ISO on Background—
New England Wind Integration Study

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John Norden, Director, Operations

ISO New England Inc.
December 15, 2010

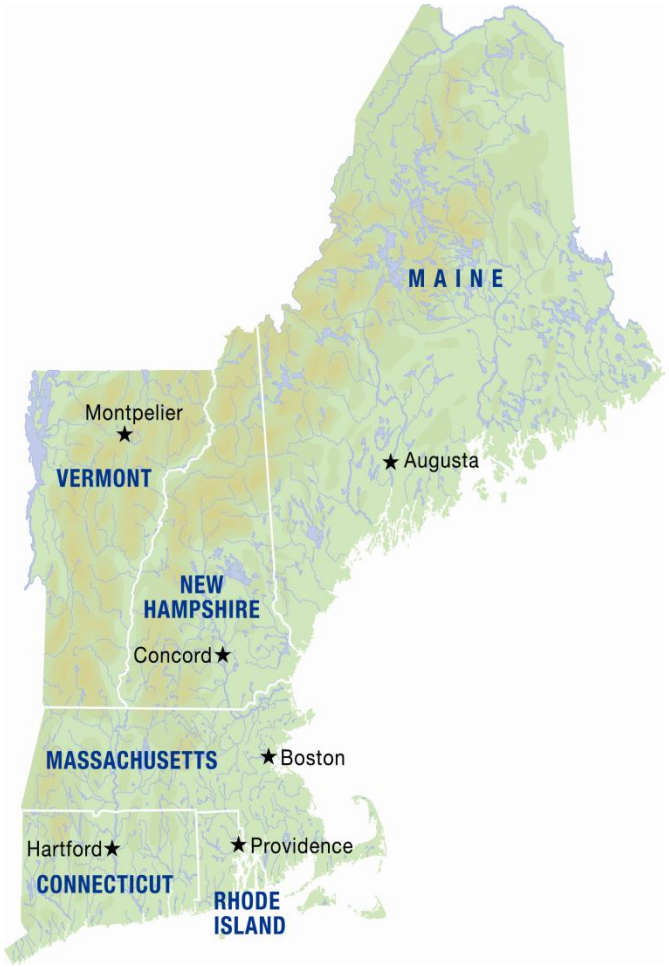
ISO new england

About ISO New England

- Private, not-for-profit corporation created in 1997 to oversee New England's restructured wholesale electric power system
  - Independent of companies doing business in the market
  - Regulated by the Federal Energy Regulatory Commission (FERC)
- 460 employees headquartered in Western Massachusetts

New England's Electric Power Grid at a Glance

- 6.5 million households and businesses; population 14 million
- More than 350 generators
- Over 8,000 miles of high-voltage transmission lines
- 13 interconnections to electricity systems in New York and Canada
- More than 32,000 megawatts (MW) of total supply
- More than 2,000 megawatts of demand response (February 2010)
- All-time peak demand of 28,130 megawatts, set on August 2, 2006
- Over 400 participants in the market
- $5.4 billion annual total energy market value (2009)



About the *ISO on Background* Series

- An informal opportunity for media to learn more about the trends affecting New England's electricity industry
- Sessions will be hosted by ISO New England senior management and other subject matter experts
- Content is considered on-the-record and attributable to the speaker

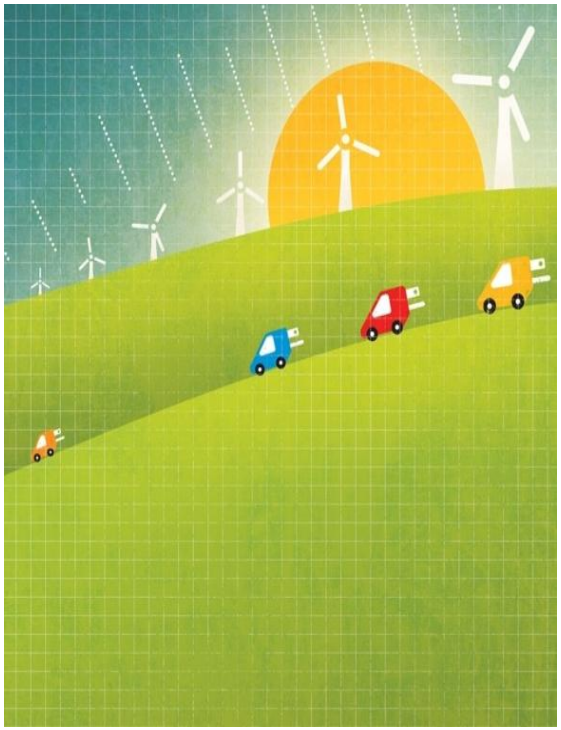
Overview of Today's Discussion

Topic	Speaker
New England Wind Integration Study Introduction and Why ISO-NE Conducted the Study	Gordon van Welie
NEWIS Study Findings and Recommendations	John Norden

