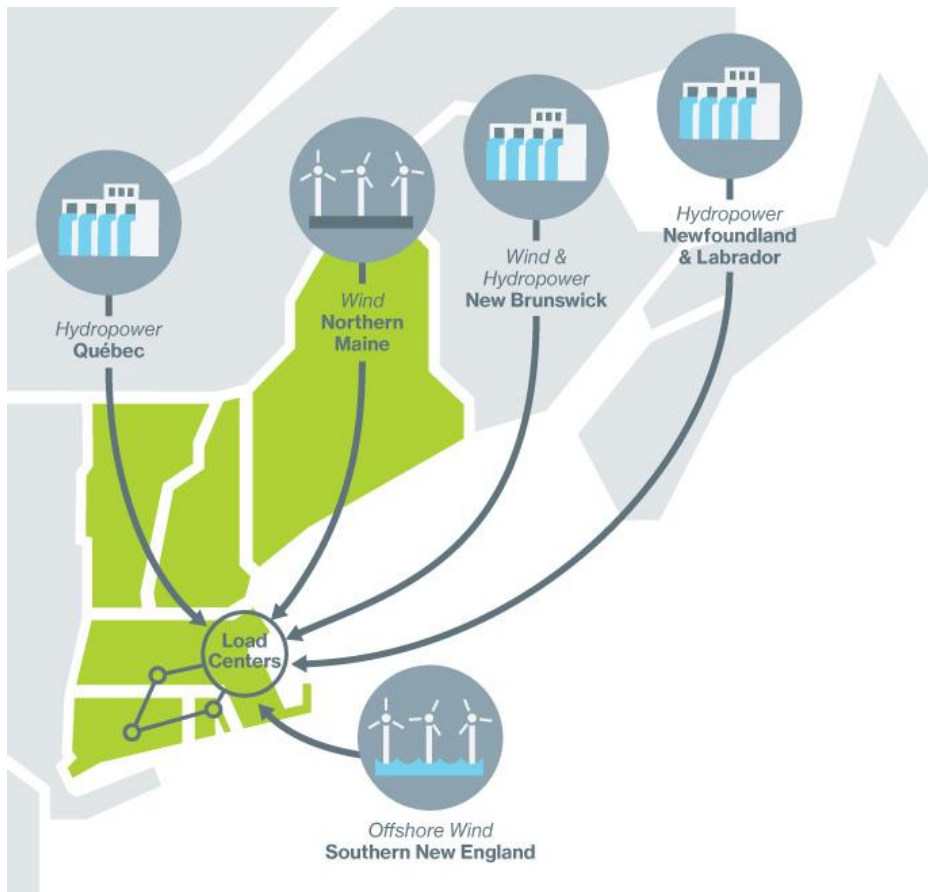
Energy Efficiency and Solar PV Are Slowing Peak Demand Growth and Flattening Energy Use



- 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)

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



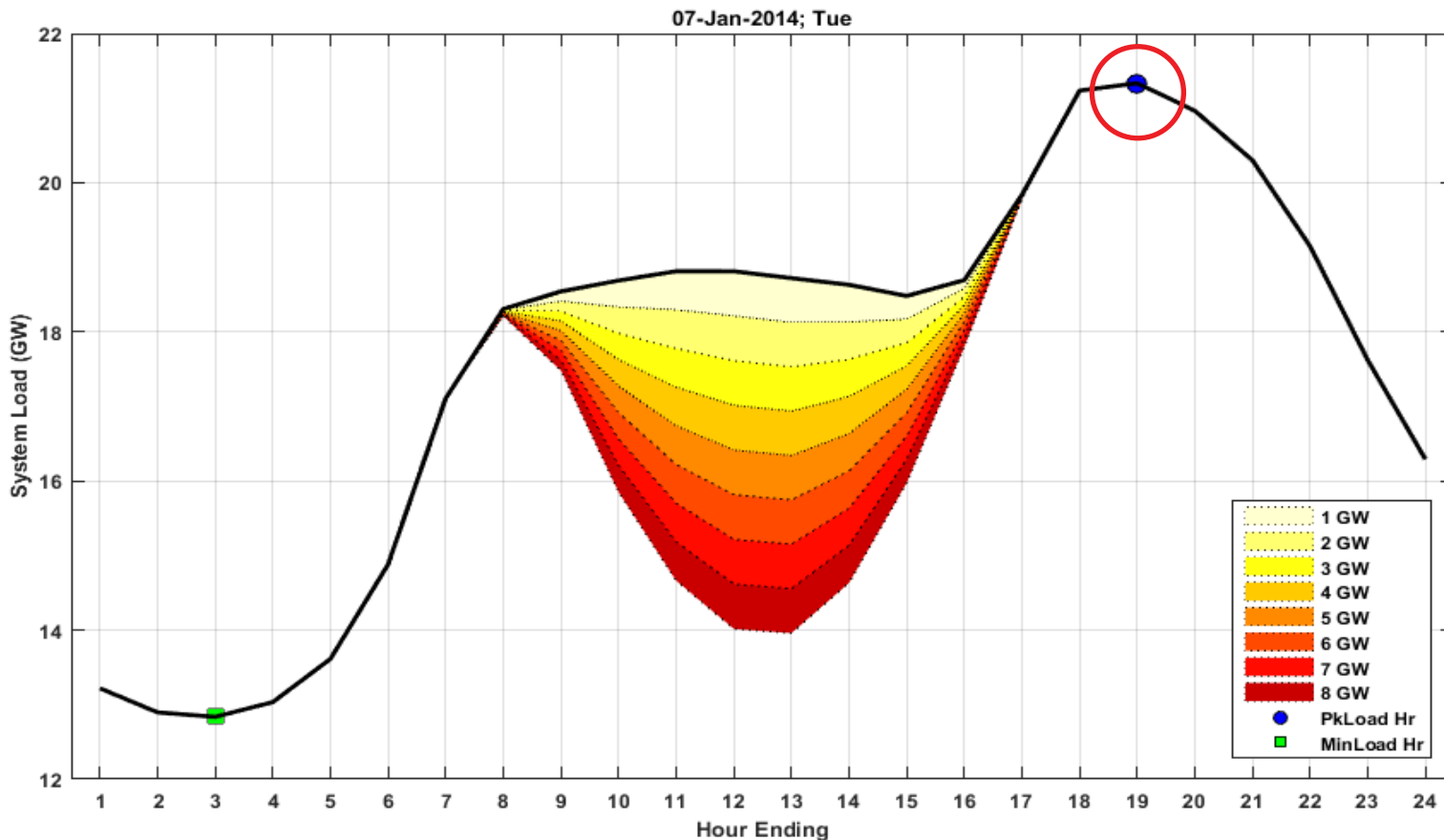
Map is representative of the types of projects announced for the region in recent years

