



# State of the Grid: 2019

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*ISO in Depth*

Gordon van Welie

PRESIDENT & CEO, ISO NEW ENGLAND INC.



# About the *ISO in Depth* Series

- Opportunities for reporters 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](http://www.iso-ne.com)>About Us>News and Media>Press Releases



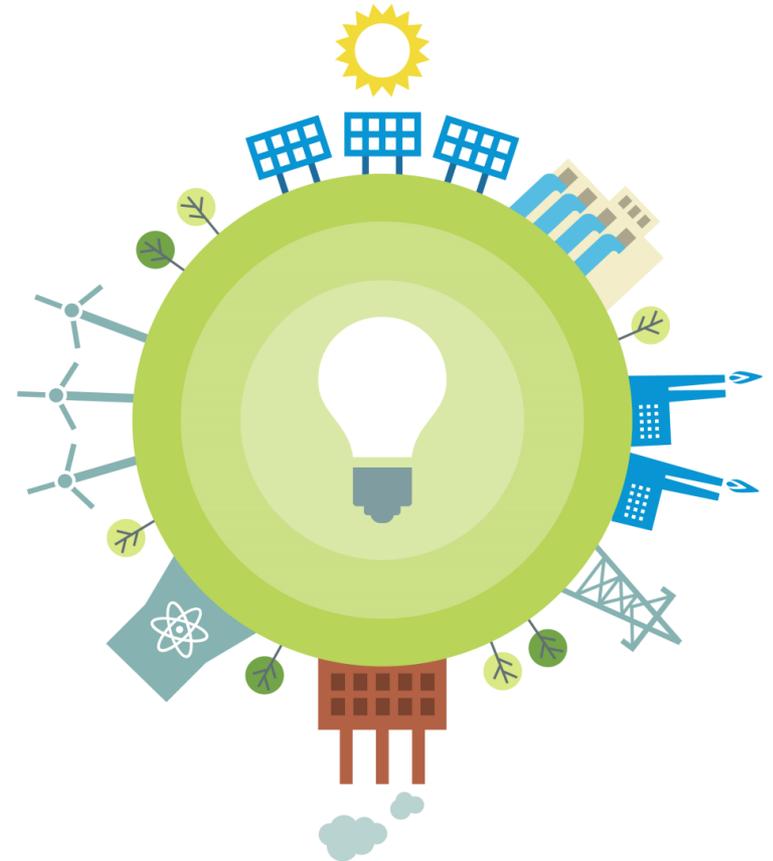
# Agenda

- 10 to 10:05 a.m. **Welcome**  
Ellen Foley, director, Corporate, Media, and Web Communications
- 10:05 to 10:30 a.m. **State of the Grid: 2019**  
Gordon van Welie, president and CEO
- 10:30 to 11:00 a.m. **Question-and-Answer Session**



# Overview of State of the Grid: 2019

- About ISO New England
- Key Takeaways
- 2018 Highlights
- Evolving Resource Mix
- Energy Security Risk
- Challenges to Competitive Markets
- Solutions
- Conclusions
- Appendix: 2018 Data Recap



# ABOUT ISO NEW ENGLAND



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

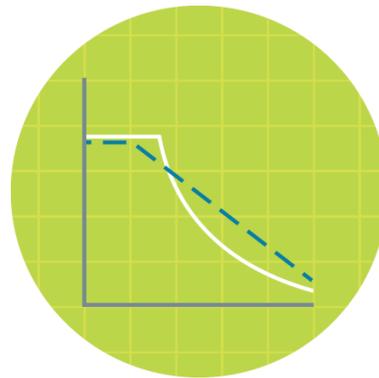
## Grid Operation

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



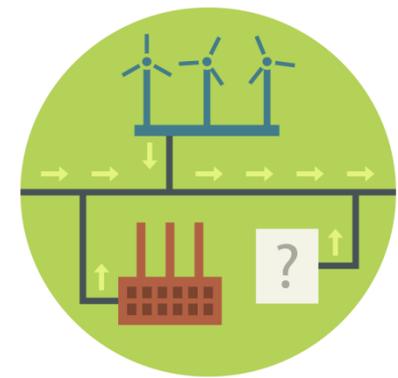
## Market Administration

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



# 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 and fuel**



# KEY TAKEAWAYS





# State of the Grid 2019: Key Takeaways

- **Grid is holding steady on a strong foundation, but the power system is changing and vulnerabilities are growing**
- **Strong foundation:** Operations, transmission, resources, & collaborative, long-term planning
- **Evolving resource mix:** Fleet is shifting from resources with on-site fuel (coal, oil, nuclear) toward:
  - Resources with “just-in-time” fuel delivery (natural gas)
  - Weather-dependent resources (wind, sun)
  - Distributed resources at homes and businesses (solar photovoltaic arrays)





# State of the Grid 2019: Key Takeaways

- **Vulnerabilities:**
  - **Energy security risk:** With an evolving resource mix and inadequate fuel delivery infrastructure, there may not be enough energy to satisfy electricity demand during extended cold weather and, increasingly, year-round
  - **Competitive markets** are under stress: Public policy initiatives provide financial support to renewables & distributed resources, artificially suppressing prices for all resources
- **Adapting markets & operations:** ISO-NE continues to adapt market rules and planning and operational procedures to ensure continued reliability and fair competition for all resource types

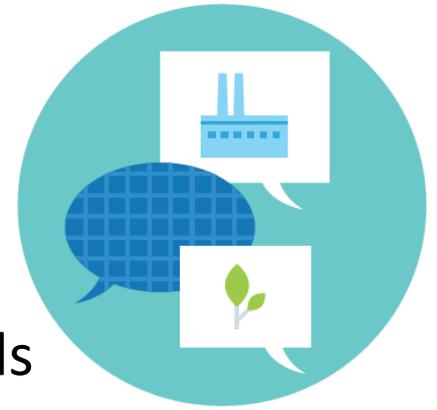


# 2018 HIGHLIGHTS



# 2018: Major Milestones

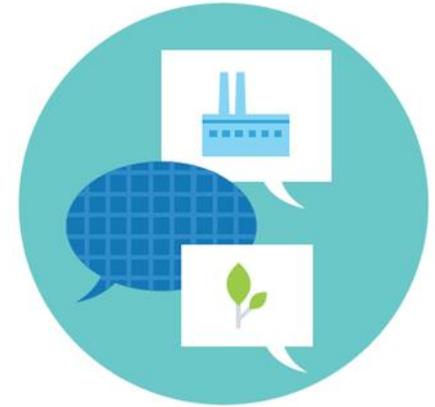
- ***Operational Fuel Security Analysis:*** Defined the growing energy security risk the region faces, particularly during extended cold periods
- **Pay-for-Performance incentives:** Addresses an array of resource performance issues, not just fuel security. PFP's scarcity pricing provides strong signal to perform when system is already "at risk", but does not provide an advance signal of impending energy security risk
- **CASPR:** FERC approved the ISO's Competitive Auctions for Sponsored Policy Resources initiative, the first in the nation to provide a path into the capacity market for resources with state-sponsored contracts



# 2018: Major Milestones

*continued*

- **Price-responsive demand:** First grid operator to dispatch and price active demand response resources in the energy market, alongside conventional power plants
- **Advanced energy storage:** ISO-NE developed market rules that recognize the unique characteristics of advanced energy storage technologies, such as batteries. Rules go into effect this spring



# EVOLVING RESOURCE MIX

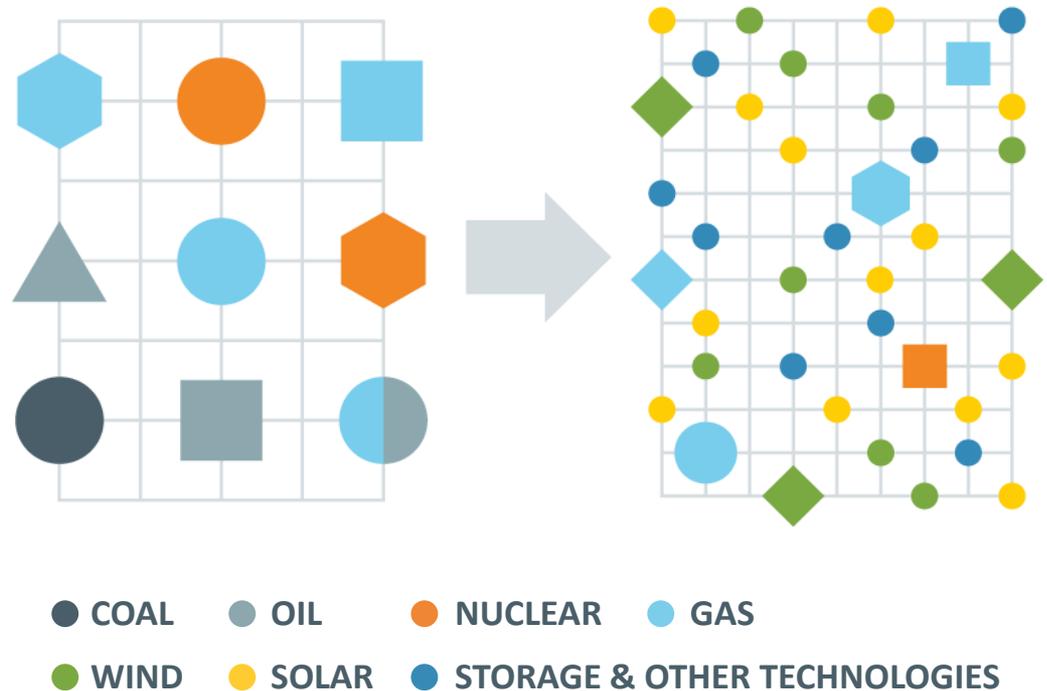


# A Hybrid Grid Is Emerging in New England

*There are two dimensions to this transition, happening simultaneously...*

1 A shift from conventional generation to renewable energy

2 A shift from centrally dispatched generation to distributed energy resources



*Maintaining reliable power system operations becomes **more complex** with the shift to more resources that face constraints on energy production*

A map of New England (Maine, New Hampshire, Vermont, Massachusetts, Connecticut, and Rhode Island) is shown in blue. Various locations are marked with circular icons. A legend at the bottom indicates that orange icons represent 'Closed or Retiring' and yellow icons represent 'Generation at Risk'. The map shows a high concentration of 'Generation at Risk' (yellow) in the northern and western parts of the region, and 'Closed or Retiring' (orange) resources scattered throughout, particularly in the southern and eastern parts.