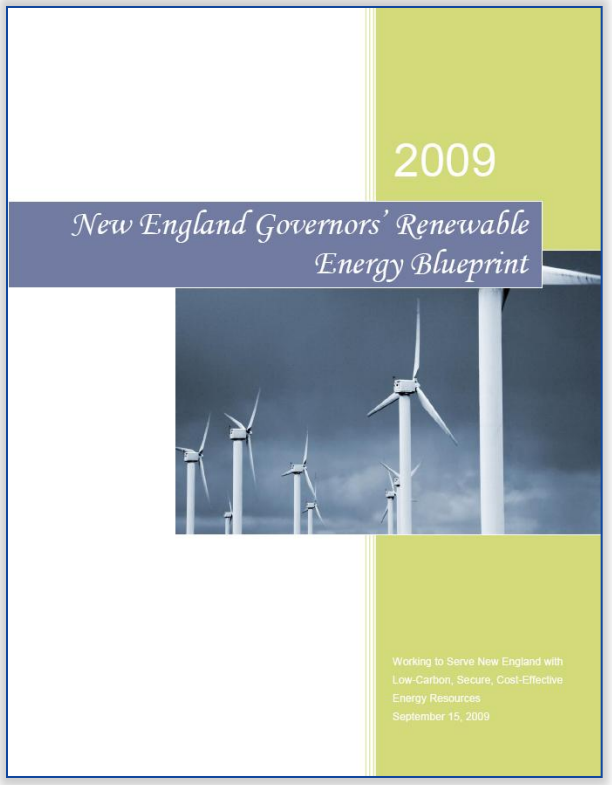
Renewables Shaping Tomorrow's Grid

State and Regional Policy Initiatives

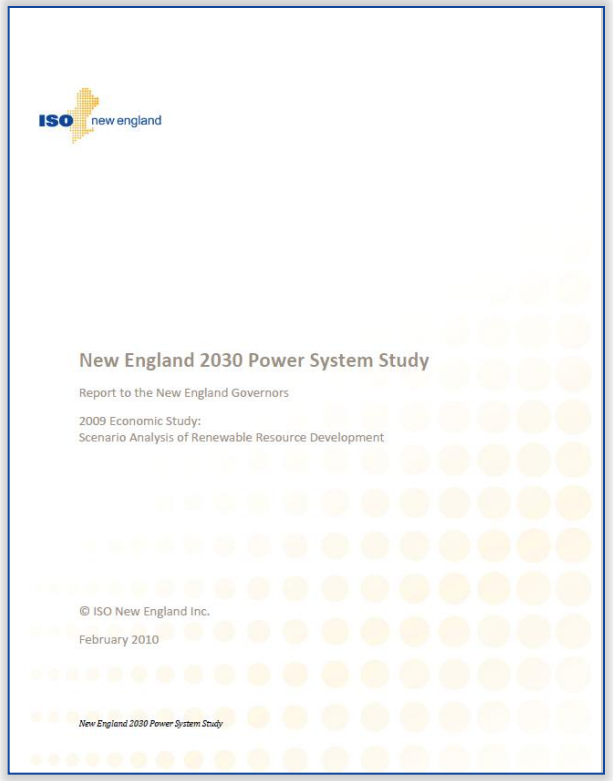
- Renewable Portfolio Standards (RPS)
  - Five of the six New England states have enacted individual RPS mandating that varying levels of electricity come from renewable sources
    - Vermont does not have a traditional RPS, but a program structured to achieve similar outcomes
  - States' collective goals call for 30 percent of New England's projected total electric energy demand to be met by renewables and energy efficiency by 2020
- Regional Greenhouse Gas Initiative
  - First market-based effort in U.S. to reduce carbon emissions from power plants



New England Governors Adopt Long-term Renewable Energy Vision



States' Blueprint as guiding policy and regulatory framework



ISO economic study as technical support

New England's Wind Energy Profile

Benefits:

- Wind energy improves fuel diversity
- Can help meet environmental targets
- Can dampen fuel cost uncertainty

Challenges:

- Higher capital costs
- Siting issues
- Cost of transmission investment
- Operational concerns

New England has about 270 MW of wind on the system now, but significant levels of wind power are proposed

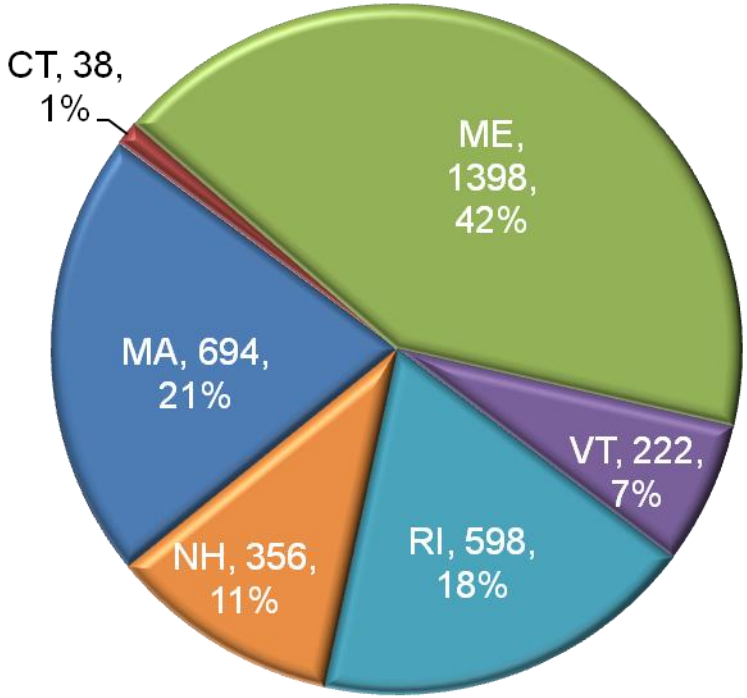
New England's Wind Potential

- New England has abundant wind energy potential, especially in northern areas and offshore
- Up to 200,000 megawatts (MW) theoretically possible
- Wind could be well positioned for large-scale growth in New England
  - Access to areas with high demand (if significant transmission upgrades are made)
  - Can compete in transparent markets with full suite of power market products
  - Regional renewable energy and emissions goals are in place
  - Region's resource fleet could aid in managing variability

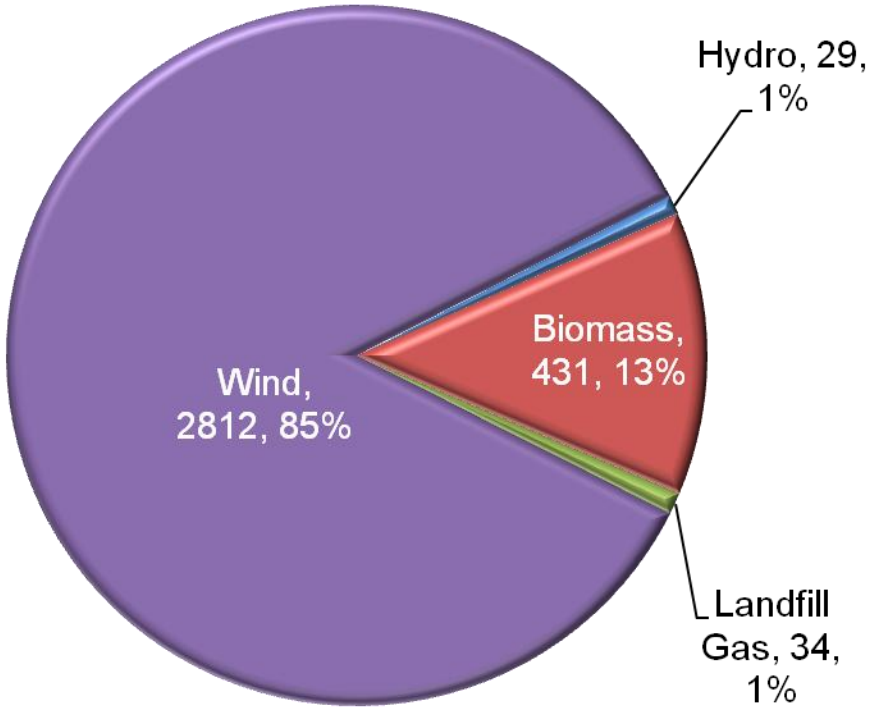
Significant Levels of Wind are in the Queue

Over 3,300 MW of renewables in ISO queue, majority wind—at these levels, New England's power system could experience operational issues

Renewables in Queue By State



Renewables in Queue By Fuel Type



December 2010 ISO Queue. Includes: Landfill Gas, Hydro, Wind , and Biomass. Pump Storage projects in the ISO Queue are not included.

