New England Wind Integration Study Abbreviated Results

MIT Wind Club Wind Integration Workshop
Jan 21, 2011

Bill Henson
Senior Engineer, Renewable Resource Integration

ISO new england

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

The Fun Stuff

- Results first? Analysis first? Hmm…
- Because I imagine that many folks here today are interested in the results, but also like to see cool pictures…
- And because you can read about it to your hearts' desire:
  - http://www.iso-ne.com/committees/comm_wkgrps/prtcpnts_comm/pac/reports/2010/index.html
  - http://www.iso-ne.com/committees/comm_wkgrps/prtcpnts_comm/pac/reports/2009/index.html
  - http://www.iso-ne.com/committees/comm_wkgrps/prtcpnts_comm/pac/mtrls/2010/nov162010/index.html
  - http://www.iso-ne.com/nwsiss/pr/2010/2010_newis_backgrounder_final_12152010.pdf
- Let me walk you through some of the "fun stuff" first
- Important colloraries:
  - 1) let's not get "bogged down" in the minutiae
  - 2) You may have to look at this presentation again to understand/appreciate it – the background doesn't come until later

Different Scenarios Studied

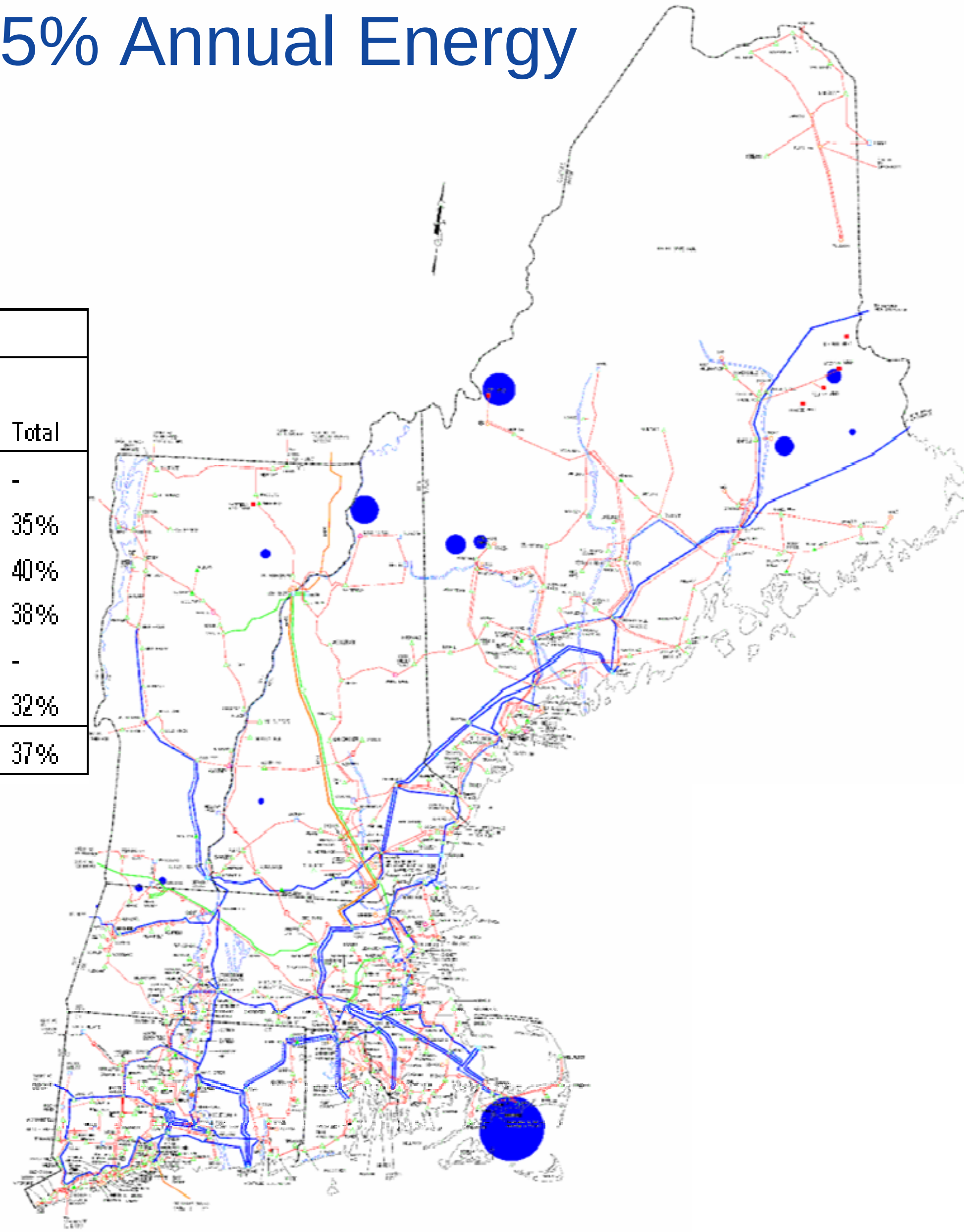
- We used CFD synthesized wind plant output data and…
- NEWIS looked at specific levels of wind generation:
  - From the interconnection queue:
    - Partial: 1.14 gigawatts (GW) or 2.5% of forecasted energy demand
    - Full: 4.17 GW or 9% of forecasted energy demand
  - Varying amounts of wind penetration with different scenario layouts:
    - 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
    - Onshore, Offshore, Mix of the two, read all about it…

  - Just in case: Important concept! -- net load equals native load minus wind output

Partial Build-out of Wind in the Queue

Total: 1.14 Gigawatts (GW) 2.5% Annual Energy Transmission System in 2019

ST.	Onshore # of Sites	Onshore Name Plate (GW)	Onshore Energy (GWh)	Offshore # of Sites	Offshore Name Plate (GW)	Offshore Energy (GWh)	Total # of Sites	Total Name Plate (GW)	Total Energy (GWh)	Capacity Factor (%) Onshore	Capacity Factor (%) Offshore	Capacity Factor (%) Total
CT	-	-	-	-	-	-	-	-	-	0%	0%	-
ME	6	0.429	1,298	-	-	-	6	0.429	1,298	35%	0%	35%
MA	2	0.044	135	1	0.460	1,615	3	0.504	1,750	35%	40%	40%
NH	2	0.136	448	-	-	-	2	0.136	448	38%	0%	38%
RI	-	-	-	-	-	-	-	-	-	0%	0%	-
VT	2	0.071	198	-	-	-	2	0.071	198	32%	0%	32%
Tot.	12	0.680	2,080	1	0.460	1,615	13	1.140	3,695	35%	40%	37%

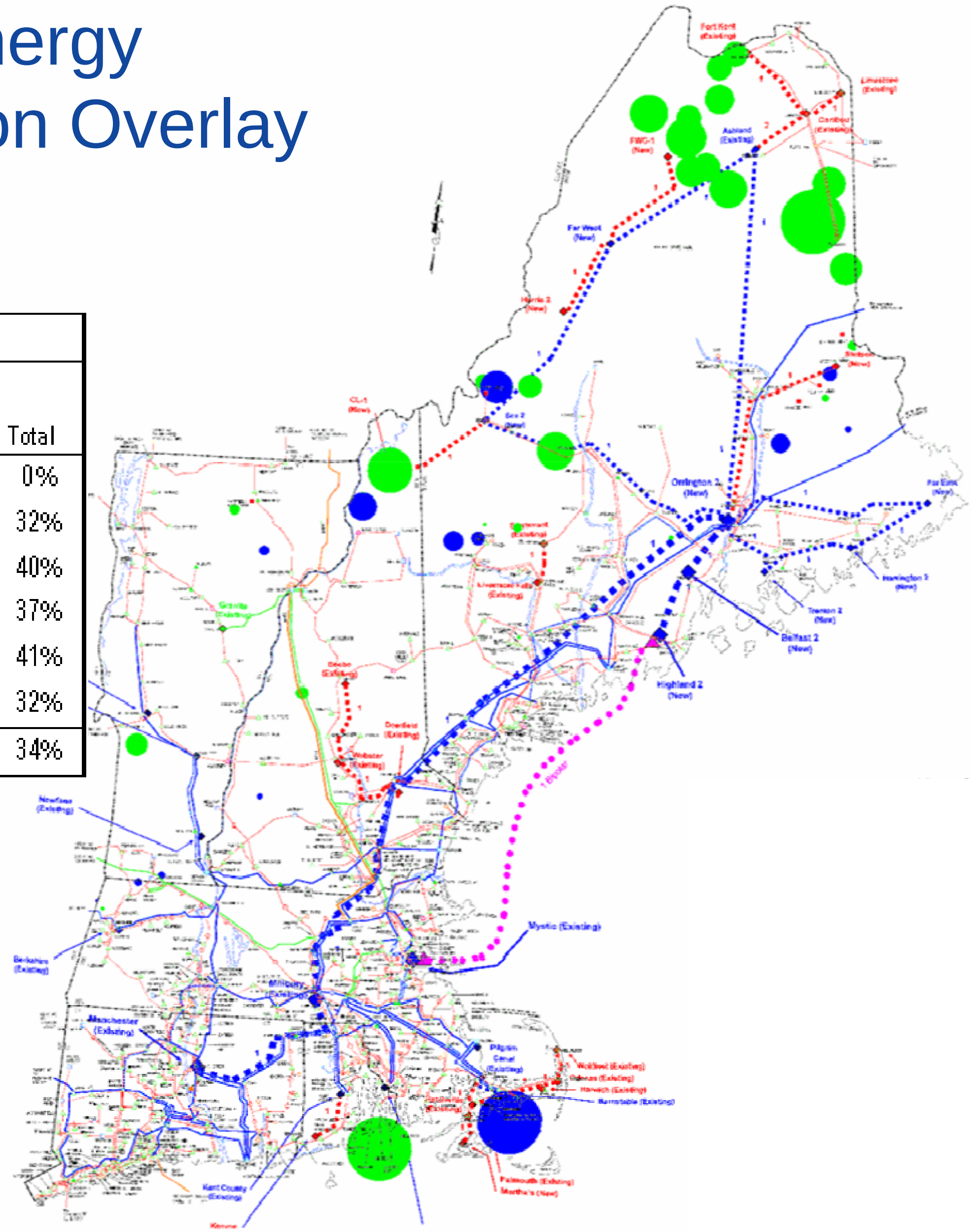


Partial Queue
Additonal Queue
Additional to 20% Energy

Full Build-out of Wind in the Queue

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

ST.	Onshore # of Sites	Onshore Name Plate (GW)	Onshore Energy (GWh)	Offshore # of Sites	Offshore Name Plate (GW)	Offshore Energy (GWh)	Total # of Sites	Total Name Plate (GW)	Total Energy (GWh)	Capacity Factor (%) Onshore	Capacity Factor (%) Offshore	Capacity Factor (%) Total
CT	-	-	-	-	0.000	-	-	-	-	0%	0%	0%
ME	28	2.681	7,486	-	0.000	-	28	2.681	7,486	32%	0%	32%
MA	3	0.059	183	1	0.460	1,615	4	0.519	1,798	35%	40%	40%
NH	5	0.400	1,290	-	0.000	-	5	0.400	1,290	37%	0%	37%
RI	-	-	-	1	0.360	1,295	1	0.360	1,295	0%	41%	41%
VT	5	0.209	584	-	0.000	-	5	0.209	584	32%	0%	32%
Tot.	41	3.349	9,543	2	0.820	2,910	43	4.169	12,453	33%	41%	34%



Best Onshore + Full Queue

Total: 9.78 GW 20% Annual Energy

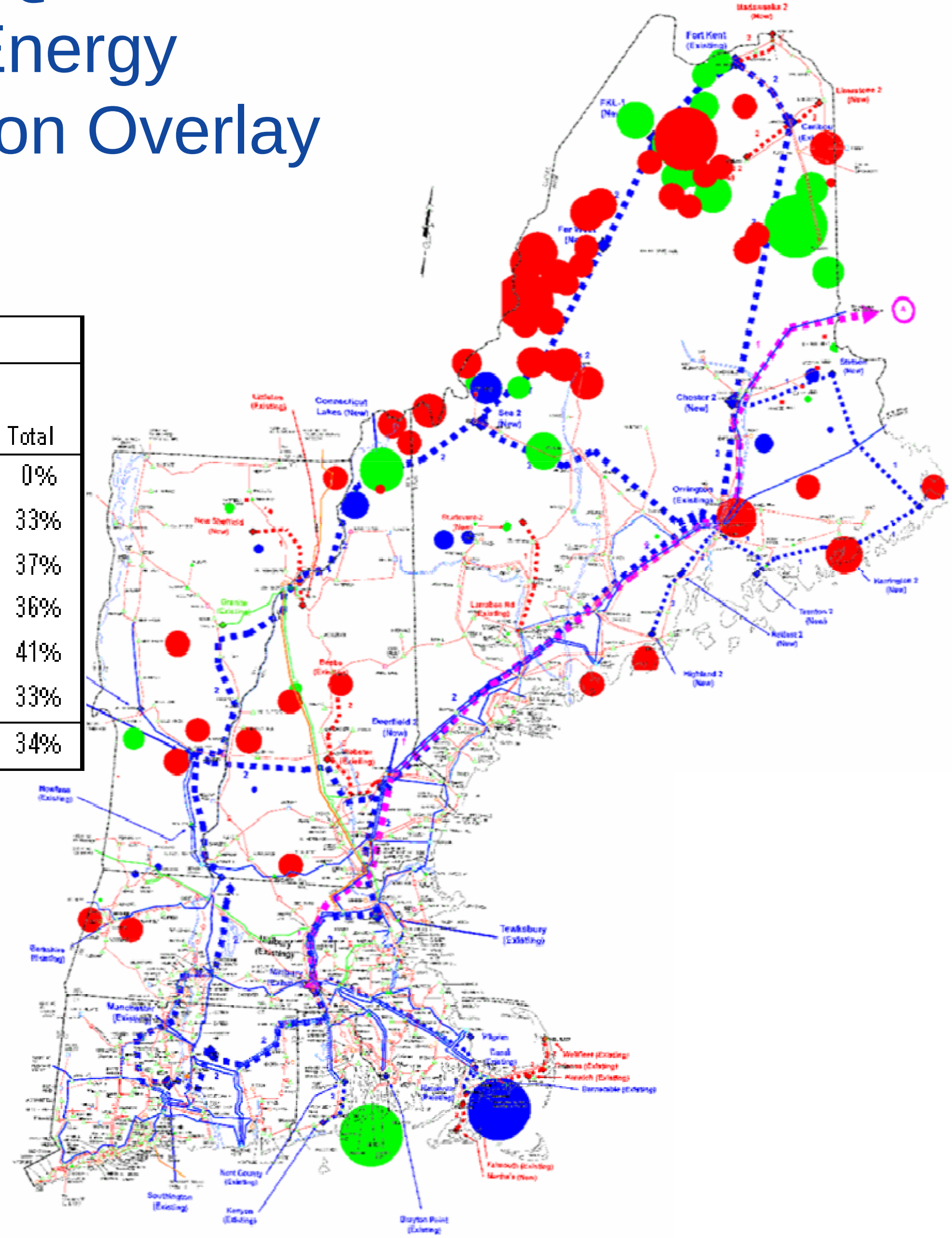
Governors' 4 GW Transmission Overlay

ST.	Onshore # of Sites	Onshore Name Plate (GW)	Onshore Energy (GWh)	Offshore # of Sites	Offshore Name Plate (GW)	Offshore Energy (GWh)	Total # of Sites	Total Name Plate (GW)	Total Energy (GWh)	Capacity Factor (%) Onshore	Capacity Factor (%) Offshore	Capacity Factor (%) Total
CT	-	-	-	-	-	-	-	-	-	0%	0%	0%
ME	63	7.001	20,226	-	-	-	63	7.001	20,226	33%	0%	33%
MA	5	0.259	744	1	0.460	1,615	6	0.719	2,359	33%	40%	37%
NH	12	1.064	3,335	-	-	-	12	1.064	3,335	36%	0%	36%
RI	-	-	-	1	0.360	1,295	1	0.360	1,295	0%	41%	41%
VT	11	0.635	1,845	-	-	-	11	0.635	1,845	33%	0%	33%
Tot.	91	8.959	26,150	2	0.820	2,910	93	9.779	29,060	33%	41%	34%

