New England Wind Integration Study

PAC Meeting

December 17, 2008

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A Wind Integration Study for ISO-NE

Presentation Contents

- Drivers for wind integration study
- Integration challenges
- Goals for wind integration study
- Scope of work for Request for Proposal (RFP) for wind integration study

Drivers for Wind Study: Scope of the Issue

- Wind energy can help to meet Renewable Portfolio Standard targets (from 05/08 PAC)
  - CT: >20% new by 2020
  - MA: 15% new by 2020 +1% per year
  - ME: 10% new (of capacity) by 2017
  - NH: 11% new by 2020
  - RI: 16% by 2019
  - NY: ~5% new by 2013
  - NB: 10% by 2010
- Wind energy can dampen fuel cost uncertainty
- Wind generation is competitive with other new resources
- Wind energy improves fuel diversity
- Wind generation is quick to build

Drivers: Fit Wind into System

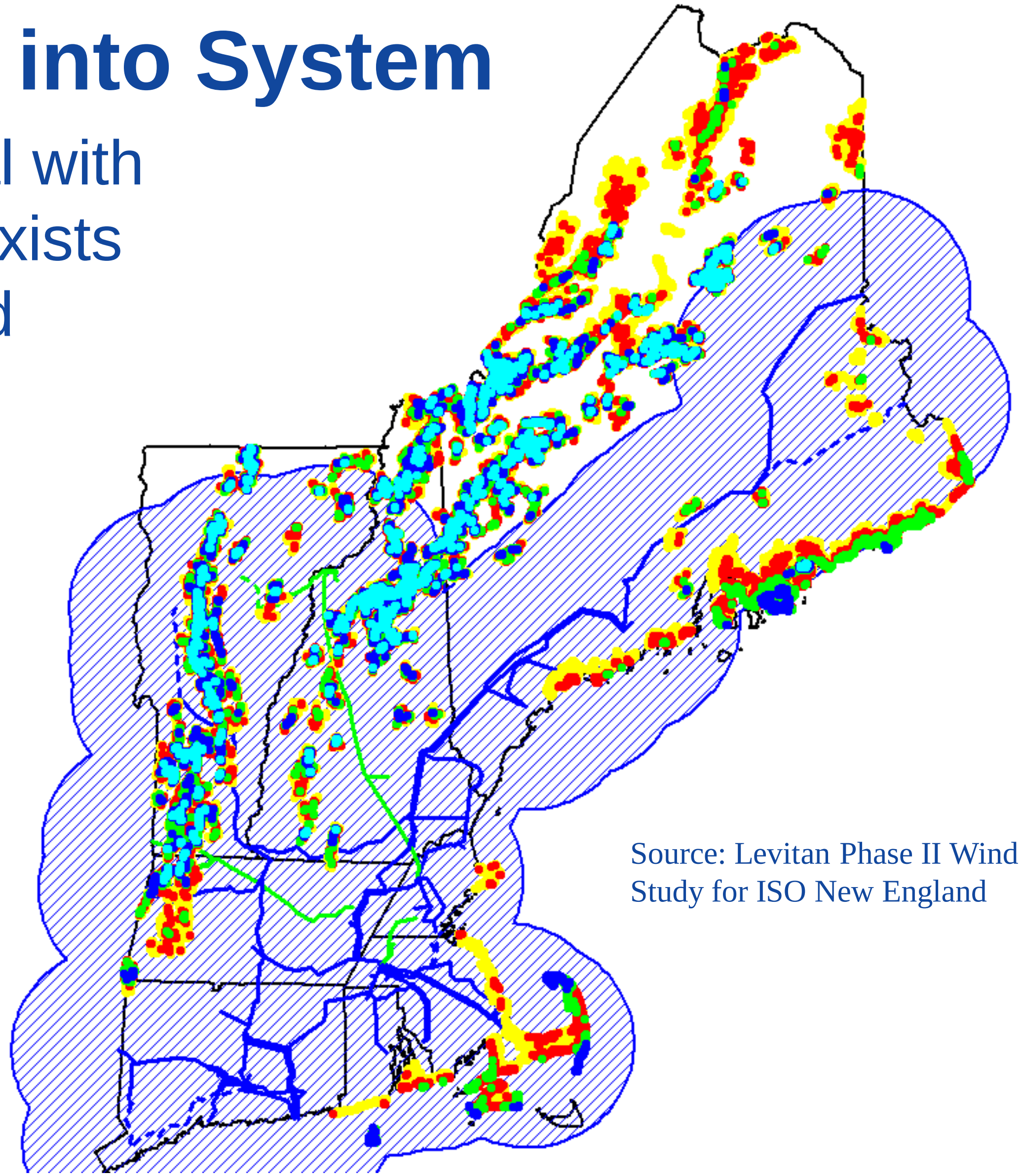
Significant wind potential with varying characteristics exists throughout New England