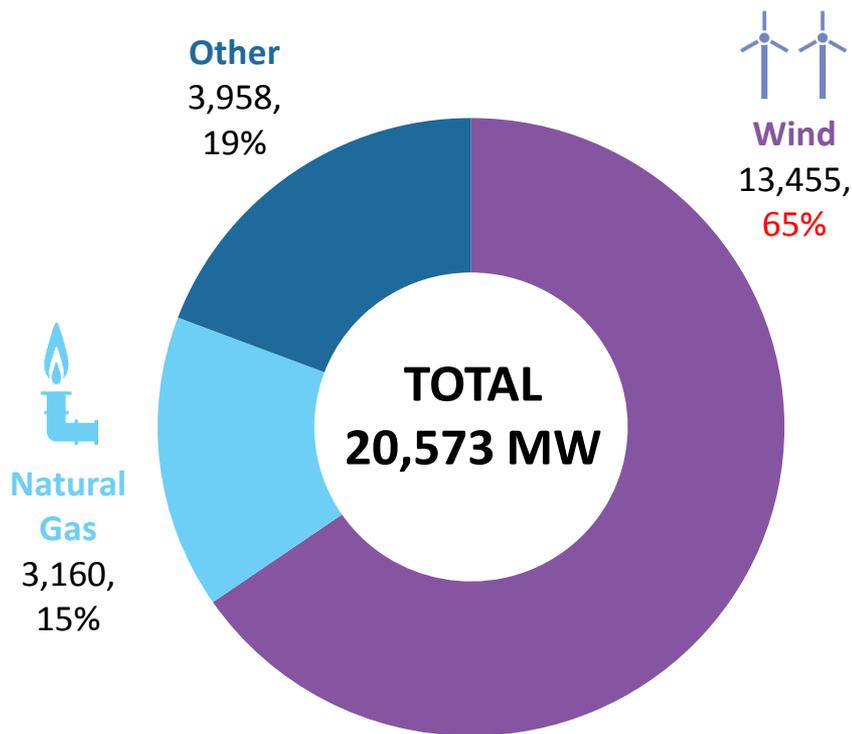
## Since 2013, More Than 5,200 MW of Generation Have Retired or Announced Plans for Retirement in the Coming Years

- Predominantly **fuel-secure** coal, oil, and nuclear resources
- Another **5,000 MW** of remaining coal and oil are at risk of retirement
- These resources have played an **important** role in recent winters when natural gas supply is constrained in New England

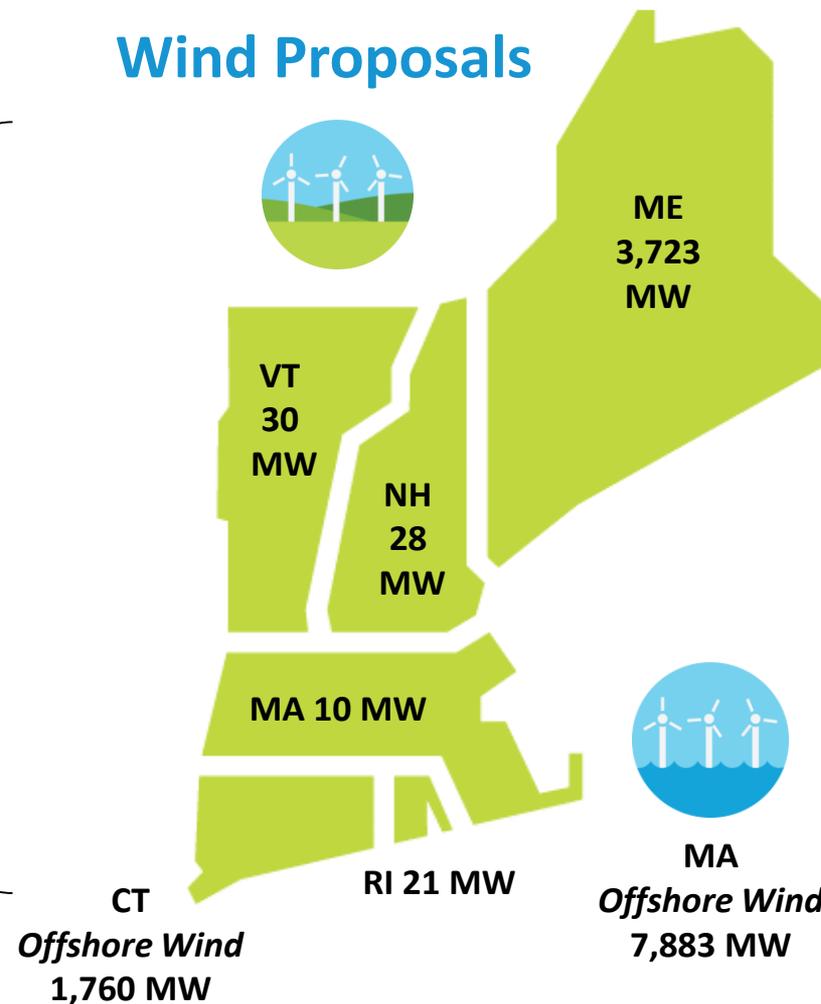
Source: [ISO New England Status of Non-Price Retirement Requests and Retirement De-list Bids](#); August 17, 2018

# Wind Power Now Comprises Two-Thirds of New Resource Proposals in the ISO Interconnection Queue

## All Proposed Generation



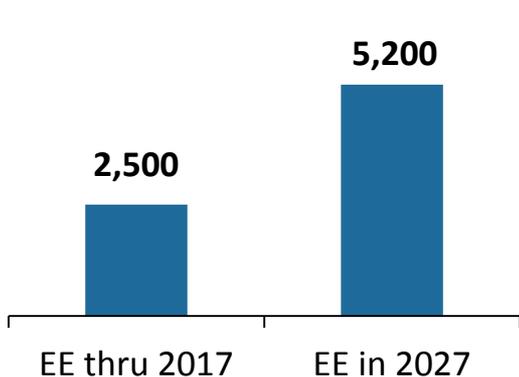
## Wind Proposals



Source: ISO Generator Interconnection Queue (January 2019)  
FERC and Non-FERC Jurisdictional Proposals; Nameplate Capacity Ratings  
Note: Some natural gas proposals include battery storage and dual-fuel units (oil). Some wind proposals include battery storage.

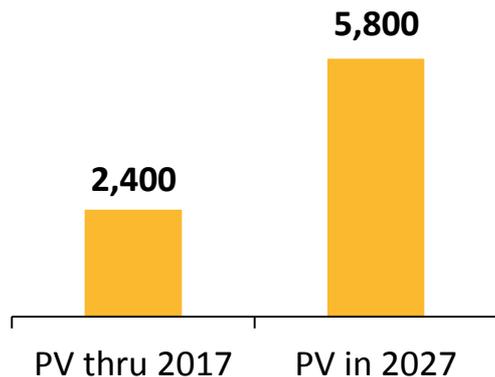
# Energy-Efficiency and Renewable Resources Are Trending Up in New England

## Energy Efficiency (MW)



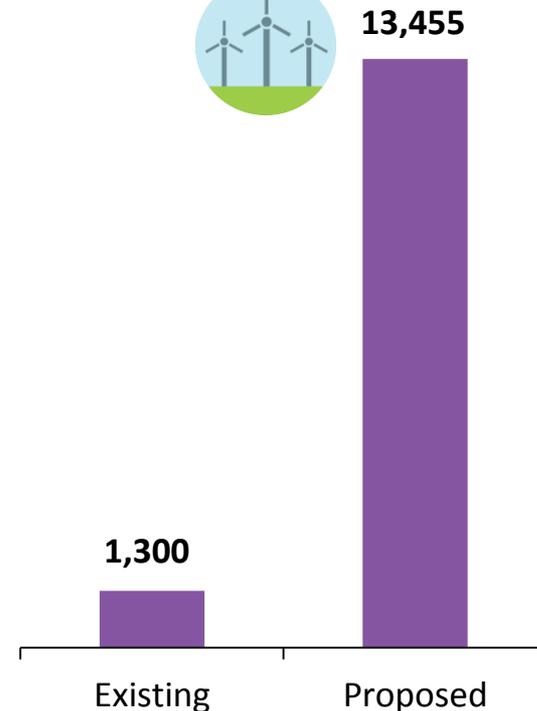
*Final 2018 CELT Report*, EE through 2017 includes EE resources participating in the Forward Capacity Market (FCM). EE in 2027 includes an ISO-NE forecast of incremental EE beyond the FCM.