Partial Queue

Additonal Queue

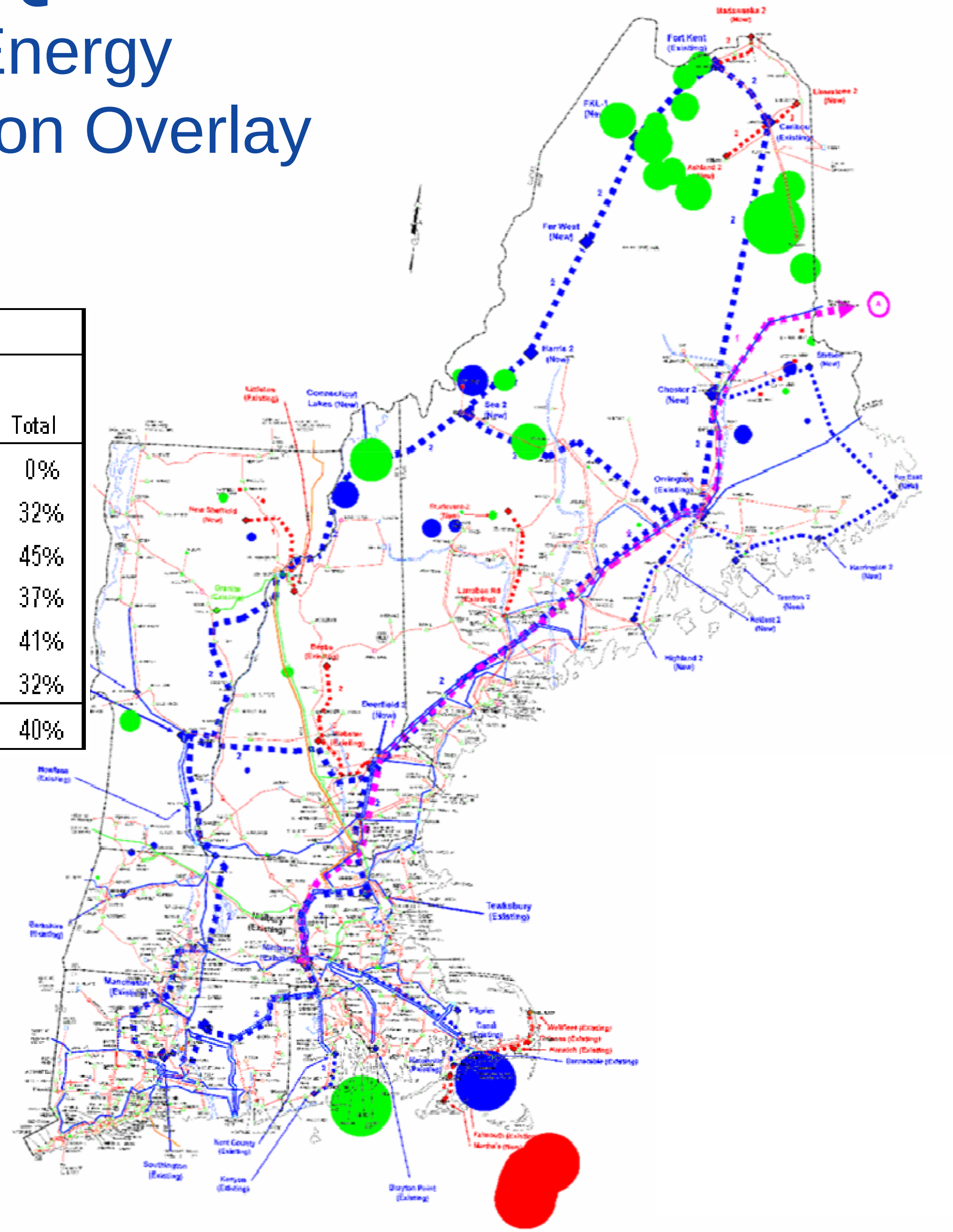
Additional to 20% Energy



Best Offshore + Full Queue

Total: 8.29 GW 20% Annual Energy
Governors' 4 GW Transmission Overlay

ST.	Onshore			Offshore			Total			Capacity Factor (%)		
	# of Sites	Name Plate (GW)	Energy (GWh)	# of Sites	Name Plate (GW)	Energy (GWh)	# of Sites	Name Plate (GW)	Total Energy (GWh)	Onshore	Offshore	Total
CT	-	-	-	-	-	-	-	-	-	0%	0%	0%
ME	28	2.681	7,486	-	-	-	28	2.681	7,486	32%	0%	32%
MA	3	0.059	183	5	4.585	18,222	8	4.644	18,405	35%	45%	45%
NH	5	0.400	1,290	-	-	-	5	0.400	1,290	37%	0%	37%
RI	-	-	-	1	0.360	1,295	1	0.360	1,295	0%	41%	41%
VT	5	0.209	584	-	-	-	5	0.209	584	32%	0%	32%
Tot.	41	3.349	9,543	6	4.945	19,517	47	8.294	29,060	33%	45%	40%



Partial Queue

Additonal Queue

Additional to 20% Energy

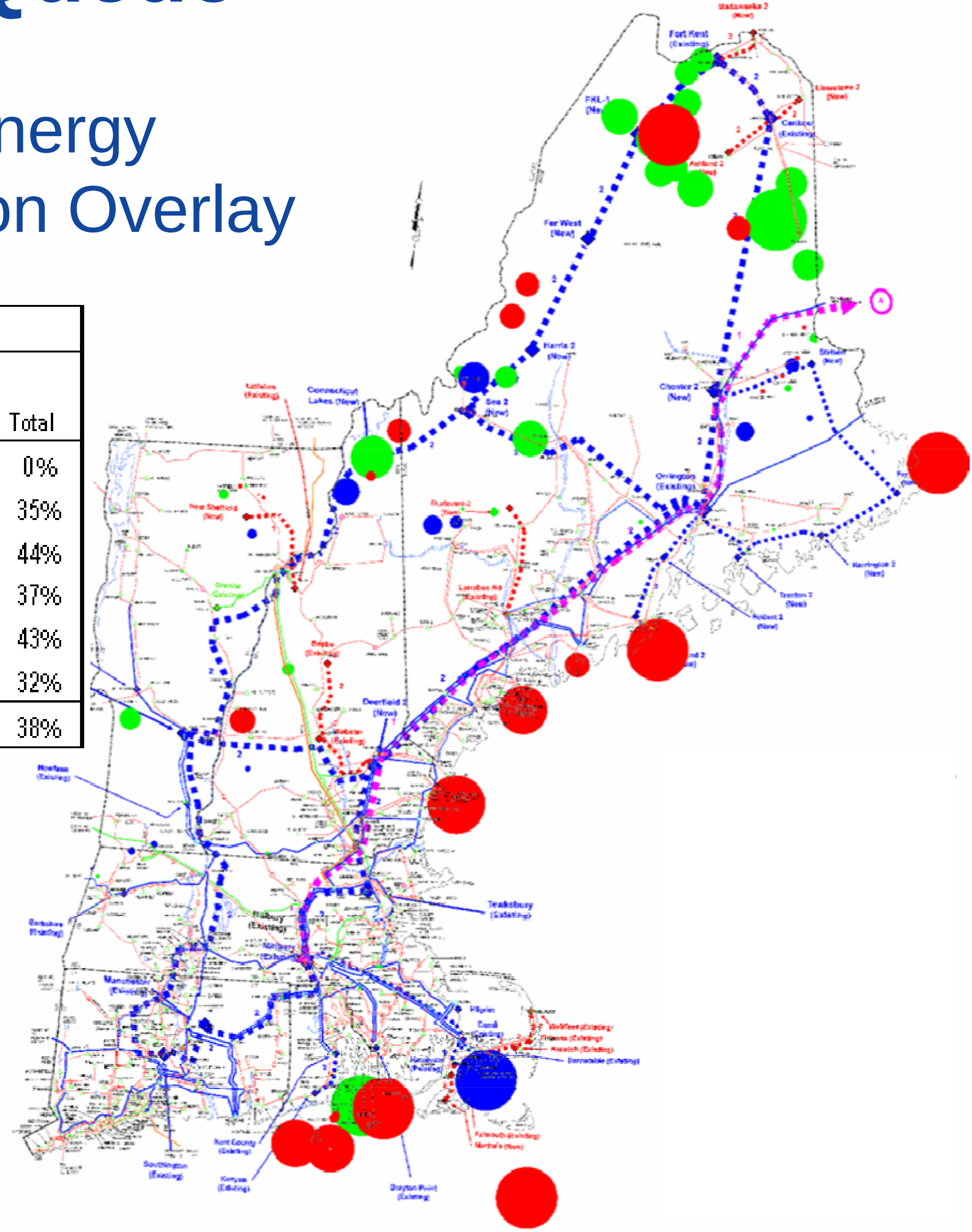
Balance Case + Full Queue

(aka. Best Sites)

Total: 8.80 GW 20% Annual Energy

Governors' 4 GW Transmission Overlay

ST.	Onshore			Offshore			Total			Capacity Factor (%)		
	# of Sites	Name Plate (GW)	Energy (GWh)	# of Sites	Name Plate (GW)	Energy (GWh)	# of Sites	Name Plate (GW)	Total Energy (GWh)	Onshore	Offshore	Total
CT	-	-	-	-	-	-	-	-	-	0%	0%	0%
ME	33	3.372	9,571	4	1.500	5,169	37	4.872	14,740	32%	39%	35%
MA	3	0.059	183	2	1.498	5,800	5	1.557	5,982	35%	44%	44%
NH	8	0.647	2,096	-	-	-	8	0.647	2,096	37%	0%	37%
RI	-	-	-	7	1.513	5,657	7	1.513	5,657	0%	43%	43%
VT	5	0.209	584	-	-	-	5	0.209	584	32%	0%	32%
Tot.	49	4.287	12,435	13	4.511	16,625	62	8.798	29,060	33%	42%	38%



- Partial Queue
- Additonal Queue
- Additional to 20% Energy

High Level Comparison of Scenarios

<u>Overall, the operational effects of the wind scenarios were very similar:</u>

This was due to several factors:

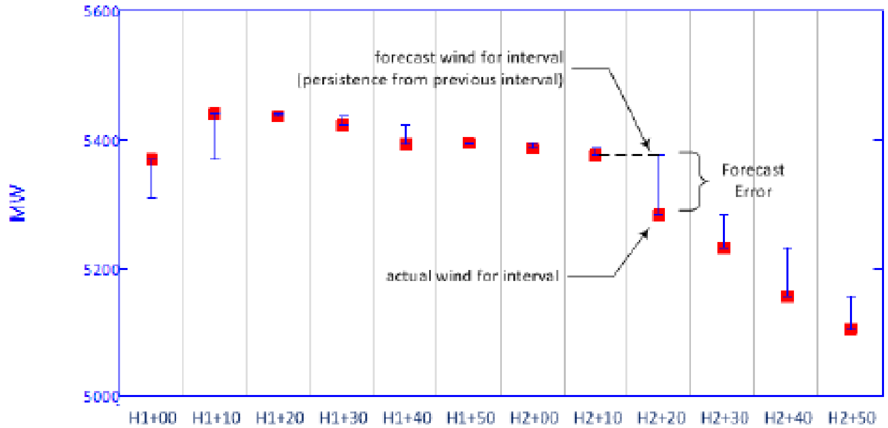
- Assumed transmission configurations
  - Essentially no (or minimal) congestion for all scenarios
- Assumed fleet of dispatchable resources
  - Very flexible
  - Wind penetrations mostly not "large enough" to "dig too deep" into the less flexible resources
- Similar wind profiles
  - Fairly similar in general
  - All 14%, 20%, and 24% scenarios utilized the full queue
    - 4.17GW
    - Substantial portion of 7.25GW to 10.24GW to 12GW

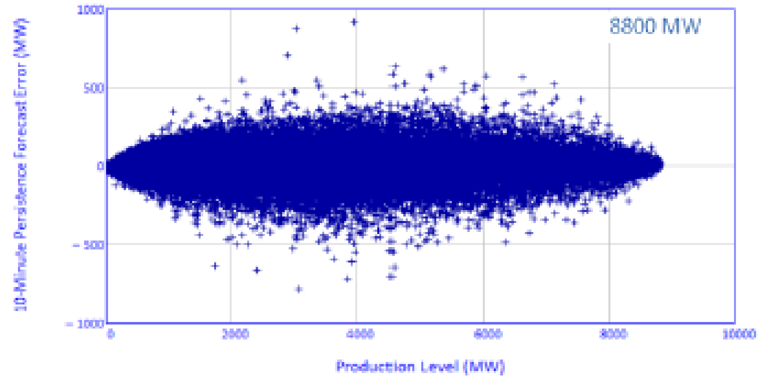
What is Regulation?

