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Rapid Transformation of the New England Power System and Implications for the Region's Wholesale Electricity Markets

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

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

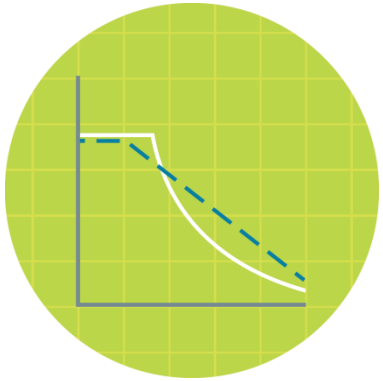
ISO New England Performs Three Critical Roles to Ensure Reliable Electricity at Competitive Prices

Grid Operation

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

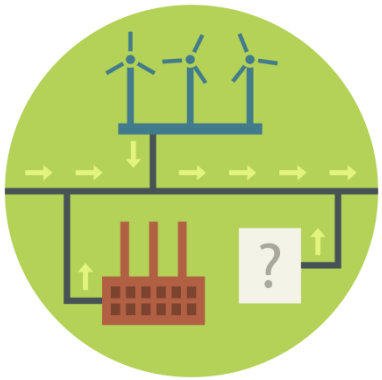
Market Administration

Design, run, and oversee the markets where wholesale electricity is bought and sold



Power System Planning

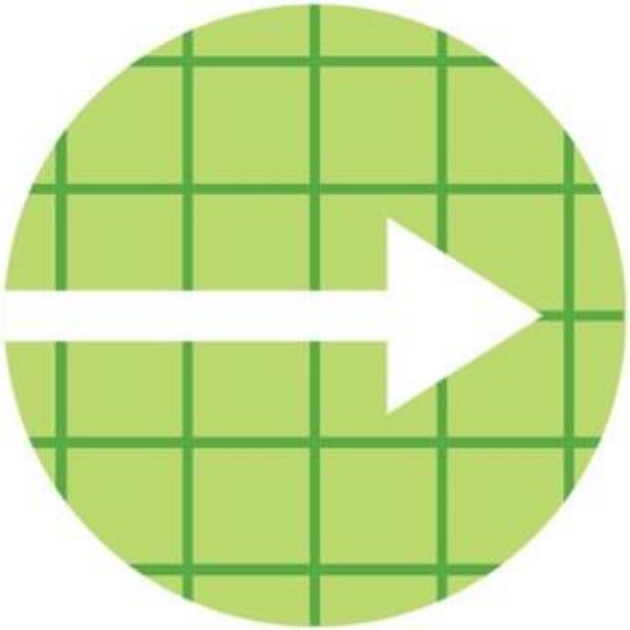
Study, analyze, and plan to make sure New England's electricity needs will be met over the next 10 years



THE INTRODUCTION OF COMPETITIVE WHOLESALE MARKETS IN 1999

Wholesale Electricity Markets in New England Began with a Specific Objective

- The region would utilize **competitive markets** as the most efficient means to ensure the availability of sufficient resources and the day-to-day optimization of the resources needed to meet demand
  - And shield consumers from **the risks of unwise investments**



Assumptions Underlying Wholesale Markets

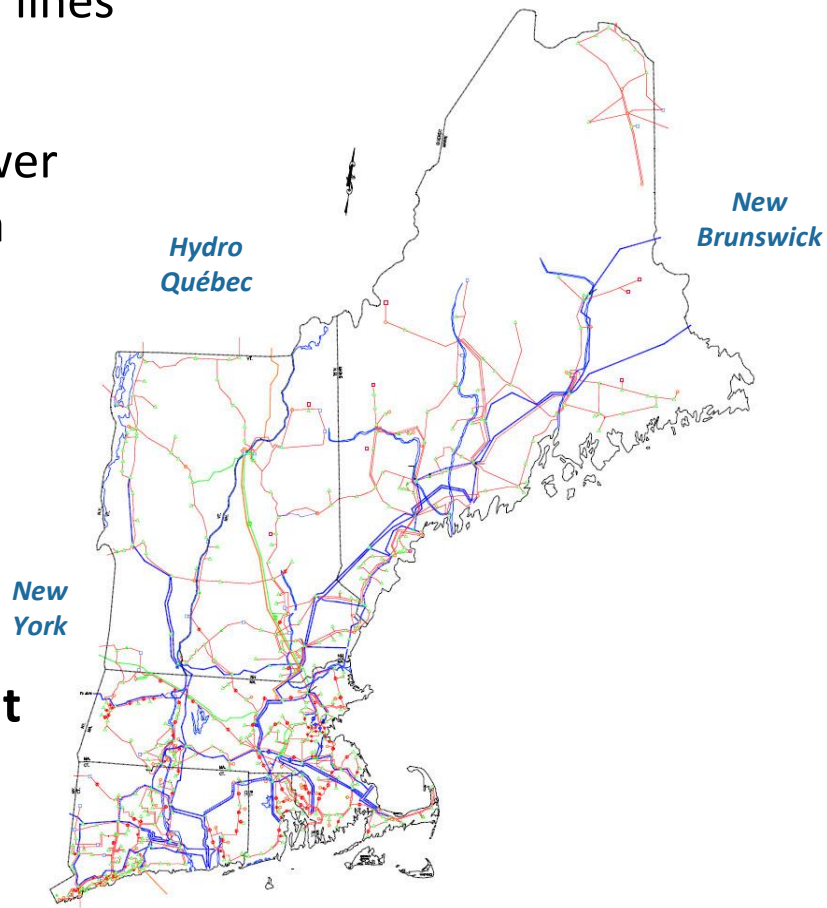
Some assumptions were *explicit* (1, 2 and 3), others were *implicit* (4 and 5)

Color code roughly indicates our experience thus far, ranging from assumptions that generally played out as expected (**green**) to those that have not (**red**), and some in-between.

1. Markets would reveal the cost of maintaining reliability (prices would be set by the marginal resource utilizing a uniform clearing price)
2. Competition would drive efficiencies and innovation
3. All resources would be compensated equally – through the market – for providing the required reliability services
4. Investors in merchant generation and transmission would be able to get energy infrastructure projects sited and developed on time
5. Fuel infrastructure would keep pace with demand for fuel; carrying cost of shared infrastructure would be paid by heating and generation industries

Today's Power System in a Nutshell

- 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
- Roughly $16 billion of **private investment** in new resources through the market
  - Mainly new gas generation, upgrades to existing generators, and demand resources



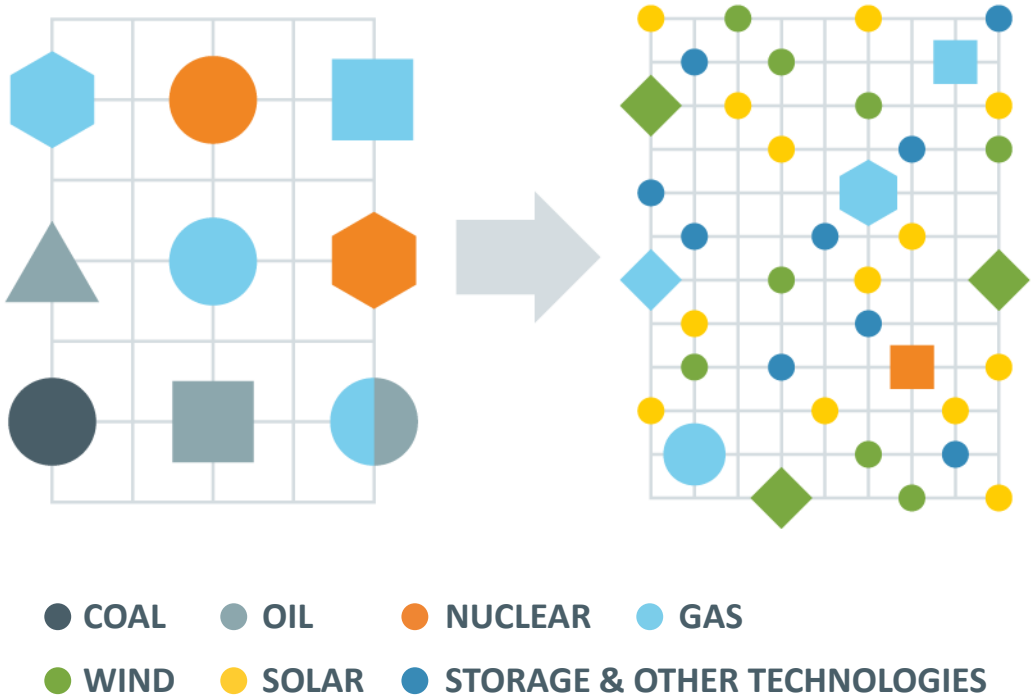
- A massive new shift is occurring towards a **hybrid grid**

What Is a Hybrid Grid?