Source: [ISO Interconnection Queue](#) (January 2017)

- 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
 - Primarily large-scale hydro resources from eastern Canada, and onshore wind resources from northern New England
- Canadian hydro can help offset the need for natural gas; but demand in Canada peaks in winter, so contracts will have to ensure Canadian hydro energy will be available for New England in winter
- Projects seek to address public policy goals, not reliability needs

As Solar Power Increases, the Demand Curve Will Change— And the Need for Fast & Flexible Generation Will Rise

Increasing levels of behind-the-meter solar reduce mid-day demand; can help preserve some natural gas & oil for power generation to meet peak demand



Energy Storage: Pumped-Storage Hydro Paves the Way for Emerging Storage Technologies

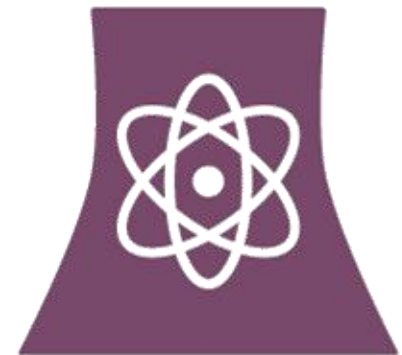
- New England has greatly benefited from grid-scale energy storage capabilities for more than 40 years
 - Two pumped-storage facilities built in the 1970s can supply 1,800 MW of energy within 10 minutes, for up to seven hours
- Battery storage projects totaling nearly 80 MW of capacity have requested interconnection to the regional power system



What Is the Outlook for Nuclear Power?

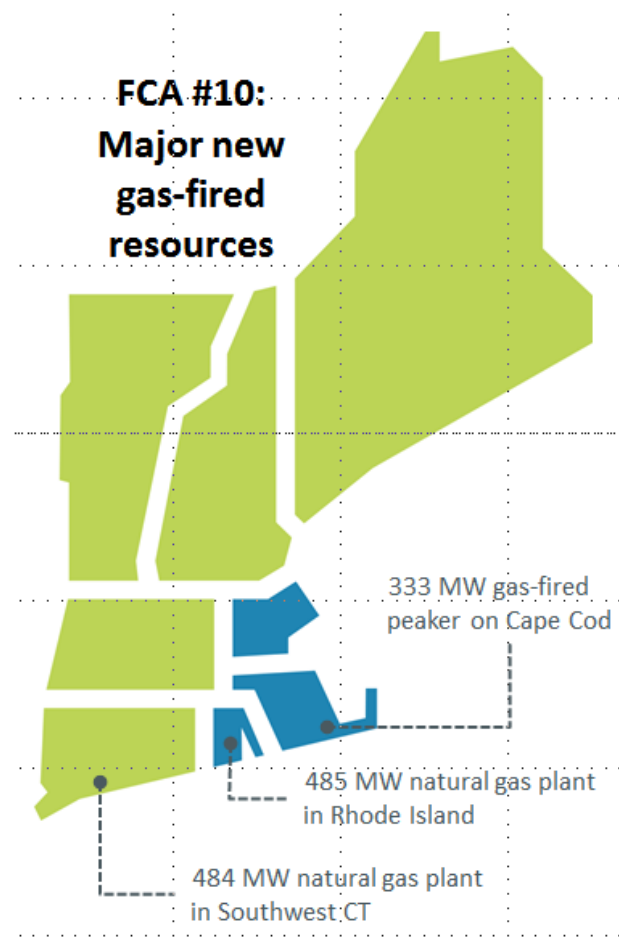
ISO-NE sees environmental, market, and operational concerns

- New England relies on nuclear power for a large portion of its energy (31% in 2016), but lacks a mechanism to appropriately value its carbon-free attributes
- The loss of nuclear generation has (at least temporarily) reversed the trend of declining emissions in the region
- The remaining nuclear generators have expressed concerns about the future economic viability of their facilities