## Solar (MW)



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

## Wind (MW)



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

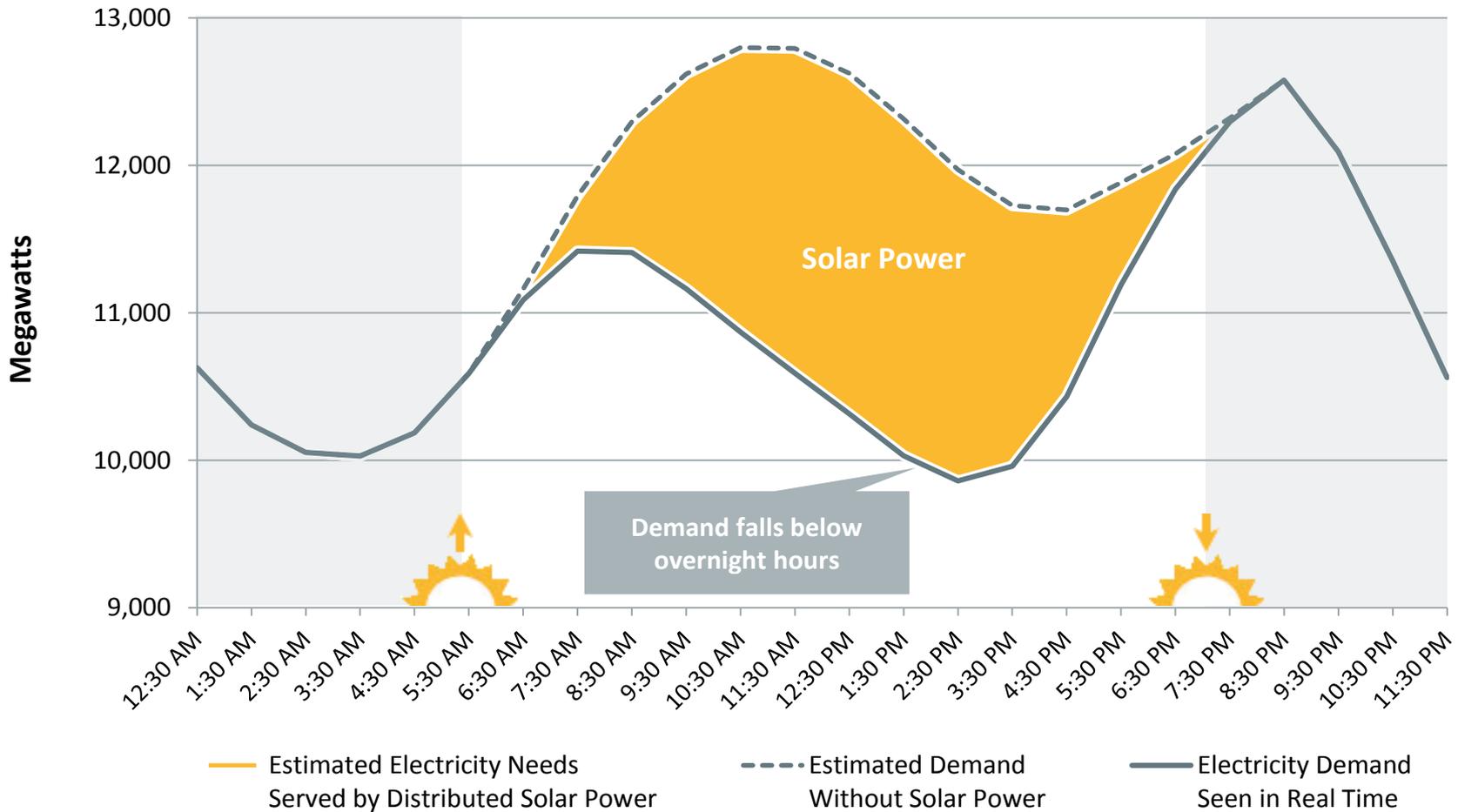
# New Energy Storage Technologies Are Coming On Line

- **20 MW** of grid-scale battery storage projects have come on line since late 2015
- Proposals for **more than 1,300 MW** of grid-scale, stand-alone energy storage projects by 2022
- A first: **20 MW** home solar and battery storage cleared FCA #13 for 2022-2023
- Meanwhile, New England has operated two large pumped-storage facilities for 40 years
  - They can supply **1,800 MW** of power in 10 minutes, for up to 7 hours



# Historic Dip in Midday Demand with Record-High Solar Power Output on April 21, 2018

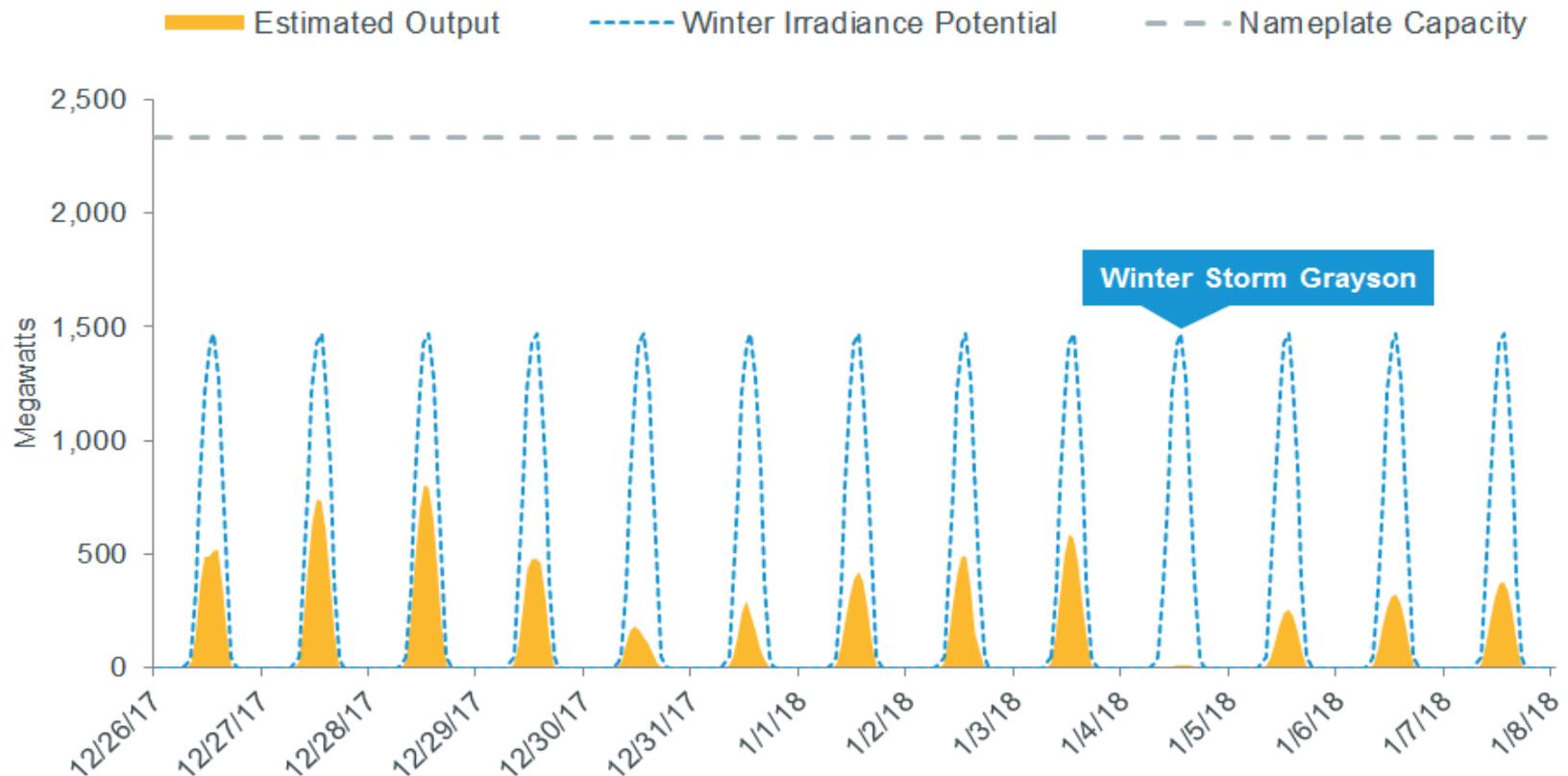
At 1:30 p.m., behind-the-meter solar reduced grid demand by more than 2,300 MW



# The Variability of Solar PV Was On Display Last Winter

*During the cold spell, clouds and snow cover reduced output from regional solar power, adding to grid demand*

## Potential vs Actual Estimated Output from Behind-the-Meter Solar Power

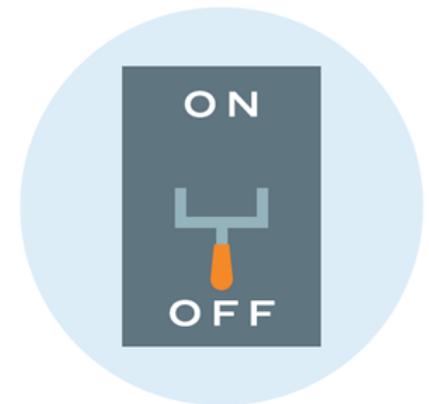


Note: Output derived from statistical sampling of actual meter readings. Winter irradiance potential reflects the energy that PV capacity could produce at this time of year with clear skies and no snow cover.

# FCA #13 Attracted & Retained Resources Needed to Ensure Resource Adequacy in 2022-2023

*Featured first substitution auction for sponsored policy resources*

- Auction concluded with sufficient capacity to meet demand in 2022-2023 & lowest clearing price in 6 years due to surplus capacity. Other highlights:
  - 783 MW of **new generation** in the primary auction
  - 4,040 MW of **energy-efficiency and demand-reduction measures**, including 654 MW of new EE & DR resources
  - 20 MW from **home solar & battery storage**, a first in the US
- First substitution auction for state-sponsored resources
  - **Vineyard Wind**, a new offshore project, will assume a **54 MW obligation** from an existing resource that will retire in 2022-2023



# ENERGY SECURITY RISK



# Several Industry Trends Make Energy Security a Growing Concern in New England



Significant retirements of large, non-gas-fired generation (coal, oil, nuclear)



Increase in natural-gas-fired generation relying on “just-in-time” fuel delivery



The shift to more resources susceptible to constraints on energy production (emerging hybrid grid)