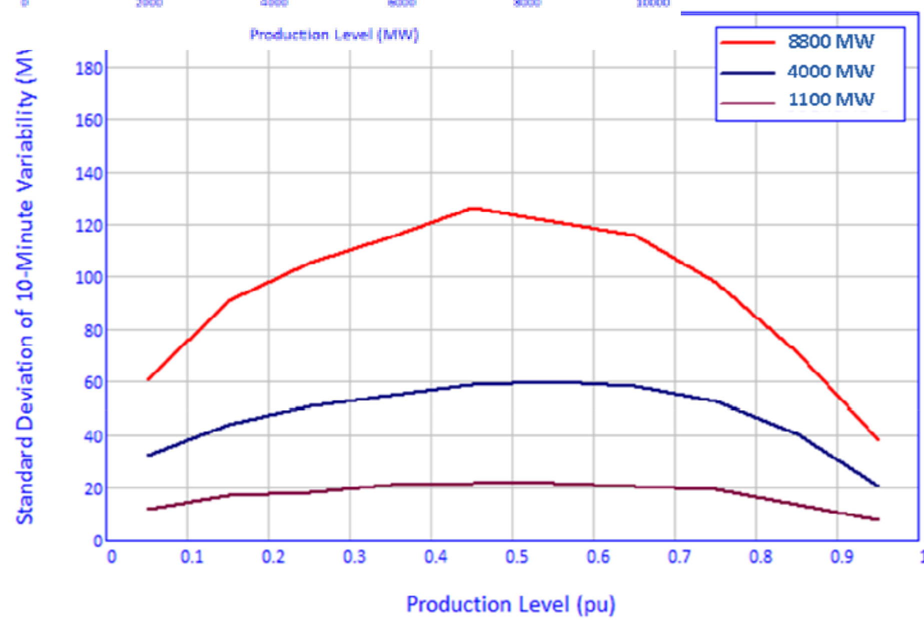
- A key power system control objective is to maintain a balance in the system between load and generation (accomplished by maintaining frequency and tie exchange).
- Regulation is the MW required from generators or loads within a Balancing Area like New England that quickly (4 seconds) respond to changes in load and system frequency.
- “Fine-tune” knob
- 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

- Regulation requirements were estimated using:
1) The short-term variability of the load
2) The short-term variability of the wind generation
3) The ten-minute persistence deviation to approximate short-term windpower forecast error
- Ten minute persistence error depends on
  - Installed nameplate
  - Total wind fleet output
- Increases in regulation are mostly due to short-term windpower forecast error that cannot be met with economic dispatch

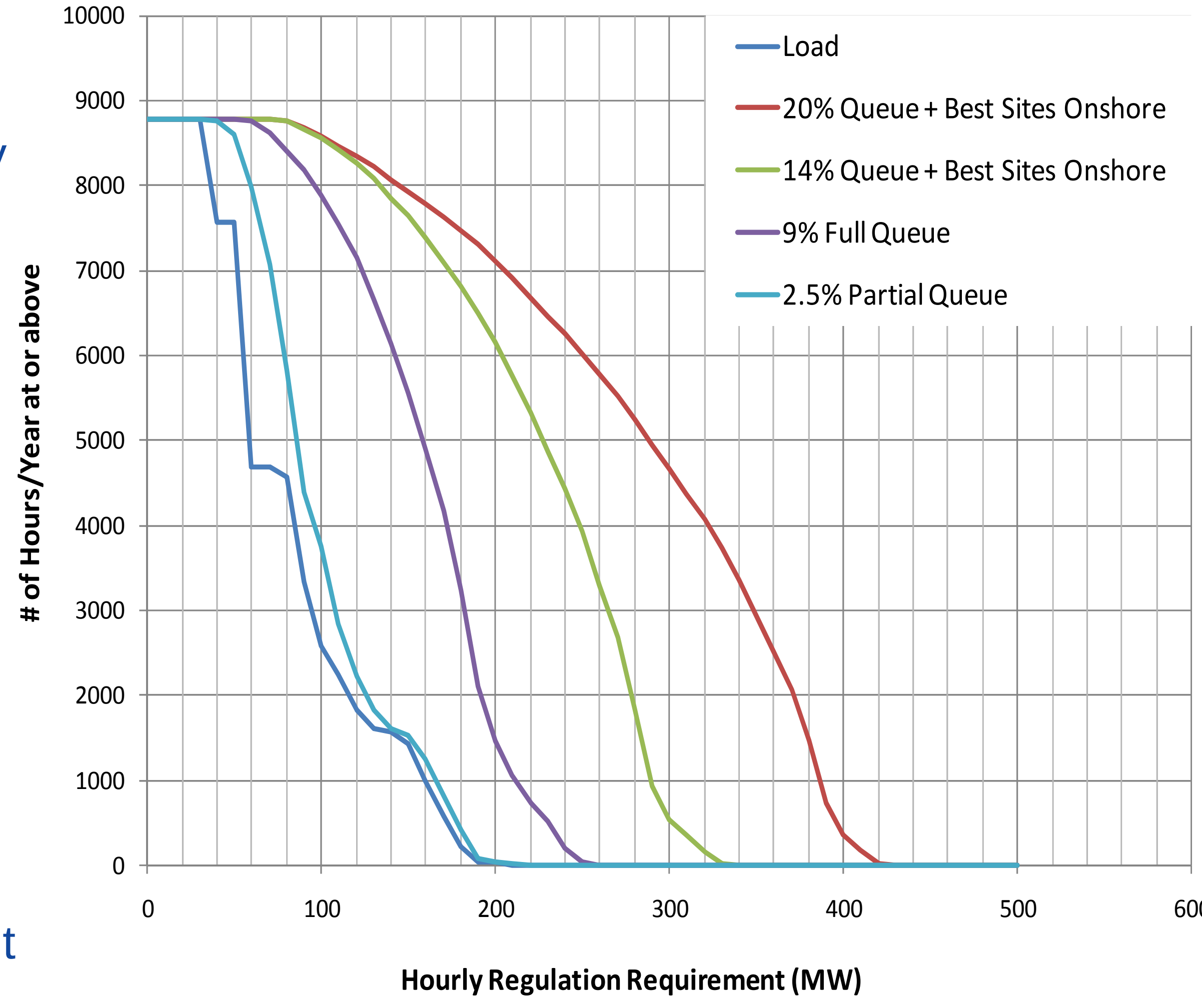






Required Regulation Increases

- Required Regulation capacity is increased
  - In all hours
  - Some cases: quite dramatically
  - Will be used much more frequently
  - For 20% scenarios average regulation requirement estimated to increase from 82 MW up to 313 MW
  - Calculation using historical ACE performance suggest smaller increases
  - Differences in regulation impacts discernable amongst scenario layouts at same penetration levels
    - Some scenarios/layouts exhibit higher variability between ten-minute intervals



Hourly Operations Analysis

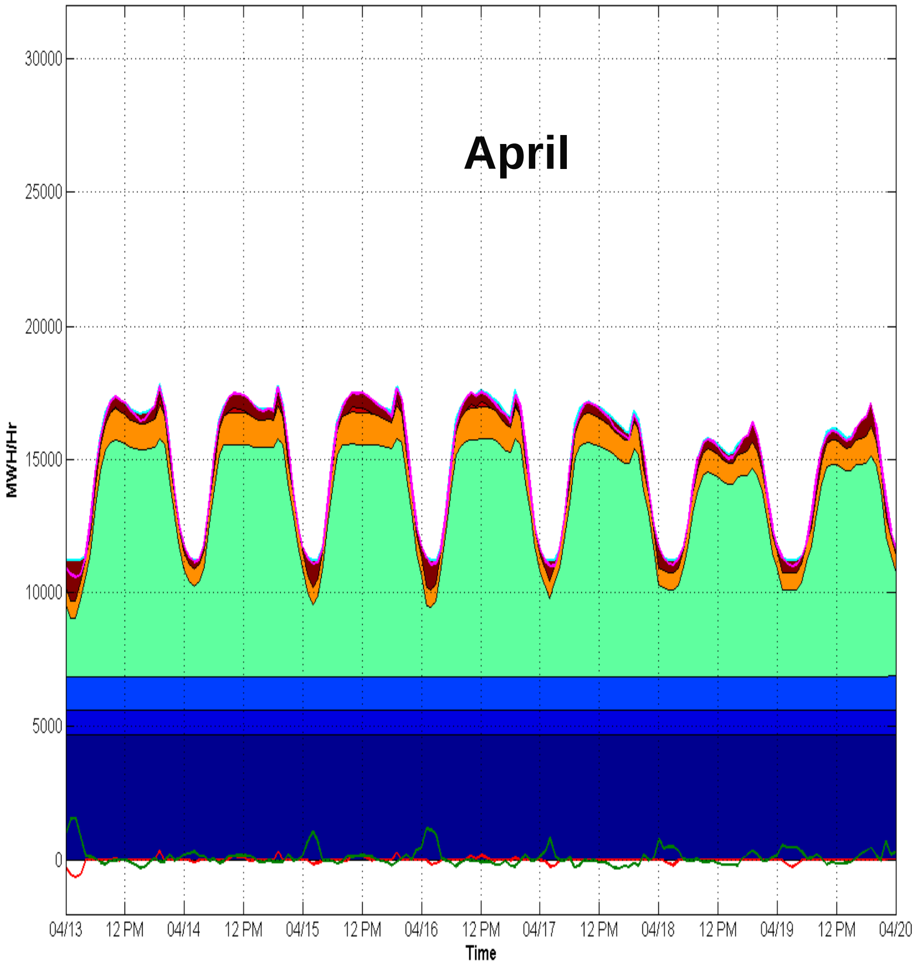
The ISO-NE system (and neighboring systems) was simulated on an hourly time-step using the GE-MAPS production simulation software

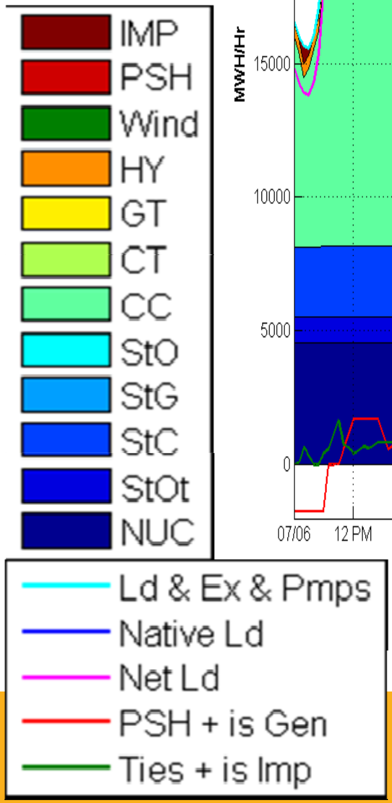
- Performs day-ahead unit commitment and an hourly dispatch recognizing transmission constraints within the system and individual unit operating characteristics (heat rates, inter-temporal constraints, fuel costs)
- Primarily in order to investigate changes in :
  - Transmission path loadings
  - Dispatch of conventional resources due to the addition of new renewable generation
  - Amount of maneuverable generation on-line during a given hour including available ramp-up and ramp-down capability to deal with grid variability
  - Also the effects of day-ahead wind forecast alternatives in unit commitment
  - Other changes observed:
    - Changes in emissions (NOx, SOx, CO2) due to renewable generation
    - Changes in costs and revenues associated with grid operation, and changes in net cost of energy
    - Changes in use and economic value of energy storage resources