There are two dimensions to the transition, happening simultaneously…

1. **A shift from conventional generation to renewable energy**

2. **A shift from centrally dispatched generation to distributed energy resources**



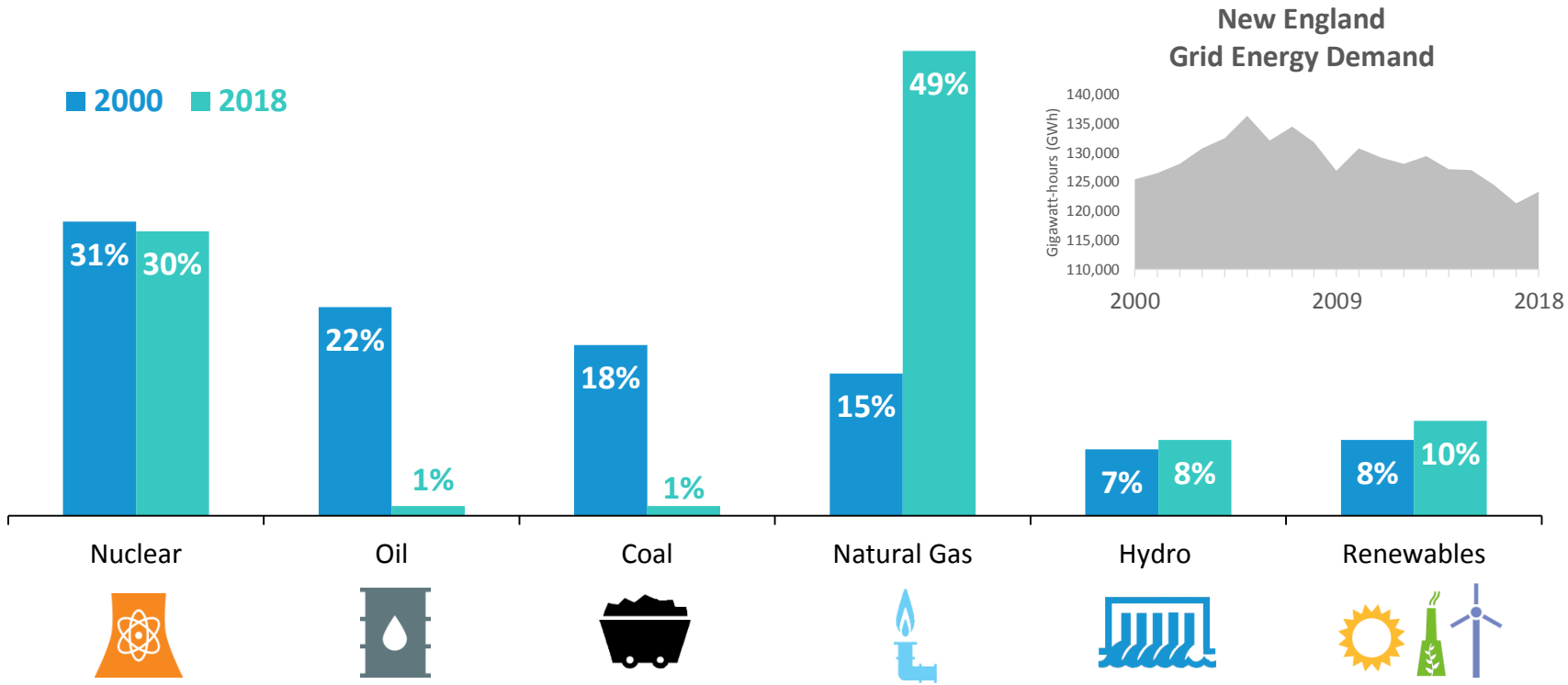
*Maintaining reliable power system operations becomes **more complex** with the shift to greater resources that face constraints on energy production*

THE SHIFT TOWARDS NATURAL GAS

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. 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.

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

- Include predominantly 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

Power Plant Emissions Have Declined with Changes in the Fuel Mix

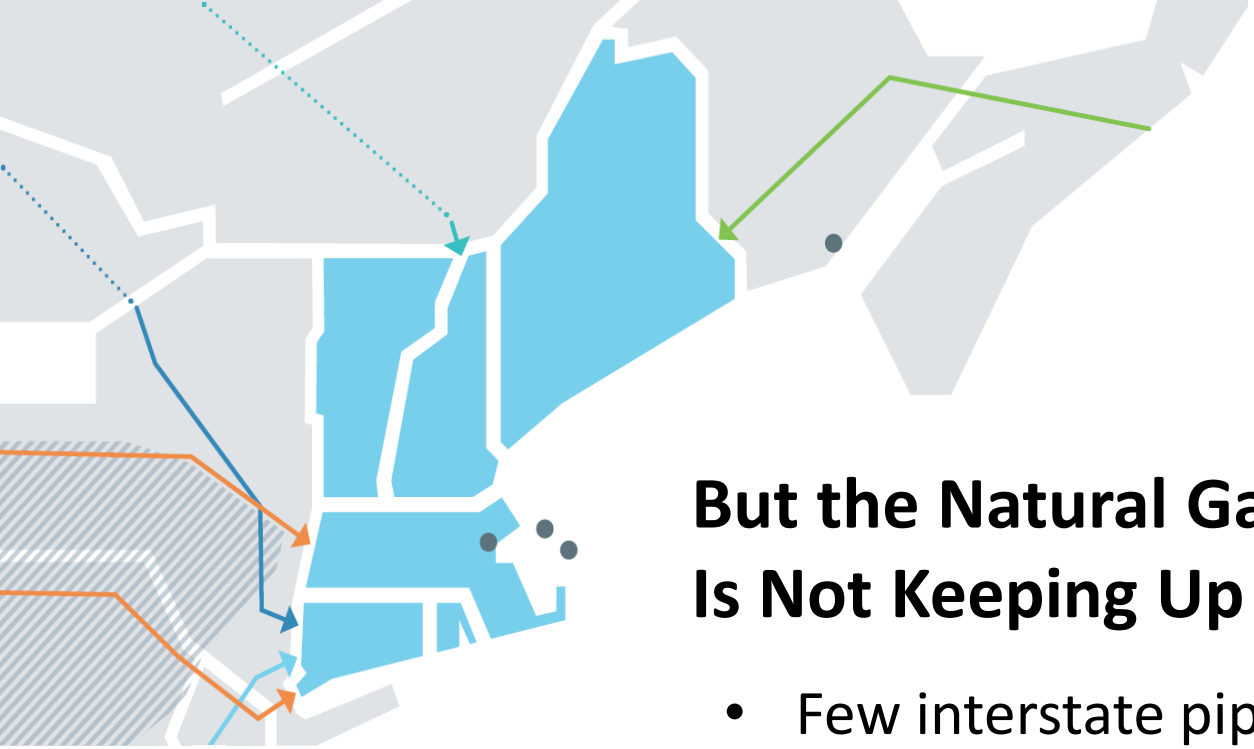
Reduction in Aggregate Emissions (ktons/yr)

Year	NO_x	SO_2	CO_2
2001	59.73	200.01	52,991
2017	15.30	4.00	34,969
% Reduction, 2001–2017	**⬇ 74%**	**⬇ 98%**	**⬇ 34%**

Reduction in Average Emission Rates (lb/MWh)

Year	NO_x	SO_2	CO_2
1999	1.36	4.52	1,009
2017	0.30	0.08	682
% Reduction, 1999–2017	**⬇78%**	**⬇ 98%**	**⬇ 32%**