ISO on Background—

Findings of the New England Wind Integration Study

John Norden, Director, Operations

December 15, 2010

Discussion topics

- Highlights
- Need to Prepare Grid Operations
- What the New England Wind Integration Study (NEWIS) Is and Is Not
- NEWIS Wind Development Scenarios
- Major Findings
- Suggestions for Further Work
- Next Steps
- Appendix: NEWIS Definitions

Highlights

- Large-scale wind integration in New England is achievable under certain conditions
- Wind resources could reduce fossil-fueled generation as an energy resource in New England
- Region needs to maintain a flexible system in order to accommodate wind power variability. This may require additional operating reserves and regulation
- Significant capacity factors and capacity values for wind in New England are achievable with adequate transmission infrastructure
- ISO will need to develop wind-power forecasting capability
- Updated technical requirements for wind interconnections must be implemented

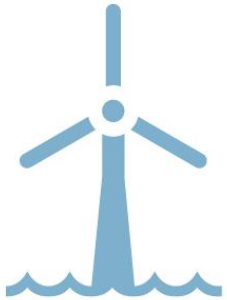
Need to Prepare Grid Operations

Operational challenges with integrating large amounts of wind power

- Wind energy rises and falls
- Difficult to forecast accurately
  - Forecast uncertainty
  - Variations on when and where wind will blow
- Power system operations must account for variability and uncertainty through:
  - Regulation
  - Reserves

New England's power system will undergo major changes in the coming years to integrate:

- Renewables
- Demand resources
- Smart grid and other new technologies



Good planning helps overcome integration challenges

What is the New England Wind Integration Study (NEWIS)?

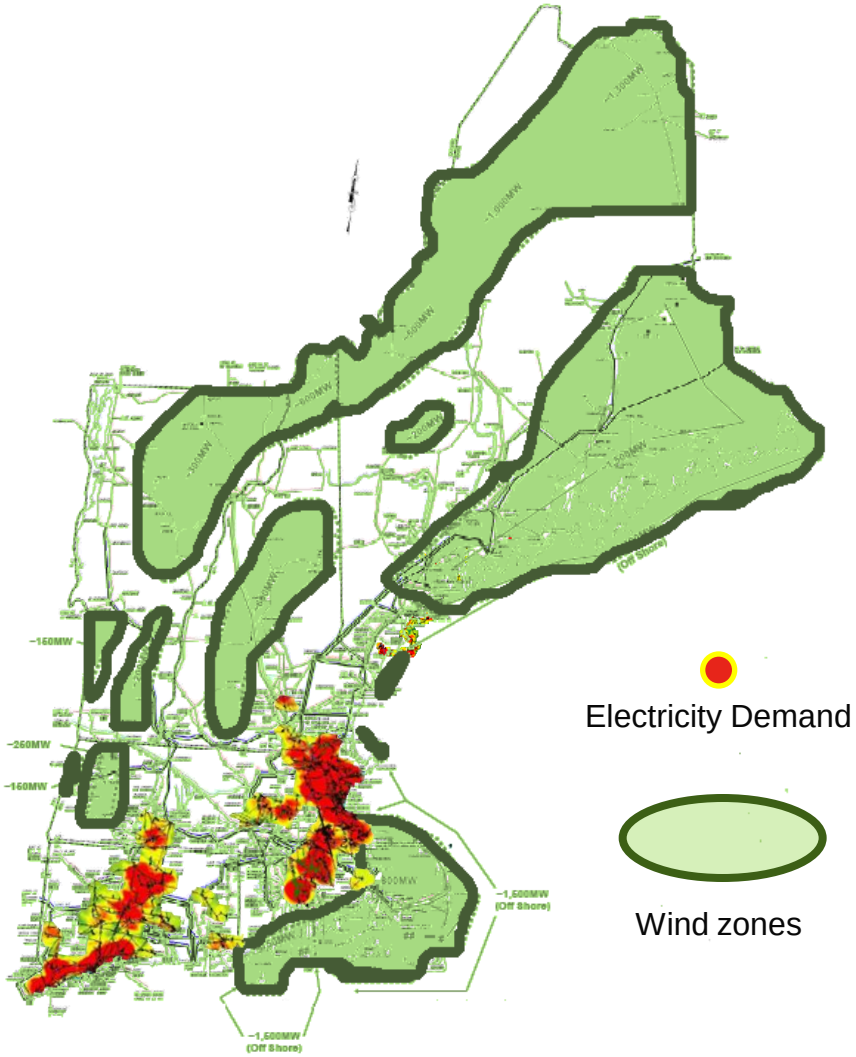
- As the system operator, ISO New England needed an analysis based on New England conditions
- New England Wind Integration Study:
  - Comprehensive, two-year wind integration study
    - Developed a detailed on- and offshore New England wind model
  - Snapshot of the year 2020 with hypothetical small, medium, and large wind power penetrations
  - Highlights the operational impact of each wind development scenario on New England's power system
  - Conducted by GE Energy Applications and Systems Engineering, with EnerNex and AWS Truepower