1 meter per second roughly 2.2 mph

Legend

MWH

Class 7	>8.8 (m/s)	cyan dot
Class 6	8-8.8 (m/s)	blue dot
Class 5	7.5-8 (m/s)	green dot
Class 4	7-7.5 (m/s)	red dot
Class 3	6.4-7 (m/s)	yellow dot
40 Miles		hatched area
230 kV		green line
345 kV		blue line



Source: Levitan Phase II Wind Study for ISO New England

Drivers: Interregional Wind Integration

- NYISO
  - '04 Studied 3.3 GW of Wind
  - ~5% of Annual Energy (TWh) ~10% of Peak Load
    - 2008 NYISO "gold book"
  - Late '08 8.6 GW Wind in the queue
- Canada
  - Maritimes: '08 study 5.5 to 7.5 GW Wind by 2025
  - ~50% to 70% of TWh ~ 75% to 100% of Peak Load
    - NPCC 2006/2007 Interregional Long Range Adequacy Overview
  - Quebec: 4 GW Wind by 2016
  - ~7% of TWh ~10% of Peak Load
    - NPCC 2006/2007 Interregional Long Range Adequacy Overview

Drivers: Wind in the ISO-NE Queue

	Total
Onshore	3038
Offshore	1259
Total	4297

- Approx 86 MW of wind generation online
- 4,297 MW in the Queue
- Of the 4,297 MW, 852 MW have System Impact Studies and I.3.9 processes complete
- At these levels, we may experience operational issues
- And what more is coming? The Queue keeps growing

Integration Challenges: Operational

- Near-term forecast uncertainty
  - Can cause over/under commitment
- Variability
  - Regulation time-scale
    - May require increased regulation capability
  - Load following time-scale
    - May require additional ramping capability
  - Day ahead time-frame
    - Complicates unit commitment
- Minimum generation issues
  - e.g., spill wind to maintain system security
- Congestion management
  - e.g. ,spill wind to maintain thermal limits

Challenges: Operational (Part 2)

- Coordination with other Balancing Areas
  - Share the variability (and reduce overall variability)
- Spinning reserve
  - Usually no effect – requirement typically based on large generators/tie-lines
  - Unless loss of wind (or forecast error) exceeds 2^{nd} largest contingency
- Non-spin reserve
  - High wind cutout can cause loss of generation on the order of approximately 25% wind plant output per hour
  - Wind variability may increase non-spin reserve requirements

Challenges: Markets & Planning

- Markets

Over–commitment	Under–commitment
Inefficient use of resources May depress LMPs May raise NCPC (uplift)	Can increase price volatility

  – Real-time vs. Day-ahead
  – Do we need to increase operating reserve requirements?
  – What are the effects of increased reserve requirements?
  – What are the effects of virtual bids?

- Planning
  – Still issues with regard to resource adequacy
  – What is Effective Load Carrying Capacity (ELCC) for wind?
    - System wide, Zonal, Per generator (incremental)?
  – Is there an effective way to plan including wind on a probabilistic or an energy basis?

Challenges: Recent Examples

- BPA water spilling (06/30/2008)
  - Communication issues – high wind/low load
- ERCOT low frequency event (02/26/08)
  - Wind forecast/control room integration – unanticipated wind loss
- Denmark high wind cut-out (01/08/05)
  - Forecast failure/High wind cutout – Hurricane causes loss of 2,000 MW (83%) over 6 hours
- Other events
  - Swinging LMPs: NY
  - High up ramps

The Goals of a Wind Integration Study

- Primarily to quantify the anticipated effects
  - Operational
    - Time frames of interest
      - Unit Commitment
      - Dispatch
      - Load-following
      - Regulation/AGC

Wind Forecasting

  - Market
    - Time frames of interest
      - Day-ahead
      - Real-time

Wind Forecasting

  - Planning
    - Resource adequacy

Goals (Part 2) of Wind Study

- What are the system operational effects vs. amount of wind penetration
- Are there thresholds e.g., hockey stick or plateaus?
- What can be done to facilitate wind?
- How does ISO-NE plan for large amounts of wind?
- What are the ISO-NE specific challenges?
- What if other system parameters change substantially?
  - DR, PHEVs, storage
  - Wind patterns, wind turbine improvements
  - Load forecast (increases/decreases)
  - Fuel prices

Why do another study?