Source: Draft 2017 ISO New England Electric Generator Air Emissions Report, January 2019



Pipelines

LNG facilities

Marcellus shale

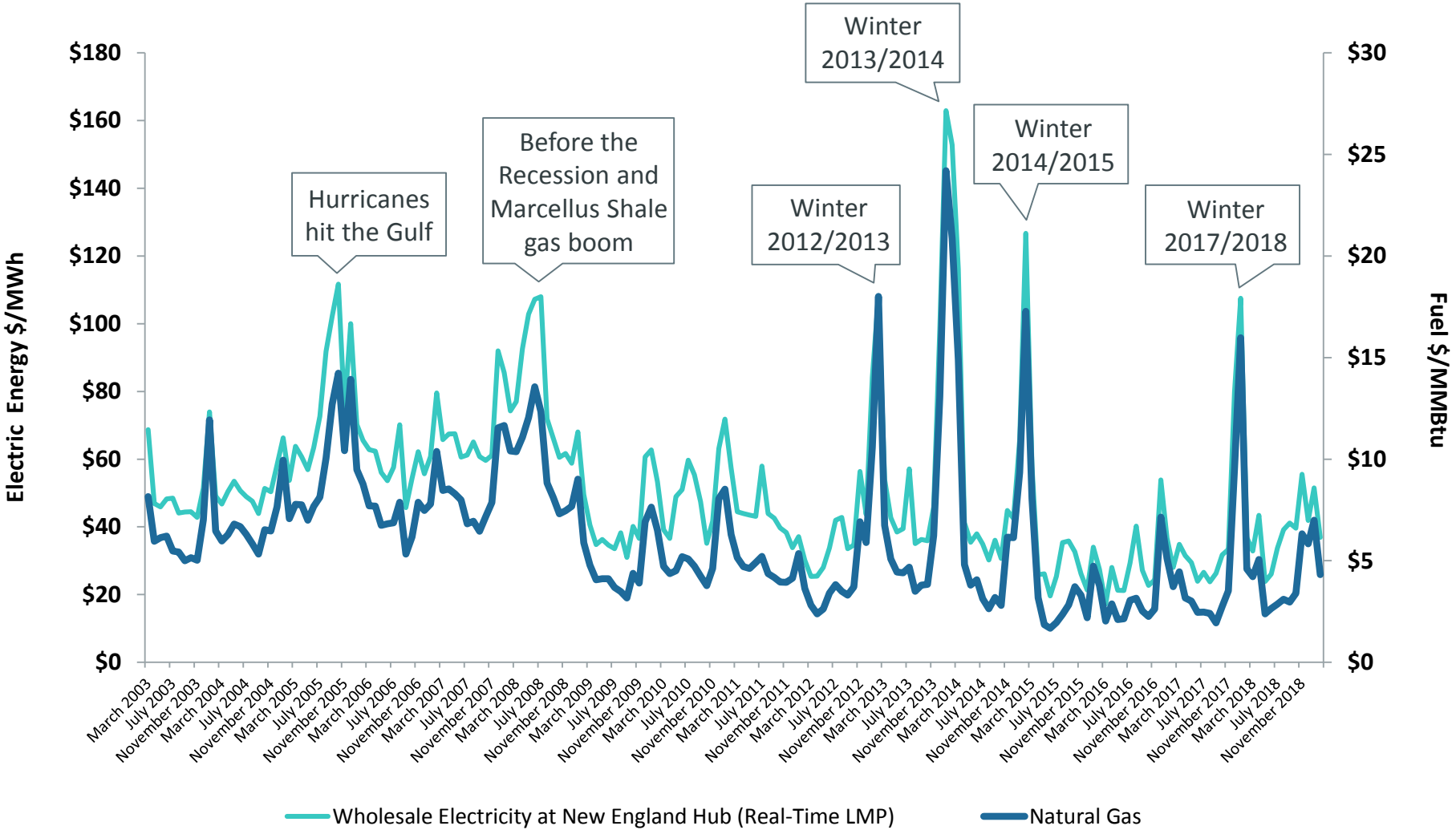
Source: ISO New England

But the Natural Gas Delivery System Is Not Keeping Up with Demand

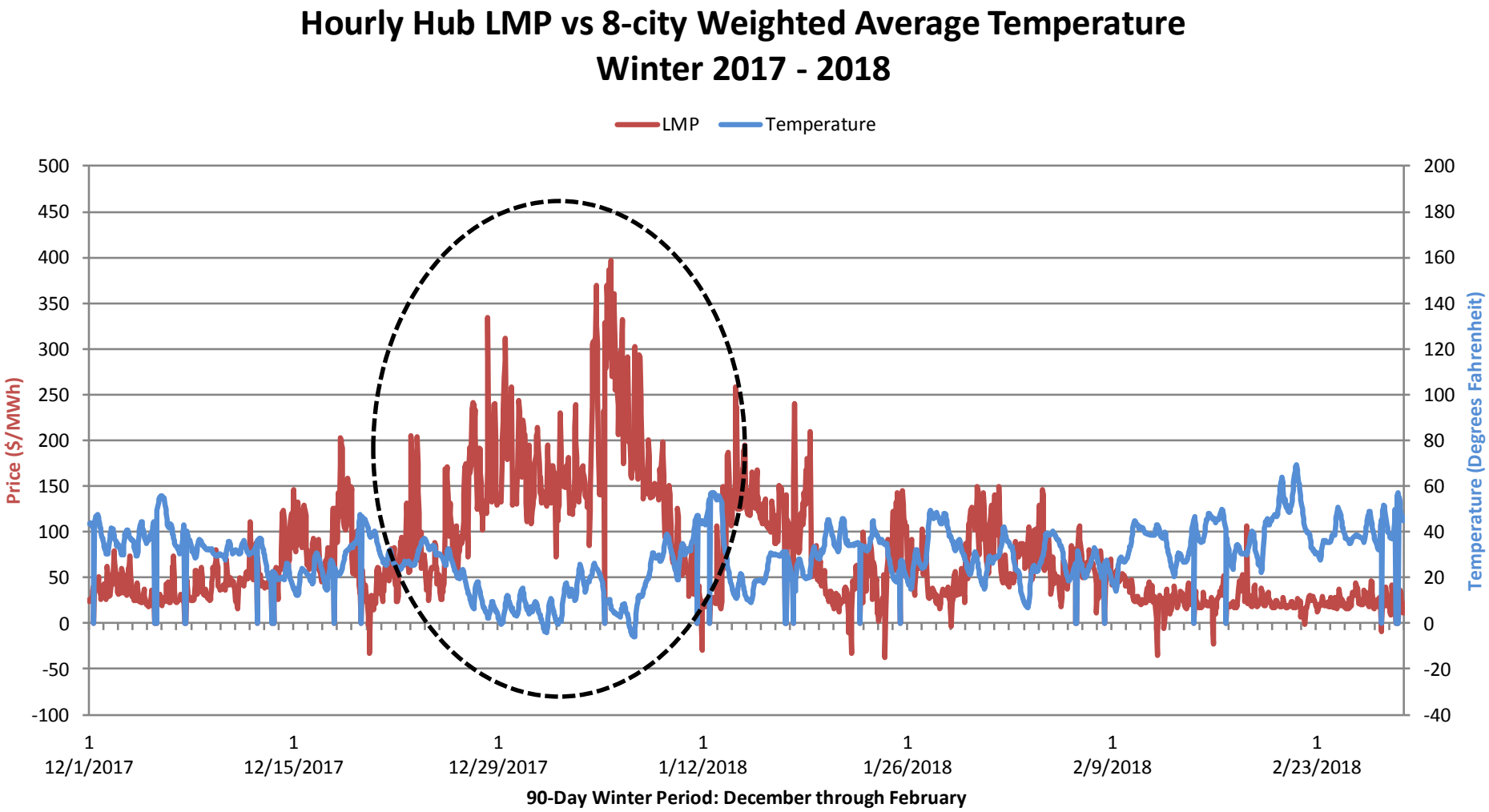
- Few interstate pipelines and liquefied natural gas (LNG) delivery points
- LNG provides peaking supply
- Regional pipelines are:
  - Built to serve heating demand, not power generation
  - Running at or near maximum capacity during winter