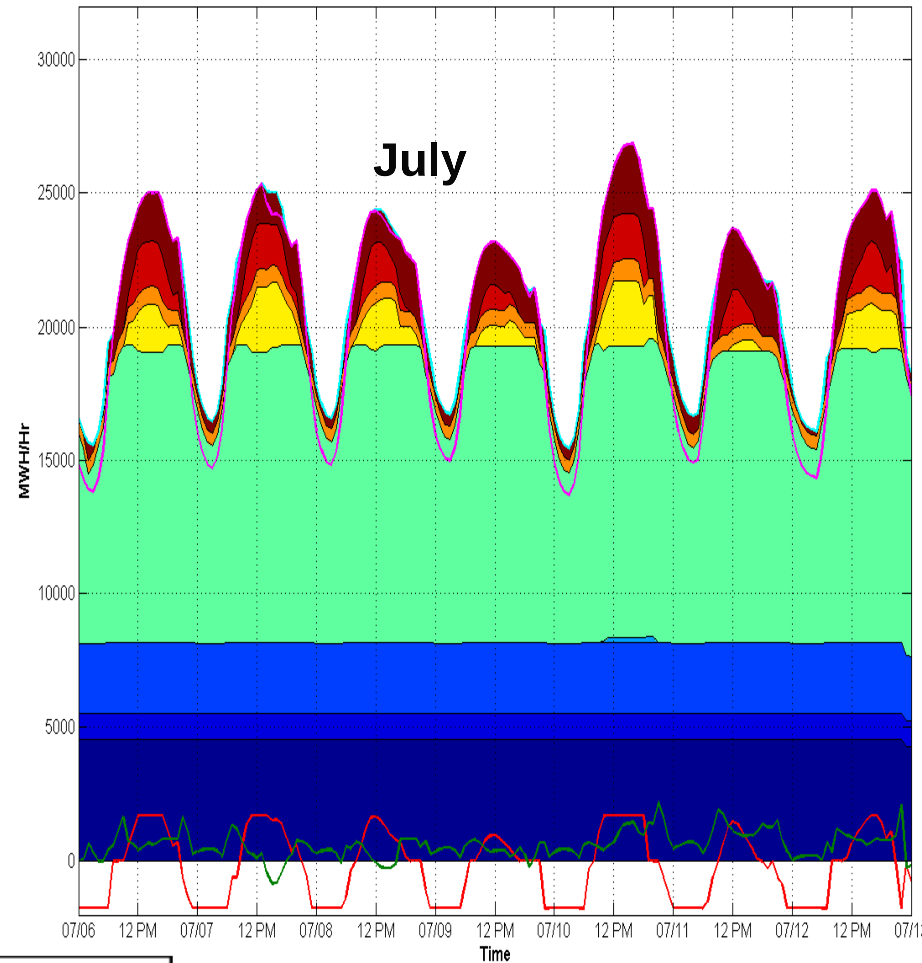
Hourly Operations: System dispatch

Week of April 13 & July 6

No Wind



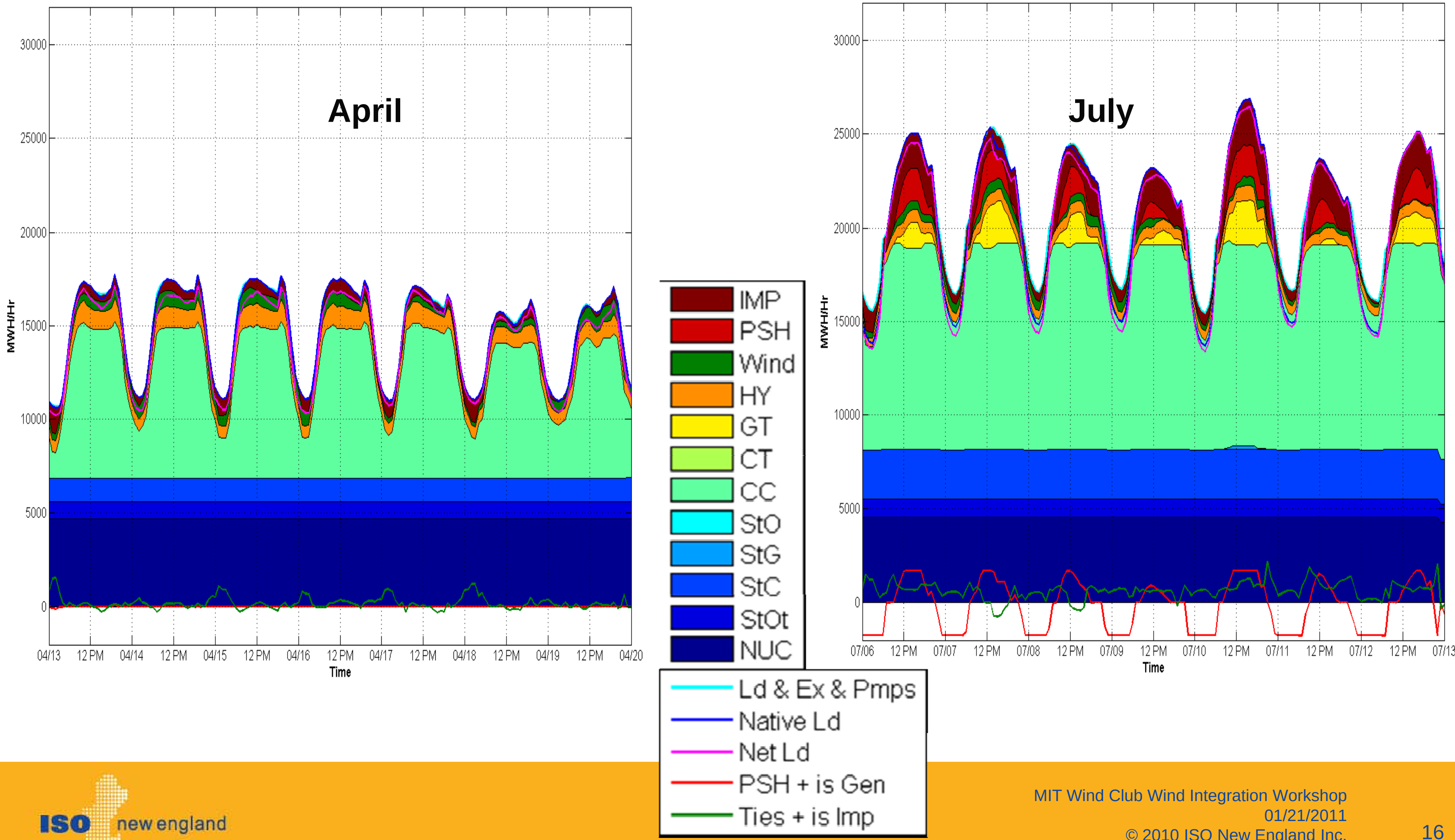




Hourly Operations: System dispatch

Week of April 13 & July 6

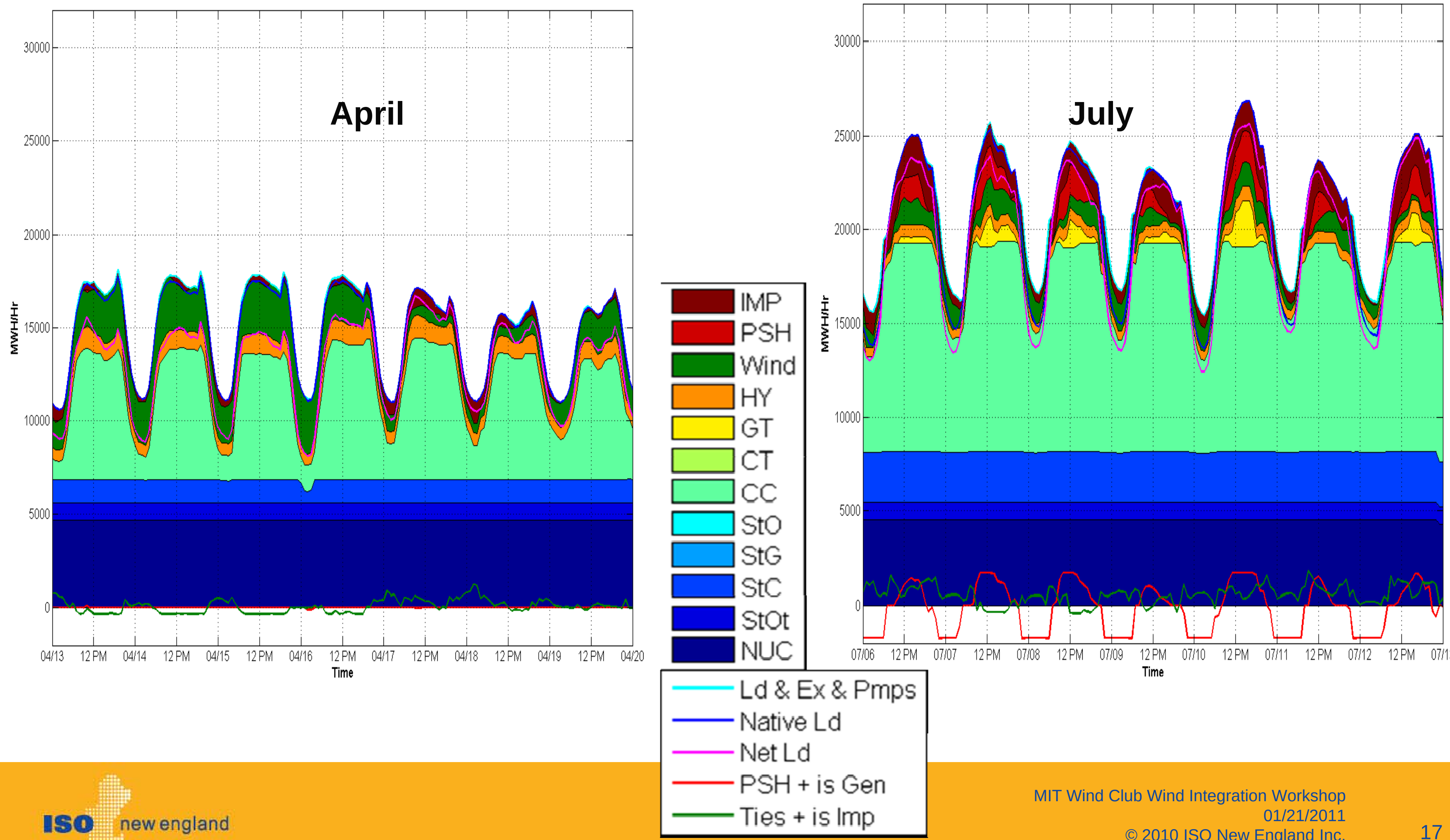
2.5% Energy



Hourly Operations: System dispatch

Week of April 13 & July 6

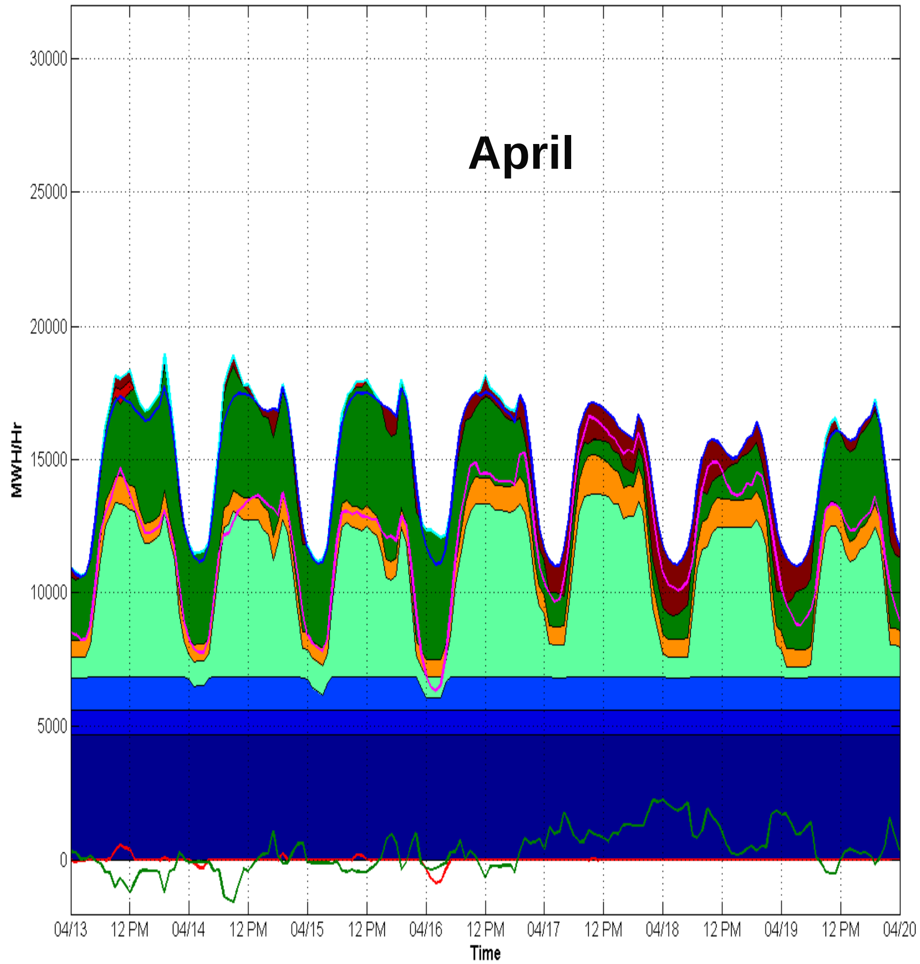
Full Queue

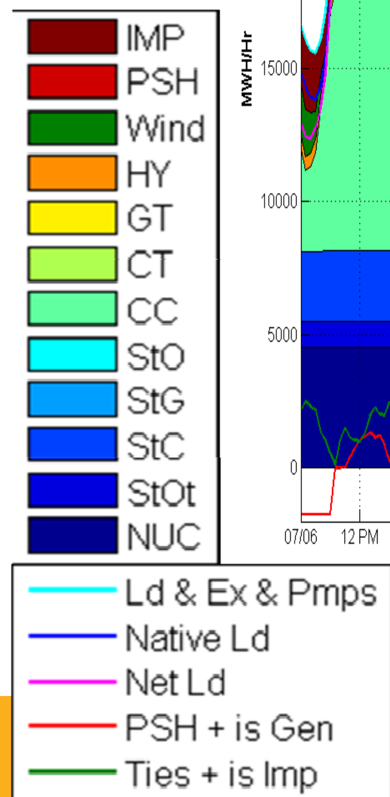


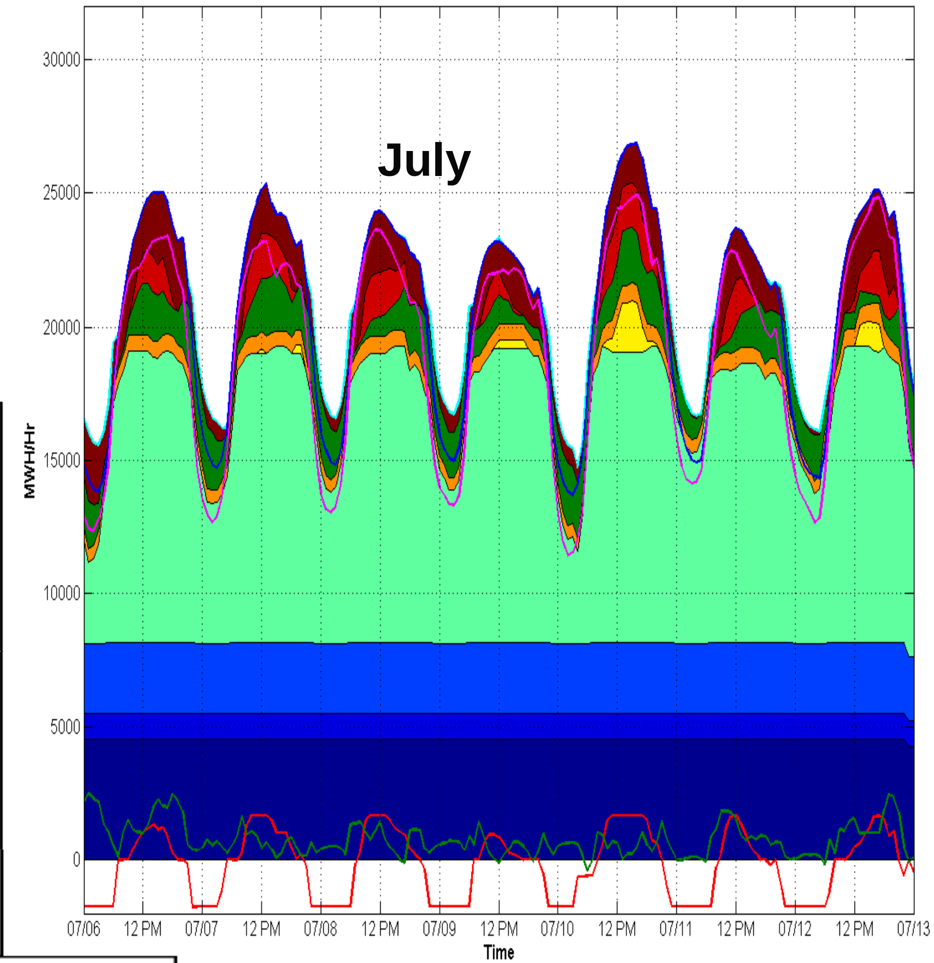
Hourly Operations: System dispatch

Week of April 13 & July 6

14% Energy



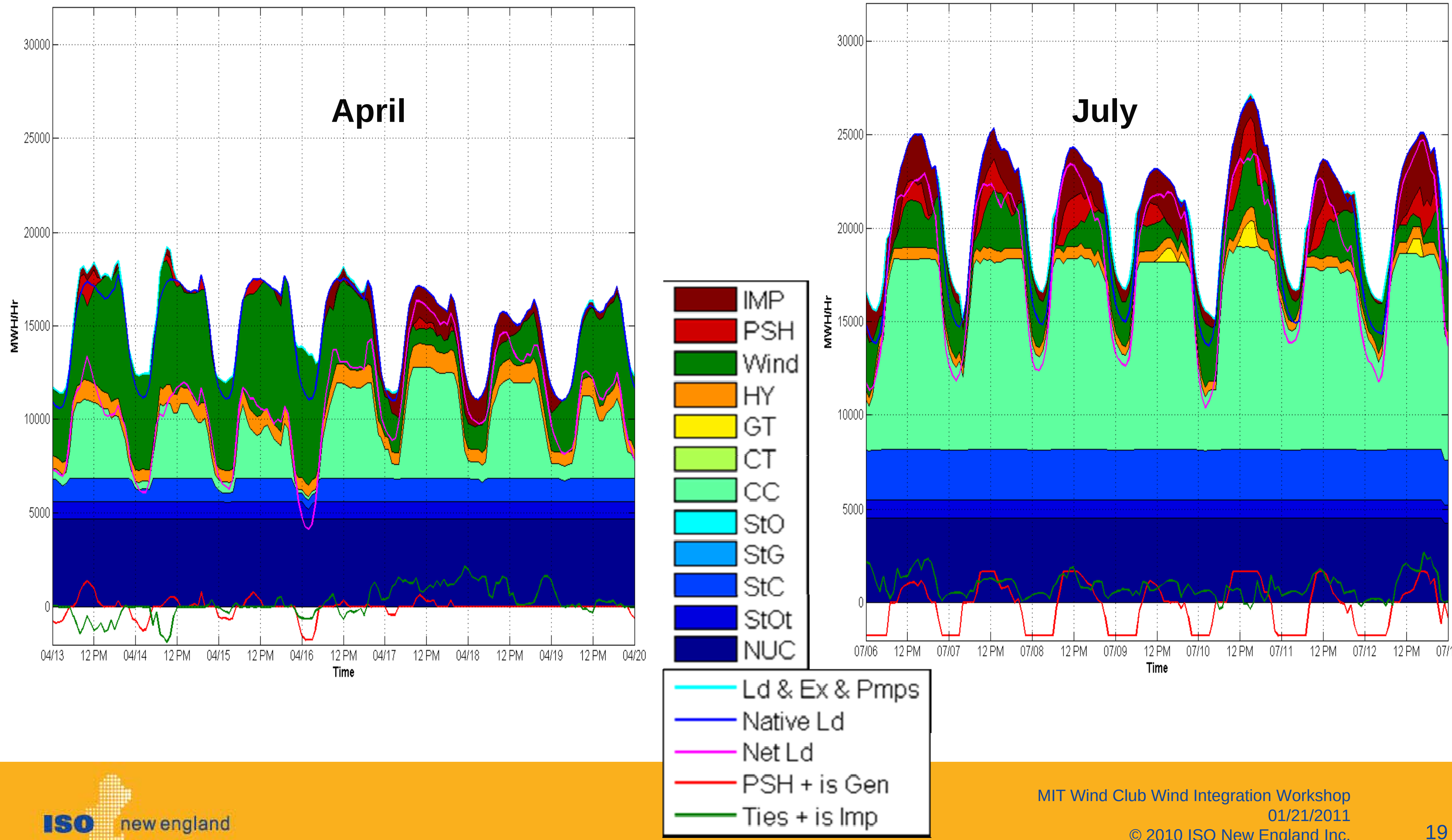




Hourly Operations: System dispatch

Week of April 13 & July 6

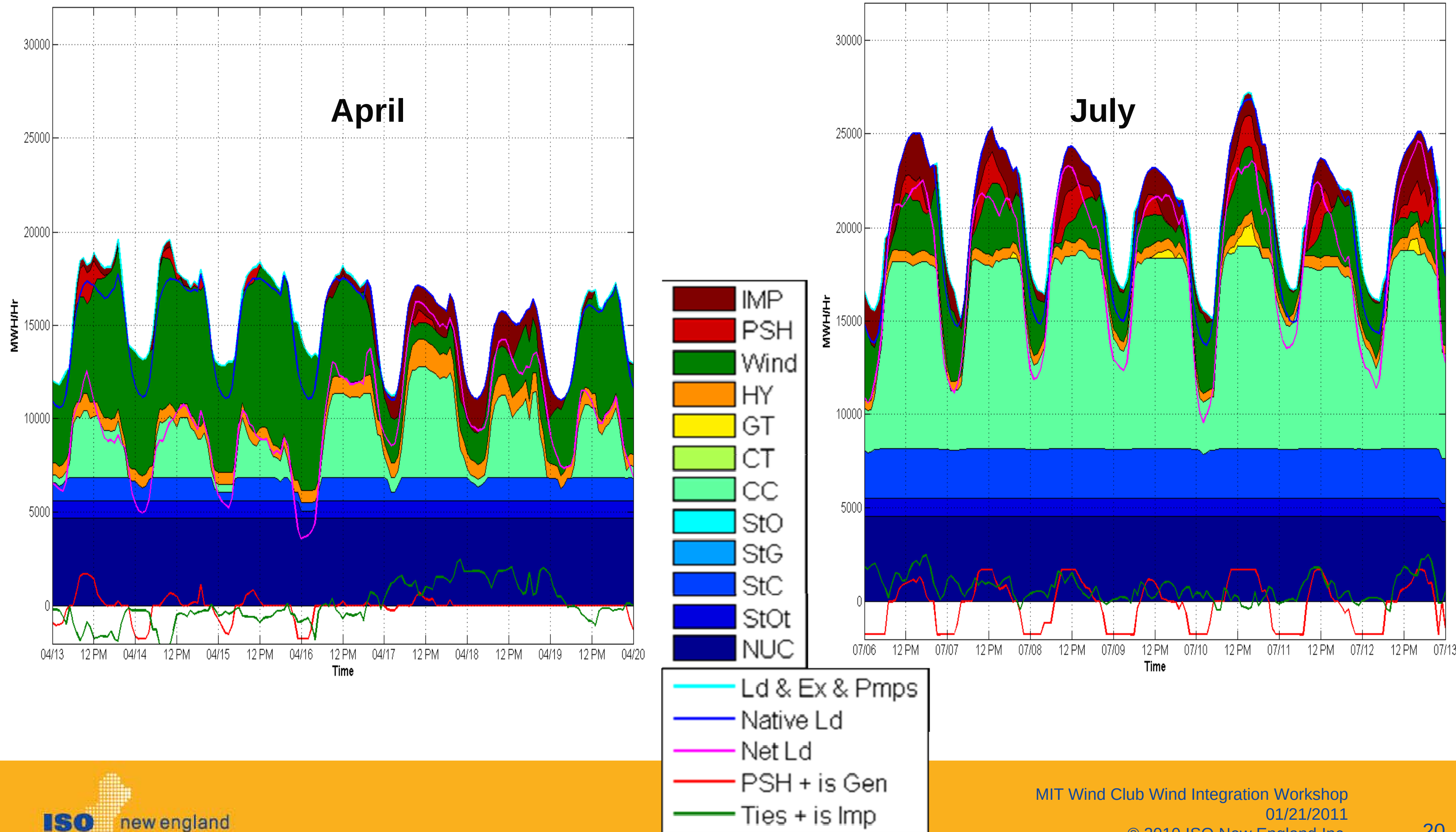
20% Energy



Hourly Operations: System dispatch

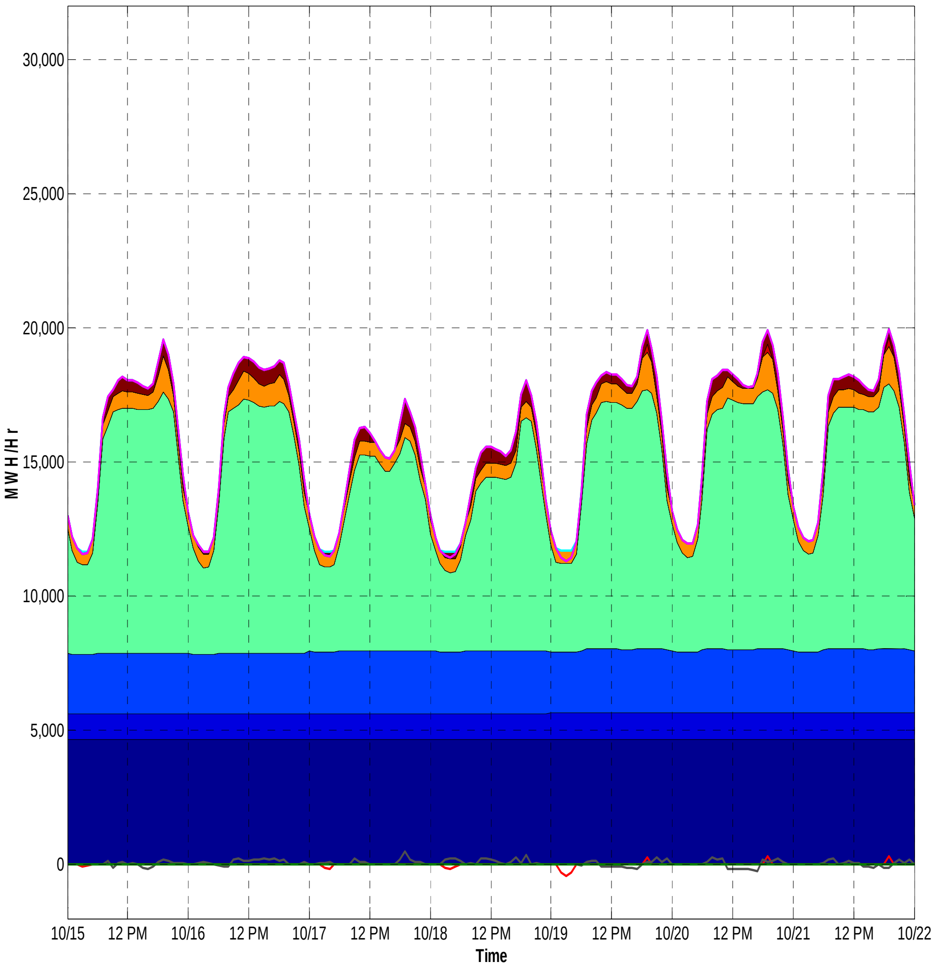
Week of April 13 & July 6

24% Energy

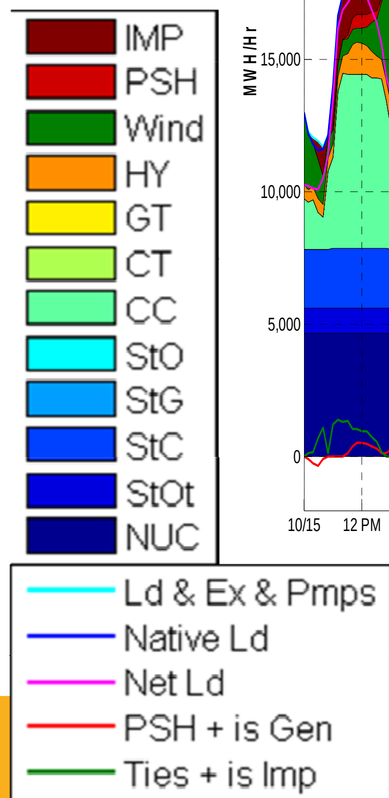


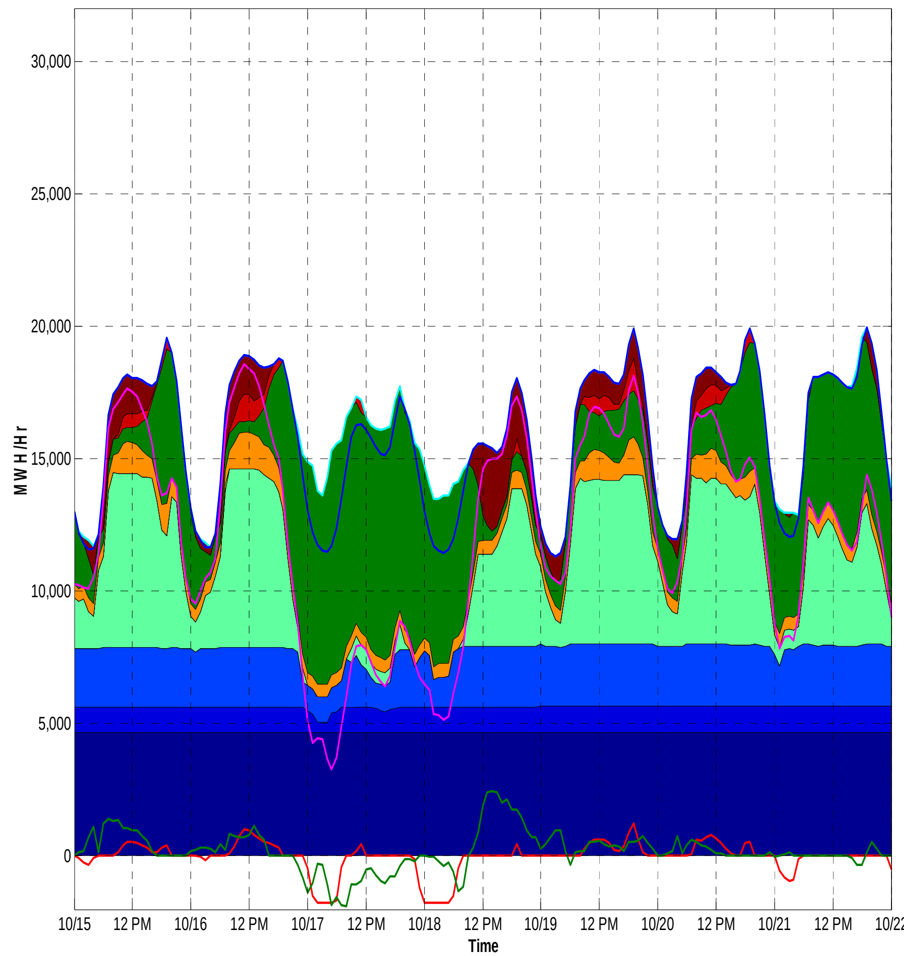
Hourly Operations: low minimum load

Week of October 15 to October 22



No Wind

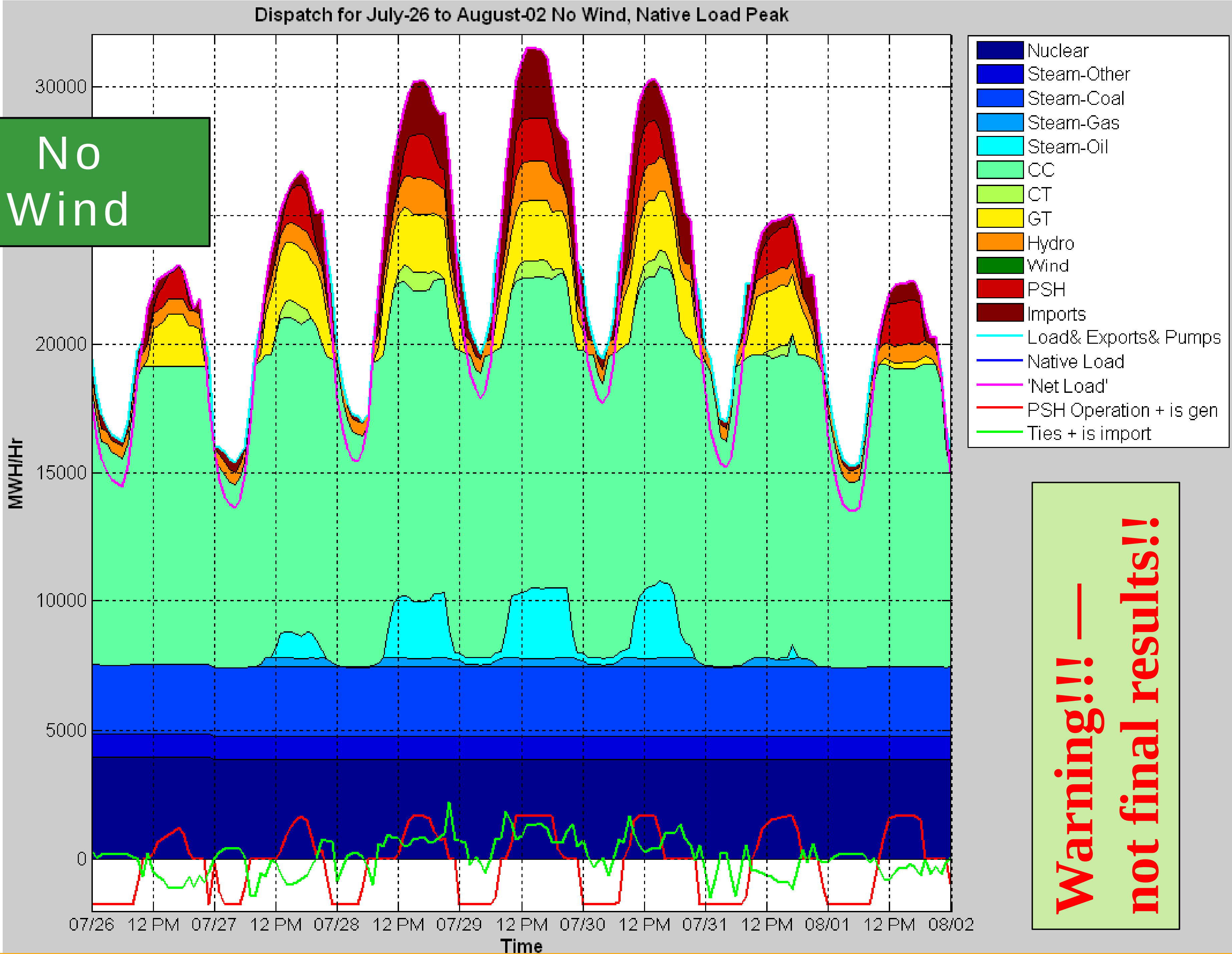




20% Wind: Best Onshore Case