Forward Capacity Market Auctions Procure the Resources Shaping the Grid of the Future

- **FCA #10:**
 - Sufficient resources cleared in 2016 auction for 2019-2020
 - Three new, dual-fuel power plants totaling 1,300 MW
 - Solar: 40 MW
 - Wind: 27 MW
 - Demand resources: 2,746 MW (371 MW *new*)
 - FCA #10 firsts:
 - 6.8 MW from the first offshore wind farm in US
 - Two 2.5 MW fuel cells
 - The amount of capacity needed was reduced by 390 MW to account for small-scale solar PV
- **FCA #11:**
 - Begins on February 6, 2017, to procure capacity for 2020-2021
 - Capacity requirement is 34,075 MW
 - Requirement reduced by 720 MW to account for small-scale solar PV demand reductions
 - Competition is robust: 40,463 MW qualified
 - 34,505 MW of existing capacity resources
 - 5,958 MW of new capacity resources



STATE OF THE GRID: HARMONIZING COMPETITIVE MARKETS AND CLEAN ENERGY GOALS



New England Has Two Overarching Policy Goals – *Can They Be Harmonized?*

Goal 1: Achieving reliability through competitive wholesale markets

Goal 2: Achieving reductions in carbon emissions

Goal 1 rests on the premise that competitive markets will allow merchant generators the opportunity to recover their costs and a return on equity, thereby maintaining resource adequacy

To achieve Goal 2, state initiatives provide ‘out of market’ financial support to clean-energy resources; that will require changes to competitive wholesale markets to preserve their integrity



STATE OF THE GRID: CONCLUSIONS



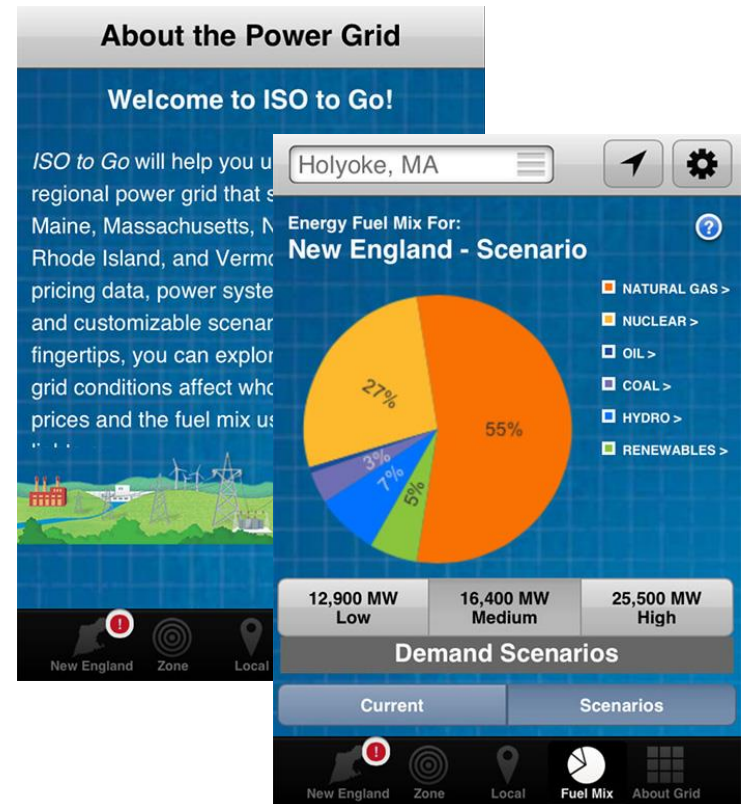
ISO New England Is Focused on Developing Solutions to the Region's Top Reliability Risks

- Ensuring resource adequacy through the competitive markets
 - As resources retire, sufficient resources will be needed to replace them, and these must be able to perform under adverse weather conditions
 - Appropriate price formation is critical to resource retention, investment and performance incentives
 - As states contract for new renewable resources, changes will be required to the wholesale market rules to ensure price formation
- Resolving fuel security concerns
 - New England is challenged to meet electricity demands with existing fuel infrastructure, particularly during the winter
 - If the region cannot invest in new gas infrastructure or allow adequate use of dual-fuel capability, changes will be required to the market rules to ensure reliability through existing infrastructure and resources
- Integrating renewable resources
 - Renewable resources provide clean energy but their output is variable
 - Transmission expansion is needed to connect renewables to demand centers
 - To assure reliability, the region needs fast-responding, flexible capacity resources that are not constrained in their operation

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



STATE OF THE GRID: APPENDIX

About ISO New England, 2016 facts, history, references



Two Decades of Experience Overseeing the Region's Restructured Electric Power System

