Overview of ISO New England and Near Final Results of the New England Wind Integration Study

NEWEEP Wind Integration Webinar
October 26, 2010

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Senior Engineer, Renewable Resource Integration
Overview

- New England’s power system will undergo major changes in the coming years to integrate renewables, demand response, smart grid and other new technologies
- Good planning helps overcome integration challenges
- Wind could be well positioned for large-scale growth in New England
  - High capacity factors
  - With significant transmission upgrades: access to large load centers
  - Transparent markets with full suite of power market products
  - Aggressive regional renewable energy and emissions policies
  - Potentially flexible resource fleet may aid in managing variability
About ISO New England

• Not-for-profit corporation created in 1997 to oversee New England’s restructured electric power system
  – Regulated by the Federal Energy Regulatory Commission

• Independent System Operator
  – Independent of companies doing business in the market
  – No financial interest in companies participating in the market

• Major responsibilities:
  – Reliable system operations
  – Administer competitive wholesale electricity markets
  – Comprehensive regional system planning
At a Glance: New England’s Electric Power Grid

- 6.5 million customer meters
  - Population 14 million
- 300+ generators
- 8,000+ miles of high voltage transmission lines
- 13 interconnections to three neighboring systems: New York, New Brunswick, Quebec
- 32,000 megawatts (MW) of installed capacity
- Includes over 2,500 MW demand response and Energy Efficiency
- System peak:
  - Summer: 28,130 MW (8/06)
  - Winter: 22,818 MW (1/04)
- 400+ Market Participants
Wholesale Power Markets in New England

• Three primary market mechanisms in New England
  – Energy Markets (DayAhead and Real-time)
  – Reserve Markets (Real Time)
  – Forward Capacity Market

• All three markets are designed to reflect locational differences in prices (Locational Marginal Pricing)

• Generation, Demand Resources, and Imports all participate within the market framework
Economic Dispatch
*Selects Lowest Cost Resources to Meet Demand*

- Objective is to minimize the total cost of producing electricity while keeping the system in balance.
- Economic Dispatch uses the least-cost resources in a single period to meet the demand.
- New England assesses hourly resource costs and establishes the wholesale cost of energy based on a *Uniform Clearing Price* auction.
  - This same price formation is used in all other wholesale electricity markets in the United States.
The Uniform Clearing Price Auction

“Bid Stack” Allows ISO to Compare Resource Offers; Establishes Single Price for Resources Used to Meet Demand on the System

Each resource submits an offer that specifies its incremental cost of producing energy and represents the price at which it is willing to run. These offers are stacked from highest to lowest.

The energy clearing price for the region is set at the point where the offers from supply intersect with the demand levels to serve the next expected megawatt of electricity use.
Wholesale Electricity Prices Track Natural Gas

Natural Gas and wholesale electricity prices have both recently declined.
Proposed Renewable Resources in the ISO Interconnection Queue

Total: Approximately 3,400 MW

- Wind 85.2%
- Biomass 13.7%
- Landfill gas 1.0%
- Solar 0.6%
- Hydro 1.0%

As of June 1, 2010

States’ Blueprint as guiding policy and regulatory framework

ISO economic study as technical support
Connecting Wind Energy to Load Centers

• Population and electric demand are concentrated along the coast in central and southern New England

• Study identified 12,000 MW of onshore and offshore wind potential
  – Preliminary screening eliminated wind sites near urban areas and sensitive geographic locations (e.g. Appalachian Trail)

• Significant transmission will be required to connect potential wind resources to load centers in New England
What is the New England Wind Integration Study (NEWIS) Study?

- ISO-NE needed a New England-focused analysis
- New England Wind Integration Study
  - Is a comprehensive wind integration study
    - Includes models of: windy neighbors, offshore, market system
    - Highlights operational effects of large-scale wind integration
    - Uses statistical and simulation analysis
      - Based on 3 years of historical data, develops
        - Highly detailed load dataset
        - Highly detailed and realistic representation of windpower
        - Includes trending to predict incremental effects
        - Learns from each iteration of simulation and analysis
  
- Today I will share some details and near-final results of the NEWIS.
NEWIS – Additional Objectives

• **Develop interconnection requirements**
  – Grid support functions
  – “Best practices” capacity value determination for wind power
    • Both for the entire region and for incremental wind power
  – Data/telemetry requirements
  – Wind forecasting

• **Show longer-term issues**
  – Capacity factors
  – Reliability effects of wind (LOLE, ELCC)

• **Several levels of review**
  – Stakeholder feedback
  – Internal ISO-NE review
  – Independent Technical Review Committee (TRC) of recognized experts

* Publicly released Recommendations in November, 2009 available at:
Different Scenarios Studied