Important Caveats: What NEWIS is Not

- It is important to recognize what NEWIS is not:
  - NEWIS is not a blueprint for wind power development
  - It is not a transmission planning study
  - Evaluation of any market implications are beyond the scope of NEWIS
  - Future conditions cannot be predicted with certainty
- The ISO aims to meet its responsibility to operate the system reliably, now and into the future, while recognizing New England states' policy objectives

Connecting wind energy to demand centers

- Population and electric demand are concentrated along the coast in central and southern New England
- Transmission will be required to connect potential wind resources to demand centers in New England
- NEWIS uses theoretical transmission overlays, developed for the Governors' study, that could reach hypothetical wind farms in areas with strongest wind



Overview of the NEWIS Study Process

Identify

- New England-specific *wind regime* based on extensive weather data from 2004–2006
  - Expanded to include Canadian Maritimes
- New England electric energy demand in 2020, extrapolating historical peak-load and hourly profile data from 2004–2006

Model

- Effect of wind regime on five wind-plant build-out scenarios
  - Range: 1–12 GW nameplate capacity (on- and offshore wind), and
  - 2.5%–24% of total system energy
  - Targeted five other scenarios with the best (highest) capacity factors
- Transmission system topology in 2020
  - Assumed projects in RSP and transmission configurations from 2009 Governors' Economic Study

Evaluate

- Operational impacts of a range of *hypothetical* large-scale wind integration *scenarios*
- Load served by *variable* wind generation, and
- The amount of *flexible* resources required to serve the remaining "net load" reliably

NEWIS Wind-integration Scenarios

In all, 14 different configurations were evaluated

Five wind development scenarios:

1. Partial ISO Queue
   1 GW, 2.5% energy
2. Full ISO Queue
   4 GW, 9% energy
3. ***Medium wind penetration***
   6–7 GW, 14% energy
4. ***High wind penetration***
   8–10 GW, 20% energy
5. Extra-high wind penetration
   10–12 GW, 24% energy

Targeted scenarios:

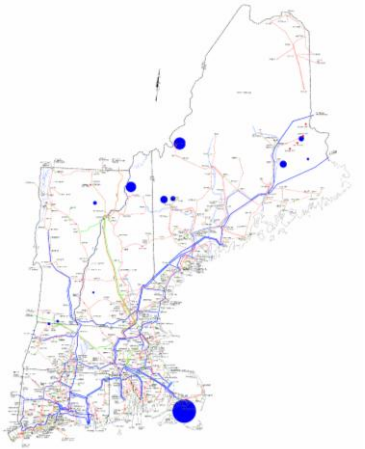
***Five scenarios target the highest capacity-factor sites in each location*:**