Reliability is the core of ISO New England's mission

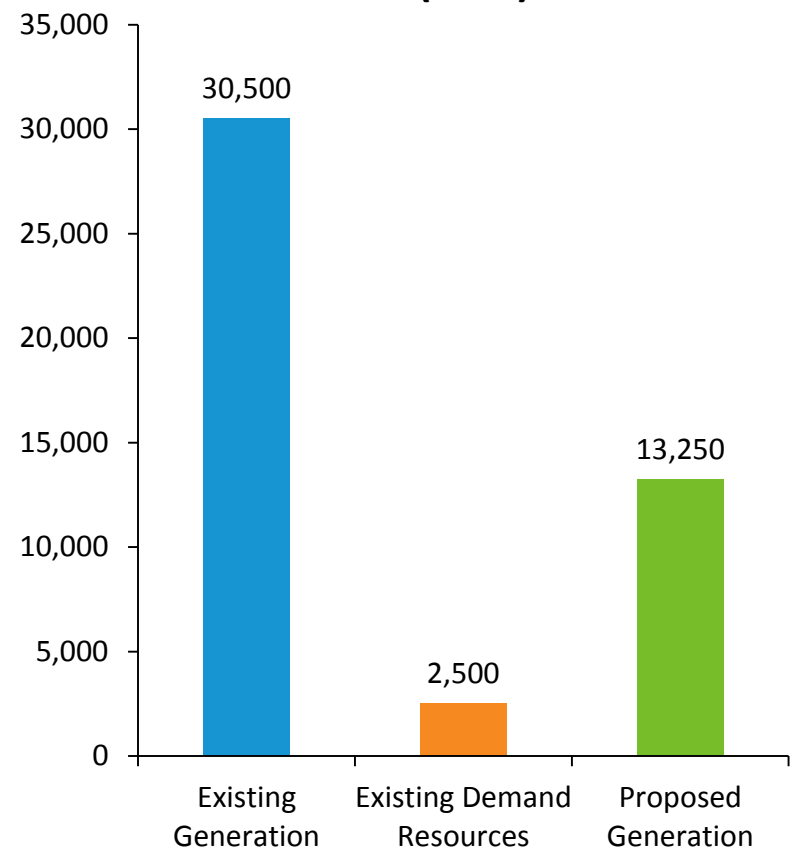
- **ISO New England created July 1, 1997**
- **Regulated by** the Federal Energy Regulatory Commission
- **Three core responsibilities**
 - Operating the regional power system
 - Administering the region's competitive wholesale electricity markets
 - Planning for the regional power system
- **Independent** of companies in the marketplace and neutral on technology and fuels. ISO-NE does not:
 - Buy or sell power
 - Own generation or transmission equipment
 - Have any involvement in the natural gas industry
 - Take a position on any pipeline or elective transmission project proposal



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)*

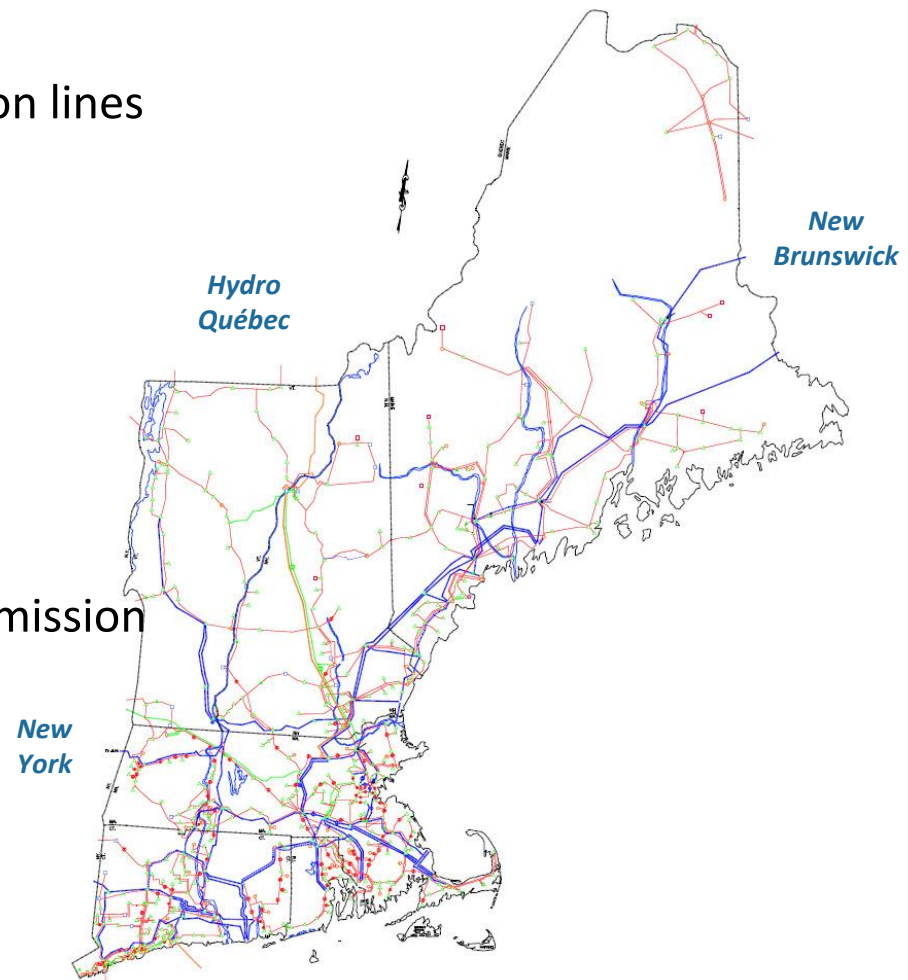
Existing and Future Resources (MW)



* 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
 - 10% of region's energy imported from Quebec; most of that is hydro energy
- **\$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