Natural Gas and Wholesale Electricity Prices Are Linked

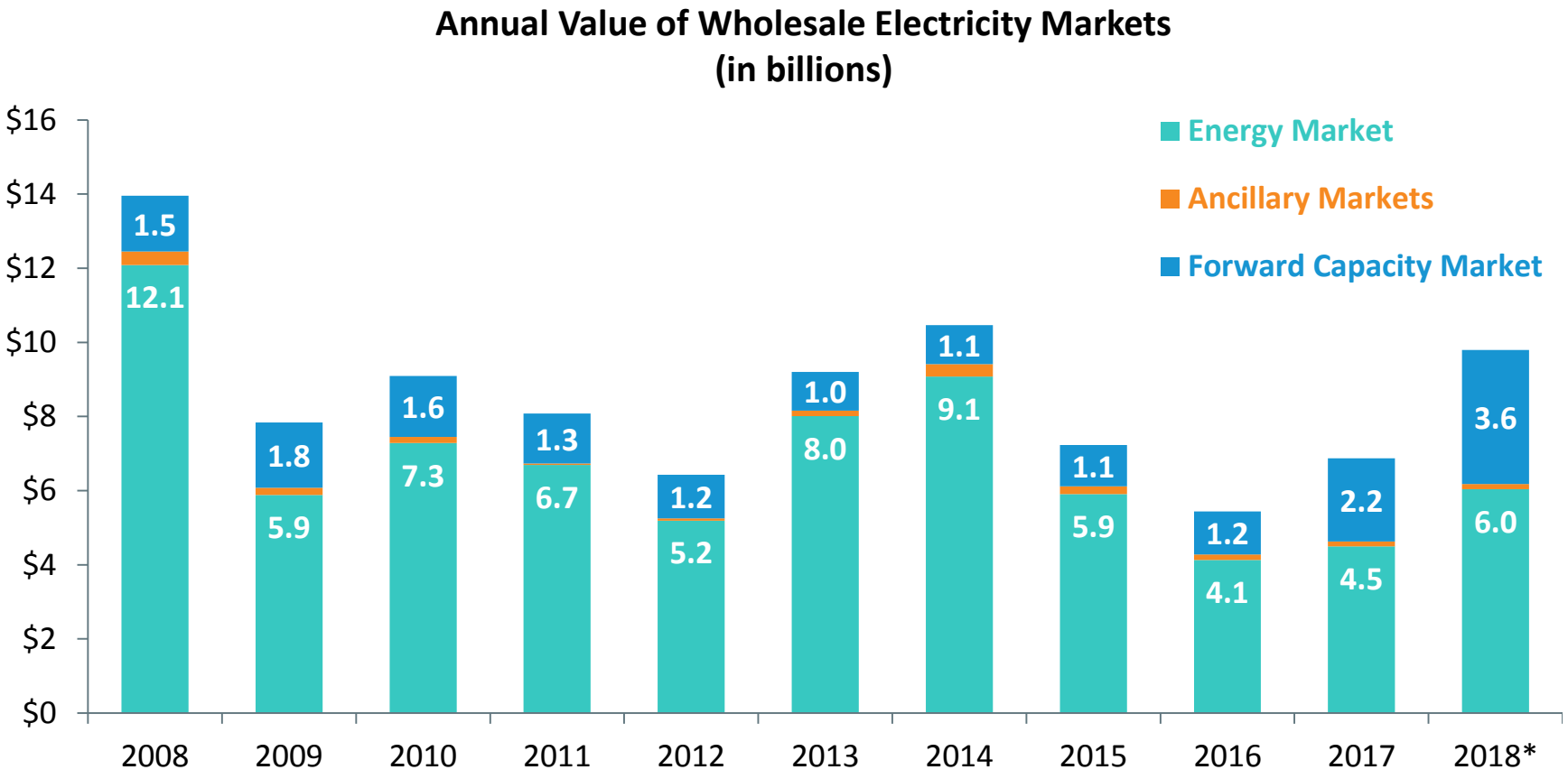
Monthly average natural gas and wholesale electricity prices at the New England hub



Wholesale Electricity Prices Surged Last Winter as Temperatures Plunged in December/January Cold Spell

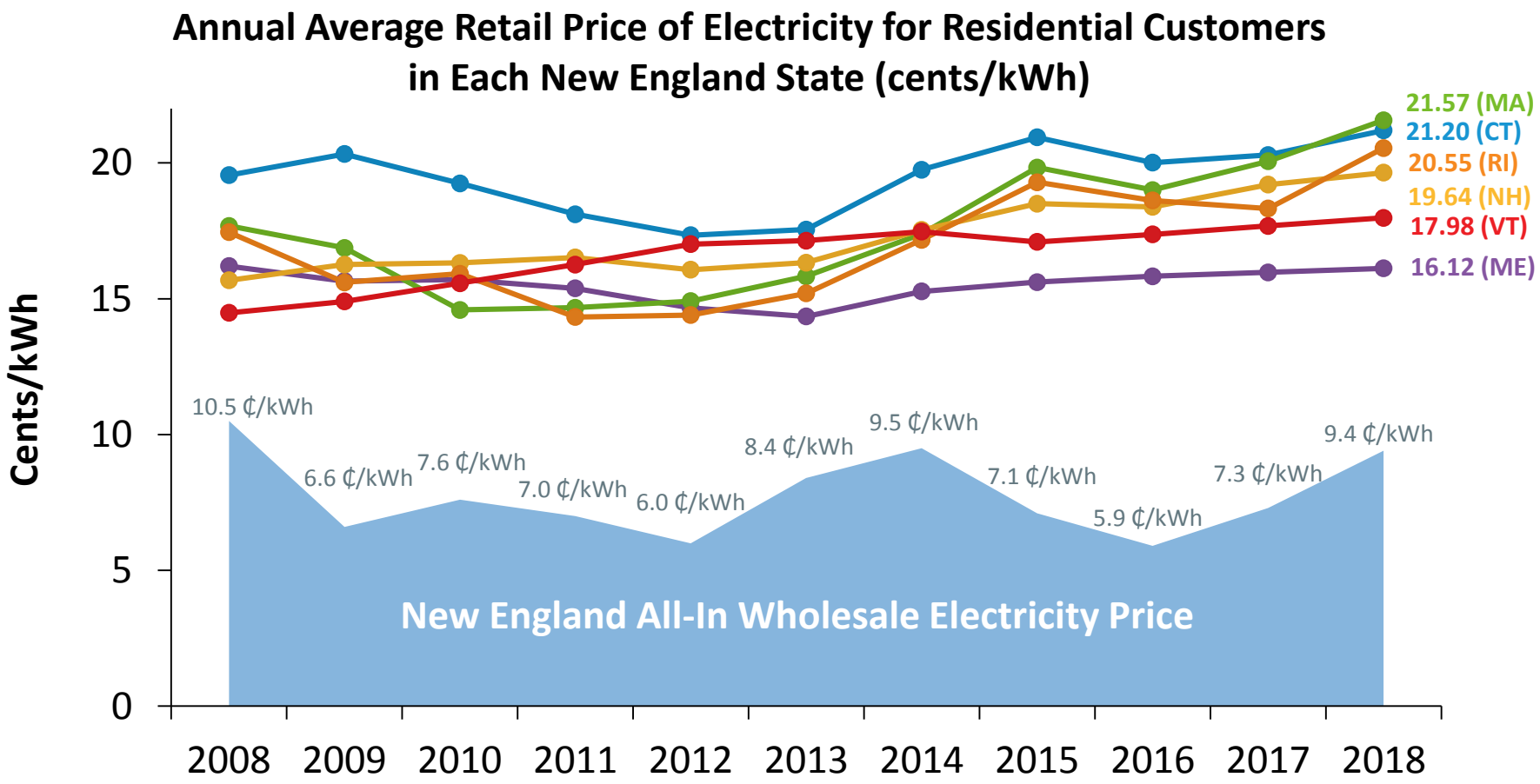


Energy Market Values Vary with Fuel Prices While Capacity Market Values Vary with Changes in Supply