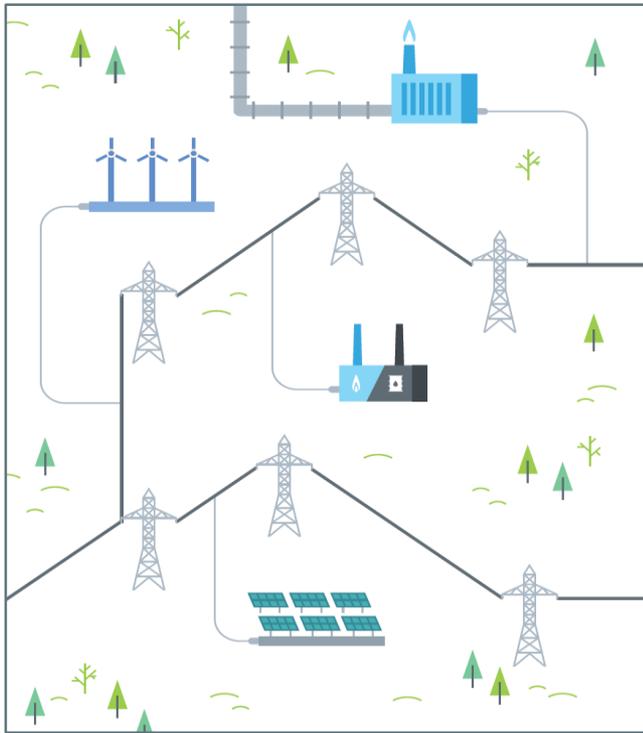


Challenges with fuel-delivery logistics during cold weather conditions



Limited dual-fuel storage and tightening emission limits on (most) oil-fired generation

# Winter Energy Security Is an *Energy Supply* Problem, Not a *Capacity* Shortfall Problem



- New England has sufficient *capacity* to meet highest peak demand
- Risk is insufficient fuel--natural gas, oil, wind, water, sun--for that *capacity* to generate all the *energy* needed, esp. in winter
- As hybrid grid develops, the risk could occur year-round with more just-in-time fuel and weather-dependent resources
- New market design will compensate resources that maintain energy inventory to protect the system against:
  - **Extended cold** weather conditions
  - Loss of **large energy production facilities**
  - Unexpected **re-supply challenges**

# Nuclear Power Plants in New England

- In 1990, NE had 8 nuclear power stations
- They made up 25% of capacity
- Today 3 stations make up 13% of capacity...
- ...but generate 30% of the electricity
- Reliable, no emissions, low-cost energy
- But they are at risk

Plant Name	Location	Capacity (MW)	Shut down
Yankee Rowe	MA	185	1991
Millstone 1	CT	652	1995
CT Yankee	CT	619	1996
Maine Yankee	ME	870	1996
Vermont Yankee	VT	604	2014
Pilgrim	MA	677	May 31 2019
Millstone 2 & 3	CT	2,102	<b>3,347 MW</b>
Seabrook	NH	1,245	
<b>Total</b>	<b>New England</b>	<b>6,954</b>	

# CHALLENGES TO COMPETITIVE MARKETS

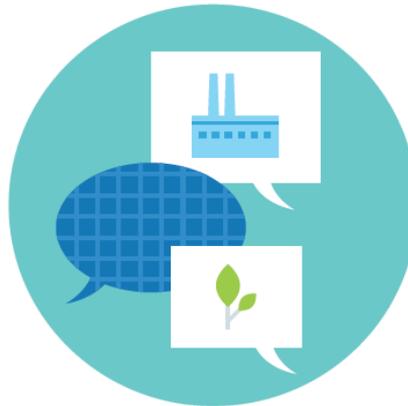


# Why Competitive Markets?

*New England restructured its power industry and launched competitive wholesale electricity markets in the late 1990s based on several key principles*



**Competition** among wholesale electricity buyers and sellers yield prices that accurately reflect a resource's true operating costs



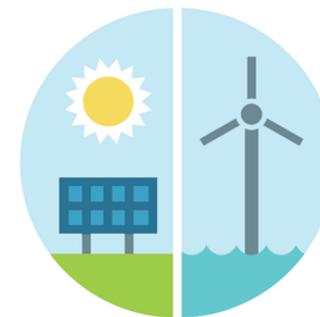
**Efficiency and transparency** spur innovation and investment in new technologies and power resources to ensure power system reliability



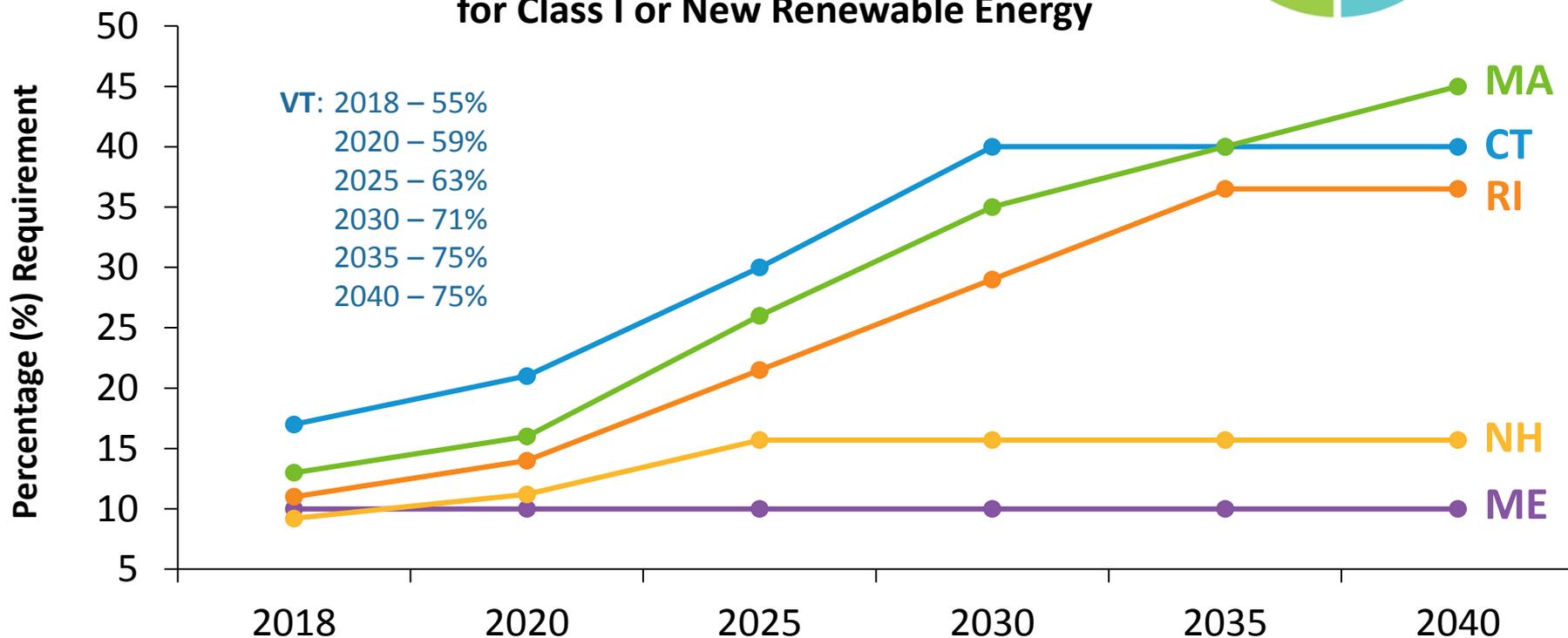
**Investment risk** associated with developing new power resources shifts from consumers to private investors

# Renewable Energy Is on the Rise

State policy requirements are a major driver



## State Renewable Portfolio Standard (RPS)\* for Class I or New Renewable Energy



Notes: State RPS requirements 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. Connecticut's Class I RPS requirement plateaus at 40% in 2030. Maine's Class I RPS requirement plateaued at 10% in 2017 and is set to expire in 2022 (but has been held constant for illustrative purposes). Massachusetts' Class I RPS requirement increases by 2% each year between 2020 and 2030, reverting back to 1% each year thereafter, with no stated expiration date. New Hampshire's percentages include the requirements for both Class I and Class II resources (Class II resources are new solar technologies beginning operation after January 1, 2006). New Hampshire's Class I and Class II RPS requirements plateau at 15.7% in 2025. Rhode Island's requirement for 'new' renewable energy plateaus at 36.5% in 2035. Vermont's 'total renewable energy' requirement plateaus at 75% in 2032; it recognizes all forms of new and existing renewable energy and is unique in classifying large-scale hydropower as renewable.

# SOLUTIONS



# ISO New England Is Focused on Developing Solutions to Today's Grid Challenges

## Addressing Energy Security

Innovating to incentivize the region's generators to have enough fuel to produce electricity when needed most, particularly in winter



## Preparing for the Hybrid Grid

Accommodating the states' clean energy goals, planning for more renewables, and maintaining competitively based capacity pricing for all resources



# CONCLUSIONS





# CONCLUSIONS

- New England's power system: Strong, but changing rapidly to a hybrid grid with conventional, renewable, and distributed resources
- System is vulnerable to:
  - Growing energy security risk: The hybrid grid will have less stored fuel and depend more on just-in-time fuel deliveries, and weather. Loss of nuclear plants will intensify the risk to reliability, and put upward pressure on emissions and prices
  - Changing goals for competitive markets: Adapting markets to maintain a reliable resource base and cost-effective pricing while realizing state clean energy goals will be complex



## CONCLUSIONS, *continued*

- ISO New England employs the tools available to it to address the risks posed by a grid dominated by limited energy resources:
  - Competitive market design (e.g., CASPR and multi-day-ahead market)
  - Operational adjustments (e.g., coordination with natural gas industry)
- The ISO is actively taking renewable and distributed resources into account in planning, operations, and markets
- There are still challenges to be addressed
- The region's capacity for innovation and collaboration will be essential during the rapid transformation of the power system