- Wind system interaction is region specific
  - Depends on wind patterns
  - Depends on installed generation
  - Depends on load patterns
- Wind technology is continually advancing
  - Turbine and plant design
  - Forecasting
  - Integration
- Other specific issues for NE
  - Offshore
  - Windy neighbors
  - Market system
  - Near the end of the Eastern Interconnect

Scope of Work

- Wind Integration Survey
- Interconnection Requirements for Wind
- Build New England Wind Resource Area (NEWRA) models
- Scenario Development/Analysis
- Scenario Simulation

Wind Integration Survey

- Review existing/contemporaneous studies
  - NYSERDA, Excel/Minnesota, CAISO/CEC, ERCOT, etc.
- Study the integration experiences of others
  - In addition to above, Red Electrica (Spain), Denmark, etc.
- Identify lessons learned
  - Find input/output relationships
    - How well do the studies predict the observations
  - Identify the most useful tools in integration
  - Identify other lessons learned (surprises?)
- Focus on aspects that are relevant to ISO-NE
  - Offshore, Windy Neighbors, Technology advances, Market, etc.

Interconnection Requirements

Make specific recommendations:

- Grid support functions
  - Low Voltage Ride Through (LVRT), Voltage/VAR Control
  - Blackstart coordination, Possible participation in AGC
- "Best of" Effective Load Carrying Capacity
  - Per wind plant, zonal, system wide
- Data/Telemetry requirements
  - Required inputs (for control and forecasting)
    - Wind data (wind speed, etc.) and Non-wind data (MW, MVAR, etc.)
    - Granularity
      - Time (update rate) and Spatial (per turbine, plant wide, up to regional)
- Wind Forecasting
    - Forecast responsibility (e.g., in-house vs. plant operator)
    - Control Room integration

Build NEWRA Models

- Mesoscale wind model
  - Simplified computational fluid dynamics model
  - Nested grid of wind speed, direction, etc.
  - Typically ten-minute time resolution
  - Multi-year to capture El Nino effects
  - Offshore & parts of neighboring systems
- Wind Plant Model
  - Translate the wind speeds to power out
  - Place the plants in locations of interest
- Develop dynamic “historical” simulations
- ISO-NE obtains the ability to use the models
  - Possible use in wind forecast/control room integration
  - Possible links to ISO-NE production system (offline)