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

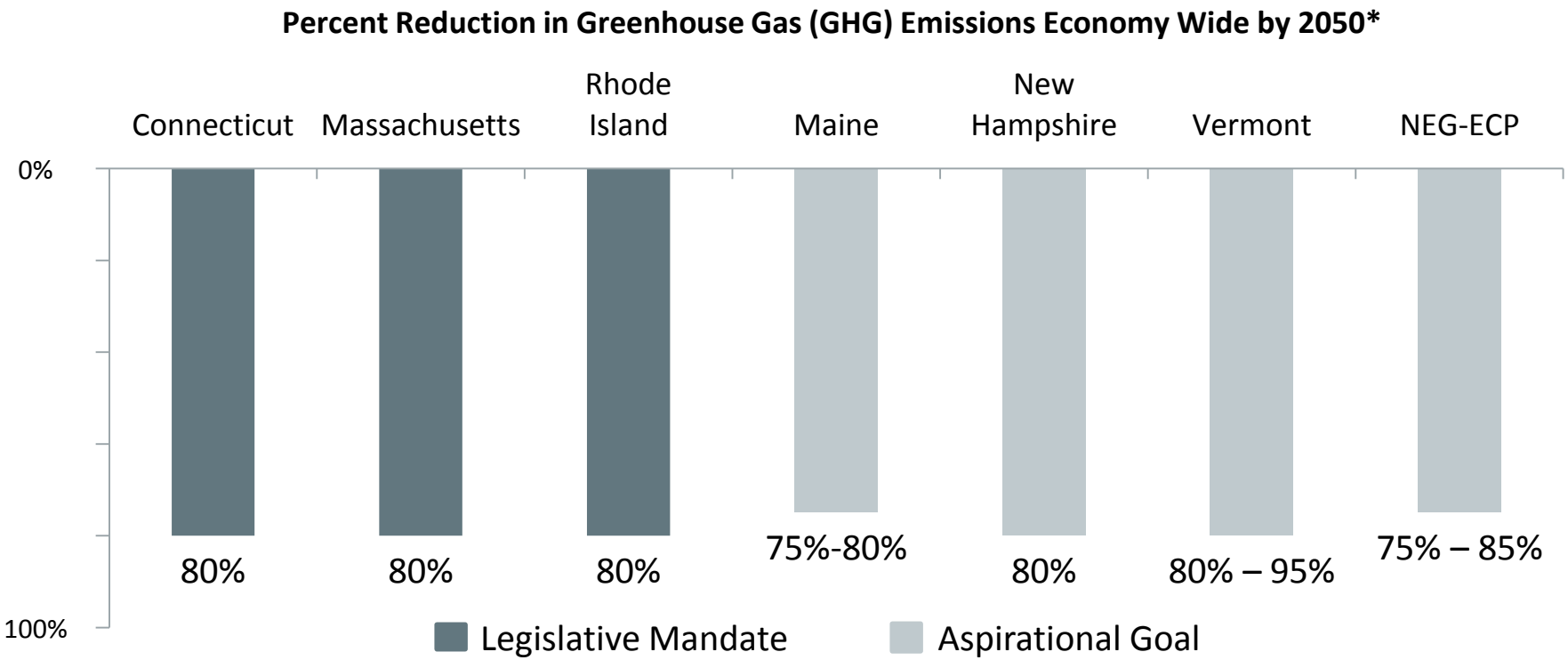
Retail Electricity Prices Follow Wholesale Prices, But Are Also Influenced by Individual State Policies



Source: U.S. Energy Information Administration, *Electric Power Monthly*, Average Retail Price of Electricity to Ultimate Customers by End-Use Sector, by State; *2018 Report of the Consumer Liaison Group*, the New England all-in wholesale electricity price is derived by dividing total wholesale electricity costs by real-time load obligation (presented for illustrative purposes; does not reflect actual charge methodologies)

THE SHIFT TOWARDS CARBON-FREE ENERGY

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

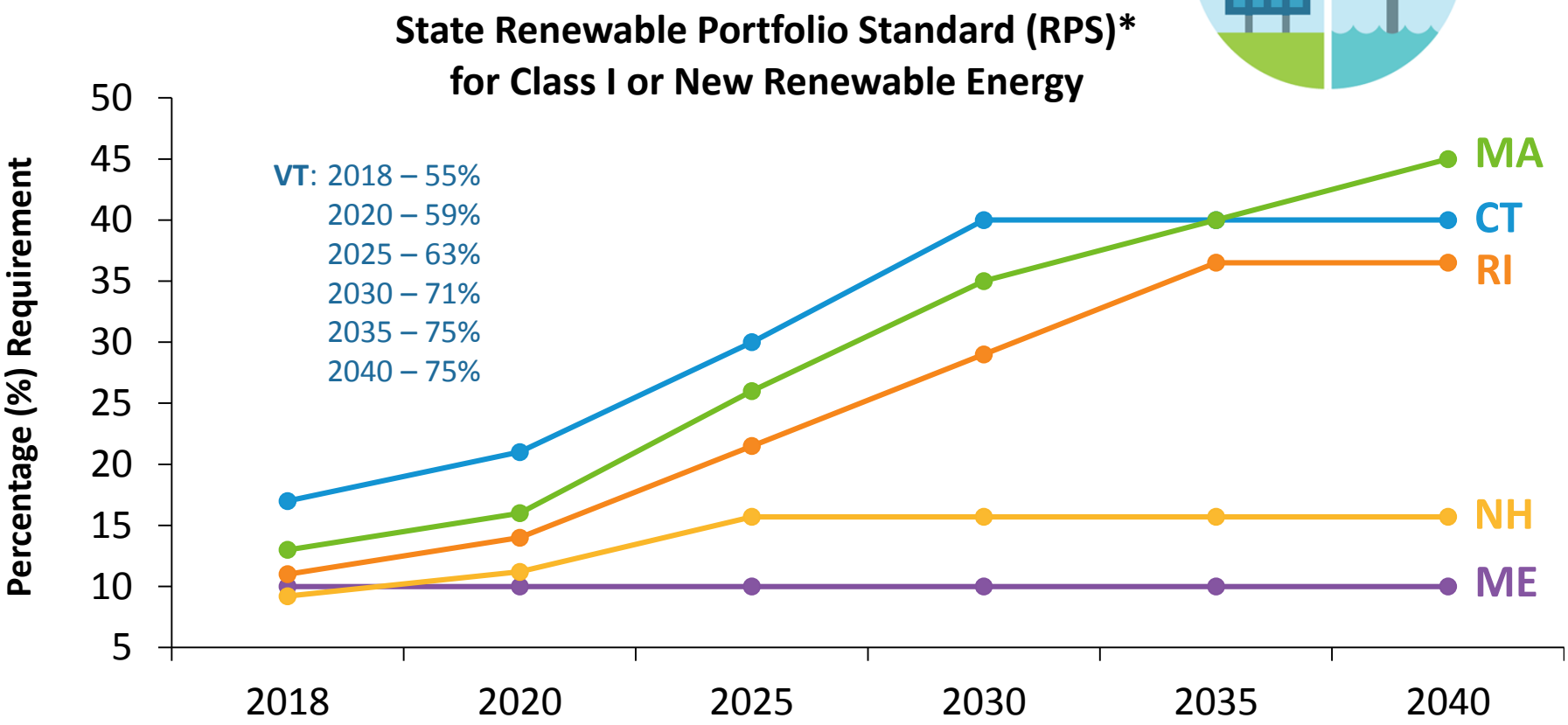


The New England states are promoting GHG reductions on a state-by-state basis, and at the regional level, through a combination of legislative mandates (e.g., CT, MA, RI) and aspirational, non-binding goals (e.g., ME, NH, VT and the New England Governors and Eastern Canadian Premiers).

* 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.