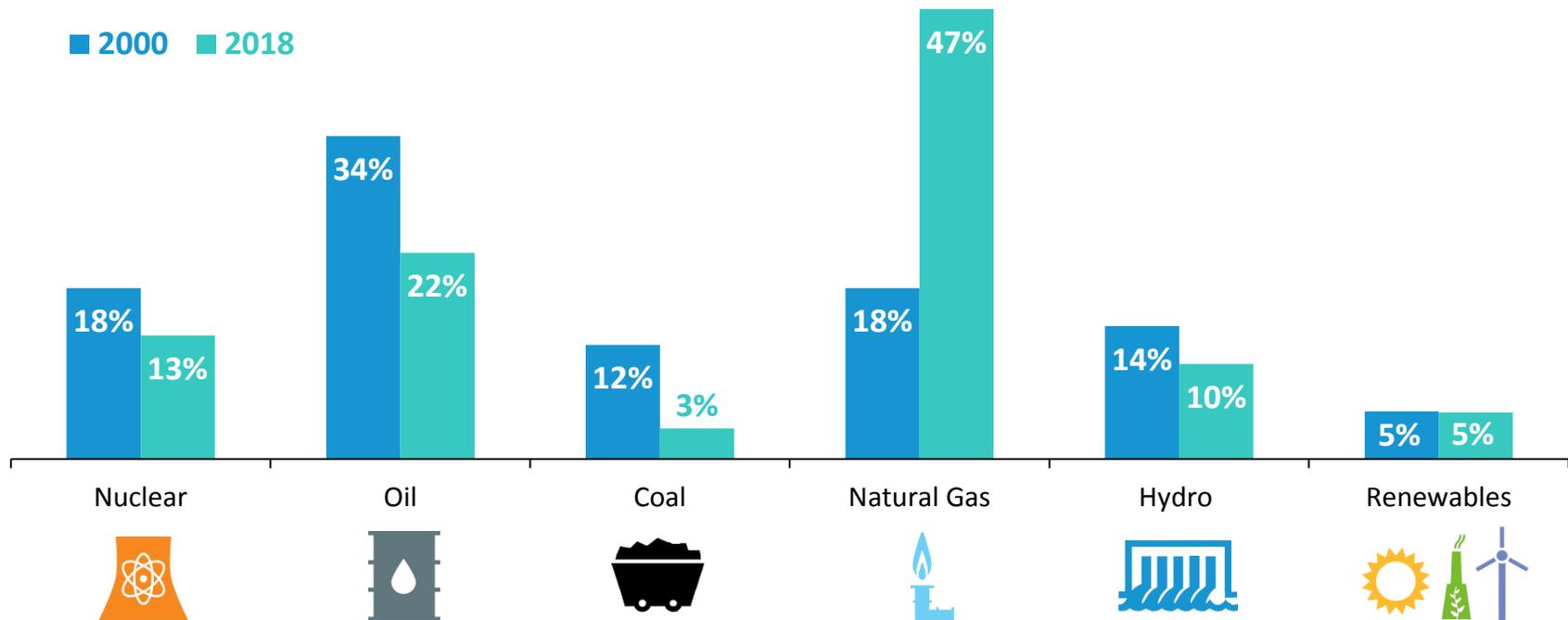
# APPENDIX: 2018 DATA RECAP



# Fleet Continues to Shift Away from Resources with On-site Fuel

*Nuclear, oil- and coal-fired resources retire and are replaced by natural gas & renewables*

Percent of Total System **Capacity** by Fuel Type  
(2000 vs. 2018)



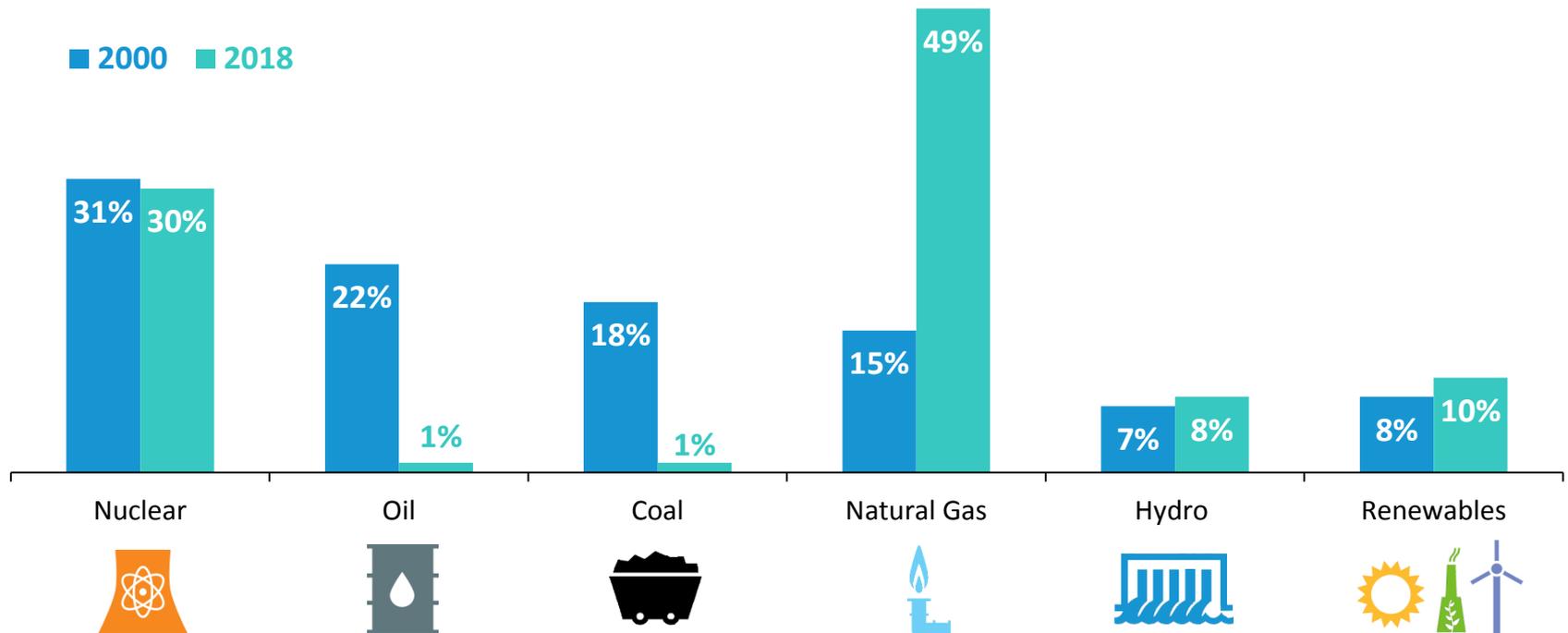
Source: [2018 CELT Report](#), Summer Seasonal Claimed Capability (SCC) Capacity

Renewables include landfill gas, biomass, other biomass gas, wind, grid-scale solar, municipal solid waste, and miscellaneous fuels.

# Dramatic Changes in the Sources of Electricity

*Fuels used to produce the region's electric energy have shifted; now natural gas-fired generators and nuclear power plants produce 79%, combined*

Percent of Total **Electric Energy** Production by Fuel Type  
(2000 vs. 2018)



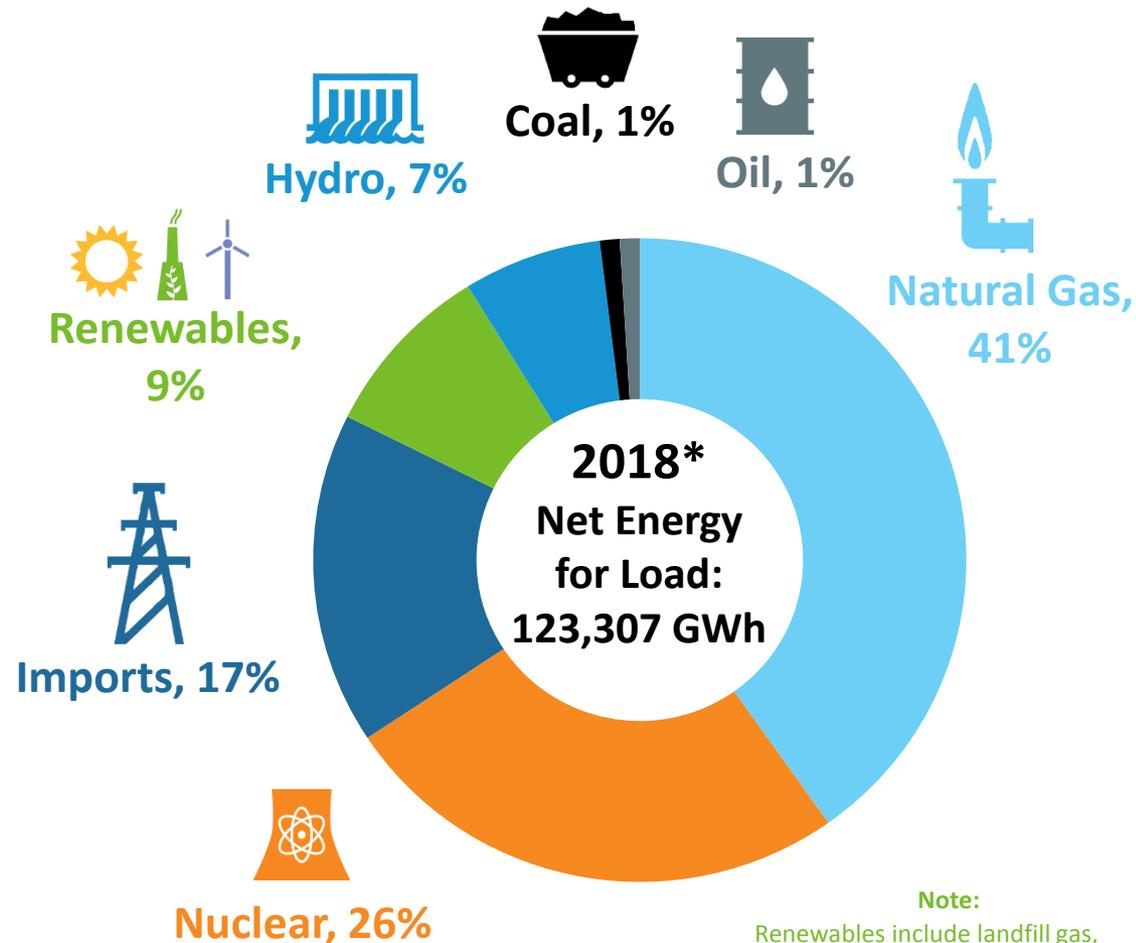
Source: ISO New England [Net Energy and Peak Load by Source](#)

Renewables include landfill gas, biomass, other biomass gas, wind, grid-scale solar, municipal solid waste, and miscellaneous fuels.

This data represents electric generation within New England; it does not include imports or behind-the-meter (BTM) resources, such as BTM solar.