- **NEWIS** looked at specific levels of wind generation:
  - From the interconnection queue:
    - Partial: 1.14 gigawatts (GW) or 2.5% of forecasted energy demand
    - Full: 4.17 GW or 9% of forecasted energy demand
  - Varying amounts of wind penetration with different siting scenarios:
    - Medium penetration: 6.13 to 7.25 GW or 14% of forecasted energy demand
    - High penetration: 8.29 to 10.24 GW or 20% of forecasted energy demand
- System level study—local issues were not accounted for
- Capacity factor: Measures productivity of a facility over time
  - Compares actual production
  - With NEWIS: compared forecasted production
Partial Build-out of Wind in the Queue
Total: 1.14 Gigawatts (GW) 2.5% Annual Energy Transmission System in 2019

<table>
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<tr>
<th>ST</th>
<th>Onshore</th>
<th>Offshore</th>
<th>Total</th>
<th>Capacity Factor (%)</th>
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# Full Build-out of Wind in the Queue

Total: 4.17 GW 9% Annual Energy
Governors’ 2 GW Transmission Overlay

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</table>

- **Partial Queue**
- **Additional Queue**
- **Additional to 20% Energy**
## Best Onshore + Full Queue

**Total: 9.78 GW 20% Annual Energy**

Governors’ 4 GW Transmission Overlay

<table>
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<th>Offshore</th>
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- Partial Queue
- Additional Queue
- Additional to 20% Energy
Best Offshore + Full Queue
Total: 8.29 GW 20% Annual Energy
Governors’ 4 GW Transmission Overlay

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<td>Tot.</td>
<td>41</td>
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- Partial Queue
- Additional Queue
- Additional to 20% Energy

NEWEEP Wind Integration Webinar
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Balance Case + Full Queue  
(aka. Best Sites)  
Total: 8.80 GW 20% Annual Energy  
Governors’ 4 GW Transmission Overlay

<table>
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<td>Tot.</td>
<td>49</td>
<td>4.287</td>
<td>12,435</td>
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What is Capacity Value?

• Capacity value calculations attempt to determine the contribution of wind generation in meeting the reliability needs of the power system
• The capacity values used in the NEWIS were calculated using a Loss of Load (LOLE) probability analysis
  – Data-driven, rigorous, industry standard approach to quantifying reliability contributions of resources
• The chart on the next slide:
  – Details the 20% scenario capacity values for each of the years modeled
  – Indicates the amount of offshore wind within the scenario
20% Energy Scenario: Capacity Values

- Onshore: 8%
- Maritimes: 9%
- Best by States: 31%
- Best Sites: 51%
- Offshore: 58%
Next Four Slides: Operational Simulation

- Graphs are from production simulation results at 20% energy—for “Native Load” peak
- “Area” plots – a.k.a. “Polychromes”
  - Each generator’s output is stacked on top of each other
  - Including pumps (PSH) running in generator mode and imports
  - Some notes:
    - Legend is the same for each plot
    - ‘Native Load’ is the ISO-NE load served
    - ‘Net Load’ = Load – wind output
    - Total load = Load + Exports + Pumps
    - Nuclear units’ output are flat (with random outages and de-rates)
    - Steam: other category
      - biomass, incinerators, etc.: low cost, often quite small
      - Also output is quite flat
    - Combined cycle units change output quite a bit
Simulation Results:

Peak Load

No Wind

Dispatch for July-26 to August-02 No Wind, Native Load Peak

- Nuclear
- Steam-Other
- Steam-Coal
- Steam-Gas
- Steam-Oil
- CC
- CT
- GT
- Hydro
- Wind
- PSH
- Imports

Load & Exports & Pumps

Native Load

Net Load

PSH Operation + is gen

Ties + is import

MW/HR

Time

07/26 12 PM 07/27 12 PM 07/28 12 PM 07/29 12 PM 07/30 12 PM 07/31 12 PM 08/01 12 PM 08/02 12 PM
Simulation Results:

Peak Load

Best Onshore Wind

Dispatch for July-26 to August-02 Best Onshore, Native Load Peak

- Nuclear
- Steam-Other
- Steam-Coal
- Steam-Gas
- Steam-Oil
- CC
- CT
- GT
- Hydro
- Wind
- PSH
- Imports

- Load & Exports & Pumps
- Native Load
- Net Load
- PSH Operation + is gen
- Ties + is import
Simulation Results:
Peak Load

Best Offshore Wind

Dispatch for July-26 to August-02 Best Offshore, Peak Native Load
Simulation Results: An Interesting Week!
Wind displaces mostly natural gas, and oil, and some coal too.
25% reduction in CO2 for 20% wind because roughly 65% of the ISO-NE generation produces CO2. 25% of the generation that produces CO2 is being displaced.
What is Regulation?