1. Onshore*
2. Offshore*
3. Balance case (hybrid of 1, 2)
4. By state
5. Maritimes

•Also applied to extra-high wind scenario

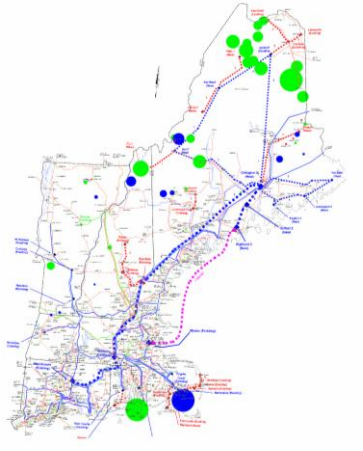
Mapping the Hypothetical

A snapshot of several NEWIS scenarios



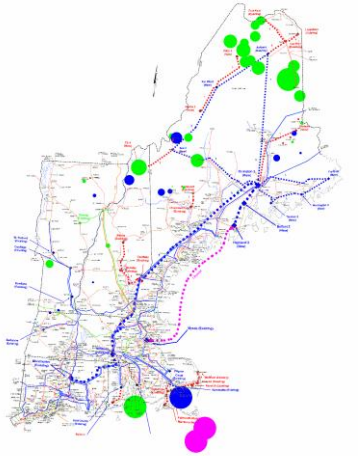
2.5%
partial queue

Nameplate: 1.14 GW
Capacity factor: 37%
Transmission:
Currently planned projects are in service



9%
full queue

Nameplate: 4.17 GW
Capacity factor: 34%
Transmission: 2 GW overlay from Governors' study



14%
offshore

Nameplate: 6.13 GW
Capacity factor: 38%
Transmission: 2 GW overlay from Governors' study
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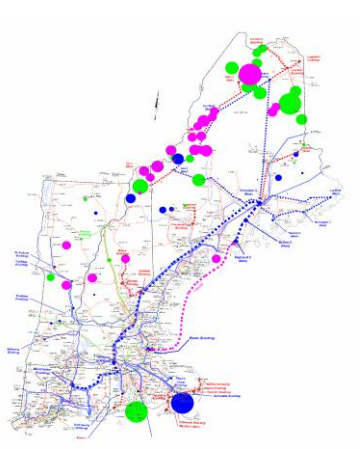
Medium Scenario range: *6 to 7 GW*



14%
onshore

Nameplate: 6.75 GW
Capacity factor: 34%
Transmission: 2 GW overlay from Governors' study
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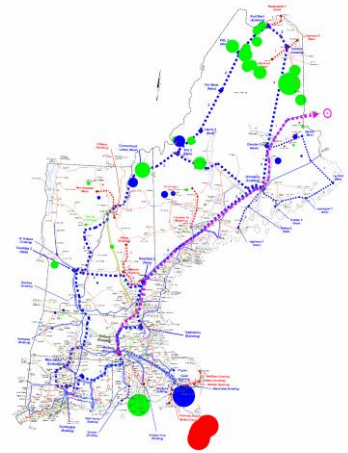
Medium Scenario range: *6 to 7 GW*

Mapping the Hypothetical (continued)

A snapshot of several NEWIS scenarios



20% offshore

Nameplate: 8.29 GW
Capacity factor: 40%
Transmission: 4 GW overlay from Governors' study

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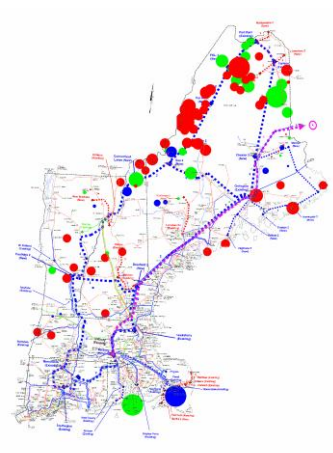
High Scenario range: *8 to 10 GW*



20% onshore

Nameplate: 9.78 GW
Capacity factor: 34%
Transmission: 4 GW overlay from Governors' study

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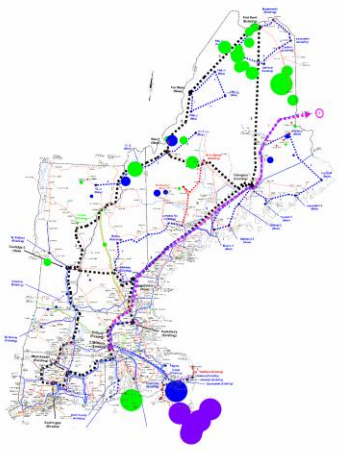
High Scenario range: *8 to 10 GW*



24% offshore

Nameplate: 9.7 GW
Capacity factor: 41%
Transmission: 8 GW overlay from Governors' study

