FEBRUARY 27, 2018

# State of the Grid: 2018

*ISO on Background*

Gordon van Welie

PRESIDENT & CEO, ISO NEW ENGLAND INC.

# About the *ISO on Background* Series

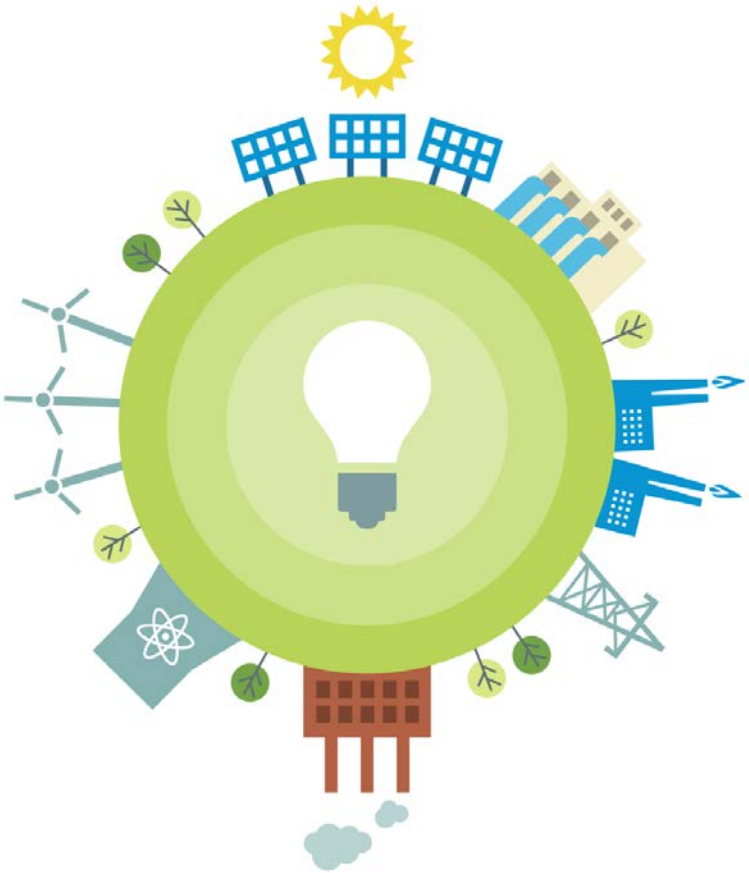
- Informal opportunity for media to learn more about trends affecting New England's electricity industry
- Hosted by ISO New England senior management
- **Content is on the record**
- Please hold questions until the Q&A session at the end of the presentation
- Presentation and remarks will be posted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

# Agenda

- 10:30 to 10:35 a.m. **Welcome**
  Ellen Foley, director, Corporate, Media, and Web Communications
- 10:35 to 11:05 a.m. **State of the Grid: 2018**
  Gordon van Welie, president and CEO
- 11:05 to 11:30 a.m. **Question-and-Answer Session**

# Overview of State of the Grid: 2018

- New England's Power System Today
- The Changing Grid
- Fuel Security
  - 2017/2018 Arctic Cold Spell
  - *Operational Fuel-Security Analysis*
- Setting the Stage for the Future
- Conclusions
- Q & A
- Appendix: Additional Data



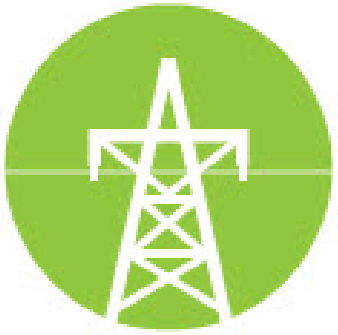
# STATE OF THE GRID: KEY TAKEAWAYS

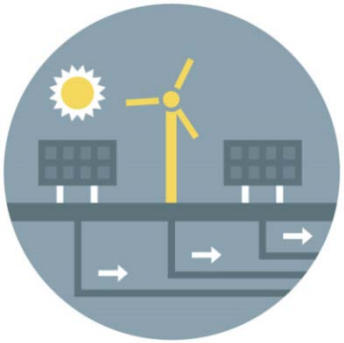
# State of the Grid 2018: Key Takeaways

- **New England's power grid is operating reliably and competitive markets are working, but challenges are looming**
- **Competitive wholesale markets:**
  - **Benefits**
    - **Reliability:** Market revenues are sufficient to retain and attract the resources needed
    - **Competitively priced, clean energy:** Competition incentivizes efficiency
      - Fewer emissions
      - Lower operating costs
    - **Investment risk:** Private developers bear the impacts of poor decisions, not ratepayers
  - **Challenges**
    - **Fuel security:** Constraints aren't priced
    - **Price formation:** Resources with state contracts have above-market revenue

# State of the Grid 2018: Key Takeaways *(continued)*

- **Fuel security is the greatest challenge to continued power system reliability**
  - 2017/2018 cold snap and the *Operational Fuel-Security Analysis*
  - Taking action will be costly; inaction will also come at a cost
- **Transmission investments bring benefits**
- **ISO New England and stakeholders will build on the region's history of strong collaboration**

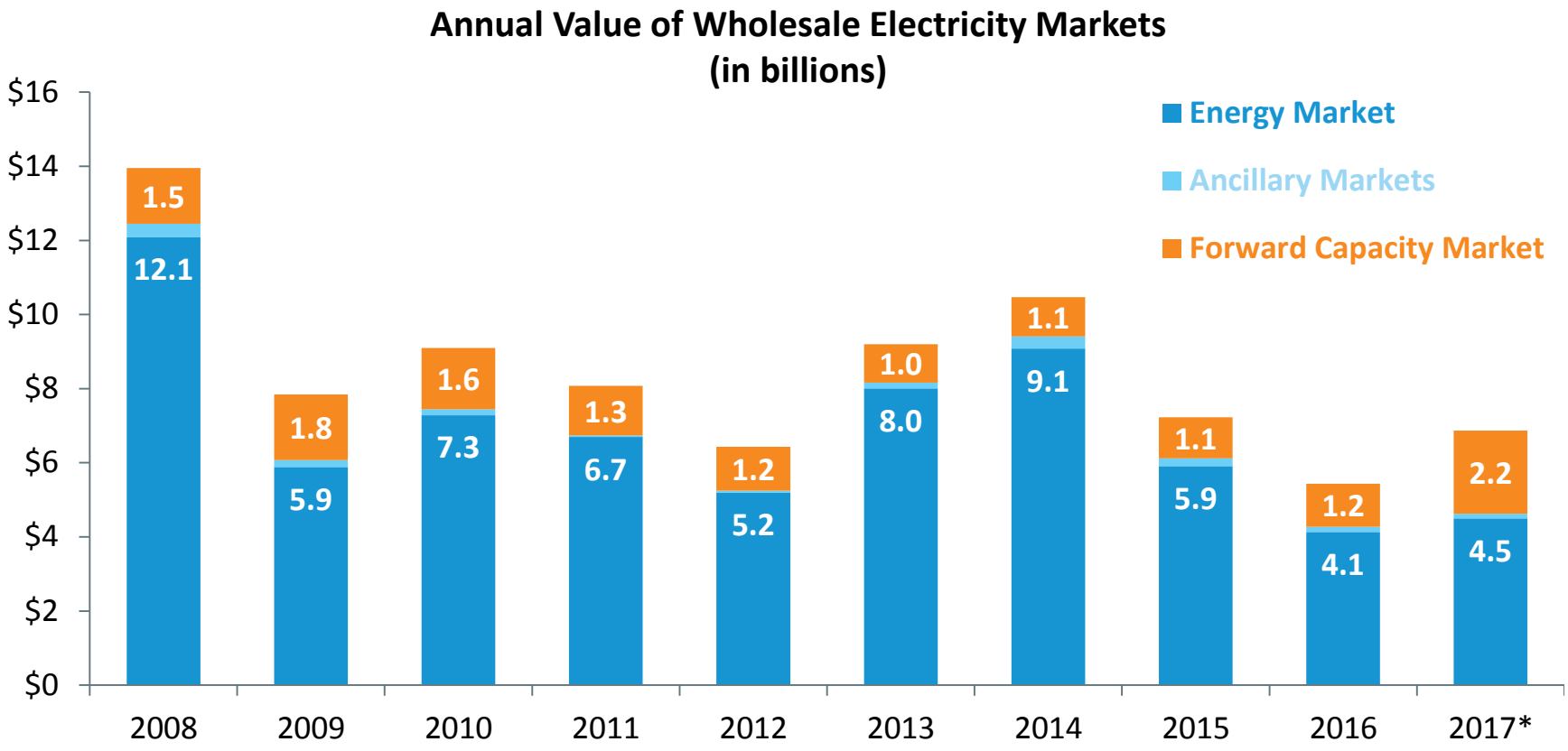




# STATE OF THE GRID: NEW ENGLAND'S POWER SYSTEM TODAY

# 2017: Second-Lowest Energy Prices Since 2003

*Competitive markets produce low prices when low-priced fuel can be delivered, and a robust transmission system provides access to the lowest-cost resources*

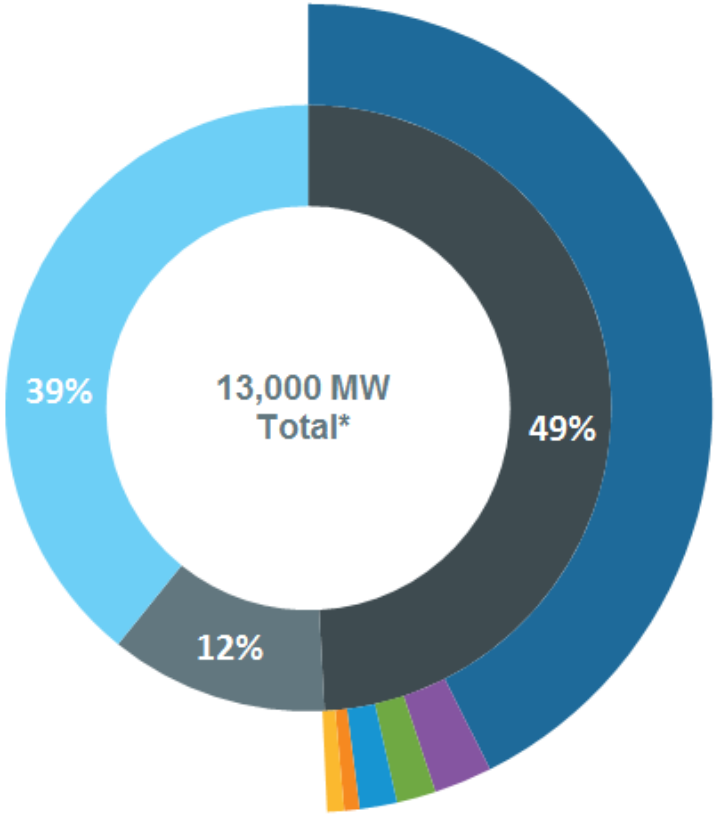



Source: 2016 Report of the Consumer Liaison Group; *2017 data is preliminary and subject to resettlement
Note: Forward Capacity Market values shown are based on auctions held roughly three years prior to each calendar year.