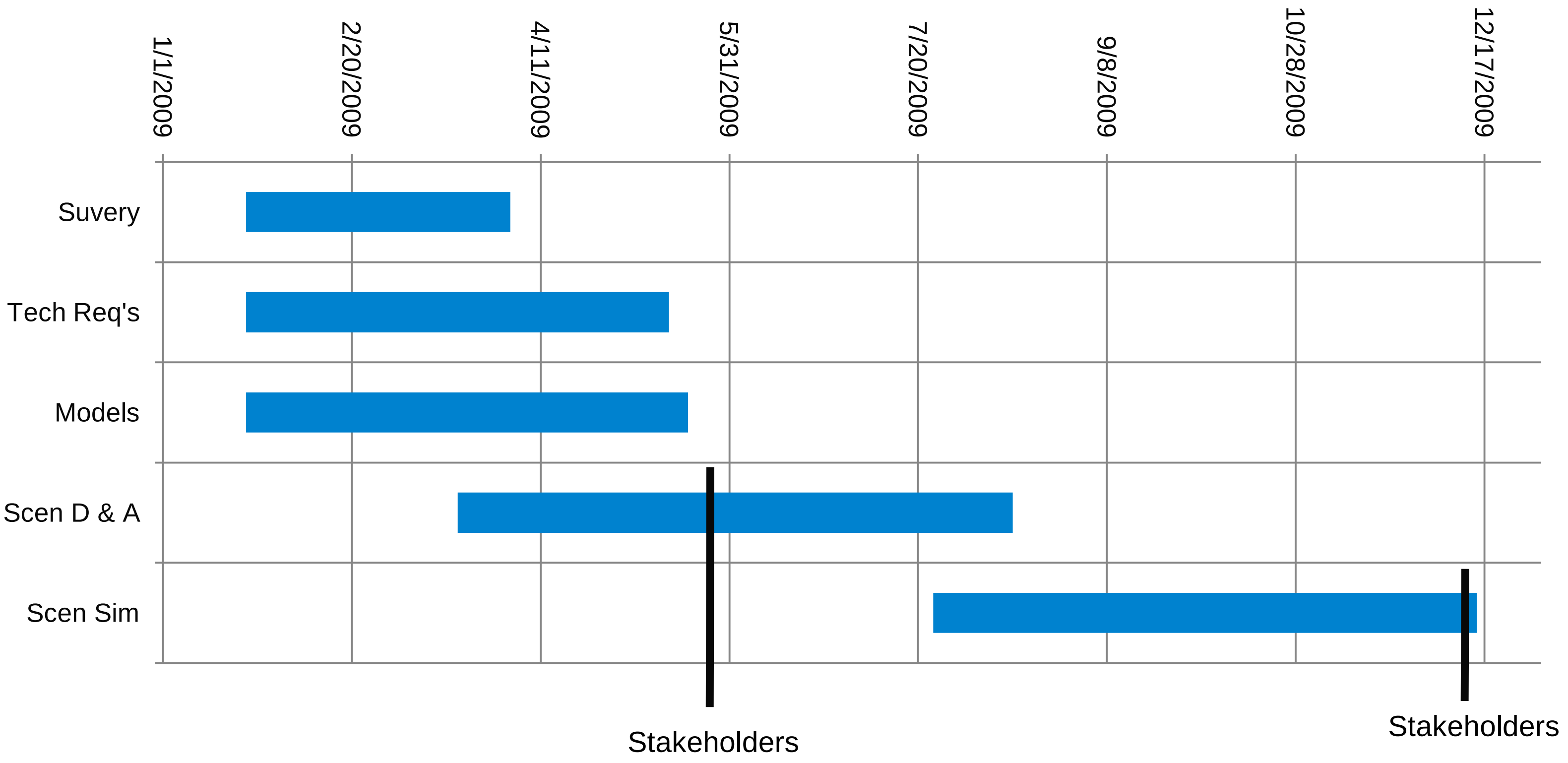
Scenario Development/Analysis

- Develop/ refine wind plant scenarios
  - 2015: 1 to 5 GW nameplate
    - Based on Queue resources
  - 2020: ~ 8 GW nameplate (~ 15% of TWh)
    - (ISO-NE Scenario Analysis: scenario 6)
  - 2020: ~12 GW nameplate (20% of TWh)
- Analyze variability using wind and load data
- Identify transmission constraints (for wind)
- Develop ELCC methodology for wind in New England
- Identify requirements for
  - Load following
  - Regulation
  - Reserves

Scenario Simulation

- Use the scenarios
- Simulation between wind and power system
  - Identify effects of/on
    - Wind power forecasting
    - Unit commitment
    - Load Following, Regulation, and Reserve capability of online gen
    - Emissions
    - LMPs
  - Suggest and investigate facilitation measures
    - Market/Operational changes (e.g., more frequent inter-area exchanges)
    - Storage
    - Demand Response

Project Timeline



Questions?

New England Wind Integration Study

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Additional Info Slides

- Wind is different for large scale generation
- Selected other wind integration studies
- Time frames of wind generation’s impact
- Wind resource map of New England
- Wind resource map of Northeastern America
- High wind cutout