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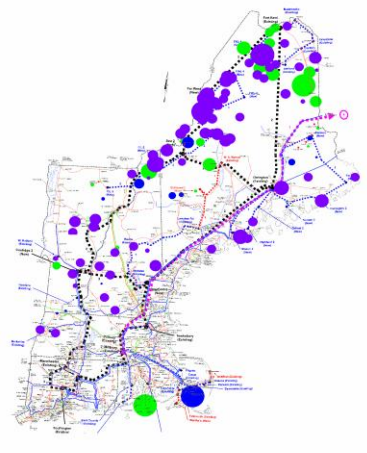
Extra-High Scenario range*: 10 to 12 GW*



24% onshore

Nameplate: 11.8 GW
Capacity factor: 34%
Transmission: 8 GW overlay from Governors' study

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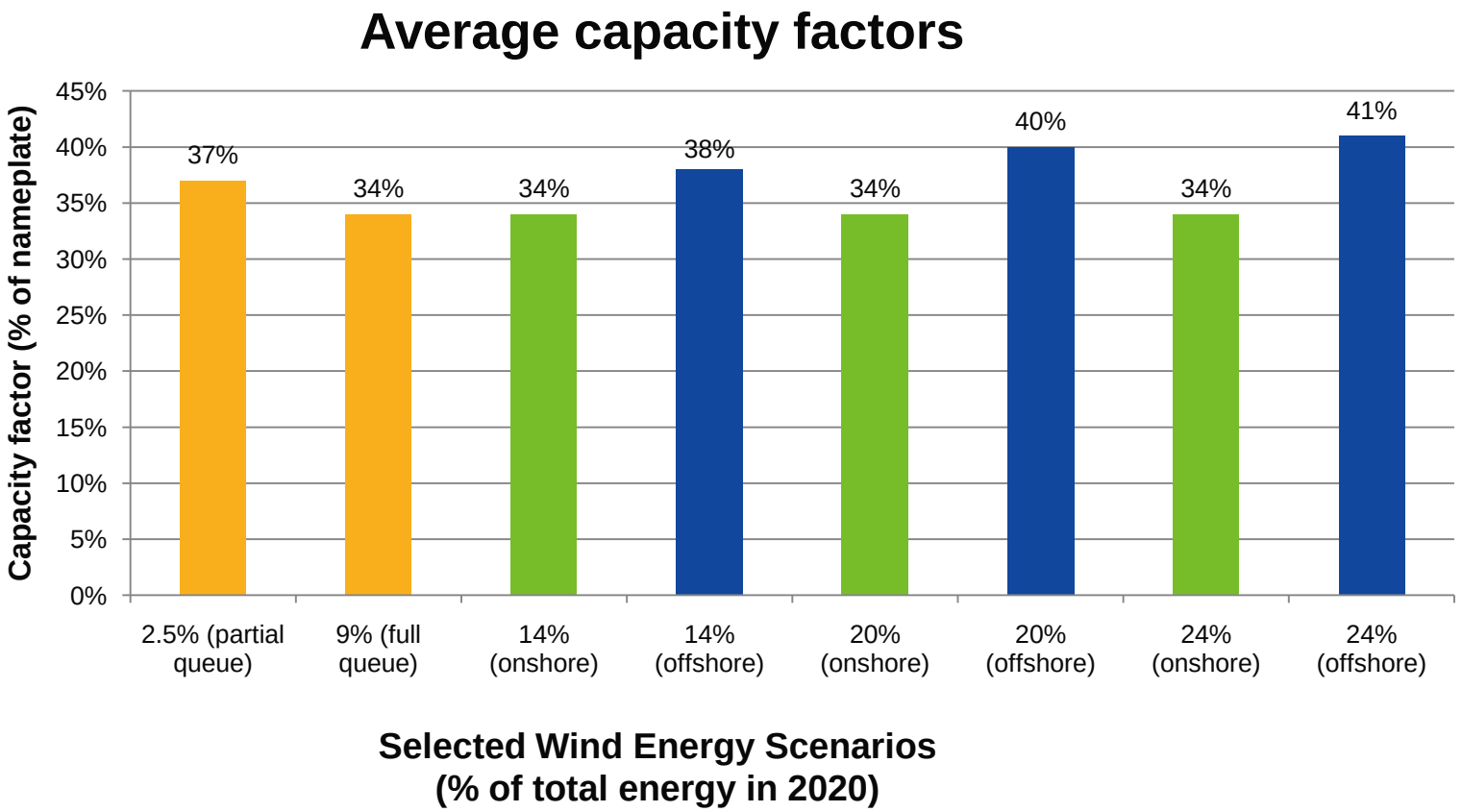
Extra-High Scenario range*: 10 to 12 GW*