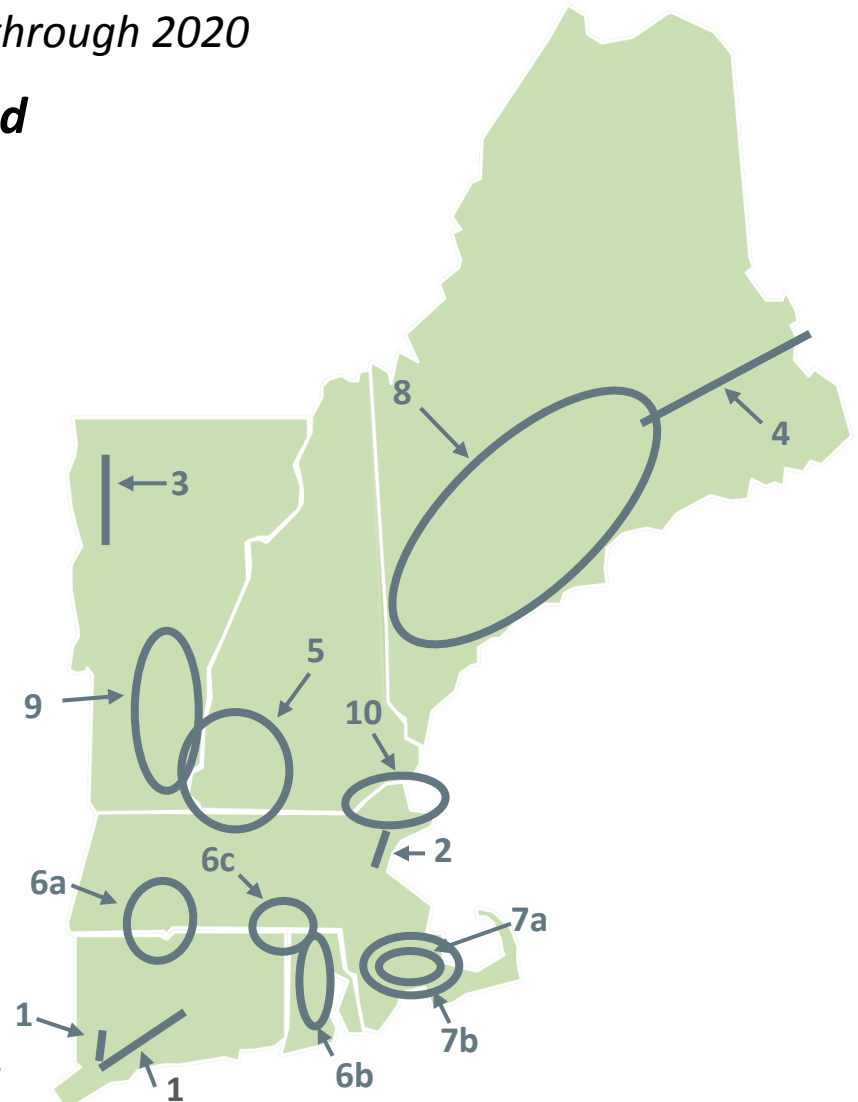


Transmission Investments Ensure a Reliable Electric Grid for New England

\$8 billion 2002-2016; \$4.1 billion estimated through 2020

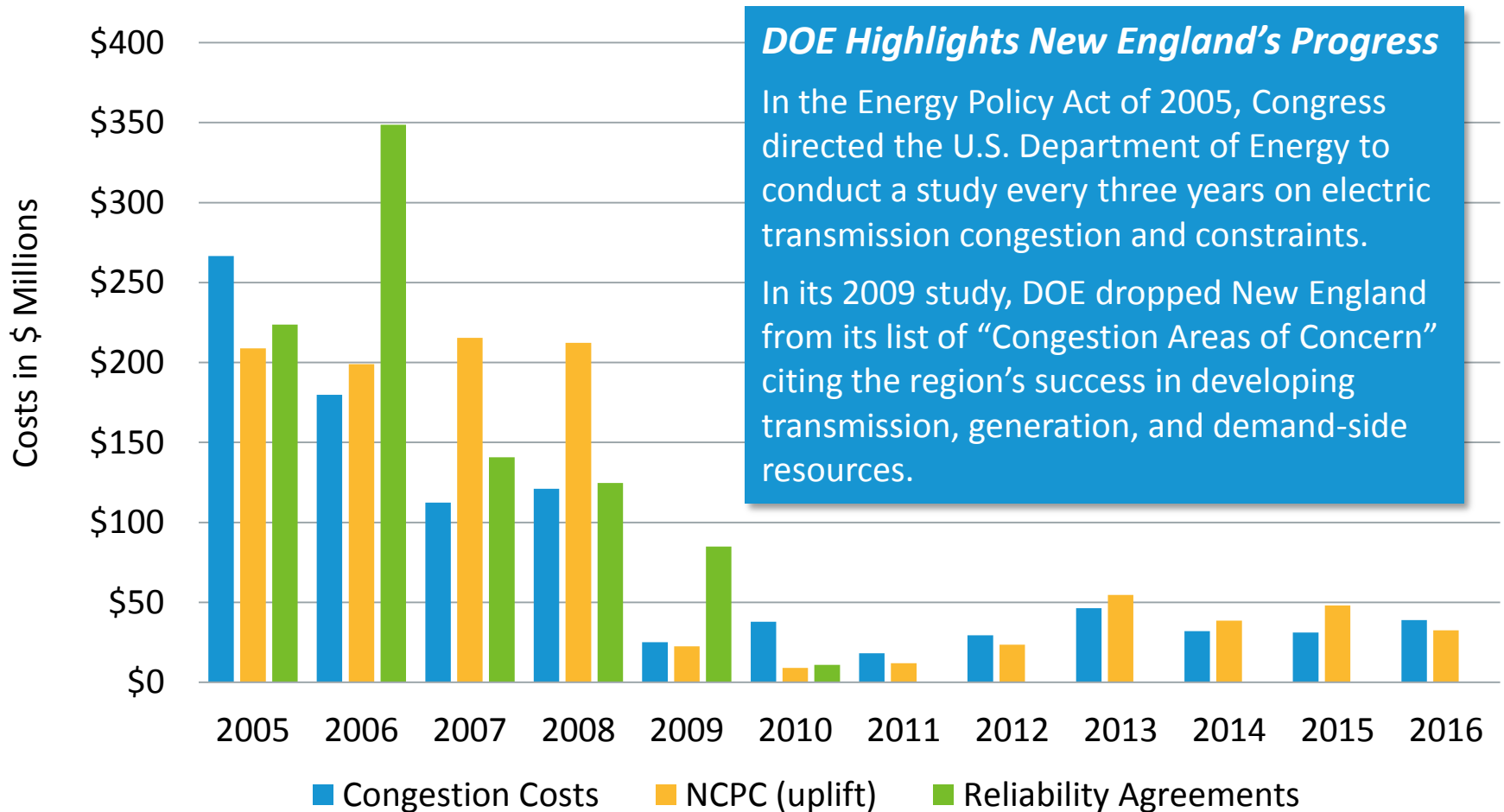
Major transmission upgrades completed

1. Southwest CT Phases I & II
2. Boston NSTAR 345 kV Project, Phases I & II
3. Northwest Vermont
4. Northeast Reliability Interconnect
5. Monadnock Area
6. New England East-West Solution
 - a. Greater Springfield Reliability Project
 - b. Rhode Island Reliability Project
 - c. Interstate Reliability Project
7. Southeast Massachusetts
 - a. Short-term upgrades
 - b. Long-term Lower SEMA Project