# The Forward Capacity Market Is Attracting New Resources Amid Retirements

## New Regional Power Resources Procured in FCAs #1–12*

- New natural gas (5,100 MW)
- New oil, coal, jet fuel, & kerosene (1,500 MW)
- Renewables & other new resource types (6,400 MW)*
  - New EE & other demand resources (5,500 MW)
  - New wind (300 MW)
  - Other new renewables (200 MW)
  - New hydro (200 MW)
  - New nuclear (80 MW)
  - New solar (90 MW)

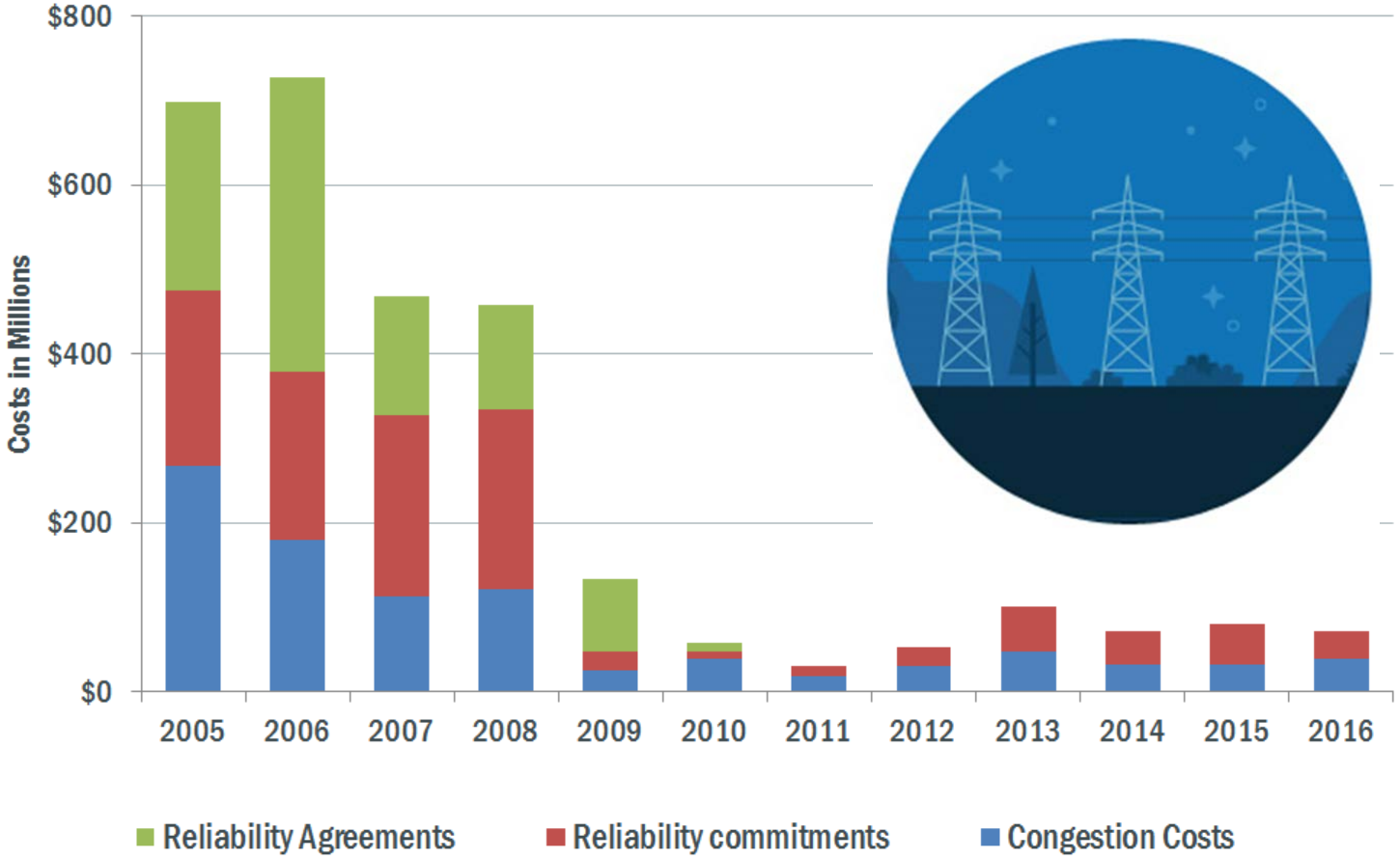



Note: Numbers are rounded.

*FCA #12 data are preliminary. Not included as new capacity here are imports (because most existing imports must requalify as new for each FCA) and the demand-resource type once known as real-time emergency generation.

# Transmission Investments Improve Reliability

*$10 billion invested, reliability enhanced, congestion & reliability costs a fraction of former levels*

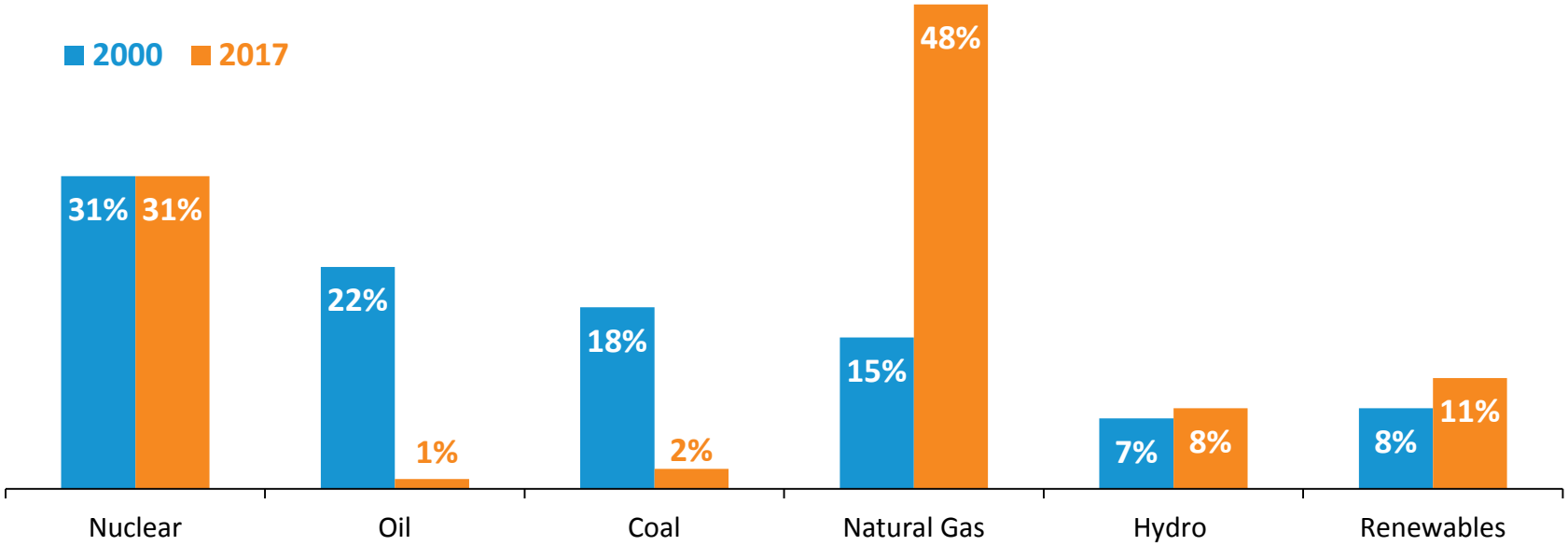



Note: Reliability agreements have not been used in the region since 2010.
Source: ISO New England

# Dramatic Changes in the Energy Mix

*The fuels used by New England's power plants to generate electricity have shifted as a result of economic and environmental factors*

Percent of Total **Electric Energy** Production by Fuel Type
(2000 vs. 2017)

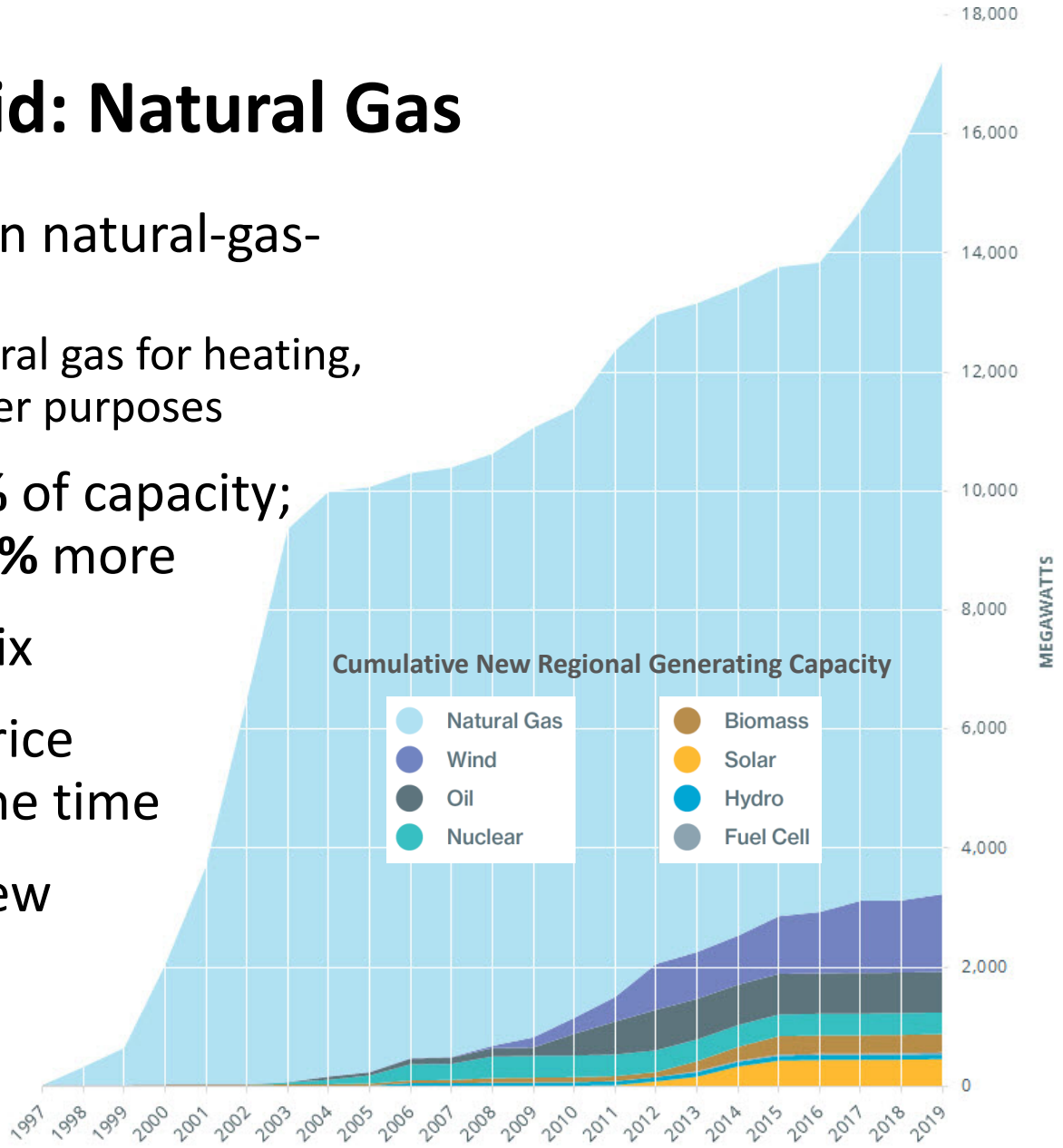



Source: ISO New England Net Energy and Peak Load by Source
Renewables include landfill gas, biomass, other biomass gas, wind, solar, municipal solid waste, and miscellaneous fuels

# STATE OF THE GRID: THE CHANGING GRID

# The Changing Grid: Natural Gas

- Increased reliance on natural-gas-fired generation
  - Growing use of natural gas for heating, generation, and other purposes
- Primary fuel for **45%** of capacity; alternate fuel for **11%** more
- **48%** of 2017 fuel mix
- Sets the real-time price more than **75%** of the time
- **31%** of proposed new generating capacity

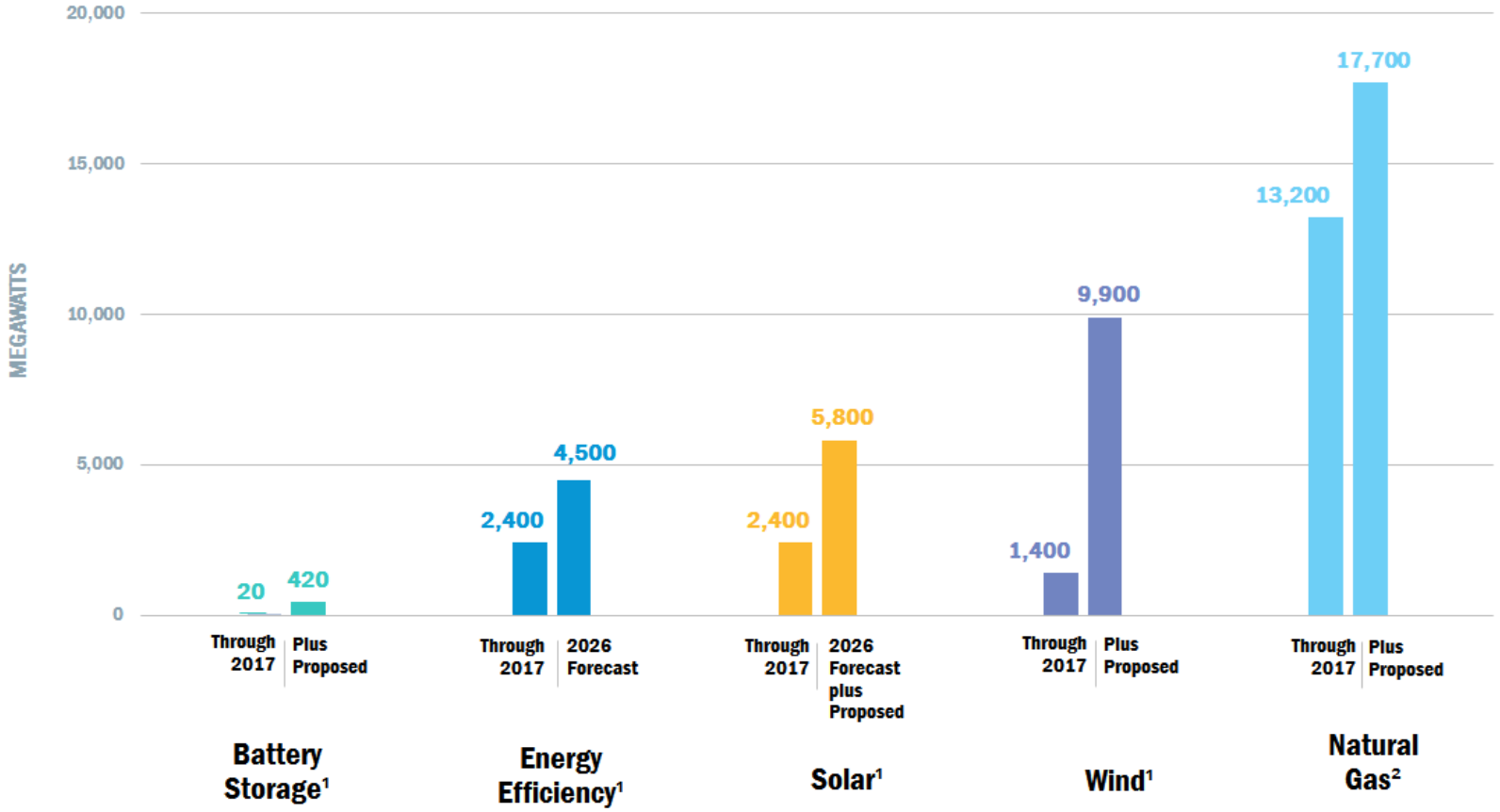



Note: New generating capacity for years 2016–2019 includes resources clearing in recent Forward Capacity Auctions.