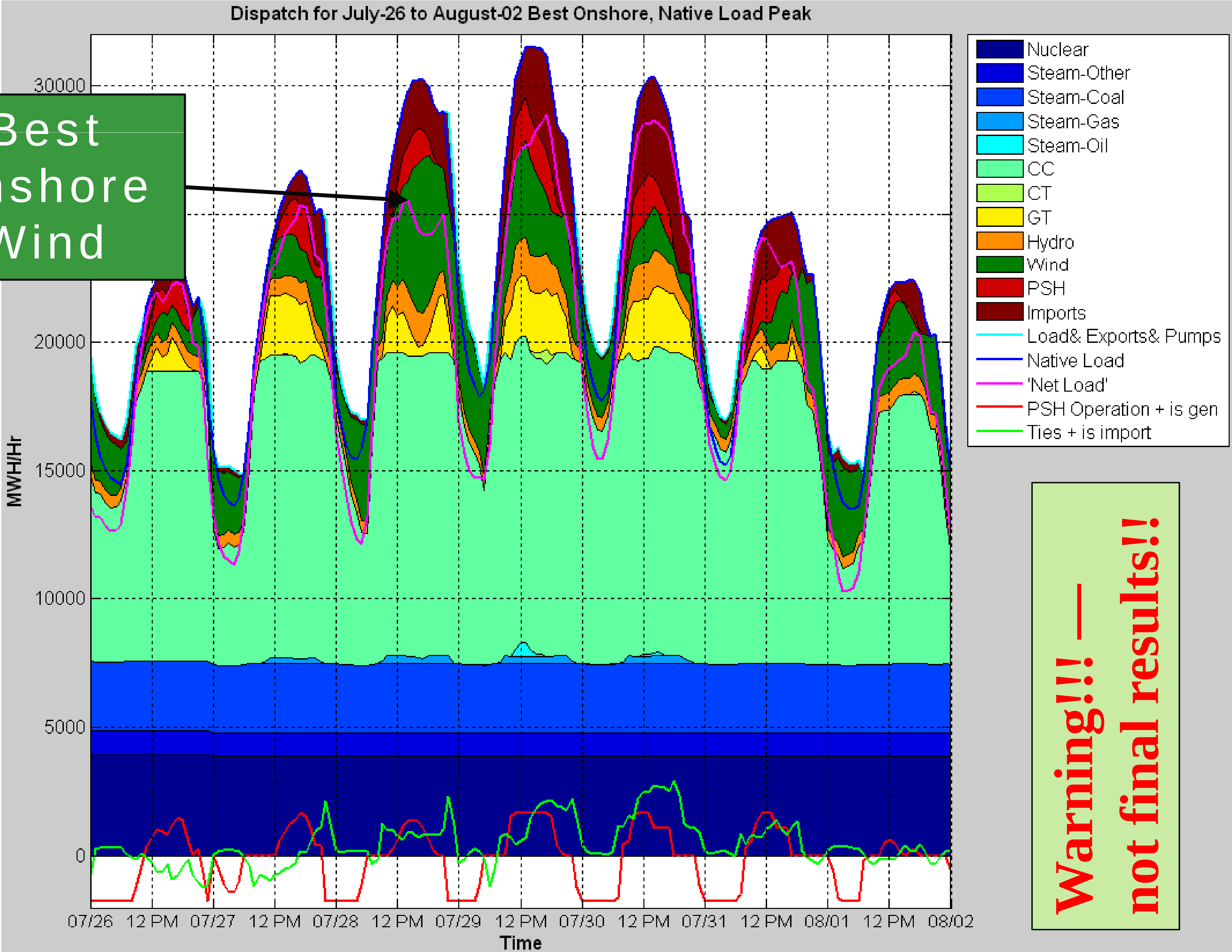
Simulation Results: Peak Native Load

No Wind



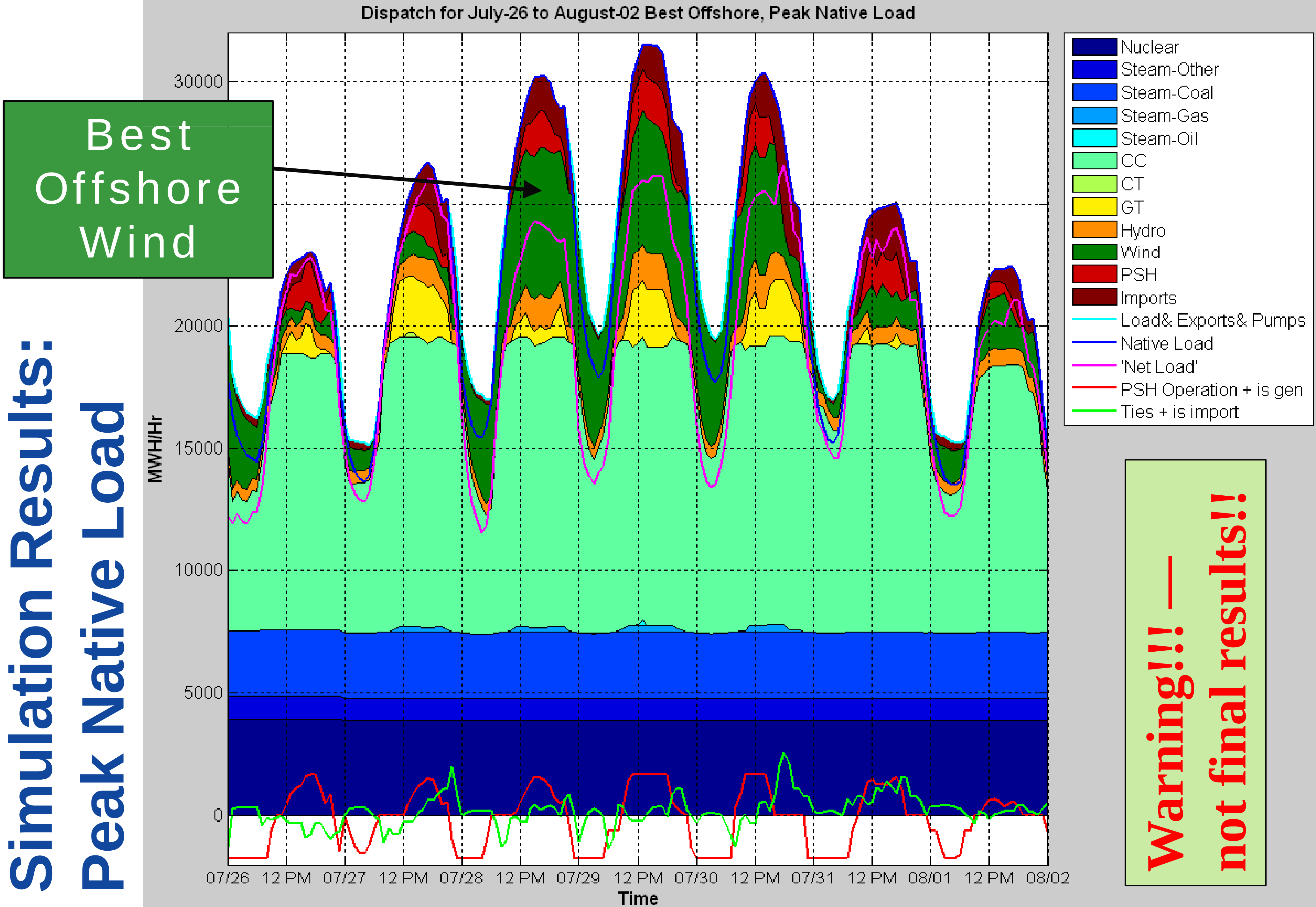
Warning!!! — not final results!!

Simulation Results: Peak Native Load



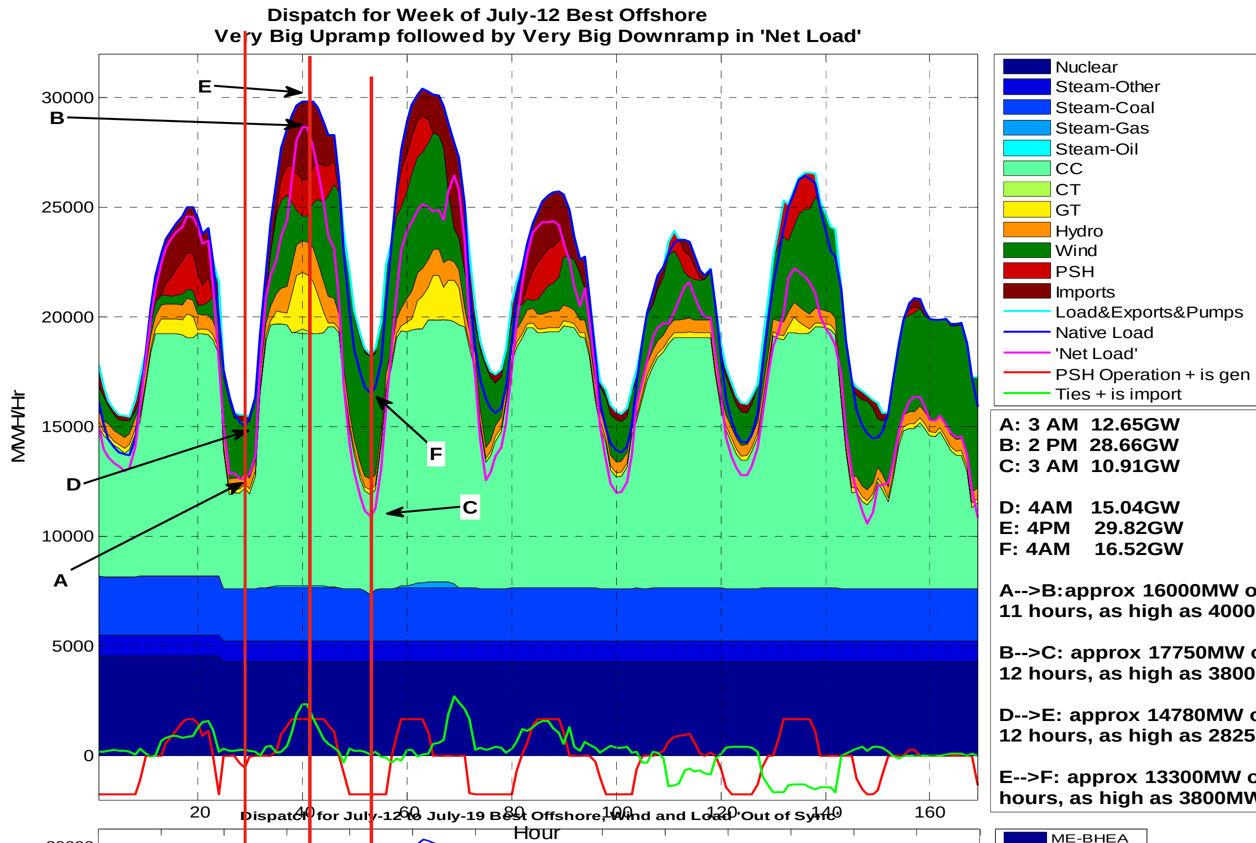
Warning!!! — not final results!!

Simulation Results: Peak Native Load



Warning!!! — not final results!!

Simulation Results: An Interesting Week!



A: 3 AM 12.65GW
B: 2 PM 28.66GW
C: 3 AM 10.91GW

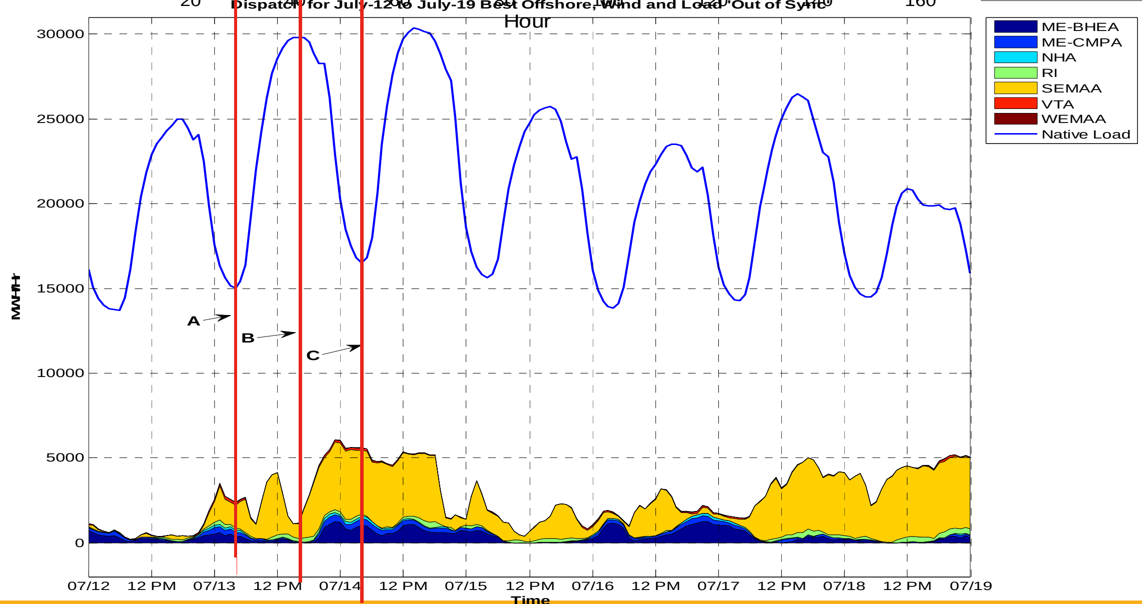
D: 4AM 15.04GW
E: 4PM 29.82GW
F: 4AM 16.52GW

A-->B:approx 16000MW over 11 hours, as high as 4000MW/Hr

B-->C: approx 17750MW over 12 hours, as high as 3800MW/Hr

D-->E: approx 14780MW over 12 hours, as high as 2825MW/

E-->F: approx 13300MW over hours, as high as 3800MW/Hr



Warning!!! — not final results!!

What NEWIS is and is not (slide 1 of 4)

- To be clear about the interpretation of the methods used, results obtained, and any recommendations provided, it is important to recognize what the NEWIS is and what it is not (next 4 slides)
  - The NEWIS is not a transmission planning study
  - The NEWIS is not a blueprint for windpower development
    - large-scale windpower might or might not occur in the region
  - The NEWIS takes a snapshot of a hypothetical future year where large windpower penetrations are assumed
  - Feedback dynamics in markets, such as the impact of overall reduced fuel use and the changes in fuel use patterns on fuel supply and cost, were not analyzed or accounted for

What NEWIS is and is not (slide 2 of 4)

- It is not a goal of ISO-NE to increase the amount of any particular resource
  - instead the ISO's goal is to provide mechanisms to ensure that it can meet its responsibilities
    - operating the system reliably
    - managing transparent and competitive power system markets
    - planning for the future needs of the system
  - while providing a means to facilitate innovation and the fulfillment of New England's policy objectives.
- In this context the NEWIS is meant to investigate whether there are any insurmountable operational challenges that would impede ISO-NE's ability to accept large amounts of windpower generation.