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

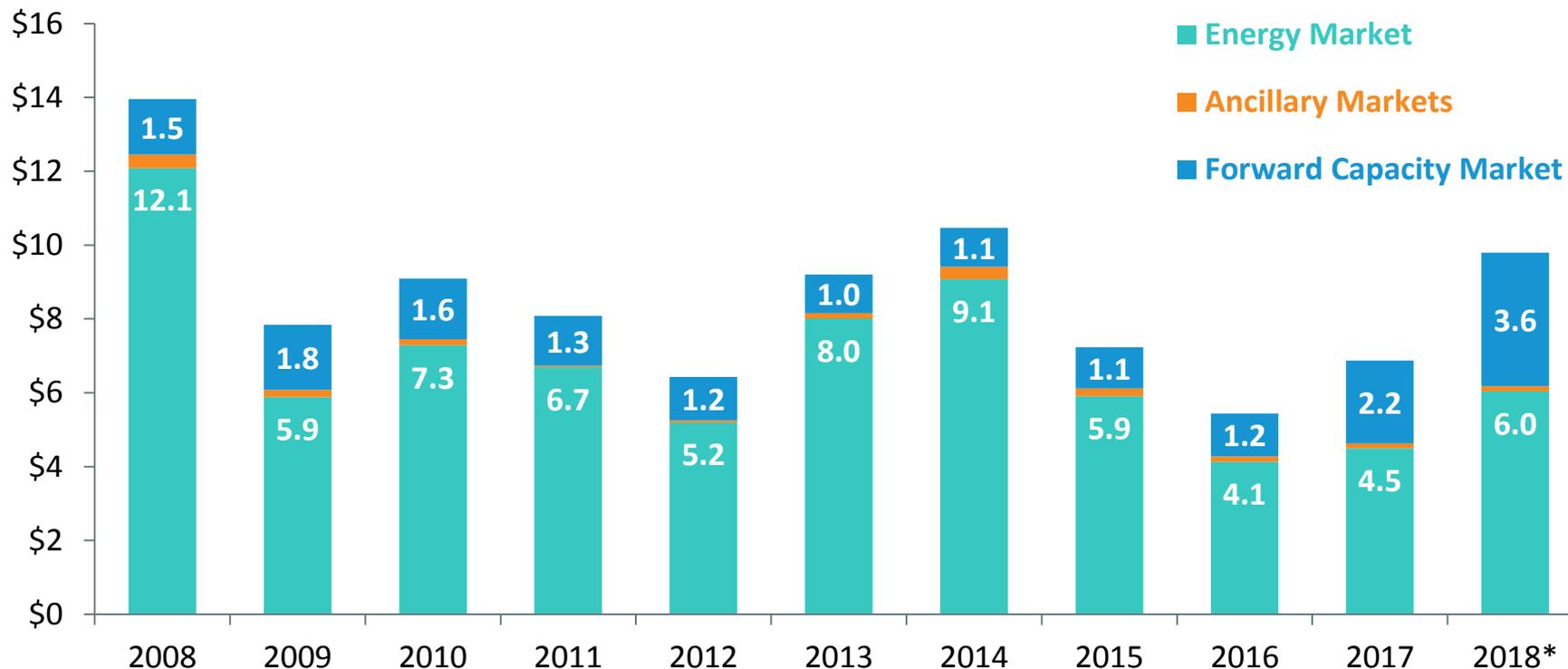
- In 2018, most of the region's energy needs were met by natural gas, nuclear, imported electricity (mostly hydropower from Eastern Canada), renewables, and other low- or non-carbon-emitting resources
- Region is transitioning away from older coal and oil resources



\* Data is preliminary and subject to resettlement

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

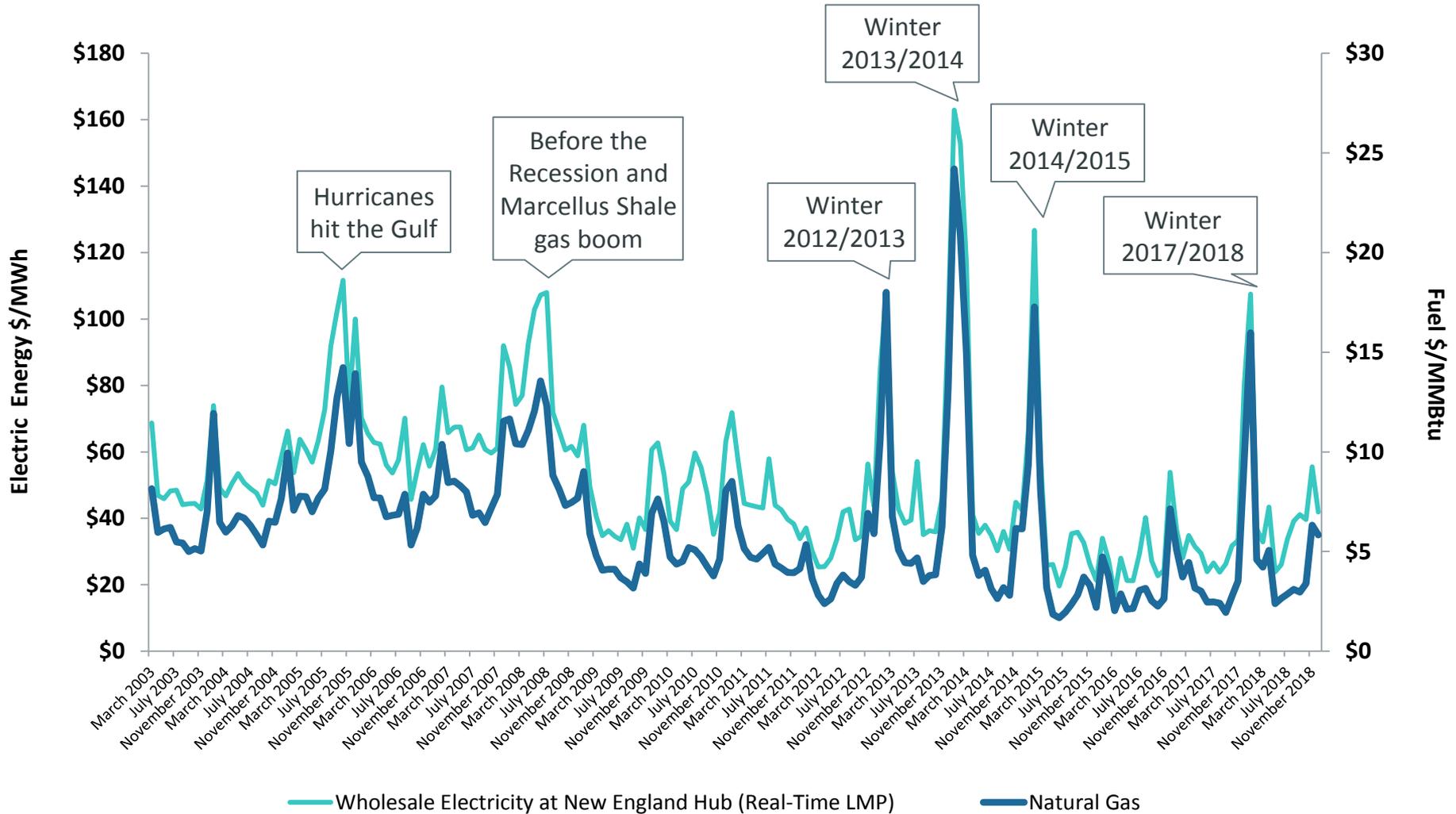
Annual Value of Wholesale Electricity Markets  
(in billions)



Source: [2017 Report of the Consumer Liaison Group](#); \*2018 data is preliminary and subject to resettlement  
Note: Forward Capacity Market values shown are based on auctions held roughly three years prior to each calendar year.

# Natural Gas and Wholesale Electricity Prices Are Linked

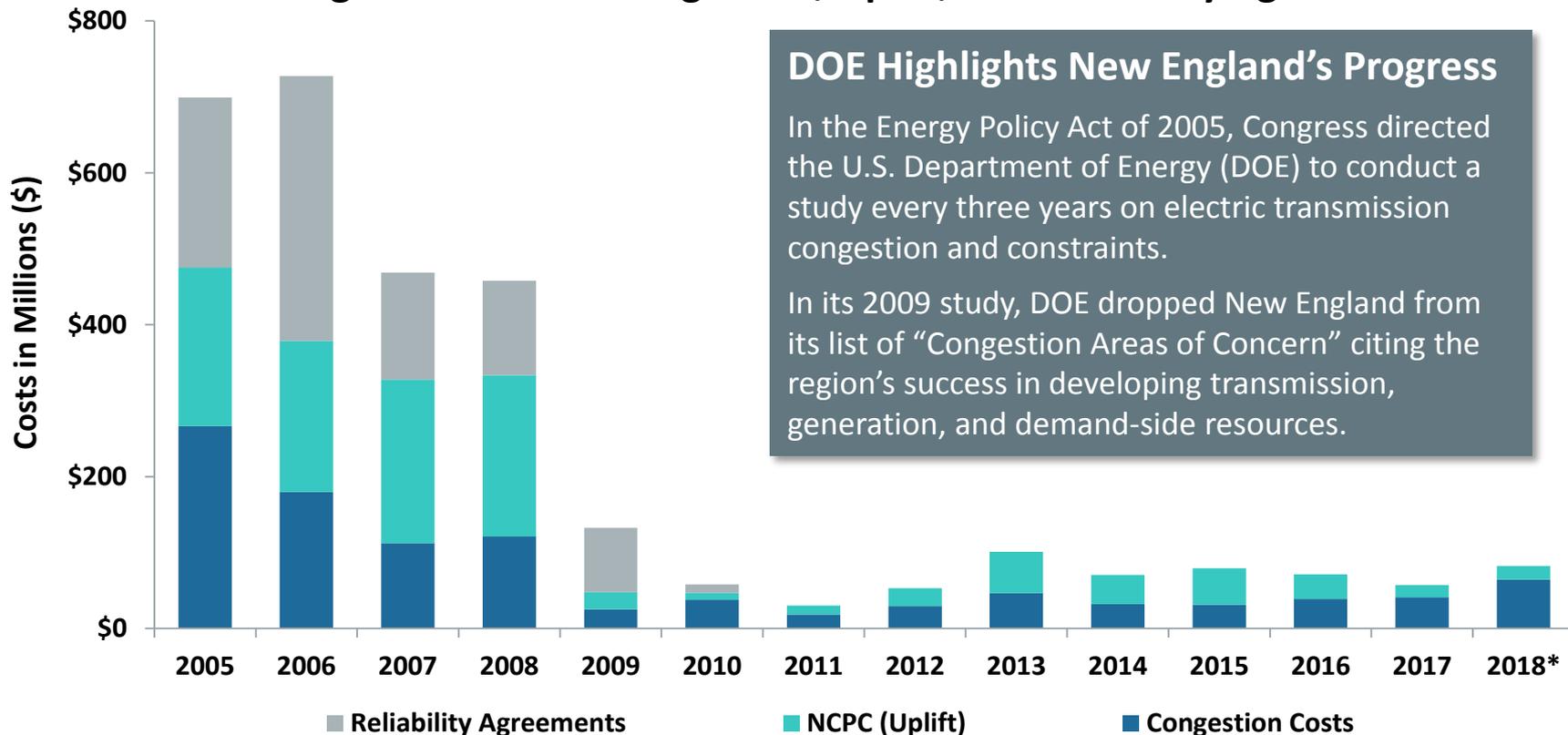
Monthly average natural gas and wholesale electricity prices at the New England hub