# The Changing Grid: Retirements of Coal, Oil, and Nuclear Resources

- 4,600 MW of coal, oil, & nuclear resources have or will retire 2013-2021 – 16% of total generating capacity
- Oil- & coal-fired plants produced just 3% of NE's generation in 2017, but still make up 26% of generating capacity
  - Still needed when demand peaks or natural gas is in short supply or more costly
- Nuclear plants make up 14% of capacity, but produced 31% of NE's generation
  - Pilgrim (680 MW) will retire by 2019
- More than 5,000 MW of remaining coal- & oil-fired generation is at risk

# The Changing Grid: Wind, Solar, Energy Efficiency, & Energy Storage




Notes: Numbers are rounded. Not all proposed new projects are built;.

[1] Nameplate capacity.

[2] Nameplate capacity for proposed projects; summer seasonal claimed capability for existing units based on primary fuel type. Does not include oil units that can switch to natural gas.

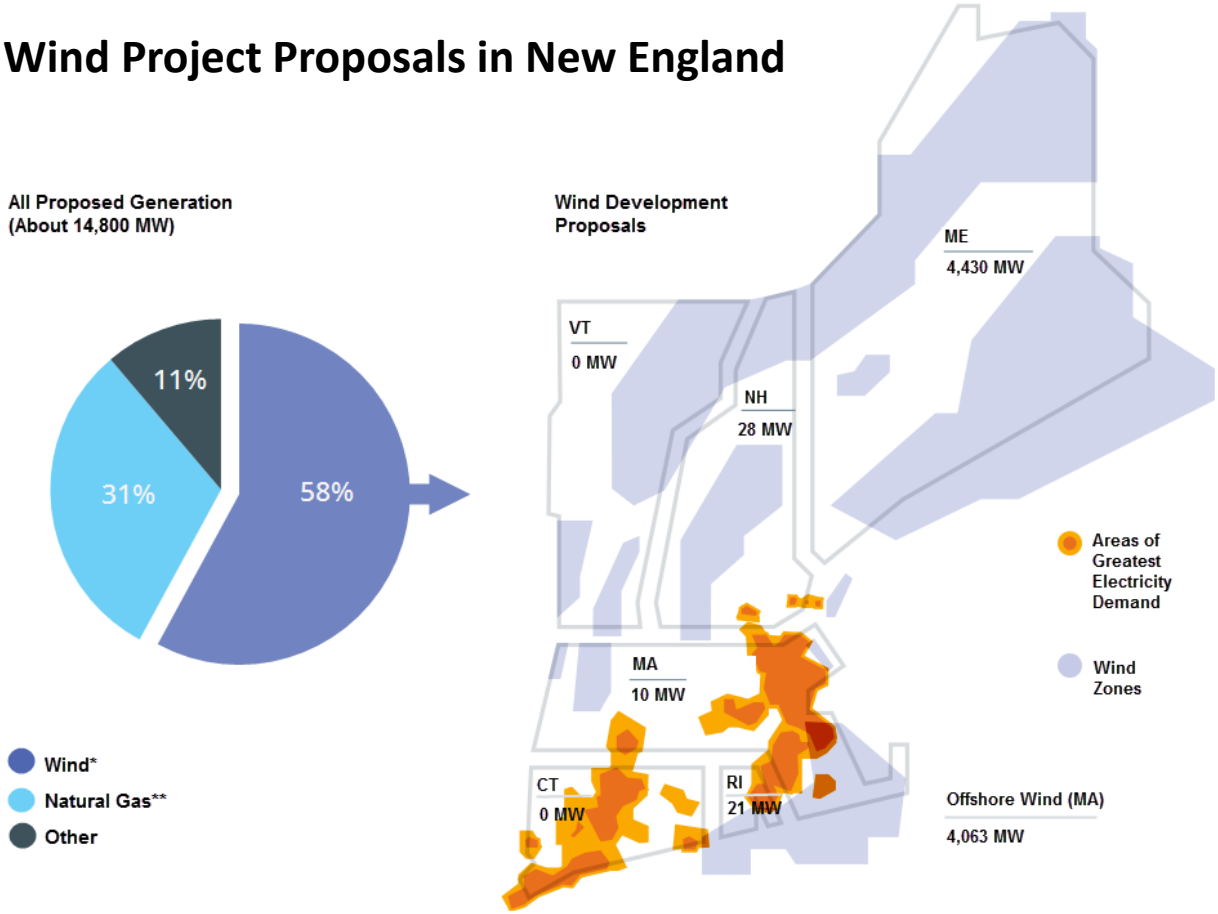
Sources: ISO New England, *ISO-NE Generator Interconnection Queue* (January 29, 2018), *CELT Report* (2010, 2016, 2017), *Final 2017 ISO-NE Solar PV Forecast,* and *Final Energy-Efficiency Forecast Report for 2021 to 2026,* and *Seasonal Claimed Capability Monthly Report* (January 2018)

# The Changing Grid: Wind

*More than half of the proposed new projects in the region are wind*

- **Onshore wind** has grown from 375 MW in 2011 to more than 1,300 MW today
- **8,600 MW** is proposed (half onshore, half offshore)

## Wind Project Proposals in New England




*Some wind and solar projects include battery storage.
**Some natural-gas projects include dual-fuel units (typically oil).

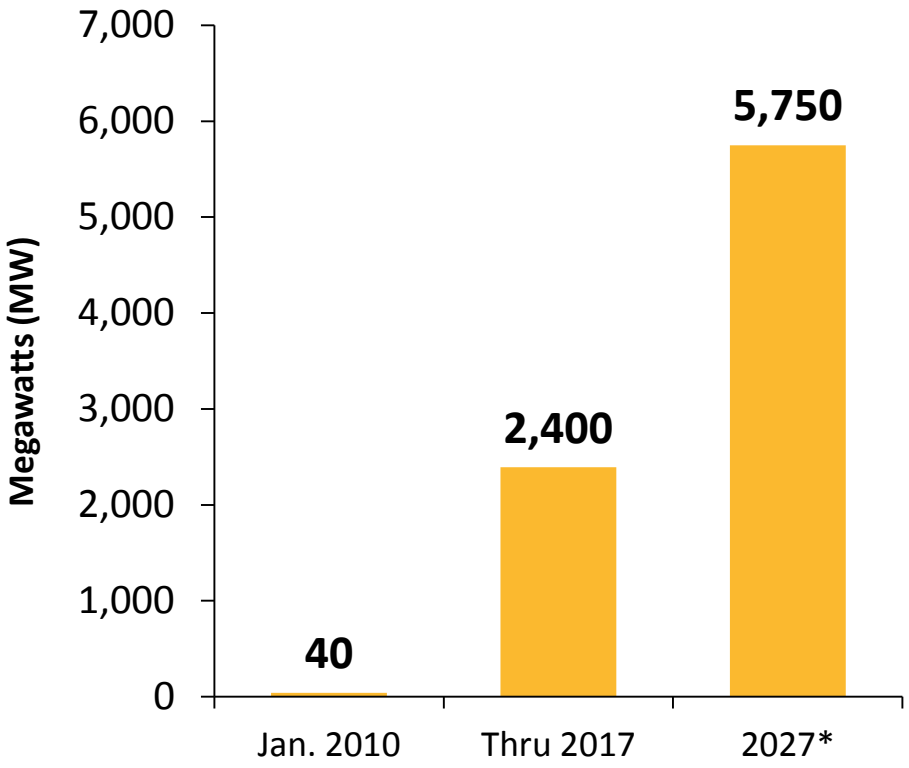
Source: ISO New England, *ISO Generator Interconnection Queue* (January 29, 2018)

# The Changing Grid: Solar PV

## December 2017 Solar PV Installed Capacity ($MW_{ac}$)

| State | Installed Capacity ($MW_{ac}$) | No. of Installations |
|---|---|---|
| Connecticut | 365.6 | 29,512 |
| Massachusetts | 1,602.3 | 78,047 |
| Maine | 33.5 | 3,598 |
| New Hampshire | 69.7 | 7,330 |
| Rhode Island | 62.2 | 4,148 |
| Vermont | 257.2 | 9,773 |
| **New England** | **2,390.5** | **132,408** |

## Cumulative Growth in Solar PV through 2027 ($MW_{ac}$)



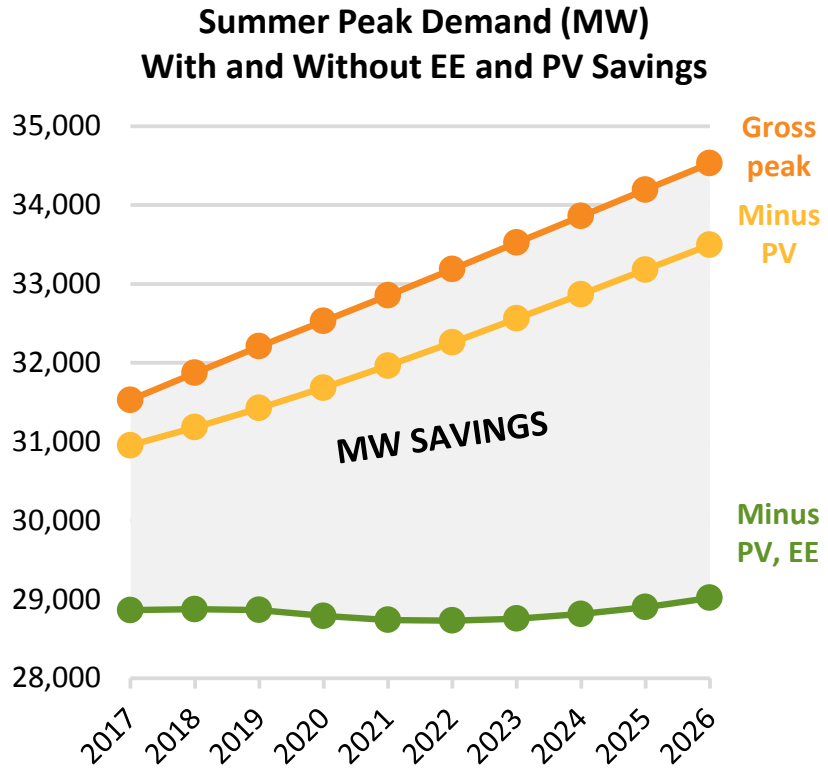

Note: The bar chart reflects the ISO's projections for nameplate capacity from PV resources participating in the region's wholesale electricity markets, as well as those connected "behind the meter." *Source: Draft 2018 PV Forecast (February 2018); MW values are AC nameplate.