What NEWIS is and is not (slide 3 of 4)

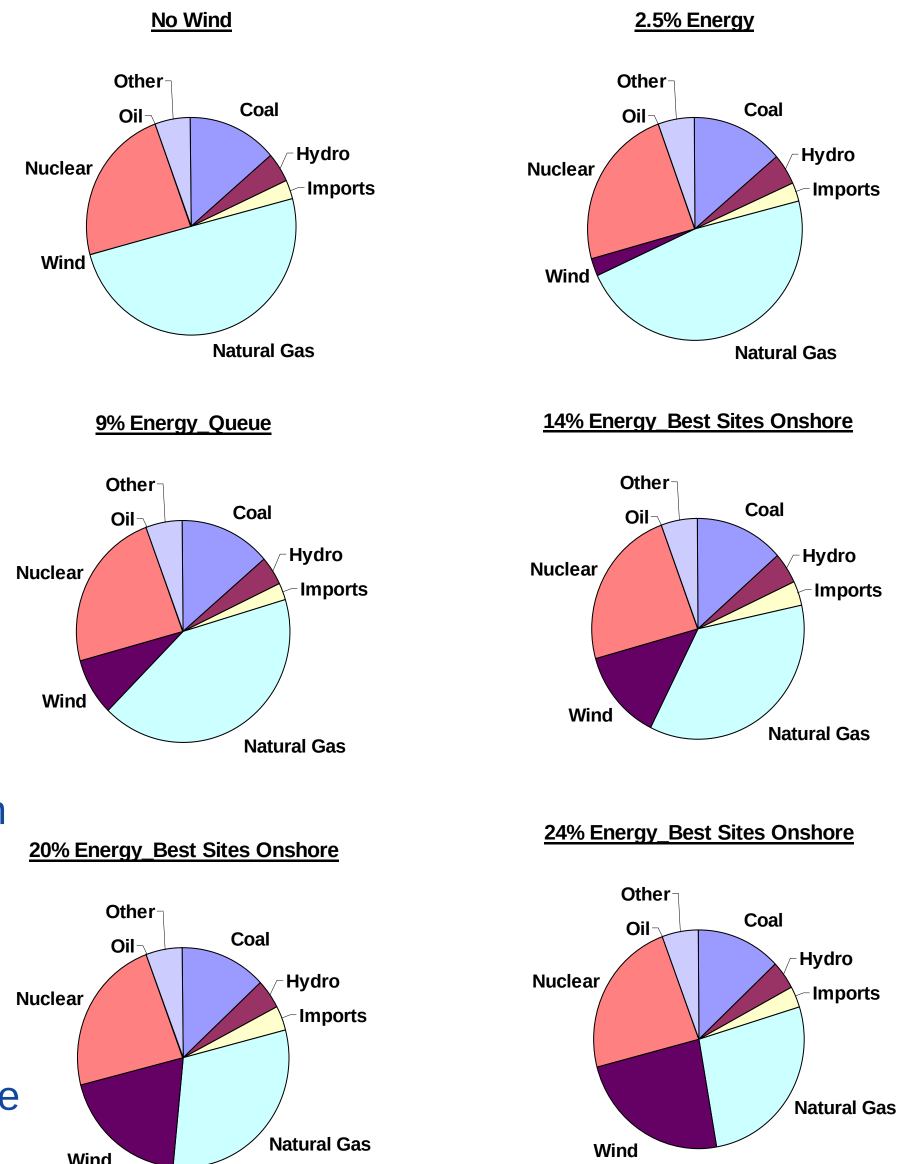
– Fundamental NEWIS study assumptions:
  1) The transmission required to integrate the hypothesized windpower generation into the bulk power system would be available
  2) Windpower resources would interconnect into those bulk transmission facilities
  3) Assumes the existing fleet remains available
  4) Assumes addition of resources that cleared FCA #2 in order to meet ICR; then adds wind
– The NEWIS does not account for local issues
– Detailed and extensive engineering analysis regarding stability and voltage limits would be required in order to determine the viability of the hypothesized transmission expansions, which in themselves will require substantial effort to site and build

What NEWIS is and is not (slide 4 of 4)

- Changes may be required to systems and procedures within the ISO organization that are yet to be determined.
- These changes would require additional analysis for increasing levels of wind penetration and for issues identified within New England, or beyond, as system operators gain experience with wind energy.
- The development, implementation, and operating costs associated with these changes are not accounted for in this study

Key Findings

- ISO-NE system has adequate resources to accommodate up to 24% annual energy penetration of wind generation
  - Assuming:
    - Transmission based on Governors' study
      - Minimal congestion, thermal analysis only
    - Increases in regulation and operating reserves
  - Resource attritions were not studied
  - Results shown for the horizon year 2020
- Existing ISO-NE generation fleet dominated by natural gas
  - Can be very flexible re: ramping and maneuvering
    - Provides about 50% of total annual generation with no wind generation
    - Most often dictates the marginal cost of energy in the ISO-NE market
    - Primary energy resource displaced by wind generation
    - Provides majority of the flexibility required for wind integration
    - Questions about how to maintain this flexibility
  - Pie charts are for the Best Sites Onshore scenario
    - The results presented are very similar across the range of scenario layouts



Other Observations

Flexible Generation

- ISO-NE system has high percentage of gas-fired generation that can have good flexibility characteristics
  - Ramping
  - Turndown
- Study results show adequate flexible generation at wind penetration levels up to 20%
- At 24% penetration, there are some periods when most gas generation is displaced by wind
  - Less flexible coal and nuclear operating with wind generation
- Decreases in system flexibility could negatively impact the ability to integrate wind

Energy Storage

- Study did not show need for additional Energy Storage capacity for hourly arbitrage
- Need for storage may increase if there is attrition of existing flexible resources
- PSH utilization increases at higher levels of wind penetration
- Fast energy storage (minute to minute) may have some application for regulation

Displacement of Energy From Conventional Generation

- Energy from wind generation in New England primarily displaces energy from natural gas fired generation
- Given that overall revenues decrease it is unclear how this will affect the ability of the dispatchable resources to provide the system flexibility benefits that are required

Other Observations

Dynamic Scheduling

- Most scenarios in this study included all necessary New England wind resources within the ISO-NE operating area, and therefore did not require dynamic scheduling
- Canadian Maritimes scenario used dynamic scheduling
  - Assumed that a portion of the ISO-NE wind generation would be imported from wind plants the Canadian Maritimes
- The results showed that ISO-NE (as assumed) has adequate resources to balance the imported Maritime wind generation

Load and Distributed Wind Forecasting

- If there are significant amounts of distributed wind, which show up as load modifiers, it will disrupt the historical accuracy of the load forecasting
- ISO-NE will need to account for the magnitude and location of distribution connected wind generation

The NEWIS Team

- Team GE
  - GE Energy and Systems Engineering
    - NYSERDA (‘04, ‘05) through to CAISO (’07) and WSIS (’10)
  - EnerNex
    - Minnesota (‘04) through to EWITS (‘09)
  - AWS Truepower
    - NYSERDA through to EWITS
- Technical Review Committee
  - J. Charles Smith: UWIG, AWEA
  - Michael Milligan, Brendan Kirby: National Energy Labs
  - Mike Jacobs: Developers/Transmission
  - Utama Abdulwahid: Wind Resource Characteristics
  - Warren Lasher: ERCOT

A good stopping point?

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

Recommended Changes to ISO-NE Operating Rules and Practices

Capacity Value:

- It is recommended that ISO-NE monitor a comparison of the LOLE / ELCC method and the current ISO practice
- A review of calculation methods for determining the Installed Capacity Requirement (ICR) or otherwise accounting for the impacts of wind's intermittency on ICR may be needed

Regulation:

- With higher penetrations of wind generation (above 9%),
  - It will likely become advantageous to adjust regulation requirements daily, as a function of forecasted and/or actual wind generation on the ISO-NE system
  - It is recommended that ISO-NE develop a methodology for calculating the regulation requirements for each hour of the next day, using day-ahead wind generation forecasts

Ten Minute Spinning Reserve (TMSR):

With increased wind penetration, regulation requirements will increase to a level where this practice should be changed – before the system reaches 9% wind energy penetration.

- Regulation should be allocated separately from TMSR, or
- TMSR should be increased to cover the increased regulation requirements.

Recommended Changes to ISO-NE Operating Rules and Practices

Ten Minute Non-Spinning Reserve (TMNSR):

- A mechanism for securing this capacity as additional TMNSR during periods of volatile wind generation may need to be developed.
- Should investigate the use of TMOR instead of and/or in combination with TMNSR

Wind Forecast:

- Day-ahead wind forecast should be included in the ISO-NE economic day-ahead security constrained unit commitment and reserve adequacy analysis (SCUC RAA).
- Production simulation results show that the benefit of including forecasted wind generation in the day-ahead unit commitment increases with wind penetration
- If wind forecasts are not included in unit commitment
    - Conventional generation will be overcommitted
        - Operating costs will be increased, LMPs will be depressed
        - Will be surplus spinning reserve
        - Excessive wind generation curtailment
  - Current practices for publishing the load forecast should be followed for publishing the wind forecast, subject to confidentiality requirements
- Intra-day wind forecasting should be performed in order to reduce dispatch inefficiencies and provide for situational awareness

Recommended Changes to ISO-NE Operating Rules and Practices

System Flexibility:

- Any conditions that reduce the system flexibility will potentially negatively impact the ability of New England to integrate large amounts of wind power.
  - Potential system flexibility reducers can be regulatory, market, operational practices, or system conditions that limit the ability of the system to use the flexibility of the available resources
    - Strict focus on (and possibly increased regulation of) marginal emissions rates as compared to total overall emissions
    - Any practices that impede the ability of all resources to provide all types of power system products within each resource's technical limits
    - Long-term outages or congestion that reduce the ability to access flexible resources
  - Self-scheduled generation also reduces the flexibility of the dispatchable generation resource and can lead to excessive wind curtailment at higher penetrations of wind generation.
    - It is recommended that ISO-NE examine its policies and practices for self scheduled generation, and possibly change those policies to encourage more generation to remain under the control of ISO-NE dispatch commands.

Recommended Changes to ISO-NE Operating Rules and Practices

Dispatch:

- ISO-NE should consider adopting a methodology that sends dispatch down signals to wind plants to control their output in a more granular and controlled manner (e.g. electronic economic dispatch).
- This method is recommended in the Task 2 report. NYISO has already implemented a similar method.

Operating Records:

- It is recommended that ISO-NE record and save sub-hourly data from existing and new wind plants.
  - System operating records, including forecasted wind, actual wind, forecasted load and actual load should also be saved. Such data will enable ISO-NE to benchmark actual system operation with respect to system studies.
  - ISO-NE should also periodically examine and analyze this data to learn from the actual performance of the ISO-NE system.

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 (Day Ahead 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

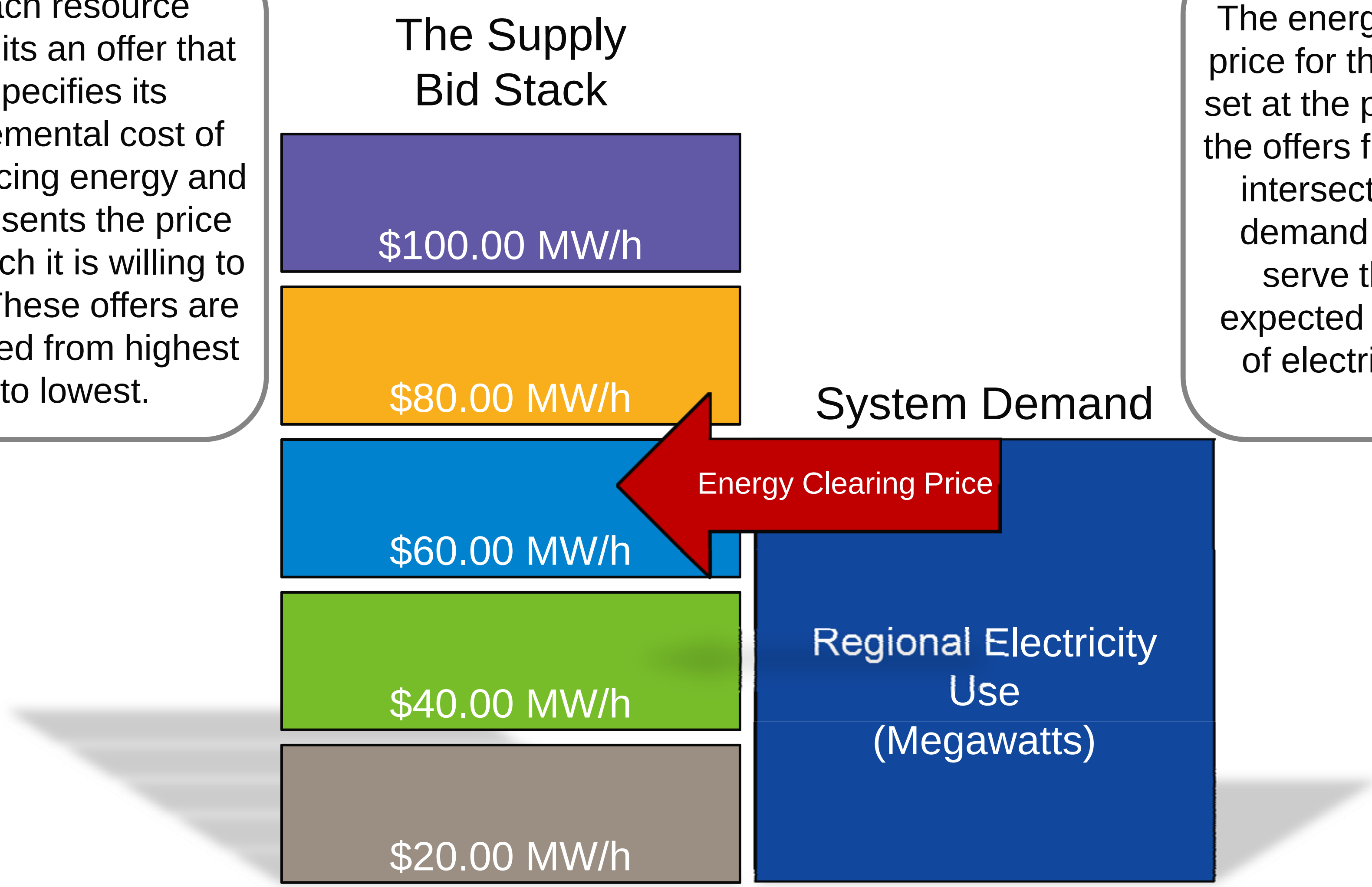
Selects Lowest Cost Resources to Meet Demand

- 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

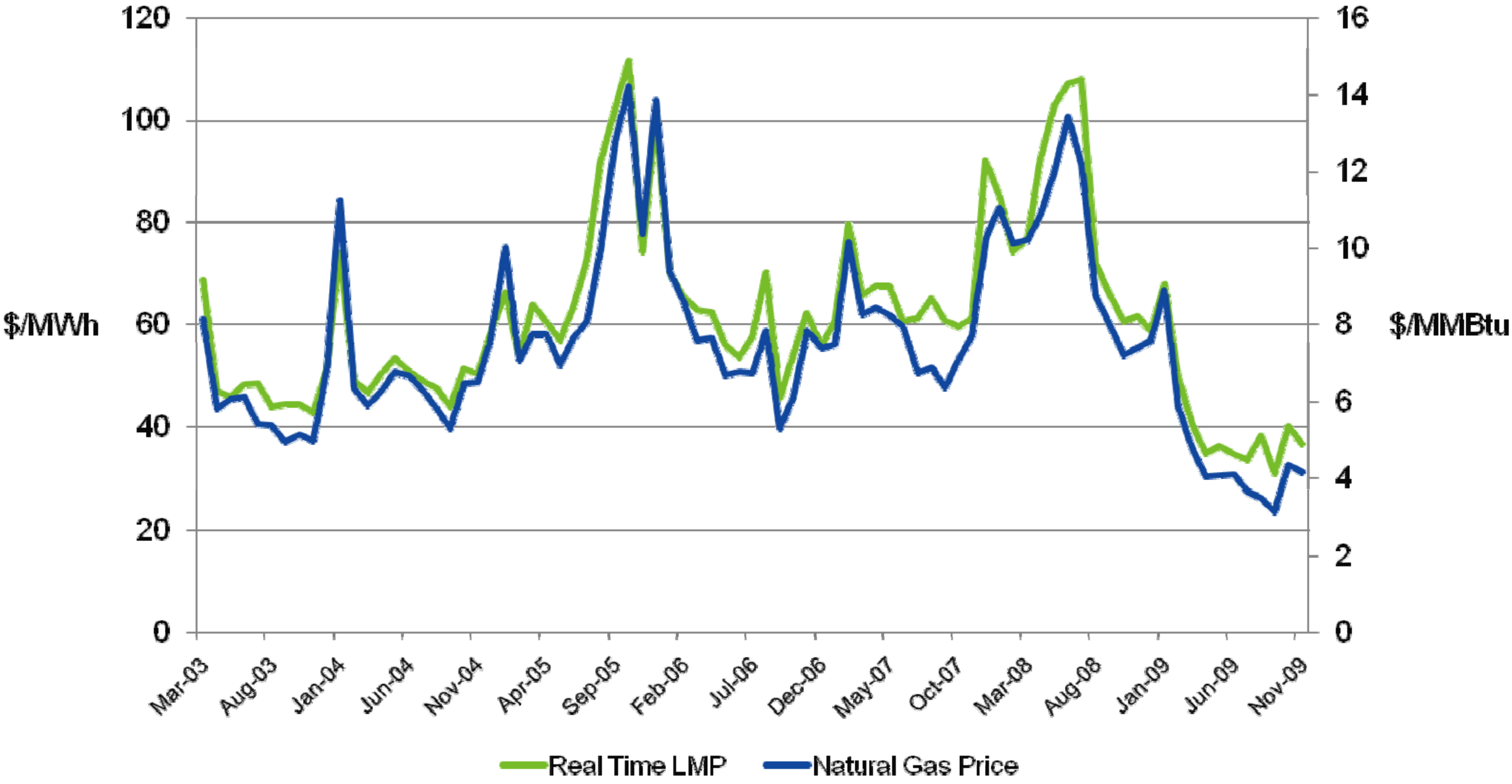
Each resource submits an offer that specifies its incremental cost of producing energy and represents the price at which it is willing to run. These offers are stacked from highest to lowest.