Renewable Energy Will Grow

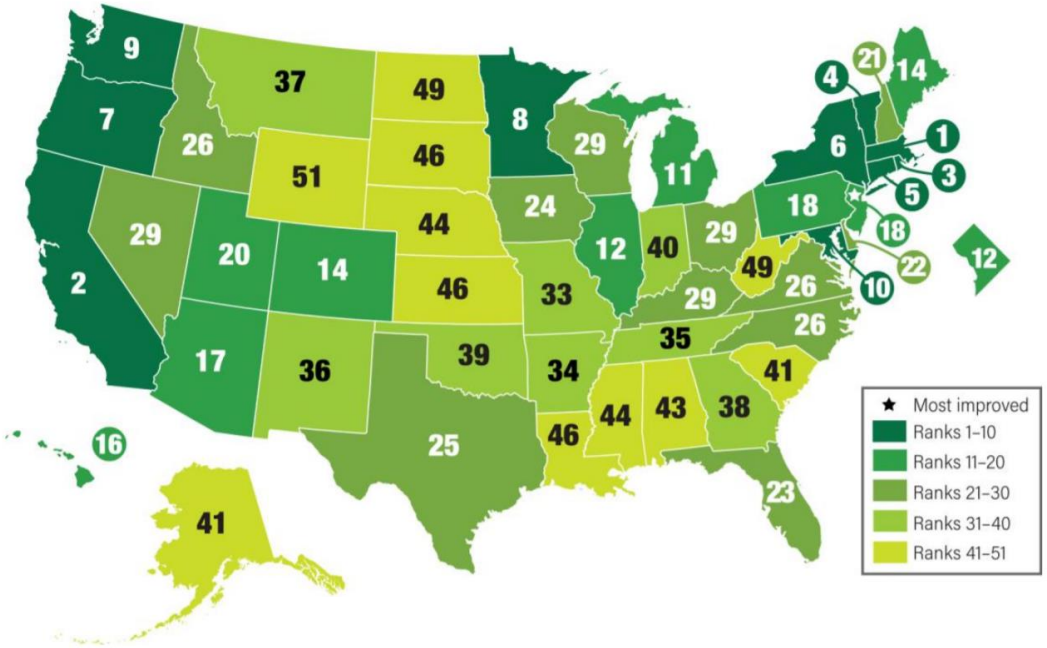
State policy requirements are a major driver



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 plateaus at 10% in 2017 and expires in 2022 (but has been held constant in this chart 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.

Energy Efficiency Is a Priority for State Policymakers

2018 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
– Rhode Island	3
– Vermont	4
– Connecticut	5
– Maine	14
– New Hampshire	21

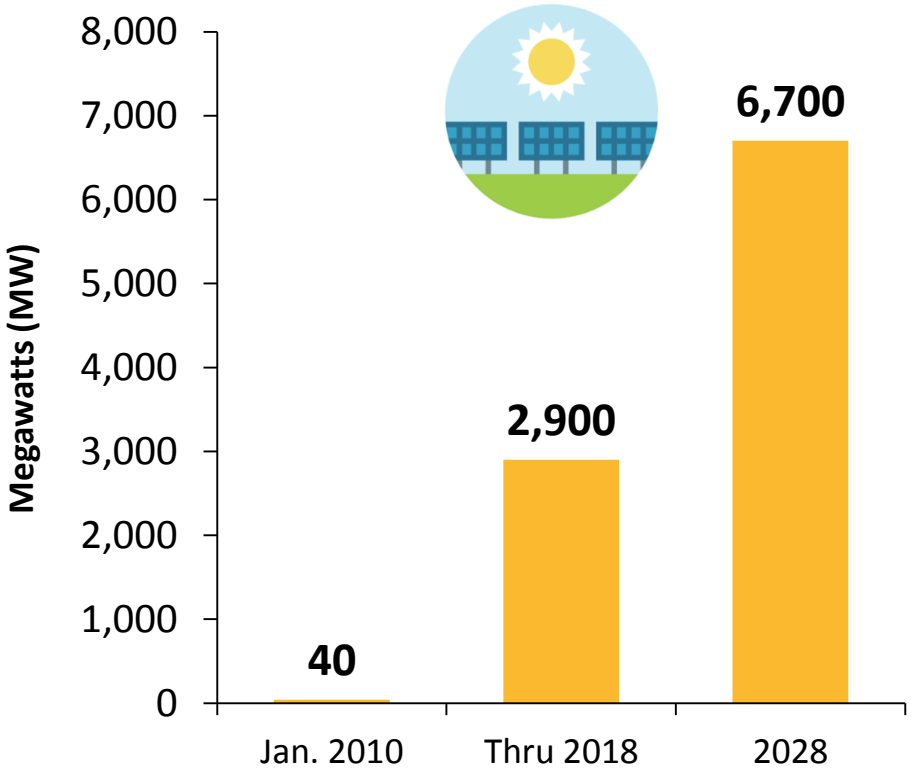
- Billions spent over the past few years and more on the horizon
  - Nearly $4.9 billion invested from 2011 to 2016
  - ISO estimates $10.5 billion to be invested in EE from 2019 to 2027

ISO New England Forecasts Strong Growth in Solar Photovoltaic (PV) Resources

December 2018 Solar PV Installed Capacity (MW_{ac})

State	Installed Capacity (MW_{ac})	No. of Installations
Connecticut	464.3	35,889
Massachusetts	1,871.3	90,720
Maine	41.4	4,309
New Hampshire	83.8	8,231
Rhode Island	116.7	5,993
Vermont	306.3	11,864
New England	**2,883.8**	**157,006**

Cumulative Growth in Solar PV through 2028 (MW_{ac})