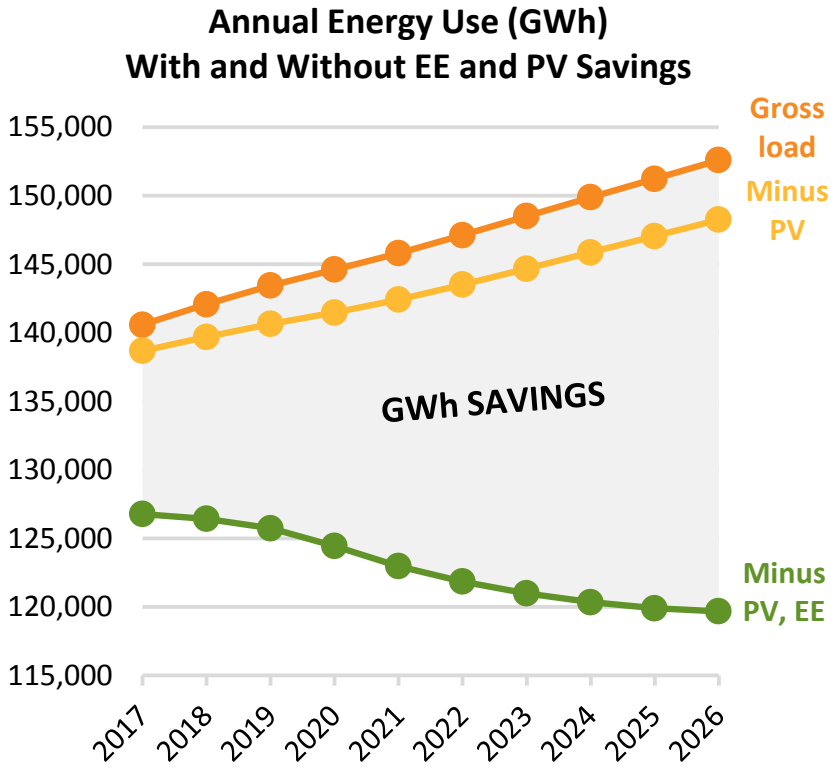
# The Changing Grid: Energy Storage

- Battery storage projects totaling more than 400 MW of capacity have requested interconnection to the regional power system
  - Currently 20 MW of battery storage on the system

- New England has benefited from grid-scale electrical energy storage capabilities for more than 40 years
  - Two pumped-storage facilities built in the 1970s can supply 1,800 MW within 10 minutes, for up to seven hours

# The Changing Grid: Energy Efficiency, PV, Annual Usage and Peak Demand



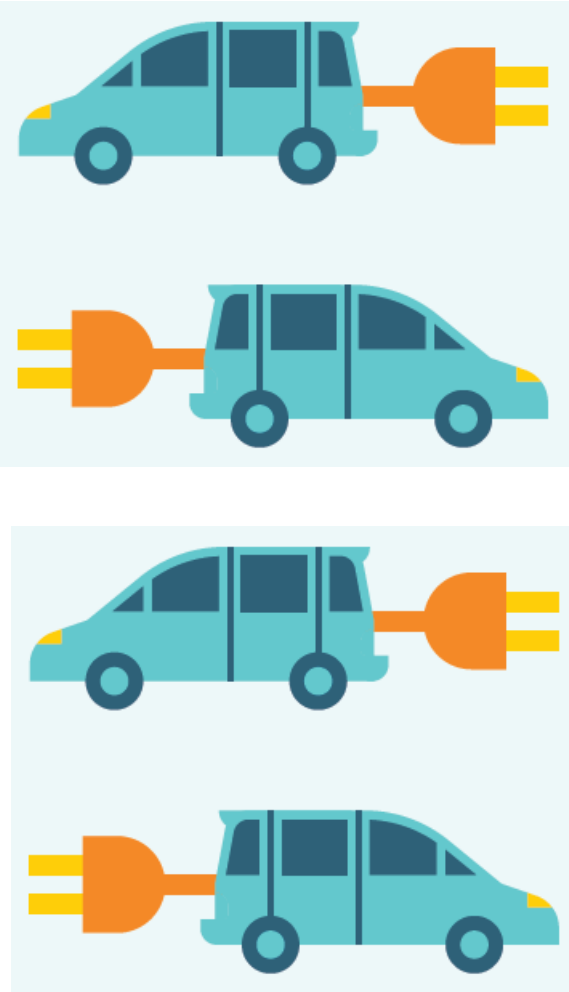




- **The gross peak and load forecast**
- **The gross peak and load forecast minus forecasted "behind-the-meter" (BTM) solar PV resources**
- **The gross peak and load forecast minus forecasted BTM solar PV, minus energy-efficiency (EE) resources in the Forward Capacity Market 2017-2020 and forecasted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

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

# The Changing Grid: Decarbonization

- New England states have decarbonization goals
- Decarbonization of transportation and heating could impact the grid
- Increased adoption of electric vehicles (EVs) across the region and greater use of electric heating could increase demand for power
- The ISO plans to start working this year with regional stakeholders to quantify the impact of the states' decarbonization policies on long-term demand

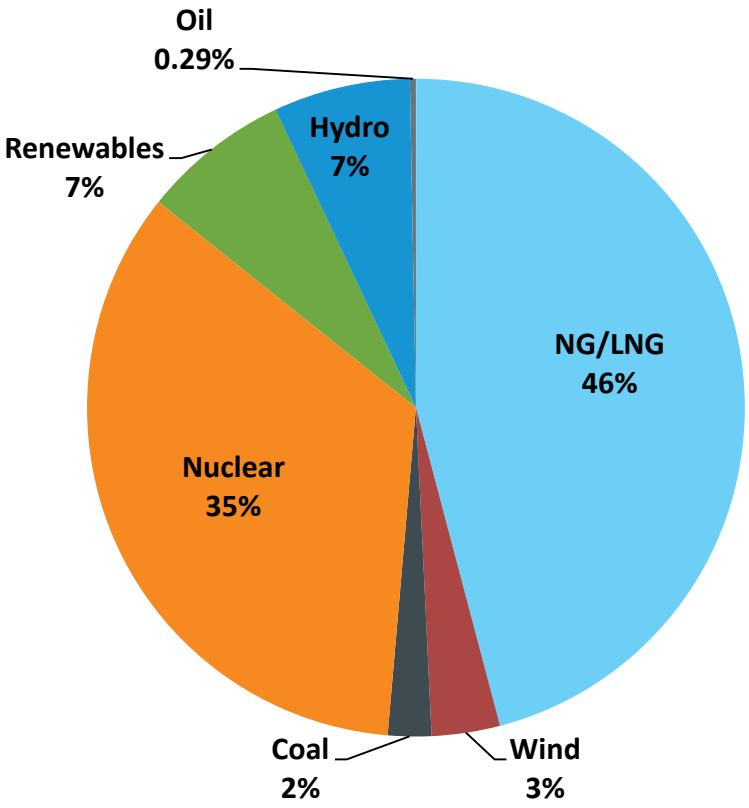


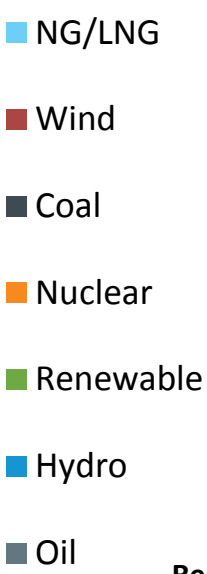
# STATE OF THE GRID: FUEL SECURITY – 2017/2018 ARCTIC COLD SPELL