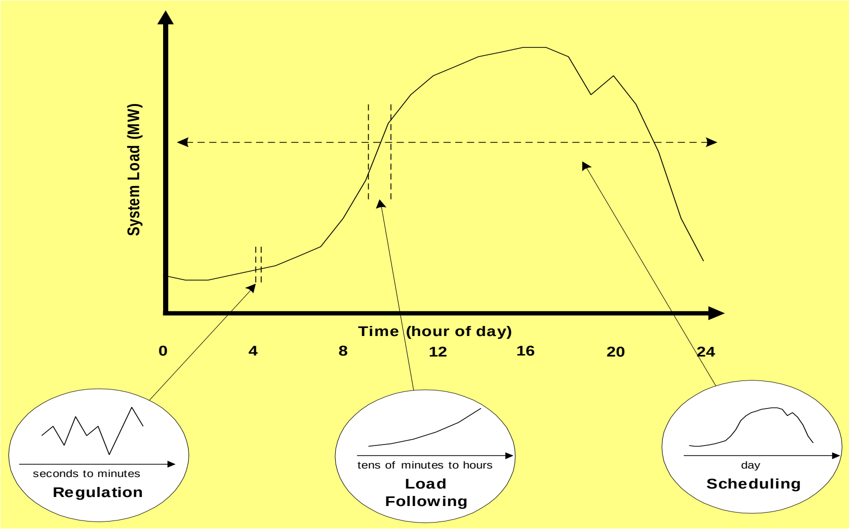
Wind is Novel for Large-Scale Generation

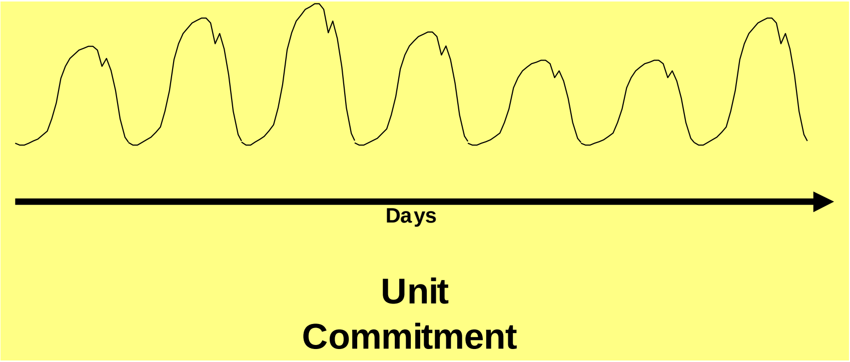
- Variable and somewhat unpredictable generation
  - Semi-dispatchable: down, not up (caveat)
  - Doesn't usually correlate well with use pattern
  - Forecast accuracy improves as time horizon shrinks
- Locationally constrained
  - Can't ship the wind in
  - Often best resources are distant from load centers
- Young technology
  - Evolving grid-awareness/support
  - Power electronics (on most machines) make them very flexible
- Small unit size (in MW)
  - Distributed Generation ~15 MW – a handful of turbines
  - Wind "farms" up to say 1 GW – tens to hundreds of turbines

Other Studies

Region	Year	Penetration
Minnesota/MISO	2004	15% - 25% Energy
Germany/Dena	2005	<20% Energy
NYISO	2005	10% Capacity
Colorado/Xcel	2006	10% - 20% Capacity
CAISO/CEC	2007	<20% - <33% Energy
ERCOT	2008	8% - 23% Capacity
Ireland/All Island	2008	23% - 59% Capacity
EWITS/JCSP	2008-2009	20% - 30% Energy
NERC IVGTF	2008-2009	N/A