8. Maine Power Reliability Program
9. Vermont Southern Loop
10. Merrimack Valley/North Shore Reliability



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

Transmission and Resource Developments Have Reduced Energy and Reliability Costs



Sources: Regional System Plans, ISO-NE Annual Markets Reports

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

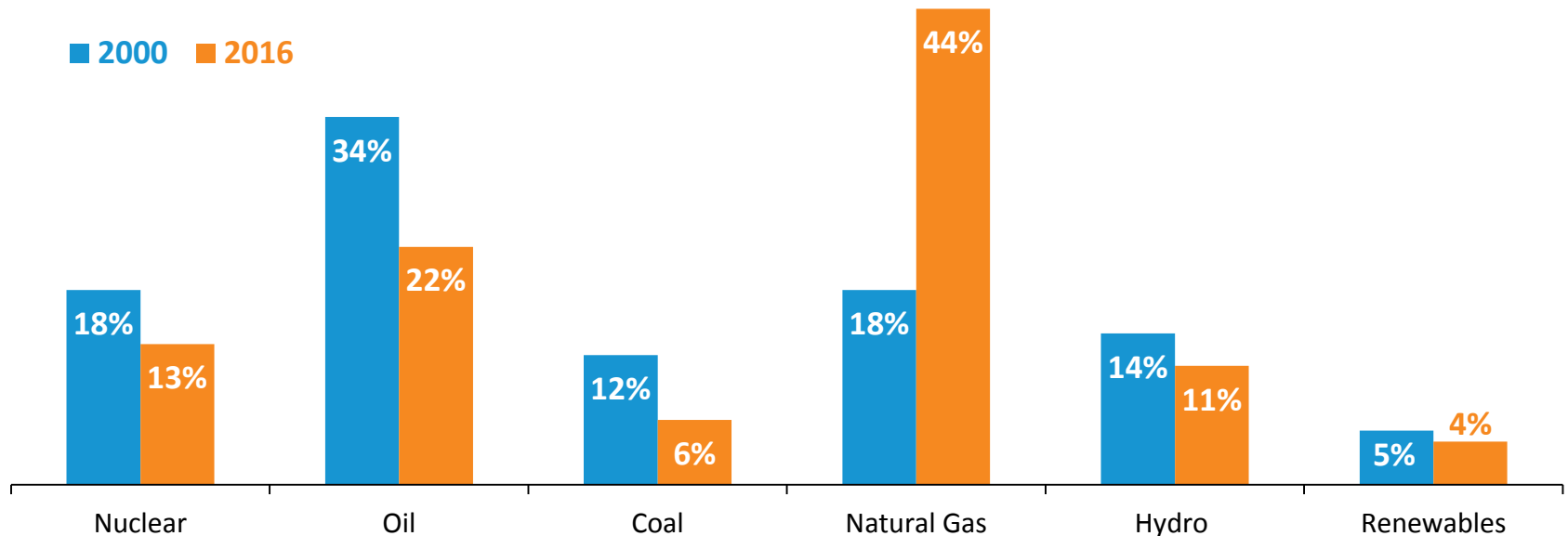


Note: Without energy efficiency and solar, the region's peak demand is forecasted to grow 1.1% annually and the region's overall electricity demand is forecasted to grow 1.0% annually. Summer peak demand is based on the "90/10" forecast for extreme summer weather.