# Shifting Fuel Mix Before and During the Two-Week Outbreak of Arctic Cold

**BEFORE**

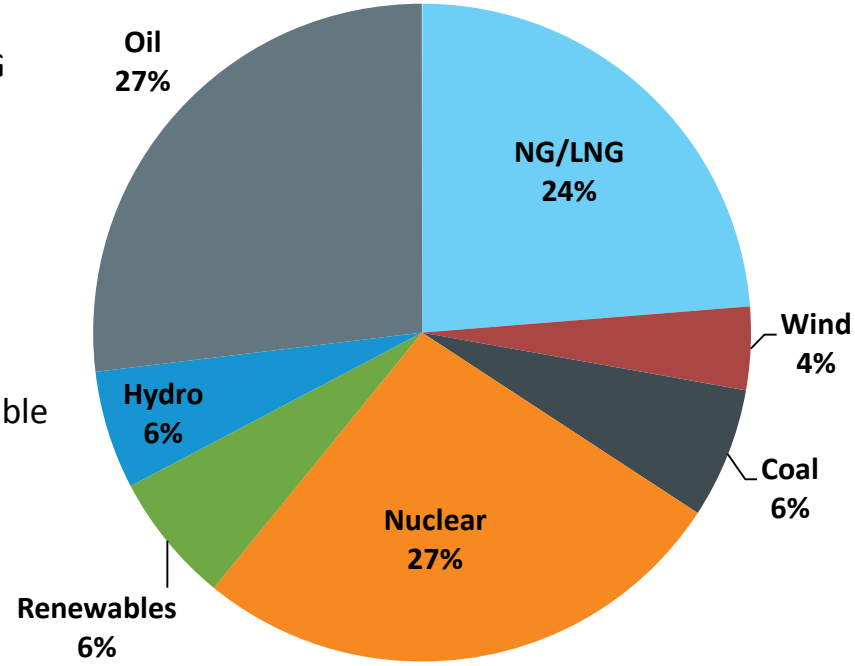
*12/1 thru 12/25/2017*



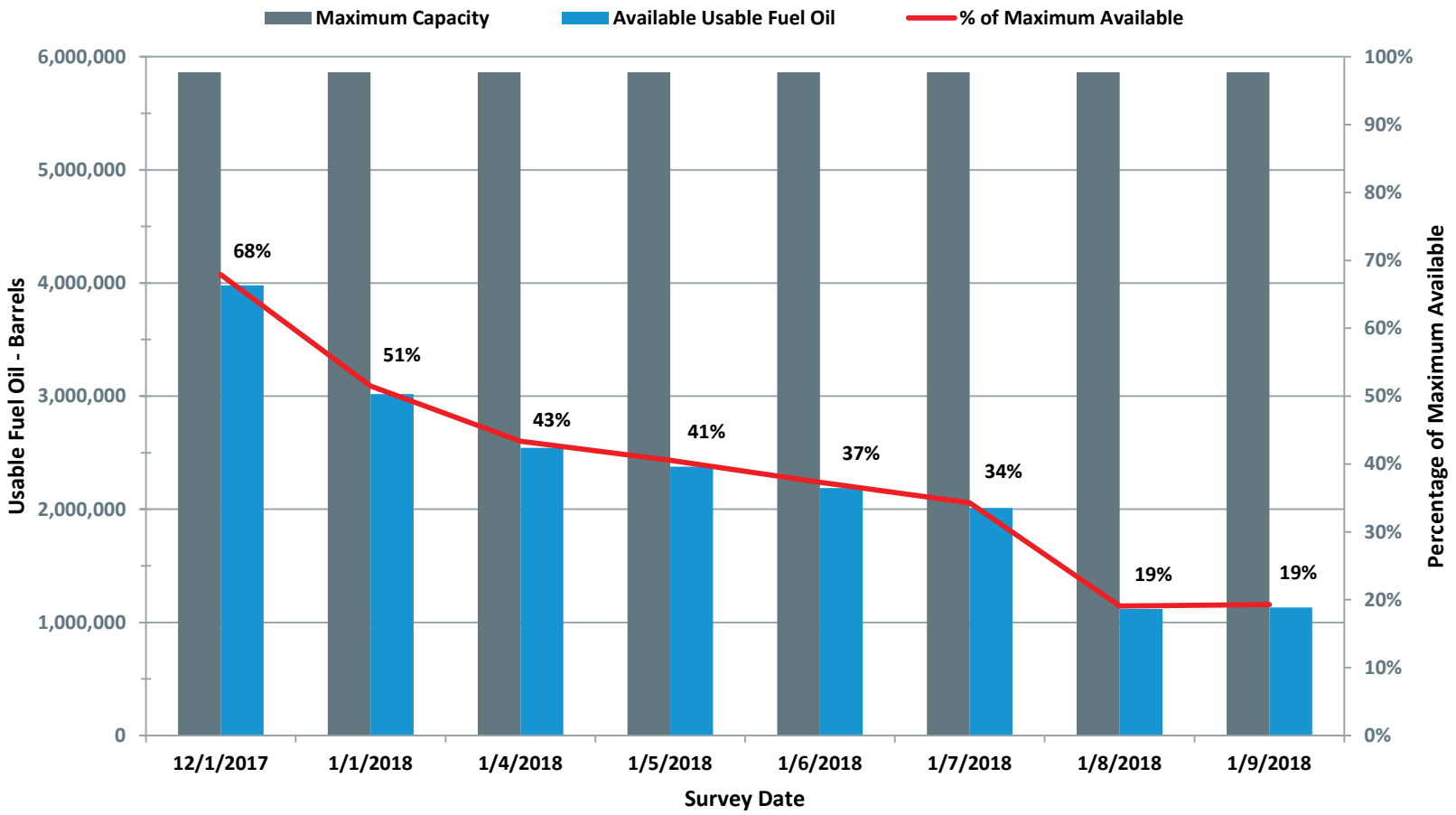

**DURING**

*12/26/17 thru 1/8/2018*



# Fuel Oil Inventories Declined Rapidly in Two Weeks

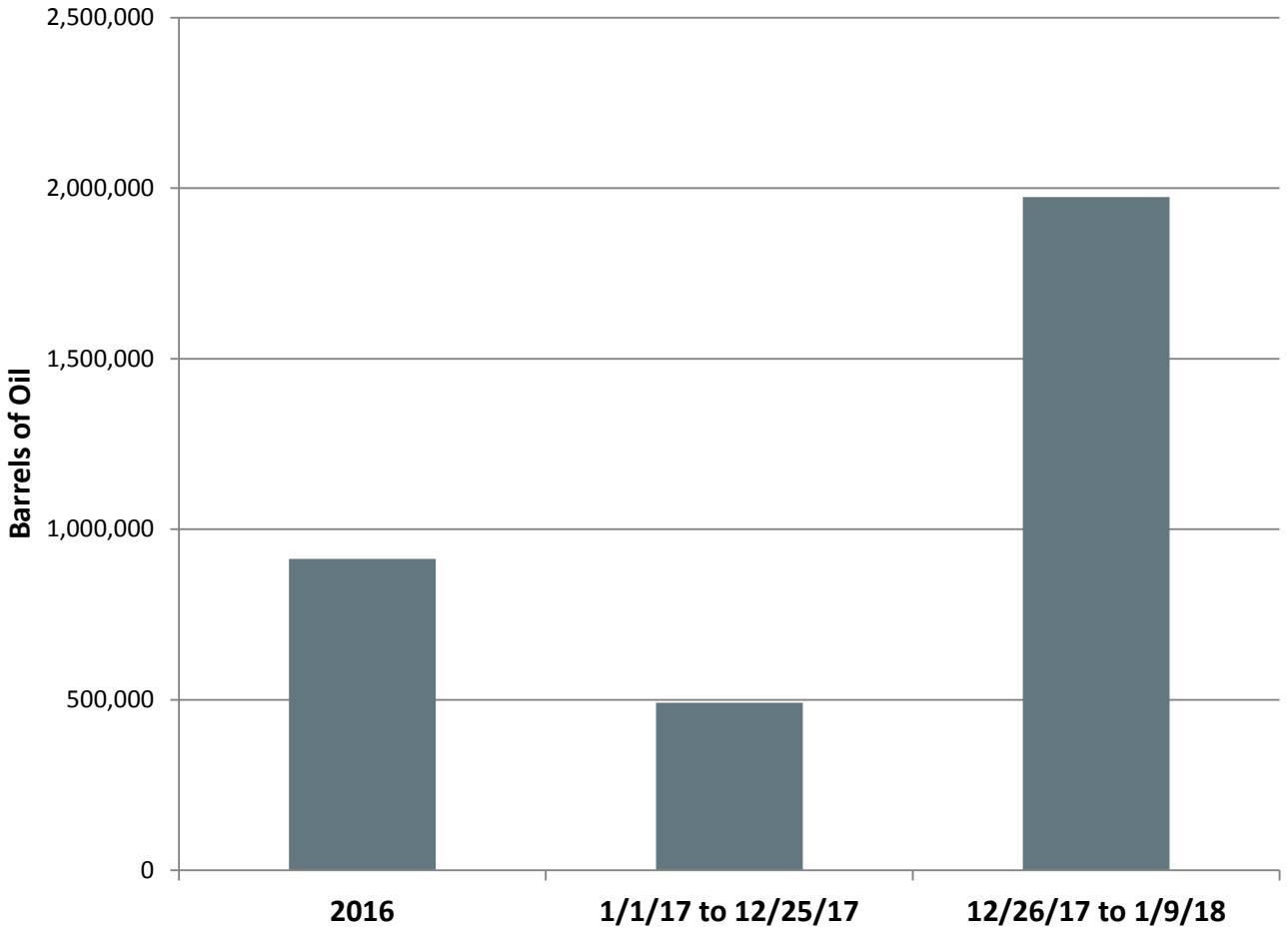
*December 1, 2017, to January 9, 2018*



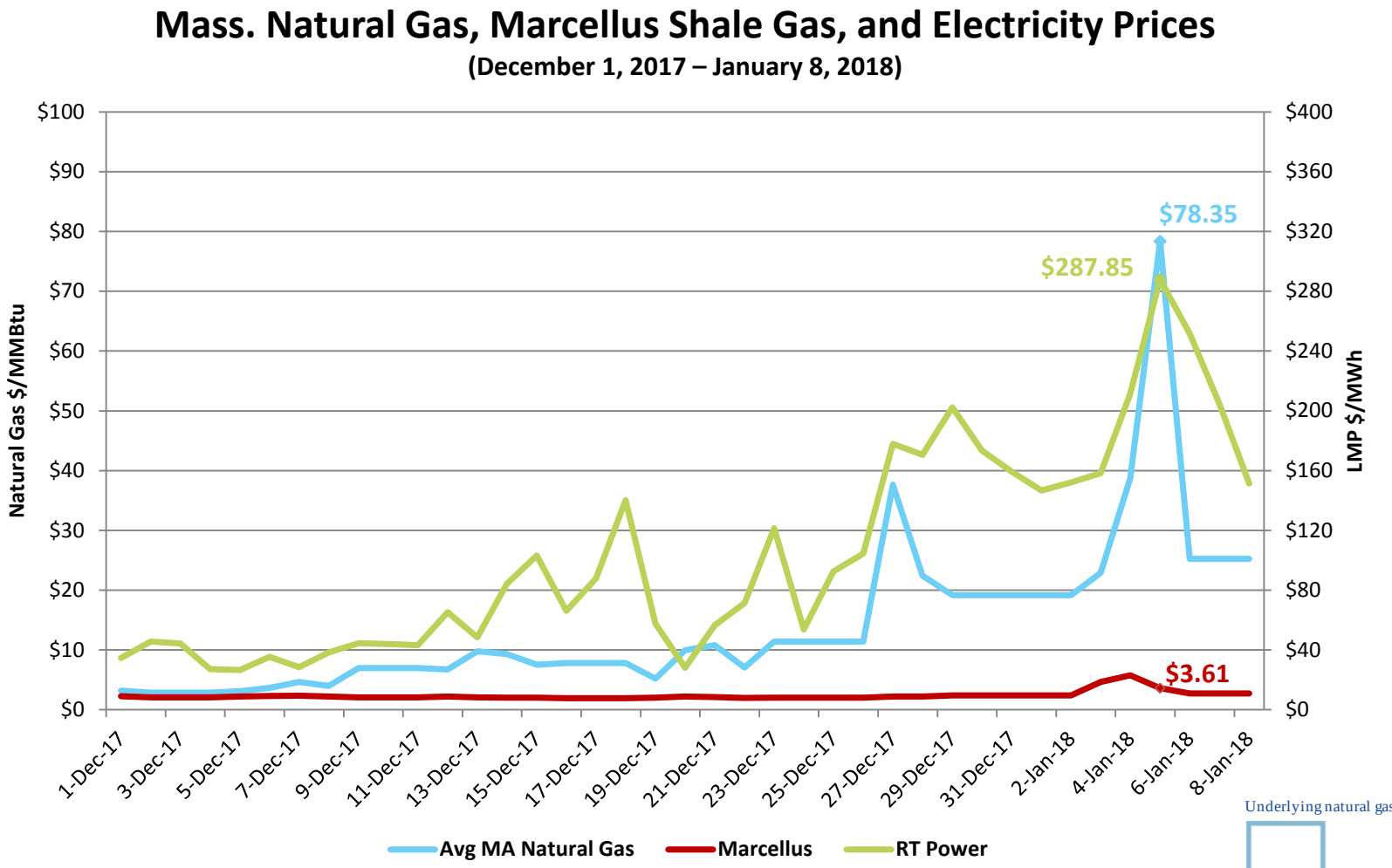

*This chart is the ISO's best approximation of usable oil ,discounting unit outages, reductions, or emissions*

# Generator Oil Burn: Two Weeks vs Twelve Months

*NE generators burned 2 million barrels of oil in 2 weeks—more than twice the amount of oil used in all of 2016*



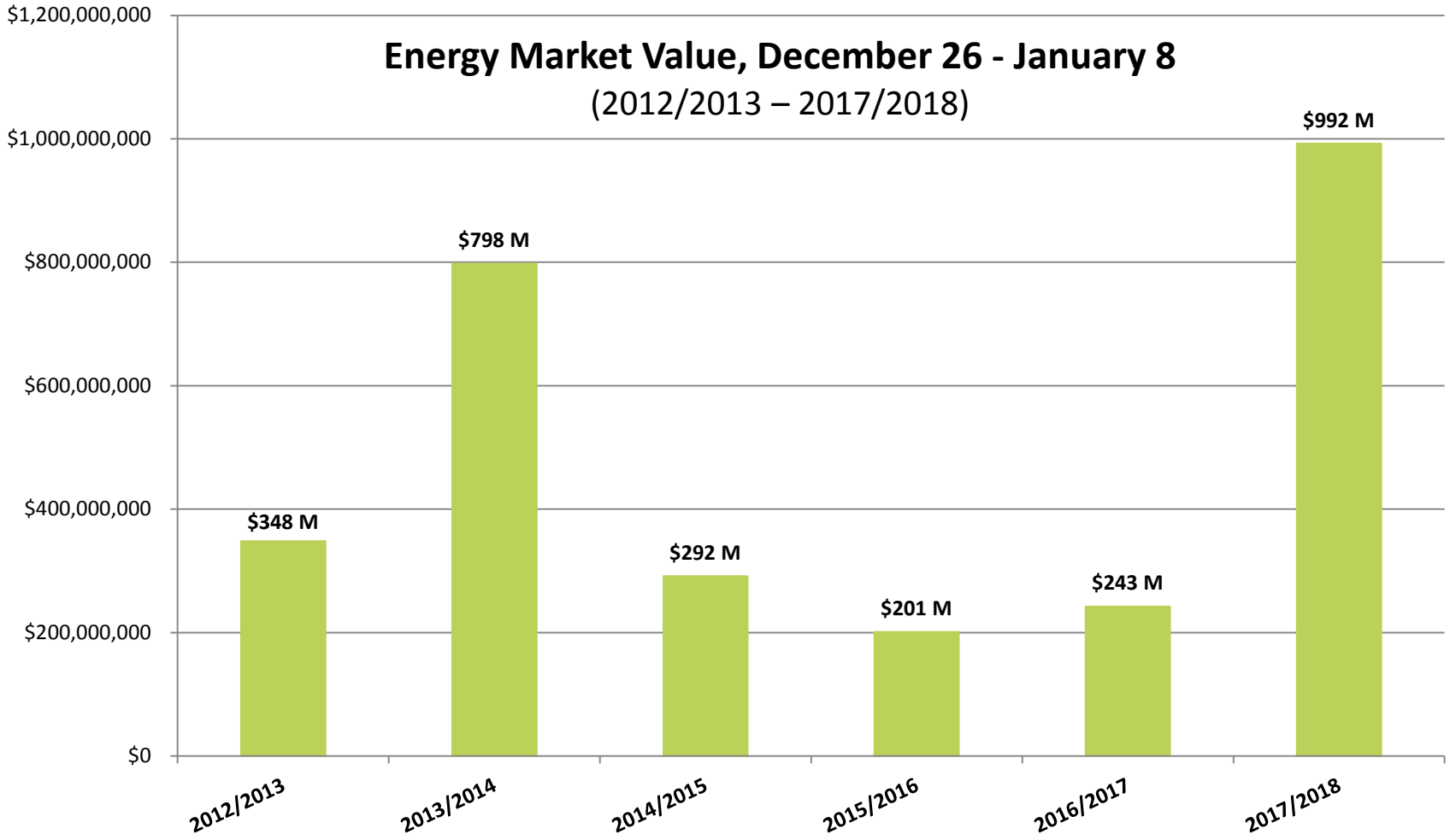
# Natural Gas Prices Outside New England, In New England, and Wholesale Power Prices