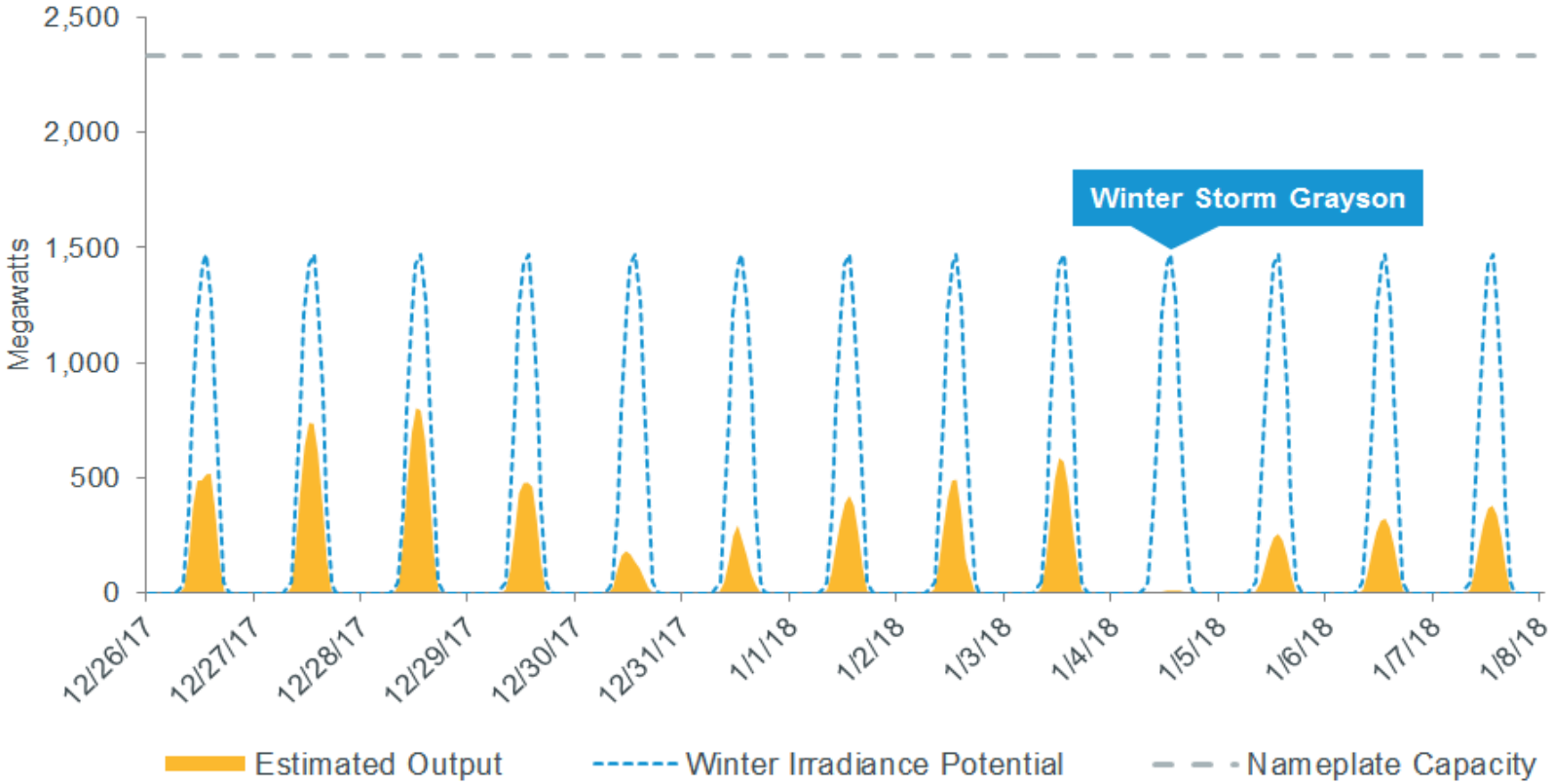


Note: The bar chart reflects the ISO's projections for nameplate capacity from PV resources participating in the region's wholesale electricity markets, as well as those connected "behind the meter." The forecast does not include forward-looking PV projects > 5 MW in nameplate capacity. Source: Final 2019 PV Forecast (March 2019); MW values are AC nameplate.

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

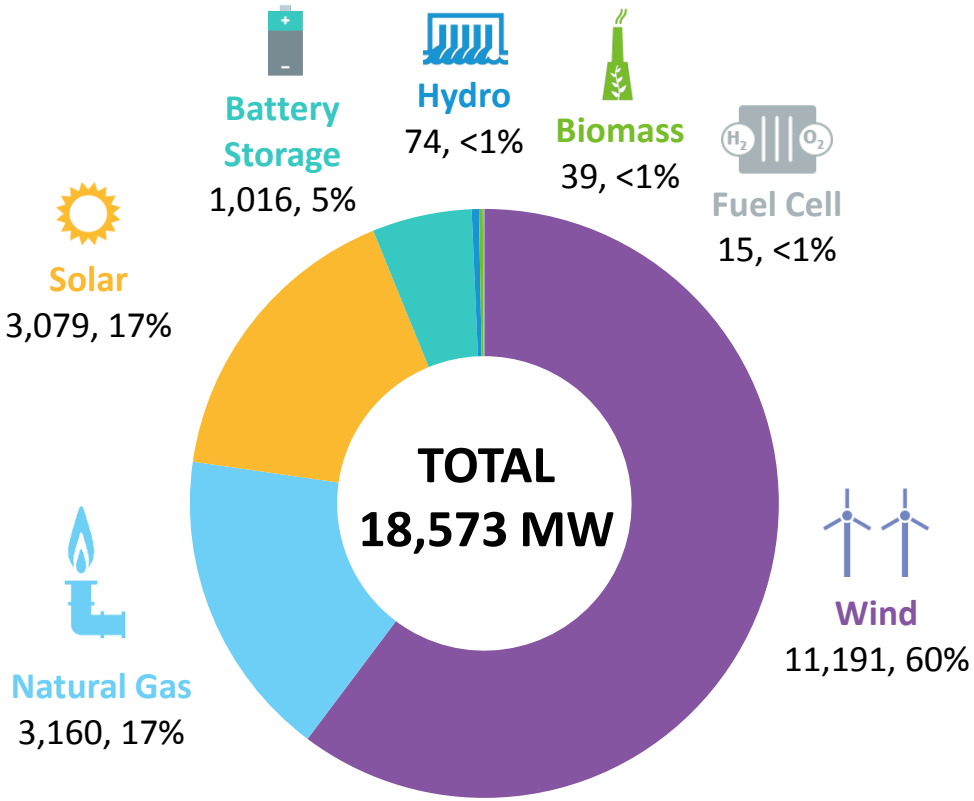
Potential vs. Actual Estimated Output from Behind-the-Meter Solar Power



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.

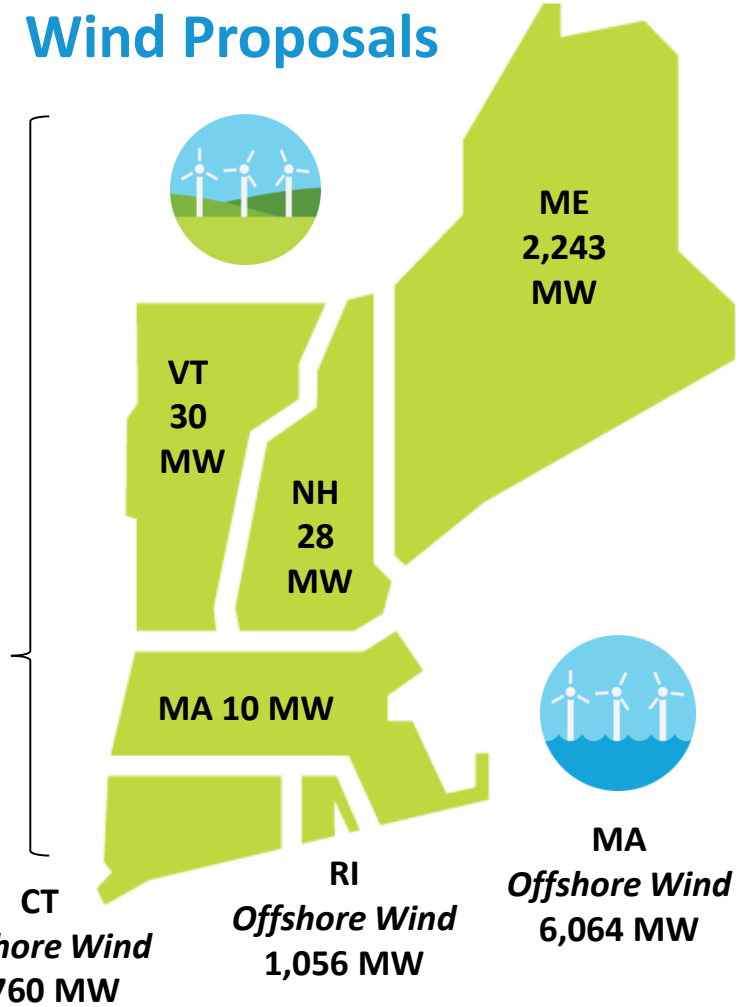
Wind Power Comprises Nearly Two Thirds of New Resource Proposals in the ISO Interconnection Queue