New England Has Seen Dramatic Changes in Power System Resources

The resources making up the region's installed generating capacity have shifted from nuclear, oil and coal to natural gas

Percent of Total System **Capacity** by Fuel Type
(2000 vs. 2016)

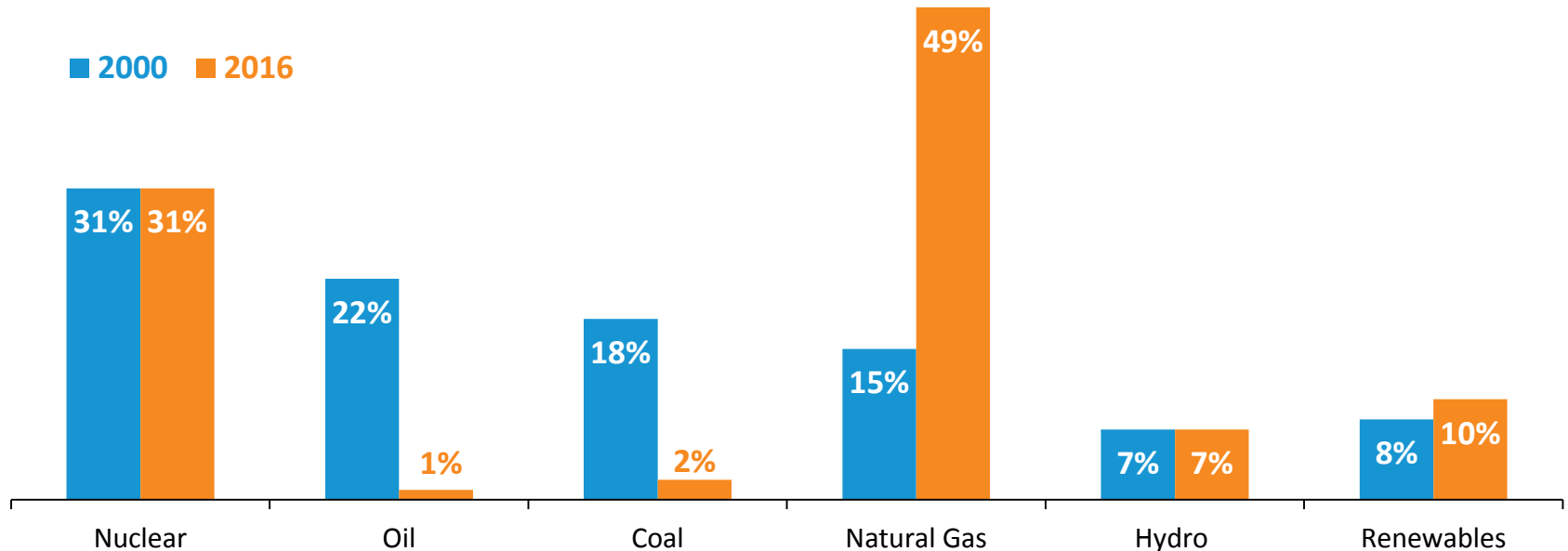


Source: [2016 CELT Report](#), Summer Seasonal Claimed Capability (SCC) Capacity
Renewables include landfill gas, biomass, other biomass gas, wind, solar, municipal solid waste, and miscellaneous fuels

