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](http://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

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

Annual Value of Wholesale Electricity Markets (in billions)

Source: 2016 Report of the Consumer Liaison Group; *2017 data is preliminary and subject to resettleemnt

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)

13,000 MW Total*

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)

- **Nuclear**: 31% (2000), 31% (2017)
- **Oil**: 22% (2000), 1% (2017)
- **Coal**: 18% (2000), 2% (2017)
- **Natural Gas**: 15% (2000), 48% (2017)
- **Hydro**: 7% (2000), 8% (2017)
- **Renewables**: 8% (2000), 11% (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
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

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.
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

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

The Changing Grid: Solar PV

December 2017 Solar PV Installed Capacity (MW<sub>ac</sub>)

<table>
<thead>
<tr>
<th>State</th>
<th>Installed Capacity (MW&lt;sub&gt;ac&lt;/sub&gt;)</th>
<th>No. of Installations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connecticut</td>
<td>365.6</td>
<td>29,512</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>1,602.3</td>
<td>78,047</td>
</tr>
<tr>
<td>Maine</td>
<td>33.5</td>
<td>3,598</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>69.7</td>
<td>7,330</td>
</tr>
<tr>
<td>Rhode Island</td>
<td>62.2</td>
<td>4,148</td>
</tr>
<tr>
<td>Vermont</td>
<td>257.2</td>
<td>9,773</td>
</tr>
<tr>
<td>New England</td>
<td>2,390.5</td>
<td>132,408</td>
</tr>
</tbody>
</table>

Cumulative Growth in Solar PV through 2027 (MW<sub>ac</sub>)

<table>
<thead>
<tr>
<th>Year</th>
<th>MW&lt;sub&gt;ac&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 2010</td>
<td>40</td>
</tr>
<tr>
<td>Thru 2017</td>
<td>2,400</td>
</tr>
<tr>
<td>2027*</td>
<td>5,750</td>
</tr>
</tbody>
</table>

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

- **Summer Peak Demand (MW)**
  - With and Without EE and PV Savings

- **Annual Energy Use (GWh)**
  - With and Without EE and PV Savings

**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).

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

**BEFORE**
12/1 thru 12/25/2017

- **NG/LNG**: 46%
- **Nuclear**: 35%
- **Renewables**: 7%
- **Coal**: 2%
- **Wind**: 3%
- **Oil**: 0.29%

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

- **NG/LNG**: 24%
- **Nuclear**: 27%
- **Renewables**: 6%
- **Coal**: 6%
- **Wind**: 4%
- **Oil**: 27%
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

Mass. Natural Gas, Marcellus Shale Gas, and Electricity Prices
(December 1, 2017 – January 8, 2018)

Underlying natural gas data furnished by: ICE
Two-Week Cold Spell: Nearly $1 Billion in Total Market Cost

Energy Market Value, December 26 - January 8

- 2012/2013: $348 M
- 2013/2014: $798 M
- 2014/2015: $292 M
- 2015/2016: $201 M
- 2016/2017: $243 M
- 2017/2018: $992 M
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

- **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](https://twitter.com/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

Hurricanes hit the Gulf
Before the Recession and Marcellus Shale gas boom
Winter 2012/2013
Winter 2013/2014
Winter 2014/2015

Underlying natural gas data furnished by:

ice Global markets in clear view
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)**

<table>
<thead>
<tr>
<th>Year</th>
<th>NO\textsubscript{x}</th>
<th>SO\textsubscript{2}</th>
<th>CO\textsubscript{2}</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>59.73</td>
<td>200.01</td>
<td>52,991</td>
</tr>
<tr>
<td>2016</td>
<td>16.27</td>
<td>4.47</td>
<td>37,467</td>
</tr>
</tbody>
</table>

% Reduction, 2001–2016 ↓ 73% ↓ 98% ↓ 29%

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

<table>
<thead>
<tr>
<th>Year</th>
<th>NO\textsubscript{x}</th>
<th>SO\textsubscript{2}</th>
<th>CO\textsubscript{2}</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>1.36</td>
<td>4.52</td>
<td>1,009</td>
</tr>
<tr>
<td>2016</td>
<td>0.31</td>
<td>0.08</td>
<td>710</td>
</tr>
</tbody>
</table>

% Reduction, 1999–2016 ↓ 77% ↓ 98% ↓ 30%

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

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

*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

*Tuesday, January 7, 2014*

PV does not reduce winter peak

High PV penetrations will increase the need for ramping capability throughout sunlight hours
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”
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

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

Source: ISO Interconnection Queue (January 2018)
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