Forecasting Load on the Distribution System with Distributed Energy Resources

Distribution Systems and Planning Training for NECPUC

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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
Energy Efficiency and Behind-the-Meter Solar Impact Peak Demand and Overall Electricity Use

• **7.1 million** retail electricity customers drive the demand for electricity in New England (14.7 million population)

• Region’s all-time summer peak demand set on August 2, 2006 at **28,130 MW**

• Region’s all-time winter peak demand set on January 15, 2004 at **22,818 MW**

• 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.
Managing Comprehensive Regional Power System Planning Is a Major Responsibility

• Manage regional power system planning in accordance with mandatory reliability standards
• Administer requests for interconnection of generation, and regional transmission system access
• Conduct transmission system needs assessments
• Plan regional transmission system to provide regional network service
• Develop Regional System Plan (RSP) with a ten-year planning horizon
Energy-Efficiency and Renewable Resources Are Trending Up in New England

**Energy Efficiency** (MW)

- EE thru 2016: 2,100
- EE in 2026: 4,500

**Solar** (MW)

- PV thru 2016: 1,900
- PV in 2026: 4,700

**Wind** (MW)

- Existing: 1,100
- Proposed: 7,300

*Final 2017 CELT Report*, EE through 2016 includes EE resources participating in the Forward Capacity Market (FCM). EE in 2026 includes an ISO-NE forecast of incremental EE beyond the FCM.

*Final 2017 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.”

Nameplate capacity of existing wind resources and proposals in the ISO-NE Generator Interconnection Queue; some wind proposals include battery storage.
Energy Efficiency Is a Priority for State Policymakers

Ranking of state EE efforts by the *American Council for an Energy-Efficient Economy*:

- Massachusetts 1
- Vermont 3
- Rhode Island 4
- Connecticut 5
- Maine 11
- New Hampshire 21

• Billions spent over the past few years and more on the horizon
  – Nearly $4.5 billion invested from 2010 to 2015
  – ISO estimates $7.2 billion to be invested in EE from 2021 to 2026
Energy-Efficiency Forecast Origins

• Since 2012, the ISO has developed a state-by-state energy-efficiency (EE) forecast to project the long-term impacts of state-sponsored EE investments on New England’s peak and overall demand for energy

• All forecast assumptions, data, and results are vetted through the Energy-Efficiency Forecast Working Group

• Each state has its own structure for planning and implementing EE programs, although all of the programs generally cover the residential, commercial, and industrial sectors

• Lighting and mixed-lighting measures constitute most of the savings in energy use and peak demand, and the commercial and industrial sectors provide a majority of the overall savings
Energy-Efficiency Forecast Origins, cont.

• The savings in energy use resulting from EE programs result in demand reductions that can be bid into the Forward Capacity Market (FCM)

• The region’s EE program administrators (PAs) typically bid their EE portfolios into this market

• Historical data on EE performance in the FCM provides the ISO with a solid understanding of the amount of EE available in the region in the one- to four-year future timeframe

• The EE forecast provides information about the amount of EE anticipated to be deployed over the five- to 10-year planning horizon beyond the current FCM forward obligations
Typical Energy Efficiency Measures

Energy Savings by Measure Type (%)
- Lighting currently accounts for the majority of regional energy savings
- In the next few years, savings from lighting are expected to decline

Production Costs ($/MWh)
- As lighting becomes saturated, future savings will have to come from more costly measures

“Other” category includes: motors/drives/variable frequency drives, education, custom, compressed air, appliances, and consumer products.
Energy Efficiency and Behind-the-Meter Solar Impact Peak Demand and Annual Energy Use

The gross peak and load forecast

The gross peak and load forecast minus forecasted “behind-the-meter” (BTM) solar PV resources

The gross peak and load forecast minus forecasted BTM solar PV, minus energy-efficiency (EE) resources in the Forward Capacity Market 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).
ISO New England Forecasts Growth in Distributed Generation Resources

• Since 2013, the ISO has led a regional Distributed Generation Forecast Working Group (DGFWG) to collect data on distributed generation (DG) policies and implementation, and to forecast long-term incremental DG growth in New England

• The DGFWG focuses on the following types of DG resources:
  – Under 5 MW
  – Connected to the distribution system
  – Not visible to the ISO directly
  – Specifically solar photovoltaic (PV) resources, the largest DG component

• The ISO forecasts strong growth in solar PV over the next 10 years
ISO New England Forecasts Strong Growth in Solar PV

December 2016 Solar PV Installed Capacity (MW_{ac})

<table>
<thead>
<tr>
<th>State</th>
<th>Installed Capacity (MW_{ac})</th>
<th>No. of Installations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connecticut</td>
<td>281.55</td>
<td>23,544</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>1,324.77</td>
<td>65,883</td>
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<tr>
<td>Maine</td>
<td>22.14</td>
<td>2,745</td>
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<tr>
<td>New Hampshire</td>
<td>54.30</td>
<td>5,873</td>
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<tr>
<td>Rhode Island</td>
<td>36.81</td>
<td>2,202</td>
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<tr>
<td>Vermont</td>
<td>198.39</td>
<td>7,612</td>
</tr>
<tr>
<td>New England</td>
<td>1,917.96</td>
<td>107,859</td>
</tr>
</tbody>
</table>

Cumulative Growth in Solar PV through 2026 (MW_{ac})

- Jan. 2010: 40
- Thru 2016: 1,918
- 2026: 4,733

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: Final 2017 PV Forecast (April 2017); MW values are AC nameplate.
Solar PV Penetration Shifts Timing of Hourly Peaks Later in the Day During Summer

*Friday, July 19, 2013*

*PV contributes less to summer peak as larger penetrations shift the peak later in the day when daylight fades*
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
Solar in Spring/Fall Displaces Generation and Increases Need to Back Down Generation in Low-Load Hours

Potential minimum generation emergency events during midday hours (minimum load hours are shown in green)
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
State Installed Solar PV “Heat Maps”

- Understanding the spatial distribution of existing solar PV resources will be critical to the ISO’s ongoing integration activities within both System Planning and System Operations.

- Based on the data provided by distribution owners, the ISO has aggregated the installed nameplate capacity by town within each state, and generated heat maps showing the results.

Note: Heat map reflects solar PV installed through April 30, 2017.
State Installed Solar PV “Heat Maps”

Note: Heat map reflects solar PV installed through April 30, 2017.
2017 Solar Eclipse – ISO-NE BTM PV Output
August 21, 2017 (5-minute resolution)

Eclipse Begins: 1:25 PM (Holyoke, MA)
Maximum Obscuration: 2:44 PM (Holyoke, MA)
Eclipse Ends: 3:58 PM (Holyoke, MA)
2017 Solar Eclipse – ISO-NE System Load
August 21, 2017

Eclipse Begins: 1:25 PM (Holyoke, MA)
Maximum Obscuration: 2:44 PM (Holyoke, MA)
Eclipse Ends: 3:58 PM (Holyoke, MA)
The ISO Is Improving the Ability of Intermittent Resources to Participate in the Wholesale Markets

• **Flexibility to Offer Negative Prices**
  – Allows generators, such as 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”
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Questions