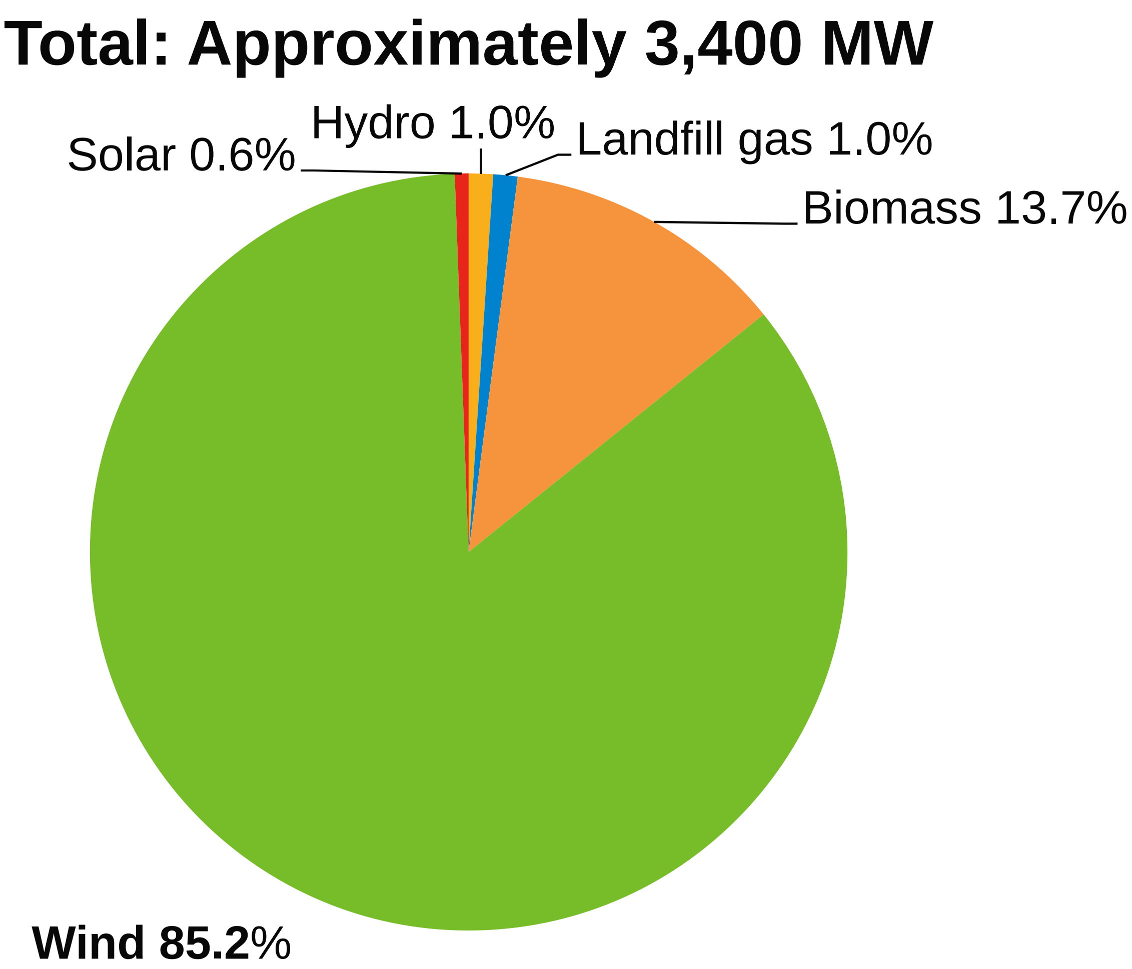
The energy clearing price for the region is set at the point where the offers from supply intersect with the demand levels to serve the next expected megawatt of electricity use.

Wholesale Electricity Prices Track Natural Gas

Natural Gas and wholesale electricity prices have both recently declined



Proposed Renewable Resources in the ISO Interconnection Queue



As of June 1, 2010

A Short History: Wind Studies at ISO-NE

- Scenario Analysis 2007:
  - Queue wind (780MW)
  - Plus approx. 5*¼*(5.4GW,8.9GW) =6.9GW, 10.9GW
- Levitan Phase I 2007
  - AWST windmap (2003): 50m hub onshore, 100m hub offshore
    - Potential wind sites screened based on annual wind speed, minimum size, population density, and (offshore) water depth and proximity to shore
- Levitan Phase II 2008
  - Refined results of Phase I (transmission proximity)
    - Onshore/Offshore Nameplate Potential: 174GW/26.5GW
- Governor's Blueprint Study
  - Conceptual Transmission Overlays for Wind integration
- The NEWIS …

Drivers for Wind Study: Scope of the issue

- Wind energy can help to meet RPS targets
- Wind energy can dampen fuel cost uncertainty
- Wind energy improves fuel diversity
- Wind generation itself is quick to build
- ISO-NE Regional Wind status as of October 2010
  - Approx 270 MW of wind generation online
    - Approx 240 MW of these are biddable assets
  - Approximately 3200 MW in the Queue
    - Approximately 1000 MW are offshore
  - At these levels, New England may experience operational issues
- How does ISO-NE plan for integration of large amounts of renewables?

Drivers: Fit Wind into System

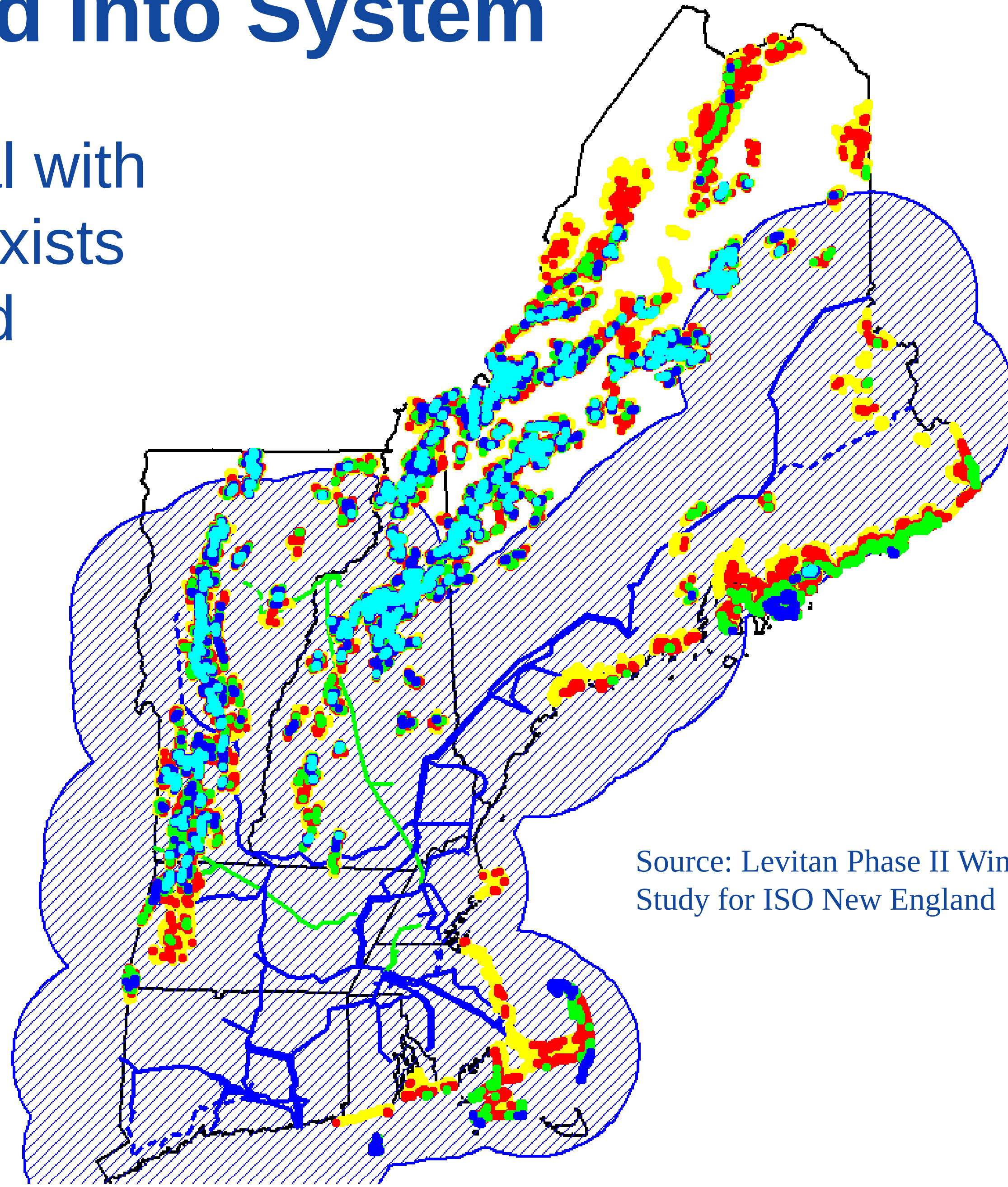
Significant wind potential with varying characteristics exists throughout New England

1 meter per second roughly 2.2 mph

Legend

MWH

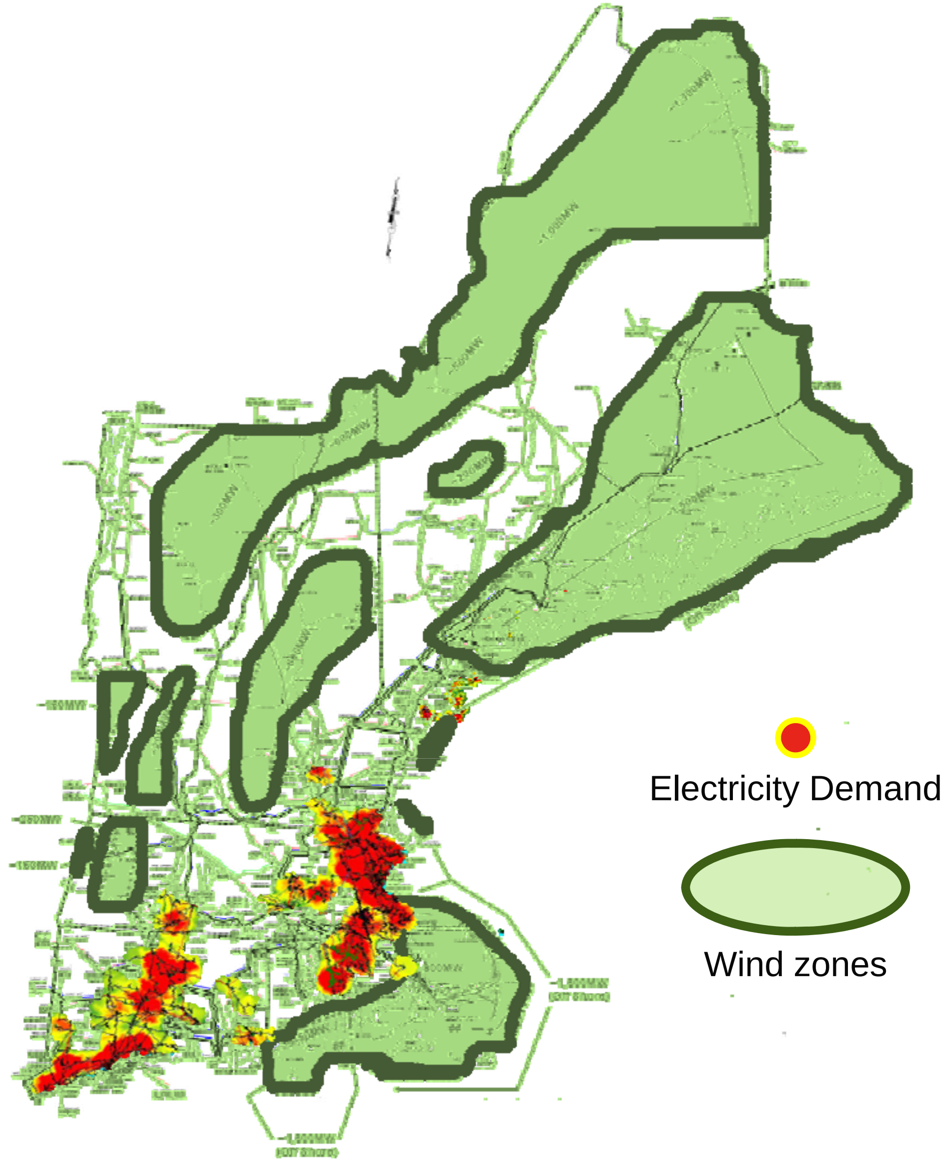
- Class 7 >8.8 (m/s)
- Class 6 8-8.8 (m/s)
- Class 5 7.5-8 (m/s)
- Class 4 7-7.5 (m/s)
- Class 3 6.4-7 (m/s)
- 40 Miles
- 230 kV
- 345 kV



Source: Levitan Phase II Wind Study for ISO New England

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

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: http://www.iso-ne.com/committees/comm_wkgrps/prtcpnts_comm/pac/reports/2009/newis_report.pdf

Task 2: Recommendations

- In general wind plants should be treated no differently than any other generator type
- However, the unique characteristics of wind energy require some special considerations
- Experience has shown that wind plants can be designed to meet requirements established for conventional units
- Wind plants are not just wind turbines
  - Collector systems, transformers, switchgear, reactive compensation, protection, substation, communication/control
- "Recommendations…are intended to provide requirements to be placed on wind plants that will enable ISO-NE to successfully operate with large amounts of wind power…"