Time Frames of Wind Impact

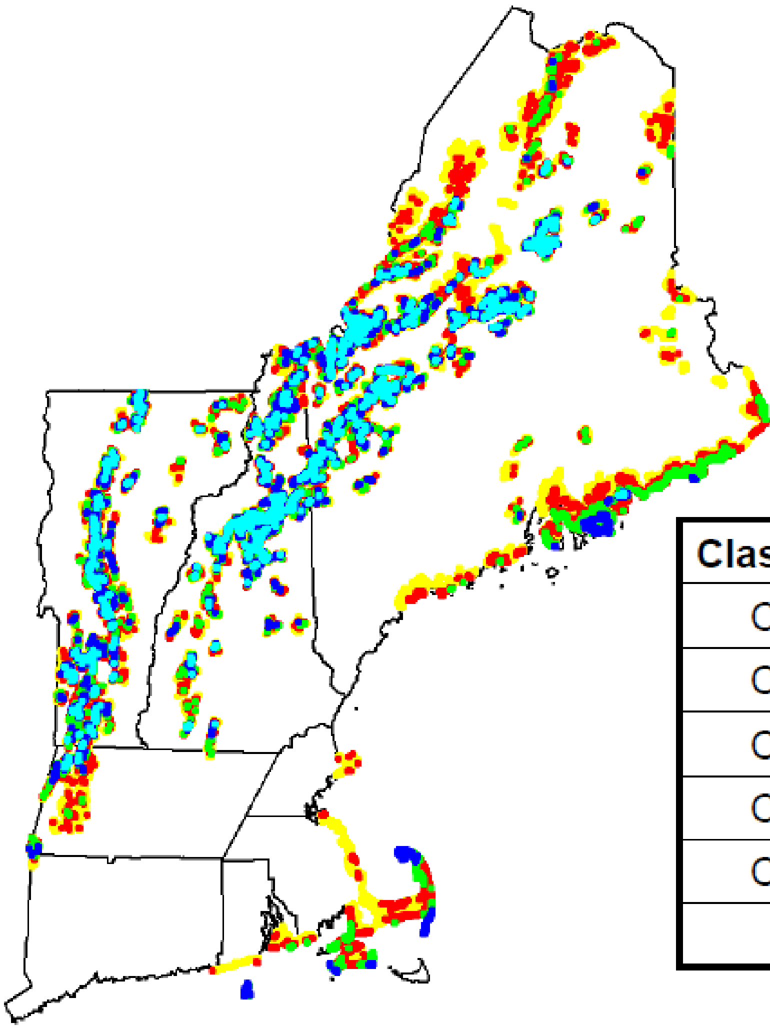




- Typical U.S. terminology
  - Regulation -- seconds to a few minutes -- similar to variations in customer demand
  - Load-following -- tens of minutes to a few hours -- demand follows predictable patterns, wind less so
  - Scheduling and commitment of generating units -- hours to several days -- wind forecasting capability?
  - Capacity value (planning): based on reliability metric (ELCC=effective load carrying capability)

Source: *www.neo.ne.gov/renew/wind-working-group/milligan_wind-integration-nppd.ppt*

NE Has Significant Wind Potential



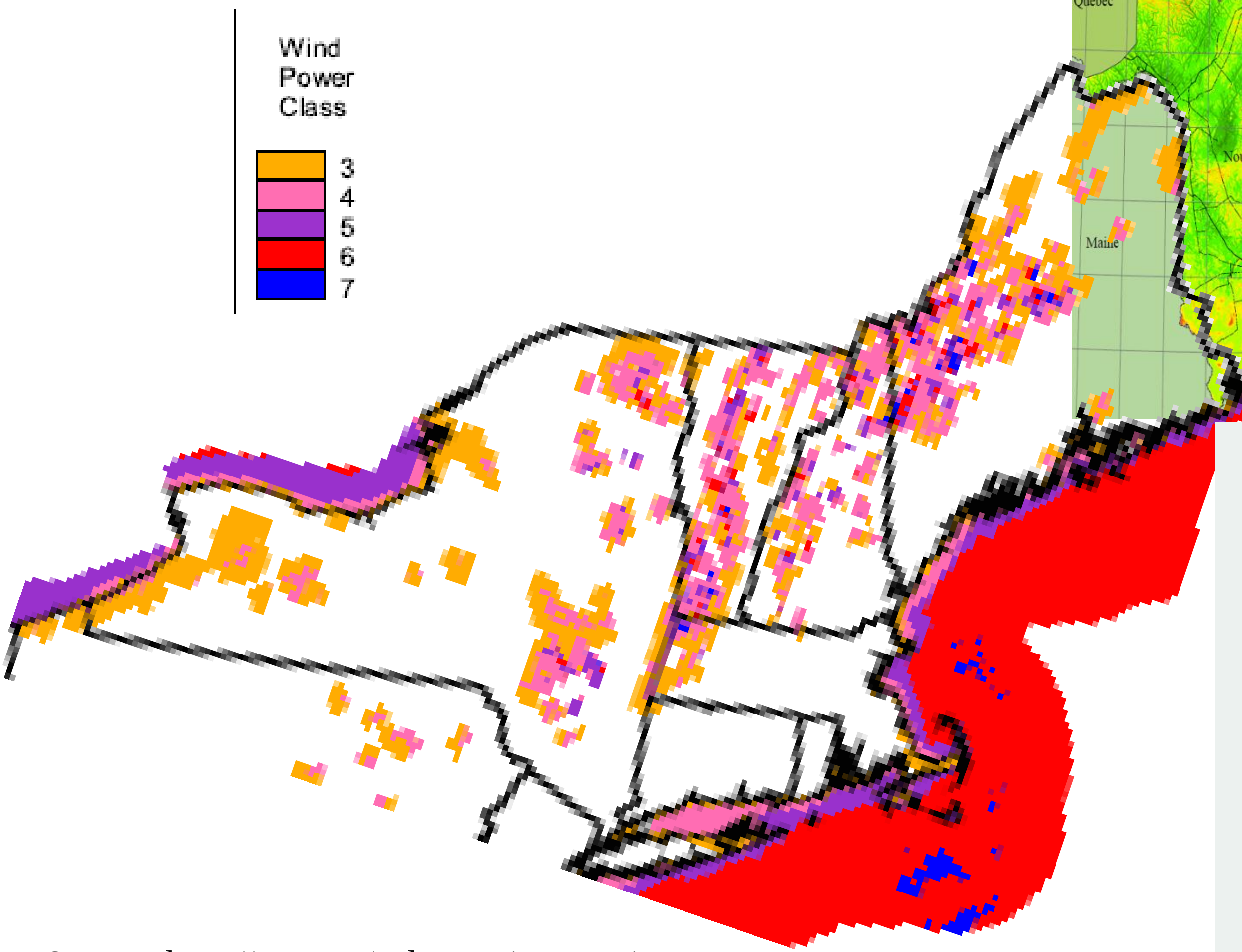
Class Rating	MW
Class 7	1,833
Class 6	3,120
Class 5	5,229
Class 4	10,170
Class 3	26,772
Total	47,124