All Proposed Resources



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

Wind Proposals



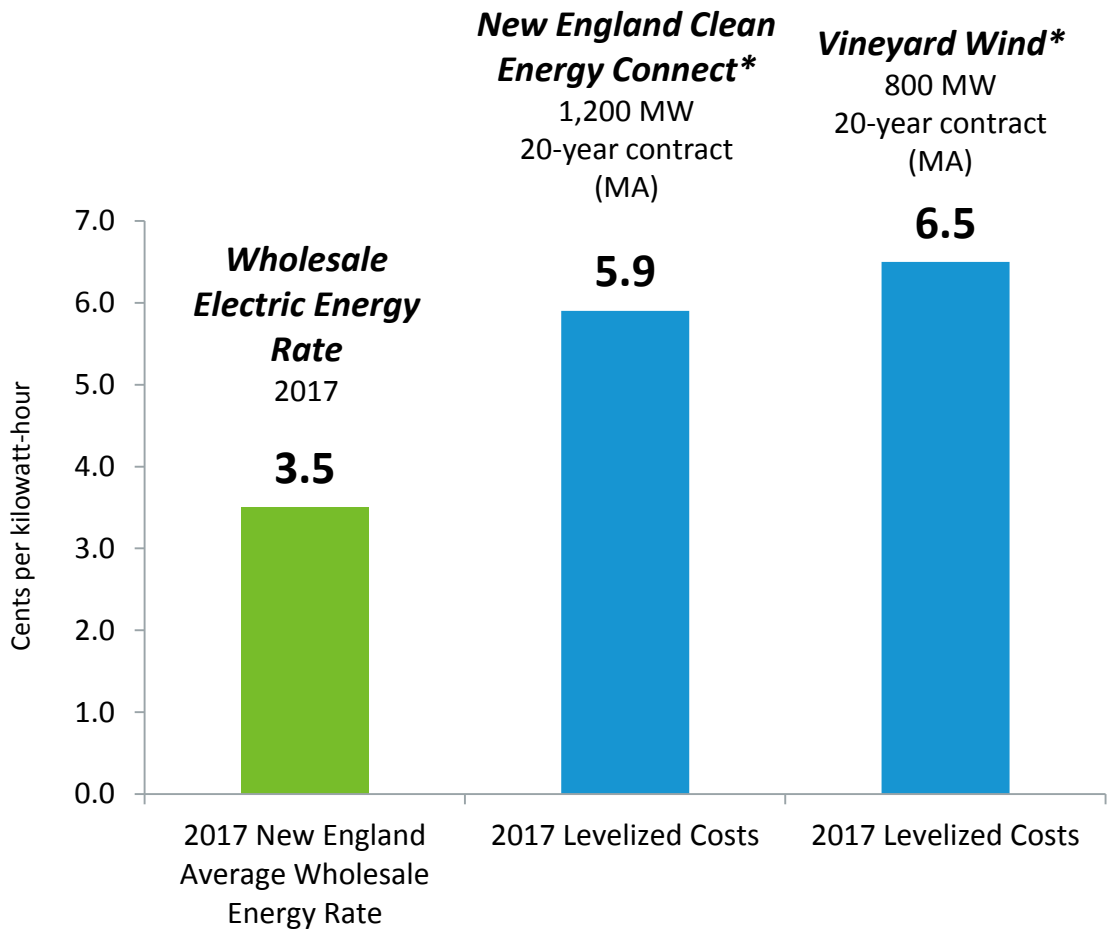
States Accelerate Procurement of Renewable Energy

The states are seeking to develop (or retain) more than 5,000 MW of clean energy resources through large-scale procurement efforts to meet public policy goals

State(s)	State Procurement Initiatives for Large-Scale Clean Energy Resources	Resources Eligible/Procured	Target MW (nameplate)
MA, CT, RI	2015 Multi-State Clean Energy RFP	Solar, Wind	390 MW
MA	2017 Section 83D Clean Energy RFP	Hydro Import	Approx. 1,200 MW (9,554,000 MWh)
MA RI	2017 Section 83C Offshore Wind RFP	Offshore Wind	1,600 MW (MA) 400 MW (RI)
CT	2018 Renewable Energy RFP	Offshore Wind, Fuel Cells, Anaerobic Digestion	252 MW
CT	2018 Zero-Carbon Resources RFP	Nuclear, Hydro, Class I Renewables, Energy Storage	Approx. 1,400 MW (12,000,000 MWh)
RI	2018 Renewable Energy RFP	Solar, Wind, Biomass, Small Hydro, Fuel Cells and Other Eligible Resources	400 MW

Note: Nameplate megawatts (MW) may be higher than qualified Forward Capacity Market (FCM) capacity MW.

State Procurements Are Priced Above Wholesale Energy Market Prices, But Include Different Attributes



- States are directing their utilities to sign long-term contracts for clean and renewable energy; these contracts include an implied price on carbon
- Retail rates are likely to rise as states continue on a path to decarbonize the economy

**Sample of state procurements; contracts are pending final approval by state public utility commissions.*

THE IMPLICATIONS FOR WHOLESALE MARKETS

Several Factors Complicate Market Design

- **New England has clear carbon objectives, but lacks a meaningful price on carbon**
  - Renewable and nuclear resources are seeking out-of-market contracts to compensate for their energy and carbon-free attributes
  - Ultimately, pricing carbon is a decision for policymakers, not the ISO
- **"Above-market" contracts create distortions**
  - Provide out-of-market revenues to renewable resources; in turn, lowers energy market prices and creates a dependency on the capacity market
  - Accelerated economic stress for existing generators; leads to the potential for premature retirements

Several Factors Complicate Market Design*, cont.*

- **Opposition to new infrastructure has multiple impacts**
  - Creates **significant friction** in the market, resulting in delayed market responses to price signals (it's easier to retire than to build new)
  - Retirements combined with delayed market responses can result in scarcity conditions
  - Fuel infrastructure constraints result in **energy constraints and price volatility** during extreme cold periods; premature retirements of non-pipeline gas resources can exacerbate these conditions
  - Frictions and fuel infrastructure constraints create a **dependency** on supply chains for importing oil and LNG that are logistically **constrained**
  - The current market design does not price emerging energy scarcity conditions on a forward basis (to incent the supply chain to respond on a timely basis during adverse conditions)

The Emergence of an Energy Constrained System

Retiring and emerging resources exhibit very different characteristics

- Resources with **onsite fuel storage** are being replaced by resources that cannot always get fuel or are entirely weather-dependent
- The remaining **nuclear power stations** are at risk for retirement, until policymakers price carbon at the level implied in renewable energy contracts, or provide them power purchase agreements
- Regional **energy storage** is important; current electric storage technology is limited in the quantity of energy stored and is useful only for short-duration events (hours)
- Addressing "energy security" will become increasingly important as the New England power system shifts toward resources that face **constraints on energy production**

The ISO's Long-Term Energy Security Improvements Are Designed to Address *Three Inter-related Problems*

- **Problem 1. Incentives and Compensation (P1)**
  - Inefficiently low market incentives for resources that face production uncertainty to make advance fuel/energy supply arrangements
- **Problem 2. Operational Uncertainty (P2)**
  - There may be insufficient energy available to withstand an unexpected, extended (multi-hour to multi-day) large generation/supply loss during cold conditions, particularly if that energy supply loss is non-gas generation
- **Problem 3. Inefficient Schedule (P3)**
  - Premature (inefficient) depletion of energy inventories for electric generation, absent a mechanism to coordinate and reward efficient preservation of limited-energy supplies

Long-Term Solution Focuses on Energy Optimization

Market-based solution optimizes use of limited energy over extended periods at least cost

1. **Change the Current Day-Ahead Energy Market to a *Multi*-Day-Ahead Market (M-DAM).** Procure resources over a rolling, multi-day-ahead horizon (*initially expected to be 2–3 days; could be extended up to 7 days*) to provide a forward price signal for resources to replenish fuel inventories when prospective supplies are tight and to avoid prematurely depleting limited energy (Focus: P3)
2. **Three New Ancillary Services Co-optimized with Multi-Day-Ahead Market for Energy.** These services, combined, provide the 'margin for uncertainty' in an increasingly energy-limited system and model the types of actions system operators need to take to ensure reliability over a multi-day horizon (Focus: P1 and P2)
   - Replacement Energy Reserves – if a day-ahead cleared resource is unable to perform
   - Generation Contingency Reserves – for fast-start/fast-ramping generation contingency response
   - Energy Imbalance Reserves – when forecast load exceeds day-ahead cleared physical supply
3. **New (Voluntary) Forward/Seasonal Market Ahead of the Winter Period.** Procure replacement energy commitments, providing incentive for resources to arrange firm energy inventory logistics and a means to recover the costs of doing so

Looking Forward…

- States will continue to invest aggressively in **energy efficiency and renewable energy**, gradually lessening dependency on fossil fuels
  - Policymakers could make investments in resources to meet carbon-reduction goals *go farther* if those investments also help meet grid-reliability needs
- Demand for power from the grid will **remain flat or slowly decrease** for at least the next five years, driving more retirements
  - However, the shift to electric vehicles and heating-system conversions may gradually reverse this trend
- While the current power system has a small surplus, imperfect coordination of the ***exit and entry*** of resources may lead to shortage conditions and price volatility
- The **margin for error** is small
  - During cold weather, when fuel infrastructure is constrained, the region is vulnerable to large outages on the gas and electric systems

Closing Thoughts…

- Wholesale electricity markets have served New England well, delivering **efficiencies, innovation, new investment and reliability**
- We have made many **enhancements** to create a framework for a **successful transition**; but there are still **challenges** to be addressed
- New England's **capacity for innovation and collaboration** will be essential during the rapid transformation of the power system, and we look forward to **working with our stakeholders** on these challenges

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