Underlying natural gas data furnished by:

ice Global markets in clear view

# Two-Week Cold Spell: Nearly $1 Billion in Total Market Cost



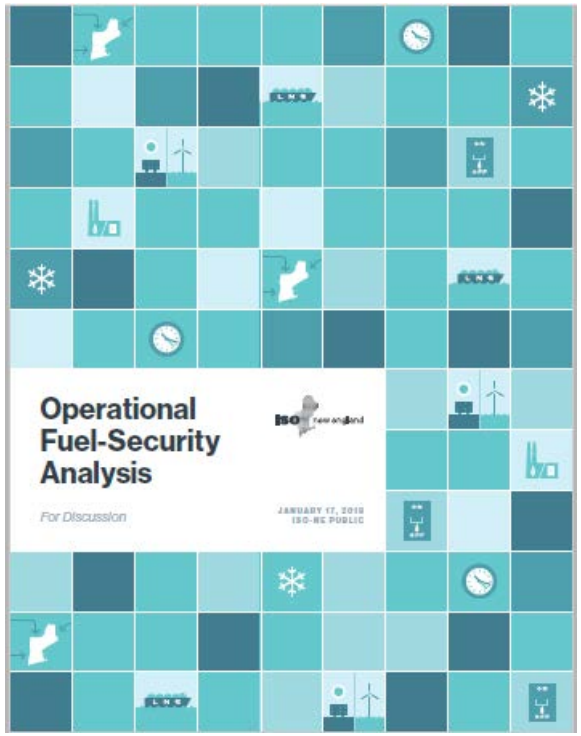
# STATE OF THE GRID: FUEL SECURITY – OPERATIONAL FUEL-SECURITY ANALYSIS

# Fuel Security

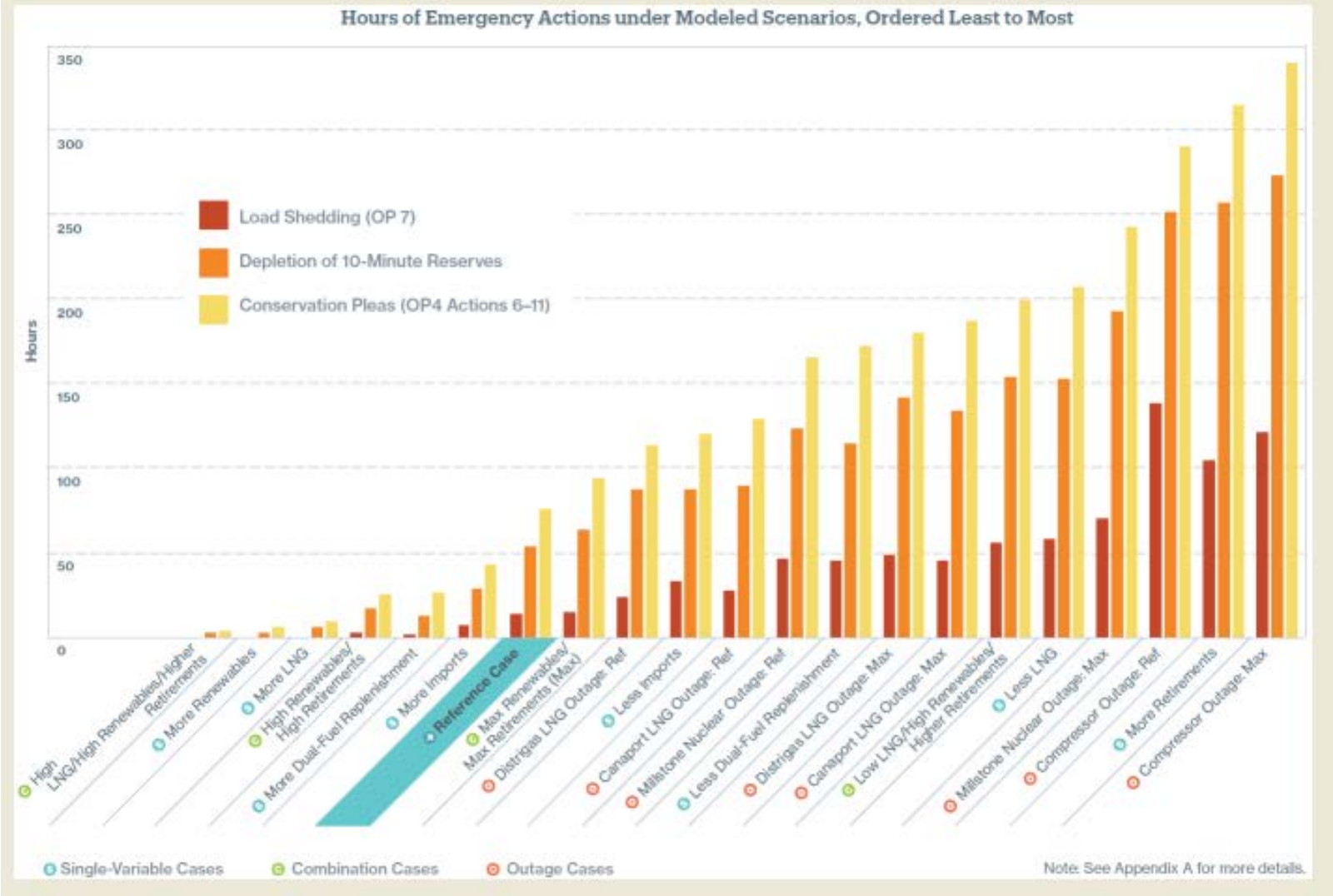
- Based on the ISO's experiences during winter as the grid operator, as well as long-standing trends, the ISO conducted a fuel-security analysis
- Ensuring adequate fuel for the region's generators is New England's most pressing challenge
- December 2017-January 2018 cold outbreak reinforced fuel security concerns

# Operational Fuel-Security Analysis

- Conducted to improve the ISO's and the region's understanding of risks to reliable operations
- Analyzed 23 possible resource combinations and outage scenarios in winter 2024/2025
- Measured number and duration of energy shortfalls that would require emergency procedures, including rolling blackouts
- Accounted for growth in EE and PV; assumed no additional natural gas pipeline capacity to serve generators would be added



# Operational Fuel-Security Analysis: Load Shedding Required in 19 of 23 Scenarios



# Operational Fuel-Security Analysis: Findings Suggest Six Major Conclusions for Winter 2024/25

- **Outages**: The region is vulnerable to the season-long outage of any of several major energy facilities.
- **Stored fuels**: Power system reliability is heavily dependent on LNG and electricity imports; more dual-fuel capability is also a key reliability factor, but permitting for construction and emissions is difficult.
- **Logistics**: Timely availability of fuel is critical, highlighting the importance of fuel-delivery logistics.
- **Risk trends**: All but four scenarios result in fuel shortages requiring load shedding, indicating current trends may intensify fuel-security risk.
- **Renewables**: More renewable resources can help lessen fuel-security risk but are likely to drive coal- and oil-fired generator retirements, requiring higher LNG imports to counteract the loss of stored fuels.
- **Positive outcomes**: Higher levels of LNG, imports, and renewables can minimize system stress and maintain reliability; delivery assurances as well as transmission expansion will be needed.

# STATE OF THE GRID: SETTING THE STAGE FOR THE FUTURE

# Goal is to Maintain Markets that are Competitive

*States have clean-energy goals and requirements*

- Above-market contracts for renewables offset their costs, so these resources can sell at artificially low prices in the capacity market
- Existing and new, non-state-sponsored resources needed for reliability are put at a disadvantage
  - Any resource without an above-market contract
- Competitive capacity pricing is essential to retain existing non-sponsored resources and attract investment in new non-subsidized new resources when needed

# ISO Proposal: Competitive Auctions for Sponsored Policy Resources (CASPR)

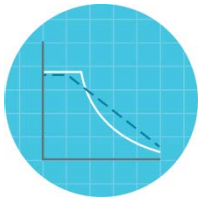
- CASPR coordinates retirements of existing resources & entry of new, sponsored resources through the capacity market
  - Retiring resources get paid
  - Sponsored resources get capacity payments
- CASPR will:
  - Maintain competitive prices in the capacity market
  - Maintain resource adequacy while helping states achieve their clean-energy goals
  - Enable state-sponsored (clean energy) resources to receive capacity payments
  - Maintain certainty for the market and attract investment when resources are needed

# Other Major Market Initiatives in 2018

- **FCM "pay-for-performance" incentives go into effect beginning June 1, 2018**
  - Rewards resources that make investments to improve performance during periods of system stress; resources that don't perform will forfeit a portion of capacity payments
- **Demand-response resource integration begins June 1, 2018**
  - ISO New England will become the first US grid operator to incorporate demand resources into the daily energy dispatch and reserves process, comparable to generators' participation
    - Demand-response resources have been able to participate in the capacity market from the beginning
- **The ability of new technologies to participate in the markets expands further**
  - Advanced storage technologies already participate in the regulation market; later this year, emerging energy-storage technologies can also participate as dispatchable resources in the energy market

# STATE OF THE GRID: KEY TAKEAWAYS

# Today's Key Takeaways



Competitive markets work.

Fuel security poses risks for reliability.

Markets must evolve to accommodate states' clean-energy goals and address fuel-security risks

Transmission investment pays dividends.

ISO New England & industry stakeholders have a history of working together to solve complex challenges.

# For More Information…

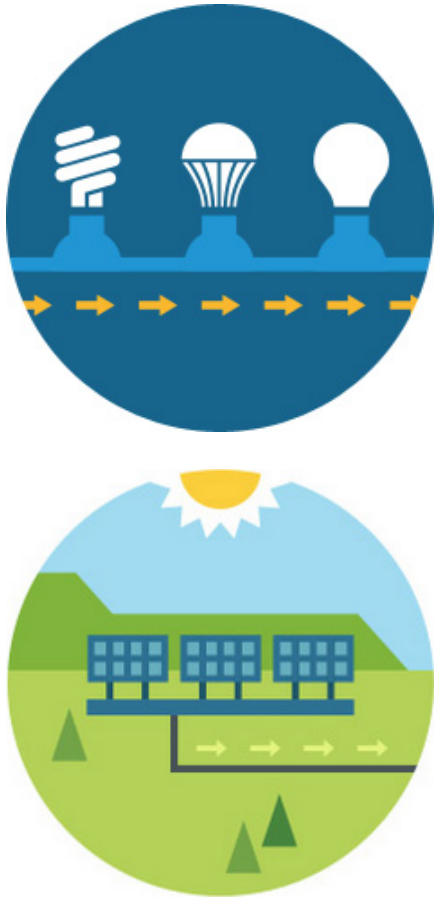
- Subscribe to the ***ISO Newswire***
  - *ISO Newswire* is your source for regular news about ISO New England and the wholesale electricity industry within the six-state region
- Log on to **ISO Express**
  - *ISO Express* provides real-time data on New England's wholesale electricity markets and power 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

# APPENDIX: ADDITIONAL DATA

# Peak Demand and Overall Electricity Use

*Energy efficiency and behind-the-meter solar are having an impact*

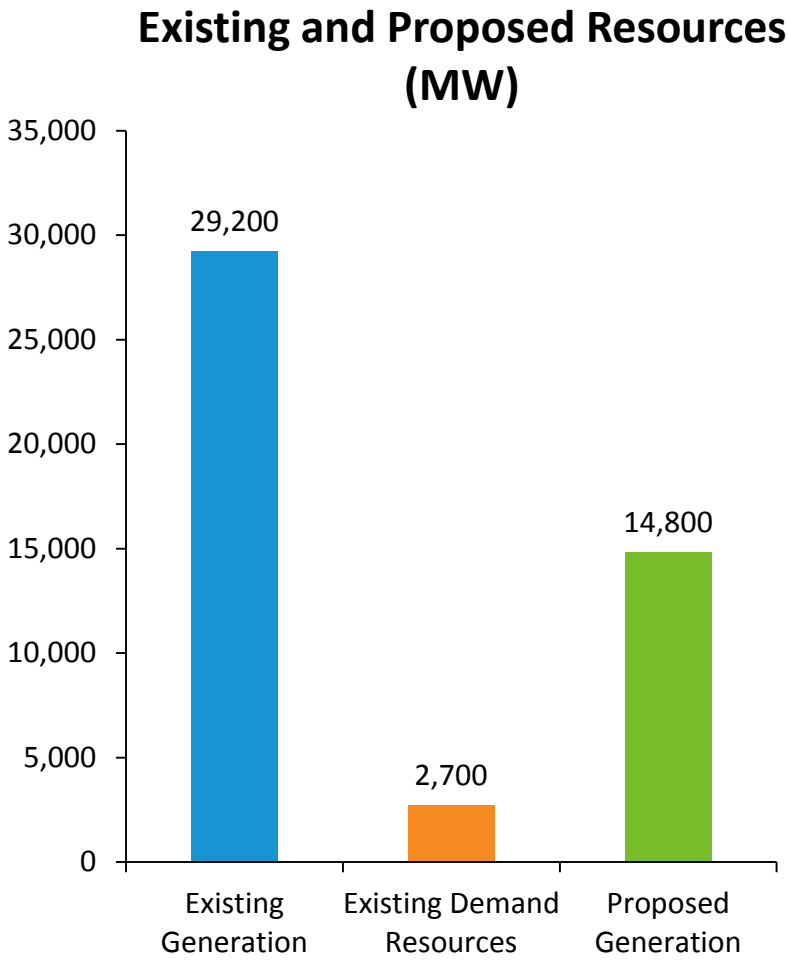
- **7.2 million** retail electricity customers drive the demand for electricity in New England (14.8 million people)
- Region's all-time summer peak demand set on August 2, 2006 at **28,130 MW**
- Region's all-time winter peak demand set on January 15, 2004 at **22,818 MW**
- The annual growth rates for summer *peak* demand and *overall* electricity use are **0.1%** and **-0.6%**, respectively, when energy efficiency and behind-the-meter solar are factored into the forecast



Note: Without energy efficiency and solar, the region's peak demand is forecasted to grow 1% 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.