Average Annual Wind Speed	
m/s	mph
>8.8	>19.7
8.0 – 8.8	17.9 –19.7
7.5 – 8.0	16.8—17.9
7.0 – 7.5	15.7—16.8
6.4 – 7.0	14.3—15.7

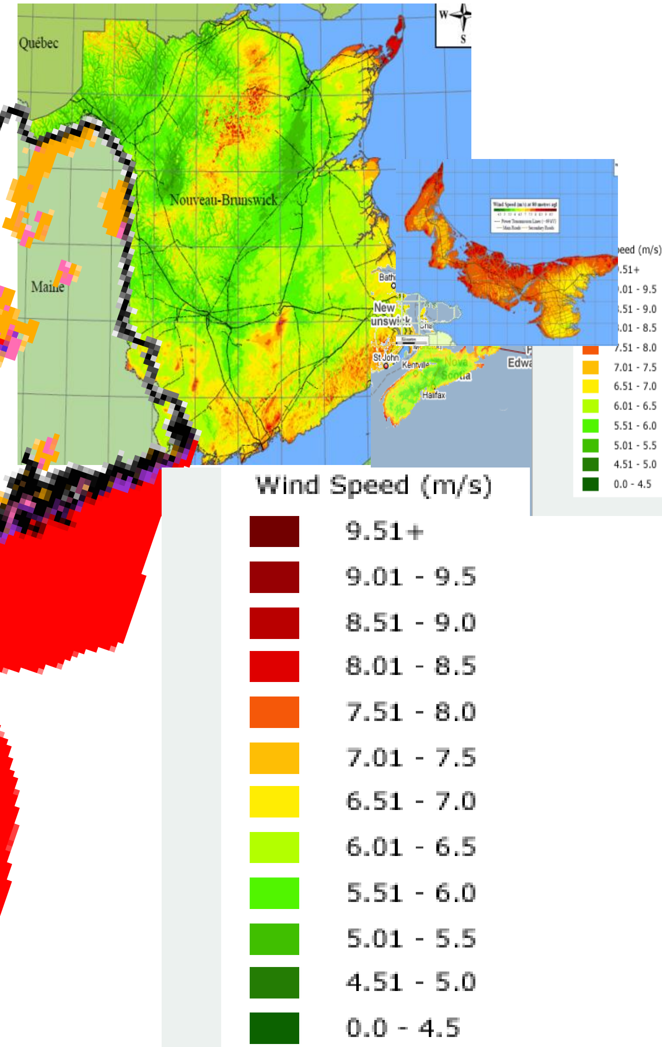
MWH

LEVITAN & ASSOCIATES, INC

North Eastern American Wind Resource



Source: http://www.windpoweringamerica.gov



Source: http://www0.umoncton.ca/chairedd/atlas_eoliens.html

High Wind Cutout