# Transmission Investments Improve Reliability and Lower Costs

*\$10.6 billion invested over 20 years*

## New England Costs for Congestion, Uplift, and Reliability Agreements



**DOE Highlights New England's Progress**

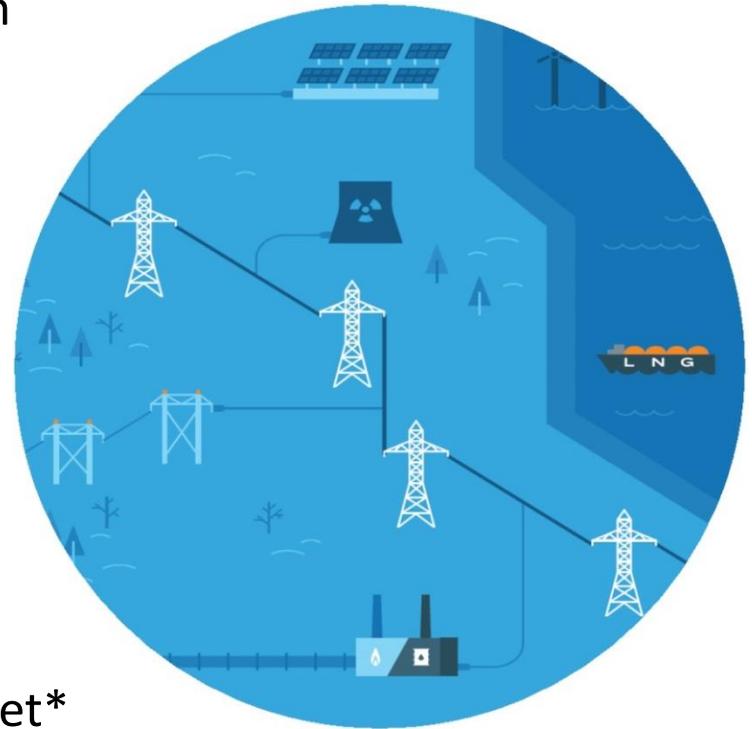
In the Energy Policy Act of 2005, Congress directed the U.S. Department of Energy (DOE) to conduct a study every three years on electric transmission congestion and constraints.

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. \*2018 data subject to adjustment.

# Generation and Demand Resources Are Used to Meet New England's Energy Needs

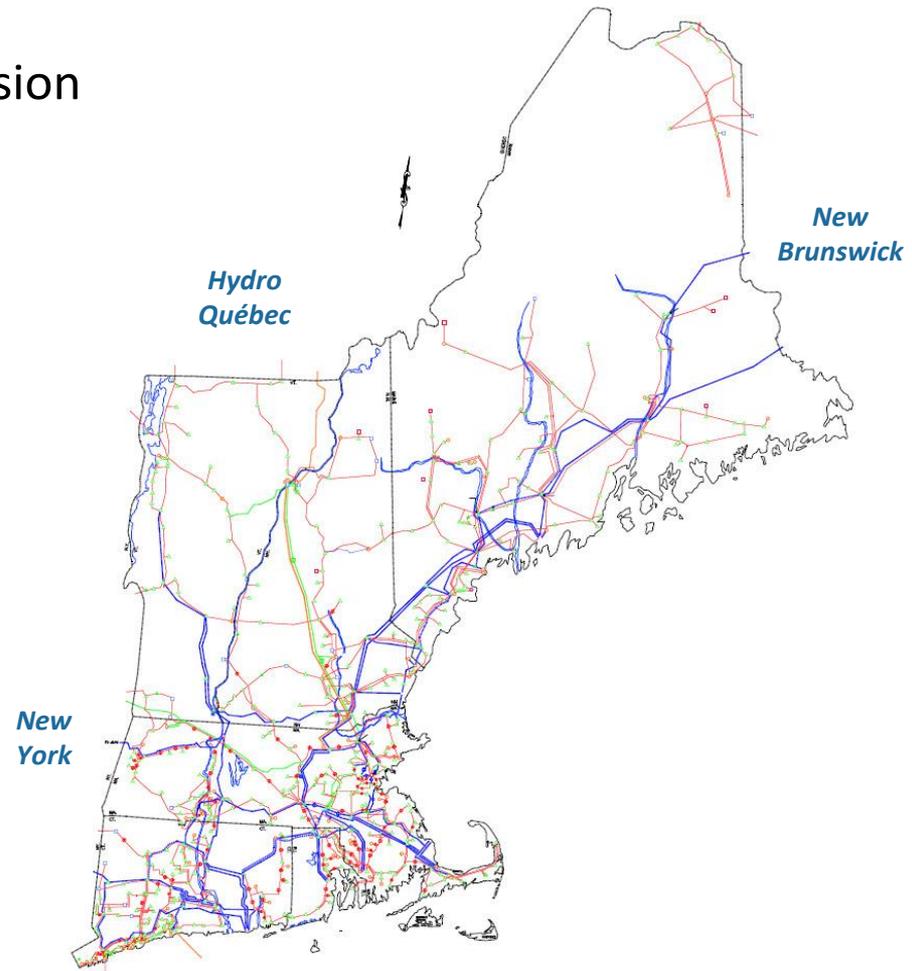
- **350** dispatchable generators in the region
- **31,000 MW** of generating capacity
- **20,600 MW** of proposed generation in the ISO Queue
  - Mostly wind and natural gas
- **5,200 MW** of generation have retired or will retire in the next few years
- **400 MW** of active demand response and **2,500 MW** of energy efficiency with obligations in the Forward Capacity Market\*
  - Effective June 1, 2018, demand resources have further opportunities in the wholesale markets



\* In the Forward Capacity Market, 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 2018
- **\$10.6 billion** invested to strengthen transmission system reliability since 2002; **\$1.7 billion** planned
- Developers have proposed multiple transmission projects to access **non-carbon-emitting resources** inside and outside the region



# Demand Patterns Are Changing



- **7.2 million** retail electricity customers drive the demand for electricity in New England (14.8 million population)
  - Region's all-time summer peak demand: **28,130 MW** on August 2, 2006
  - Region's all-time winter peak demand: **22,818 MW** on January 15, 2004
- Energy efficiency (EE) and behind-the-meter (BTM) solar are **reducing** peak demand growth and overall electricity use over the next ten years
  - **-0.2%** annual growth rate for summer peak demand (with EE and BTM solar)
  - **-0.9%** annual growth rate for overall electricity use (with EE and BTM solar)
- BTM solar is **shifting** peak demand later in the day in the summertime

Note: Without energy efficiency and solar, the region's peak demand is forecasted to grow 0.8% annually and the region's overall electricity demand is forecasted to grow 0.9% annually. Summer peak demand is based on the "90/10" forecast for extreme summer weather.

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

## Energy Market

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

## Ancillary Markets

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

## Forward Capacity Market

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

# Power Plant Emissions Have Declined with Changes in the Fuel Mix



## *Reduction in Aggregate Emissions (ktons/yr)*

Year	NO <sub>x</sub>	SO <sub>2</sub>	CO <sub>2</sub>
2001	59.73	200.01	52,991
2017	15.30	4.00	34,969
<b>% Reduction, 2001–2017</b>	<b>↓ 74%</b>	<b>↓ 98%</b>	<b>↓ 34%</b>