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

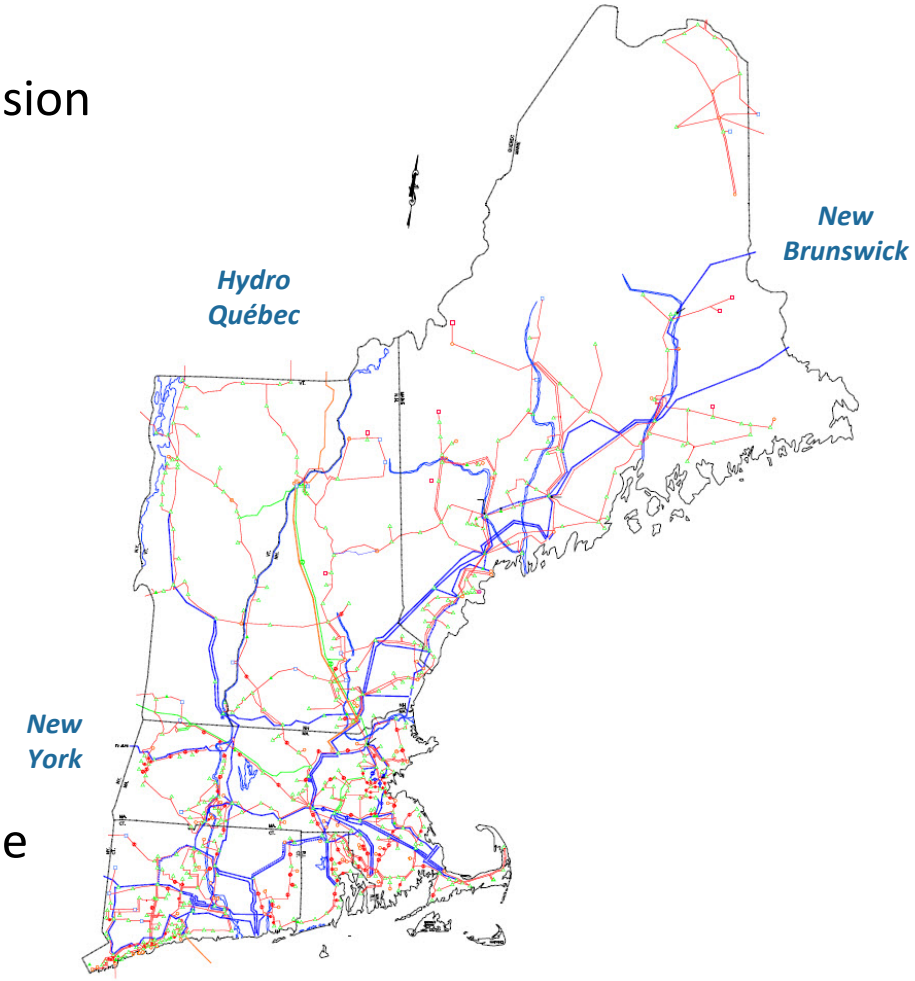
- **350** generators in the region
- **29,200 MW** of generating capacity
- **14,800 MW** of proposed generation in the ISO Queue
  - Mostly wind and natural gas
- **4,600 MW** of generation has retired or will retire in the next few years
- **400 MW** of active demand response and **2,300 MW** of energy 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

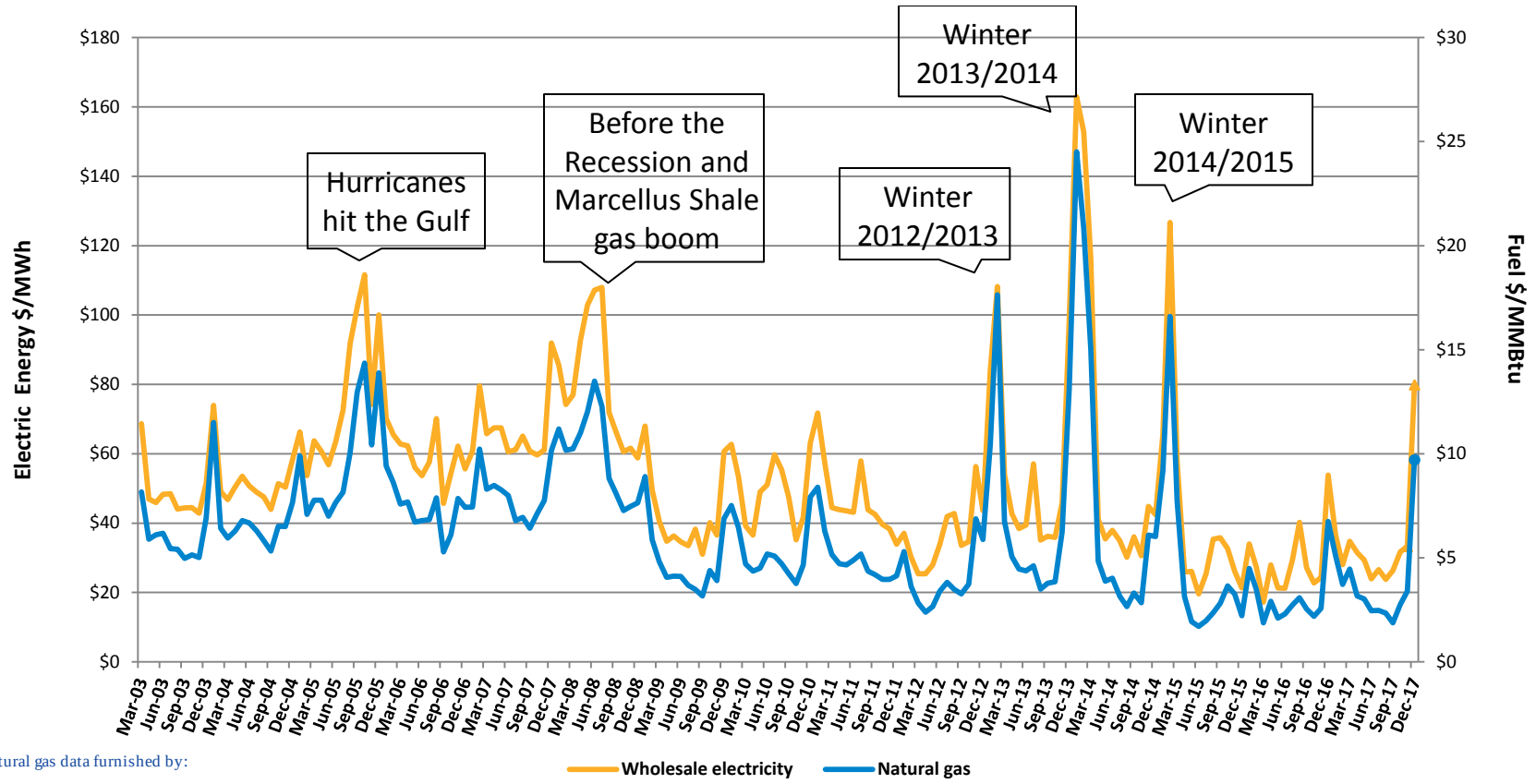
- **9,000 miles** of high-voltage transmission lines (115 kV and above)
- **13 transmission interconnections** to power systems in New York and Eastern Canada
- **17%** of region's energy needs met by imports in 2017
- **$10 billion** invested to strengthen transmission system reliability since 2002; **$2.3 billion** planned
- Developers have proposed multiple transmission projects to access non-carbon-emitting resources inside and outside the region



# Natural Gas and Wholesale Electricity Prices Are Linked

*Competitive markets use the lowest-priced resources to meet demand*

**Monthly Average Natural Gas and Wholesale Electricity Prices in New England**

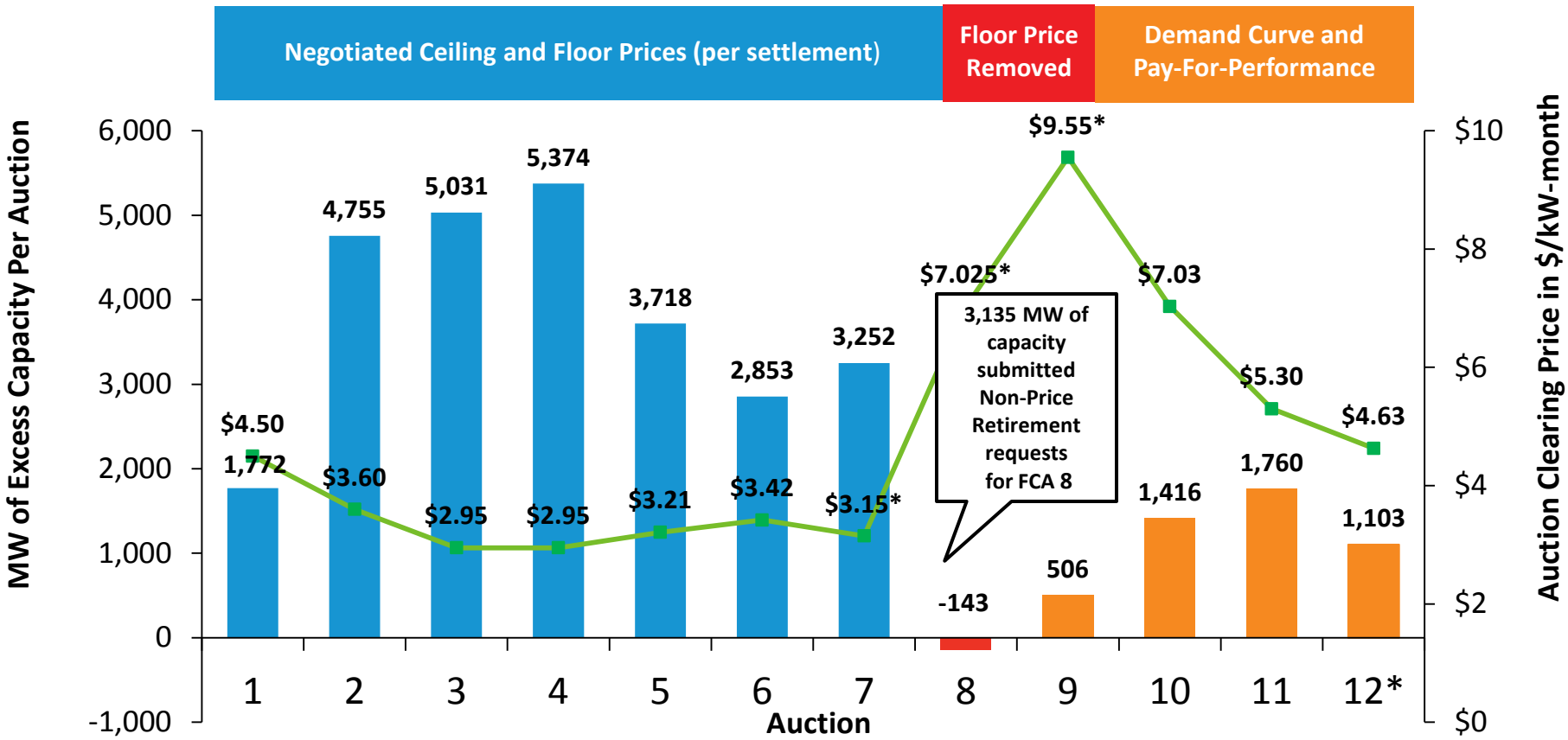



Underlying natural gas data furnished by:

ICE Global markets in clear view

# Forward Capacity Market: Changes in Supply and Performance Rules Drive Prices

## Capacity Surplus or Deficit (MW) Against Auction Clearing Prices ($/kWh-month)

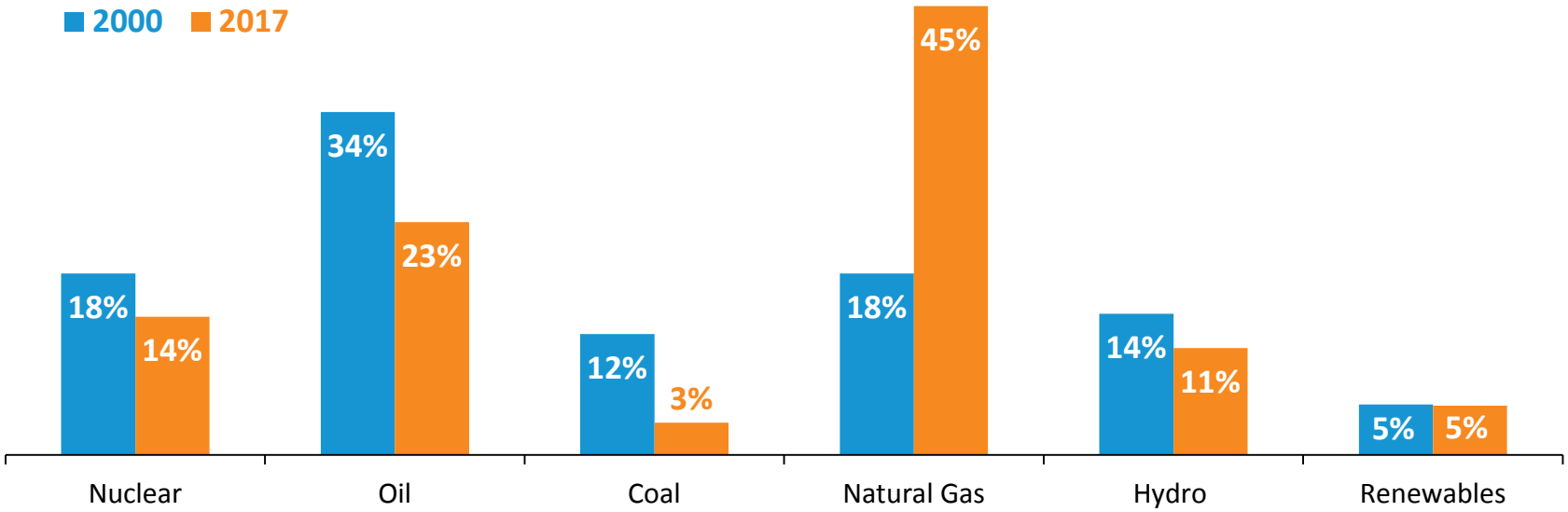



Prices cleared at the floor price in the first seven auctions due to excess capacity; resources were paid a slightly lower prorated price. FCA 7 clearing price in NEMA/Boston was $14.999/kW-month (new capacity received $14.999/kW-month & existing capacity received an administrative price of $6.66/kW-month). FCA 8 clearing price was $15.00/kW-month (new capacity in all zones & existing capacity in NEMA/Boston received $15.00/kW-month & existing capacity in all other zones received an administrative price of $7.025/kW-month). FCA 9 clearing price was $9.55/kW-month, except in SEMA/RI where administrative pricing rules were triggered due to inadequate supply (new capacity in the zone will receive the auction starting price of $17.73/kW-month & existing capacity in the zone will receive an administratively set price of $11.08/kW-month). ***FCA 12 data are preliminary**