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

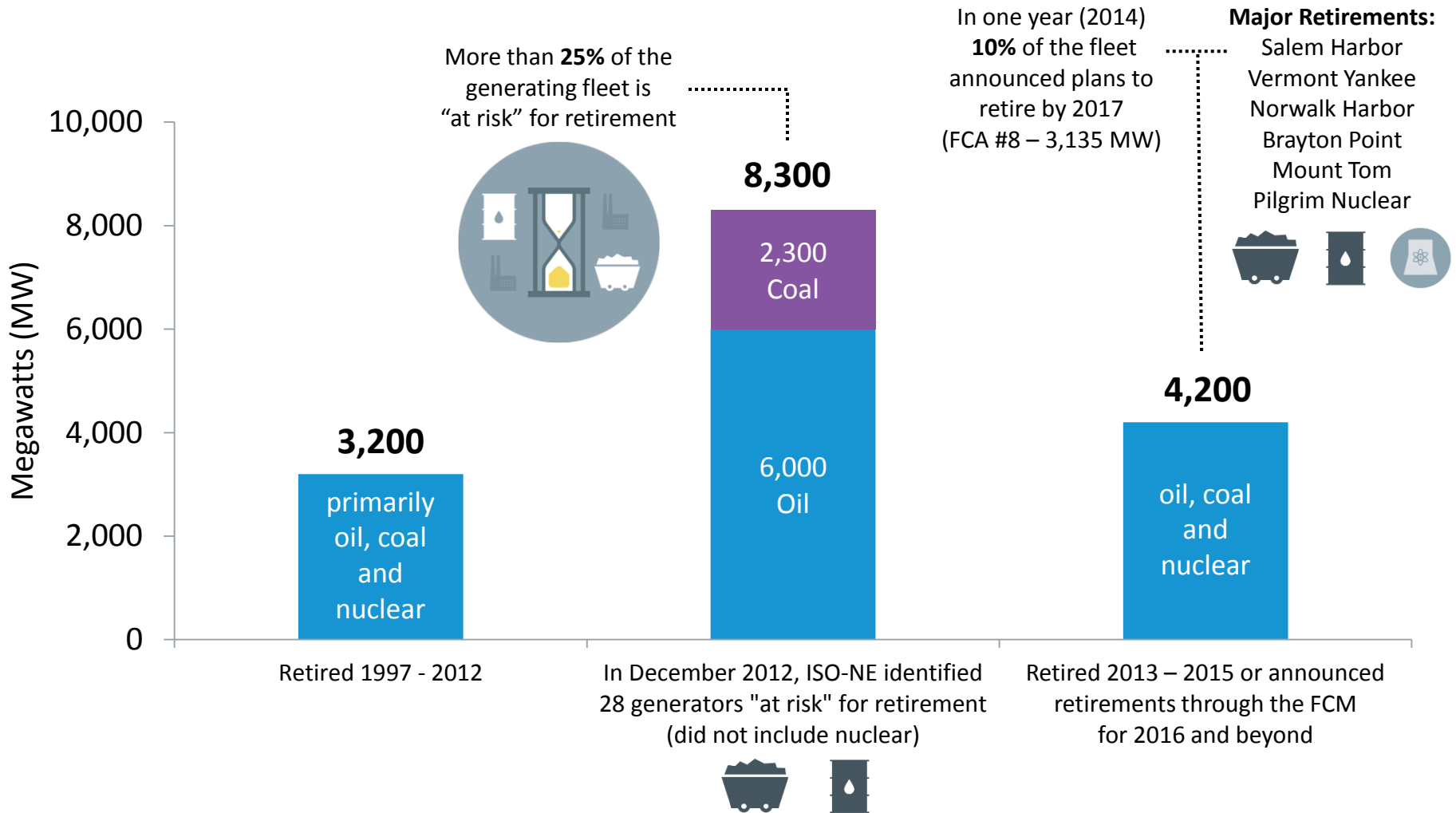
Percent of Total **Electric Energy Production** by Fuel Type
(2000 vs. 2016)



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

Large Non-Gas Generators Have Recently Retired or Announced Plans to Retire; More Retirements Likely



The First 20 Years: Goals of Electric Industry Restructuring

In the 1990s, federal and state policymakers took steps to restructure the electricity industry at the wholesale and retail levels. Goals included:

- Shifting risk of power plant investment decisions, cost-overruns, from ratepayers to investors
- Spurring technological innovation
- Increasing efficiency and competition at the wholesale, supplier level to lower costs and displace older, less efficient power plants with cleaner, more efficient generators
- Increasing competition at the retail level to lower prices and provide consumers with choices (e.g., green energy suppliers)

Region Is Taking Action to Improve Electric Market Efficiency and Enhance Gas-Electric Coordination

Recently Implemented (2012–2015)	Long-Term Actions (2016–2019)
<ul style="list-style-type: none">• Ongoing improvements to information sharing with natural gas pipeline companies• Moved Day-Ahead Energy Market timeline in 2013 to better align electricity and natural gas markets• Increased forward reserve requirements in 2013• FERC clarification of generator obligations (must purchase fuel unless physically unavailable – economics is not an excuse)• Tightened FCM Shortage Event trigger (effective November 2013)• Developed energy market offer-flexibility enhancements (effective December 2014)• Changed NCP cost allocation to drive more load to Day-Ahead Energy Market (effective December 2014)	<ul style="list-style-type: none">• Strengthen Forward Capacity Market Performance Incentives “Pay-for-Performance” (will apply to 2018-2019 capacity commitment period)• Implement Demand Curve and improve zonal modeling in capacity market• Further improvements to energy market pricing• New England States are driving investments in additional natural gas pipelines, and transmission to enable additional renewable energy

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**)



To Learn More

- US Energy Information Administration (EIA), [Wholesale power prices in 2016 fell, reflecting lower natural gas prices](#), January 12, 2017
- EIA, [Natural gas prices in 2016 were the lowest in nearly 20 years](#), January 13, 2017
- Argus Media, [New York may boost gas use post-Indian Point](#), January 13, 2017
- Commonwealth magazine, [Gordon van Welie op-ed: Grid in the Balance](#), January 10, 2017
- New England States Committee on Electricity, [“Electric Restructuring in New England – A Look Back”](#), December 2015
- FERC, [2016-2017 Winter Energy Market Assessment](#), October 2016
- FERC, [Electric Reliability Primer](#), December 2016
- EIA, [Annual Energy Outlook 2017](#), January 2017
- EIA, [New England natural gas pipeline capacity increases for the first time since 2010](#), December 2016
- EIA, [Investment in electricity transmission infrastructure shows steady increase](#), August 2014
- EIA, [Electricity transmission investments vary by region](#), September 2014
- ISO-NE, [“The Importance of a Performance-Based Capacity Market to Ensure Reliability as the Grid Adapts to a Renewable Energy Future”](#), October 2015
- US Department of Energy, Quadrennial Energy Review
 - [“Energy Transmission, Storage, and Distribution Infrastructure”](#), April 2015
 - [“Transforming the Nation’s Electricity System”](#), January 2017