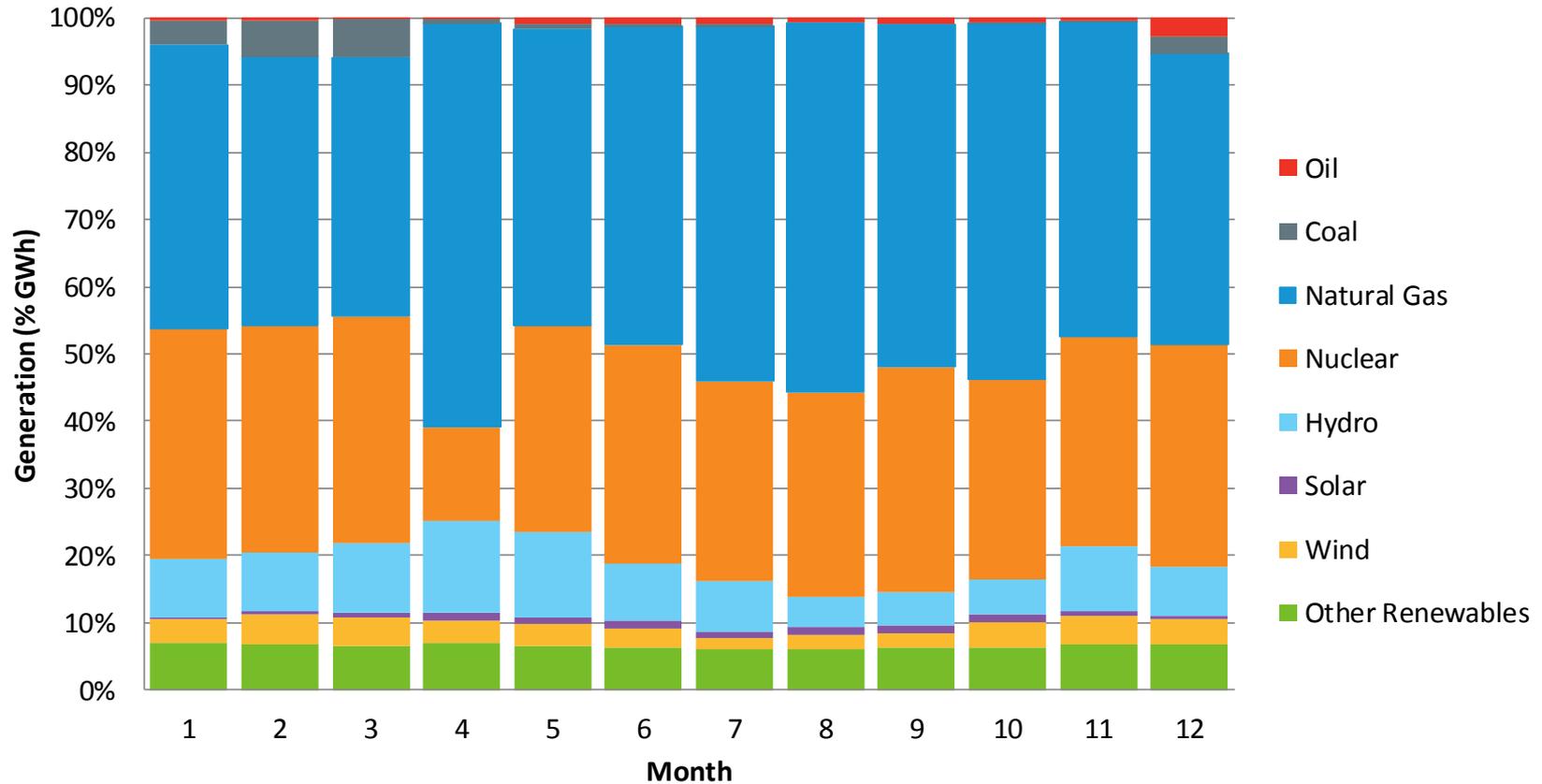
## *Reduction in Average Emission Rates (lb/MWh)*

Year	NO <sub>x</sub>	SO <sub>2</sub>	CO <sub>2</sub>
1999	1.36	4.52	1,009
2017	0.30	0.08	682
<b>% Reduction, 1999–2017</b>	<b>↓ 78%</b>	<b>↓ 98%</b>	<b>↓ 32%</b>

Source: [Draft 2017 ISO New England Electric Generator Air Emissions Report](#), December 2018

# 2017 Monthly Generation by Fuel Type (% GWh)\*

*Oil use increased during the last week of December during cold spell*



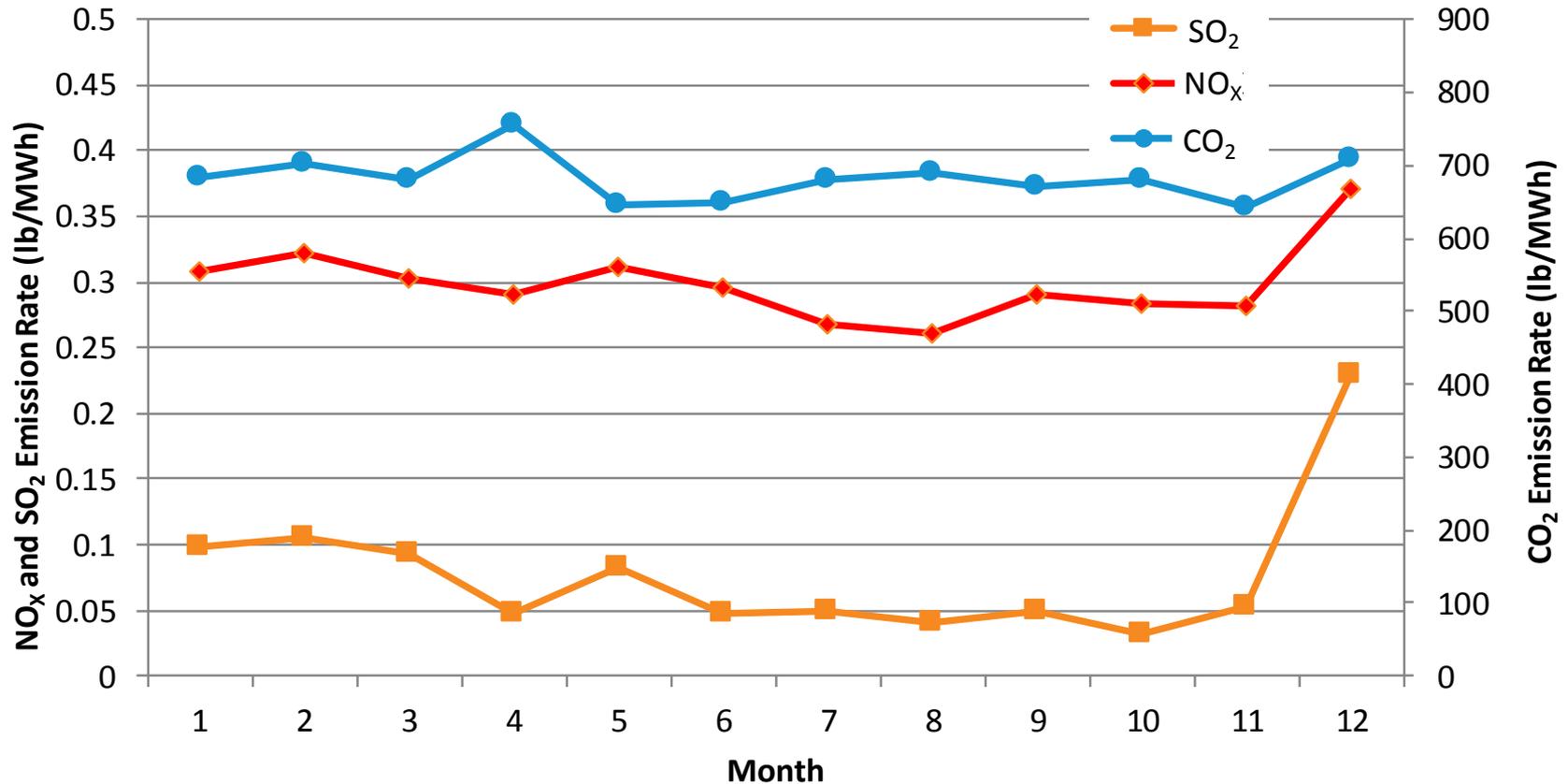
\*Data are preliminary

Source: [2017 ISO-NE Electric Generator Air Emissions Report \(draft\)](#), December 2018

Note: ISO New England generators, not including behind-the-meter (BTM) generators, such as BTM PV

# 2017 ISO-NE Average Monthly System Emission Rates (lb/MWh)\*

*Emission rates increased in December due to increased use of oil*

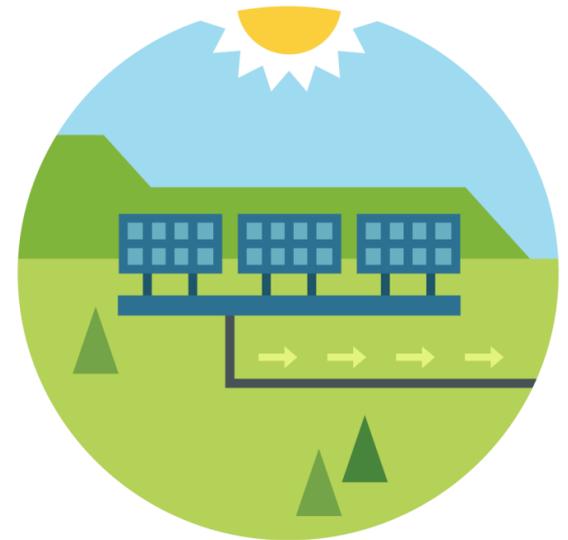


\*Data are preliminary

Source: [2017 ISO-NE Electric Generator Air Emissions Report \(draft\)](#), December 2018

# The ISO Is Leading Efforts to Account for Solar Resources Connected to the Distribution System

- **Forecasting Long-Term Solar Growth**
  - The ISO tracks historical growth and predicts levels of solar development 10 years into the future
  - The solar forecast is used in transmission planning and market needs assessments
- **Forecasting Short-Term Solar Performance**
  - The ISO creates daily forecasts of solar generation production to improve daily load forecasts and situational awareness for grid operators
- **Improving Interconnection Rules**
  - The ISO is engaged with industry stakeholders to strengthen interconnection standards and reduce reliability concerns



# ISO is Continuing to Improve the Ability of Intermittent Resources to Participate in the Wholesale Markets

- **Flexibility to Offer Negative Prices**
  - Allows generators, like wind, the opportunity to operate during low-load conditions when they otherwise might be curtailed
- **Updated Elective Transmission Upgrade (ETU) Rules**
  - Improve the interconnection study process for ETUs and ensure these resources are able to deliver capacity and energy into the wholesale electricity markets
- **Flexibility to Operate Up to a Certain Level**
  - Allows the ISO to better manage transmission congestion in a way that will maximize the use of low-cost renewable resources and alleviate the need for curtailments
  - Known as “Do-not-Exceed Dispatch Order”



# FOR MORE INFORMATION...



## Subscribe to the *ISO Newswire*

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## Log on to ISO Express

[ISO Express](#) provides real-time data on New England's wholesale electricity markets and power system operations



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## Download the ISO to Go App

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