# Dramatic Changes in the Region's Power Plant Fleet

*The resources making up the region's installed generating capacity are trending away from nuclear, oil, and coal to natural gas and renewables*

Percent of Total System **Capacity** by Fuel Type
(2000 vs. 2017)




Source: 2017 CELT Report, Summer Seasonal Claimed Capability (SCC) Capacity
Renewables include landfill gas, biomass, other biomass gas, wind, solar, municipal solid waste, and miscellaneous fuels

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

*Reduction in Aggregate Emissions (kilotons per year)*

| Year | $NO_x$ | $SO_2$ | $CO_2$ |
|---|---|---|---|
| 2001 | 59.73 | 200.01 | 52,991 |
| 2016 | 16.27 | 4.47 | 37,467 |
| **% Reduction, 2001–2016** | **⬇ 73%** | **⬇ 98%** | **⬇ 29%** |

*Reduction in Average Emission Rates (pounds per megawatt-hour)*

| Year | $NO_x$ | $SO_2$ | $CO_2$ |
|---|---|---|---|
| 1999 | 1.36 | 4.52 | 1,009 |
| 2016 | 0.31 | 0.08 | 710 |
| **% Reduction, 1999–2016** | **⬇77%** | **⬇ 98%** | **⬇ 30%** |

Source: 2016 ISO New England Electric Generator Air Emissions Report, December 2017

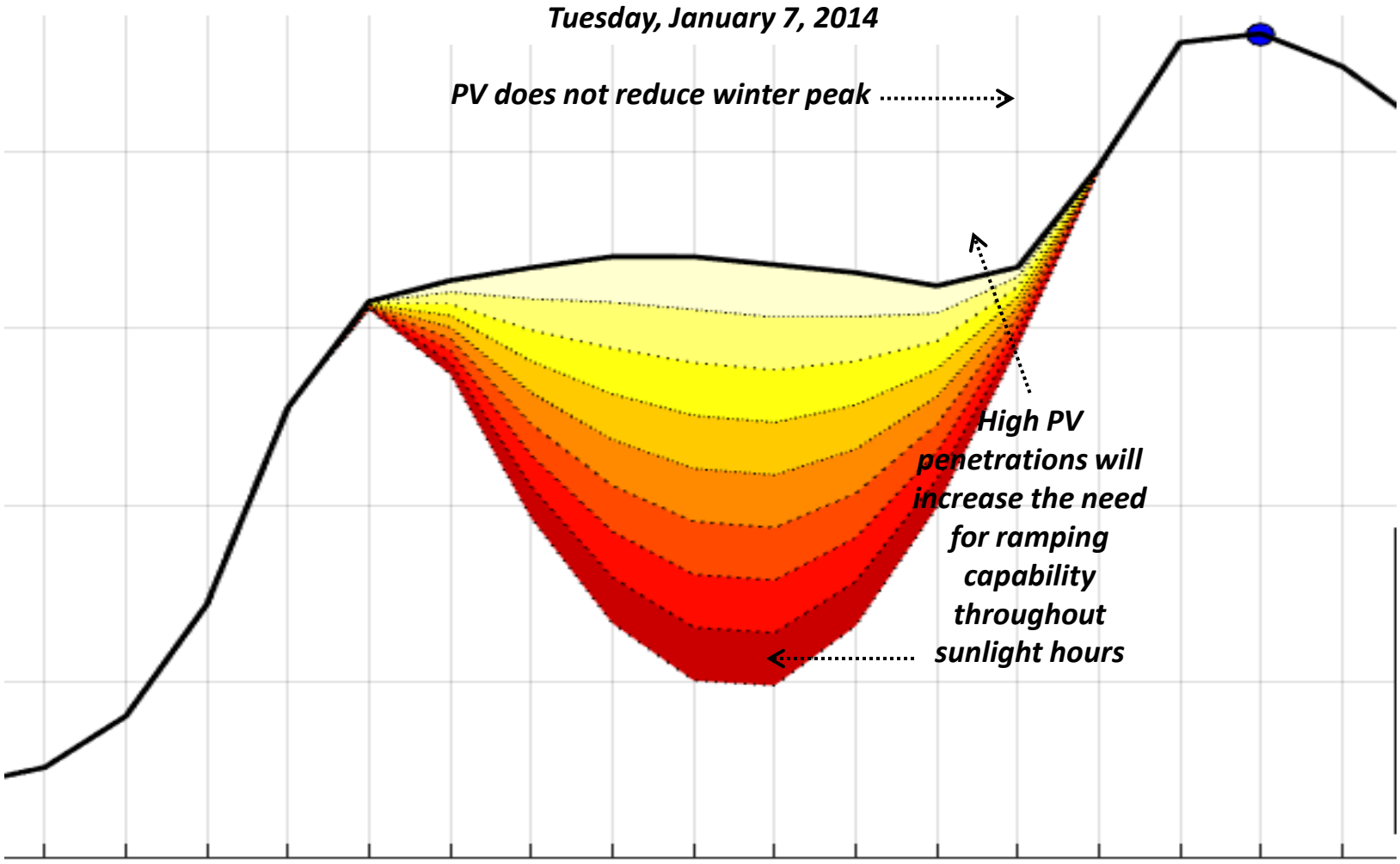
# States Are Sponsoring Clean Energy Development to Meet Their Legislative and Regulatory Goals

- Most renewable power resources are still relatively expensive to build
- States provide above-market revenues through mechanisms such as long-term contracts

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

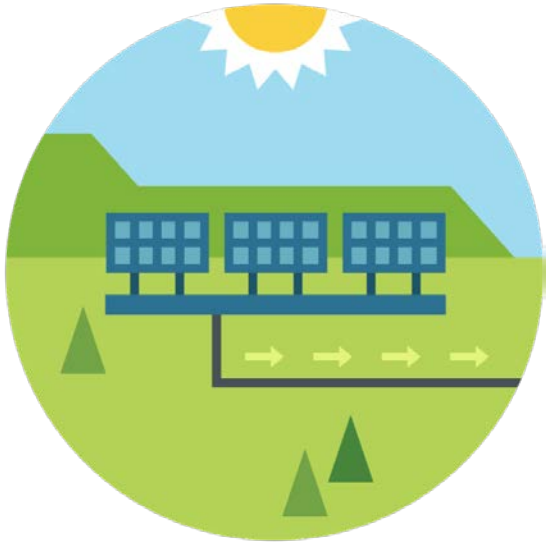
*Note: Nameplate MW may be higher than qualified FCM capacity MW

# Deep Load Reductions During Winter Daylight Hours Result in Steep Ramp Into the Evening Peak



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

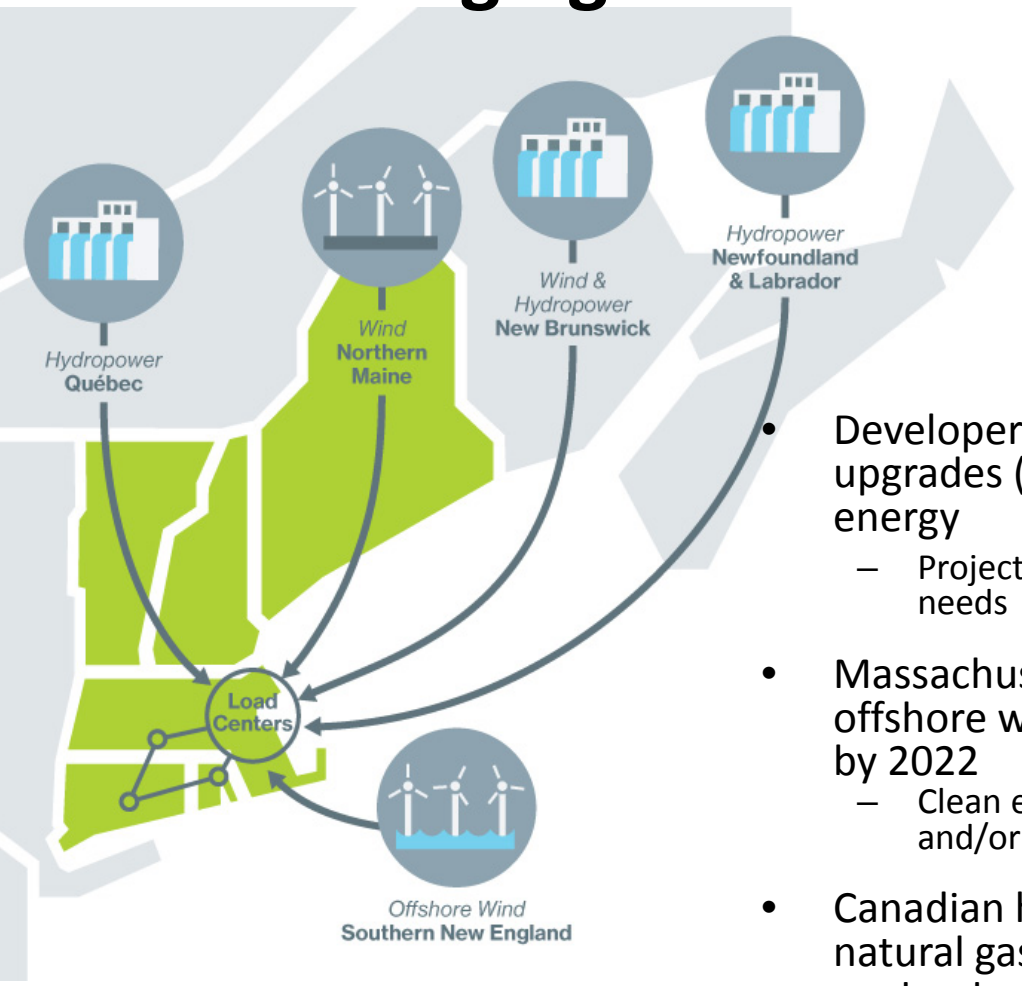
- **Forecasting Long-Term Solar Growth**
  - The ISO tracks historical growth and predicts levels of solar development 10 years into the future
  - The solar forecast is used in transmission planning and market needs assessments
- **Forecasting Short-Term Solar Performance**
  - The ISO creates daily 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 New England Has Enhanced the Ability of Intermittent Resources to Participate in the 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”

# The Changing Grid: Elective Transmission




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

Source: ISO Interconnection Queue (January 2018)

- Developers are proposing **20+** elective transmission upgrades (ETUs) to help deliver **16,500+ MW** of clean energy
  - Projects seek to address public policy goals, not reliability needs
- Massachusetts plans to contract for **1,600 MW** of offshore wind by 2027 and **1,200** MW of clean energy by 2022
  - Clean energy contracts would be mostly Canadian hydro and/or onshore wind from northern New England
- Canadian hydro and wind can 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

# Operational Fuel-Security Analysis: 5 Key Fuel Variables

*23 resource combinations modeled in winter 2024-2025*


Retirements of coal- and oil-fired generators

Imports of electricity over transmission lines from New York and Canada

Oil tank inventories (how often on-site oil tanks at dual-fuel power plants are filled during winter)


Level of liquefied natural gas (LNG) injections into the region's natural gas delivery and storage infrastructure

Level of renewable resources on the system