• A key power system control objective is to maintain a balance in the system between load and generation (accomplished by maintaining frequency and tie exchange).
• Regulation is the MW required from generators or loads within a Balancing Area like New England that quickly (4 seconds) respond to changes in load and system frequency.
• Changes will be required to our regulation requirements to integrate higher penetrations of wind that were studied as part of the NEWIS
• Increase is mostly due to shot-term windpower forecast error—not the short-term fluctuations in wind
Regulation Statistics for 20% Energy (Preliminary)

Regulation Requirement as a Function of Wind Penetration

Required regulation capacity increases with wind penetration
Reserves

• Reserves are the “insurance policy” that grid operators use to protect against credible contingencies (i.e. realistic power system faults and combinations of faults) that would negatively affect the operation of the power system.

• ISO-NE uses several types of reserves
  – Ten Minute Spinning Reserve (TMSR)
    • Synchronized with grid, can provide inertia and governor response
    • Units on Regulation can be counted towards TMSR
  – Ten Minute Non-spinning Reserve (TMNSR)
    • “Quick start” generation
  – Thirty Minute Operating Reserves (TMOR)

• Due to the imperfect ability to forecast it, wind will increase the need for Reserves
Required capacity for spinning and non-spinning reserves also increases with wind penetration.
Observations

• Capacity factors and capacity values for wind
  – Diminish with increasing penetration or if transmission is not available
  – More expansive results will be presented to New England Stakeholders at the Planning Advisory Committee

• Wind could displace combined cycle, oil and gas-fired steam units (under higher penetration scenarios) in the energy market

• High levels of flexibility will be needed to manage variability
  – Important to maintain fleet flexibility even under decreased energy market revenues

• Some coal displaced at higher levels if you assume no carbon tax

• Centralized windpower forecasting will be required
  – Will require high quality data from wind projects

• As wind penetration levels increase New England will require more regulation and reserves capability in order to maintain reliability

• Significant transmission expansion is required for wind penetration levels above 2.5% annual energy to be effectively integrated, particularly for the onshore scenarios
Questions?
Bonus Material
Best By State + Full Queue
Total: 10.24 GW 20% Annual Energy
Governors’ 4 GW Transmission Overlay

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<th>Offshore</th>
<th>Total</th>
<th>Capacity Factor (%)</th>
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- Partial Queue
- Additional Queue
- Additional to 20% Energy
Maritimes
Plus Full Queue
Total: 8.96 GW 20%
Annual Energy
Governors’ 4 GW
Transmission Overlay

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- Partial Queue
- Additional Queue
- Additional to 20% Energy
Energy Balance For ISO-NE
Wind Model Validation (1)
Wind Model Validation (2)
Wind Model Validation (3)
Wind Model Validation (4)
What is “Smart Grid”? 

“A modernization of the nation’s electricity transmission and distribution system to maintain a reliable and secure electricity infrastructure that can meet future demand growth”

*Energy Independence and Security Act of 2007*
Federal Policy Drivers Behind Smart Grid

• *Energy Independence and Security Act of 2007 (EISA), Section XIII*
  – Founding document for smart grid implementation

• *American Recovery and Reinvestment Act of 2009 (ARRA)*
  – Economic stimulus bill that provides funding for smart grid

• **FERC/NARUC Smart Grid Collaborative**
  – Forum for regulators to discuss issues and make recommendations for state and federal policies to support smart grid

• **FERC Policy on Smart Grid**
Regional Recovery Act Selections for Smart Grid Investment Grant Awards

Central Maine Power
$95.9 M

VT Transco
$68.9 M

NHEC
$15.8 M

CMEEC
$9.2 M

Massachusetts
NSTAR  $10.1 M
Danvers   $8.5 M
Marblehead $1.3 M
Vineyard Energy $.8 M
Honeywell International $11.4 M
ISO-NE   $7.9 M
Total     $40 M

Regional Recovery Grant Funding: $230 M
Regional Total Project Costs: $470 M
## Smart Grid Progress at ISO New England

<table>
<thead>
<tr>
<th>Smart Grid Category</th>
<th>Initiative</th>
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<tbody>
<tr>
<td>Manage Network</td>
<td>Wide Area Monitoring Systems with Phasor Measurement</td>
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<td></td>
<td>Situational Awareness/Visualization</td>
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<td>Real Time Stability Analysis and Control</td>
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<td>System Blackstart and Restoration Automation</td>
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<td>FACTS and HVDC devices</td>
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<tr>
<td>Manage Power System Resources</td>
<td>Electronic Dispatch Upgrade</td>
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<td>Demand Response (DR) Reserves Pilot</td>
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<td>Demand Response Programs</td>
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<td>Integration of DR Resources in ISO/RTO Operations</td>
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<td>Alternative Technology Regulation Pilot</td>
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Measures of Smart Grid Success

• For Reliability
  – More capacity from transmission and distribution resources
  – Intelligent devices that automate monitoring and respond to emergency situations
  – Efficient production, movement and consumption of electricity

• For the Environment
  – Reduction in greenhouse gases
  – Enables greater penetration of renewables, energy storage and demand resources

• For Consumer Control
  – Transparent electricity usage and prices
  – Opportunities for consumers to supply energy, capacity, and ancillary services