NE Wind Offers Significant Capacity Factors

Higher for offshore than onshore wind; offshore is less variable than onshore wind



Major Findings of NEWIS

- **Large-scale wind integration in New England—as much as 24%—is achievable under certain conditions. Large-scale wind integration will require:**
  - Transmission upgrades comparable to configurations identified in the Governors' study
  - Continued availability of existing supply- and demand-side resources plus new resources that will be in service by 2012
  - Increases in regulation and operating reserves as recommended by NEWIS
- **When available to provide energy, wind resources could reduce fossil-fueled generation as an energy resource**
  - When available, wind generation would primarily reduce natural-gas-fired generation as an energy resource
  - The results show that when available, wind generation would almost fully reduce use of oil-fired generation

Major Findings of NEWIS (continued)

- **The region needs to maintain a system with flexible resources to manage variability**
  - Any conditions that reduce system flexibility may potentially have a negative effect on the system's ability to integrate large amounts of wind power
  - The natural gas fleet provides much of that flexibility
  - Wind is at its lowest levels in the summer, when demand is peaking
  - Market design may need to evolve to maintain the capacity required for peak demand days with low wind
- **Significant capacity factors and capacity values for wind**
  - Diminishes with increasing penetration or if transmission is not available to move the high-quality wind
  - Both are higher for offshore than onshore wind sites

Major Findings of NEWIS (continued)

- **Technical requirements for wind interconnections must be implemented**
  - Recommendations from first phase of NEWIS address turbine and plant technology, wind generation forecasting, and grid operations with significant wind generation
- **Centralized wind power forecasting will be required**
  - Will require accurate intra-day and day-ahead wind-power forecasts to ensure efficient unit commitment and market operation
  - Will require tools to forecast wind ramping so system operators can prepare for volatile wind situations by obtaining additional reserves or taking other steps

Photo courtesy of U.S. DOE/NREL Credit : Todd Spink

Suggestions for Future Work

- **GE Energy identified the following as areas where further work could be of significant value**
  - **Evaluate refinement of conceptual transmission overlays** developed initially for the New England Governors' study
  - **Conduct detailed transmission planning studies** (such as voltage and stability studies) if levels of wind integration contemplated in this study are to be pursued
  - **Incorporate actual wind data into ISO operations analysis** to enhance ISO processes for reliable wind forecasting, operations and system planning as more wind comes online
  - **Study the ability to maintain an adequate fleet of flexible resources**, assuming wind energy will reduce the use of natural gas-fired generation
  - **Evaluate the ability of demand response resources to add flexibility** to manage the variability of wind generation

Next steps

- The ISO will review the findings and suggestions for future work with New England stakeholders
- Any potential changes to procedures or market rules will go through ISO New England's comprehensive process established for stakeholder input

Appendix: NEWIS Definitions

- **Nameplate:** The maximum output of energy a generator is capable of producing
- **Capacity factor:** The actual energy production of a resource over time, expressed as a percentage of nameplate capacity
- **Capacity value:** The output of a generator during times of system need such as peak load hours, expressed as a percentage of nameplate capacity
- **Energy demand:** NEWIS projected the level of demand in 2020; each scenario posits that a certain percentage of that demand would be met by wind energy
- **Gigawatt:** One gigawatt (GW) equals 1,000 megawatts. One megawatt can serve 750 to 1,000 average homes
- **New England capacity:** Currently, supply- and demand-side resources available to produce power or reduce consumption in New England total more than 32,000 MW, or 32 GW
- **Regulation:** The megawatts required from generators that can quickly respond to a signal from the ISO every 4 seconds to change output in order to balance changes in demand and maintain system frequency
- **Reserves:** The megawatts from generators that can respond quickly in the event of unexpected contingencies, such as transmission line or generator outages
- **Future transmission system:** The base case in NEWIS assumed that all the transmission projects currently in the ISO's Regional System Plan will be completed by 2020. The study also used three hypothetical transmission overlay scenarios developed for the New England Governors' Study: 2 GW, 4 GW and 8 GW