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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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 (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

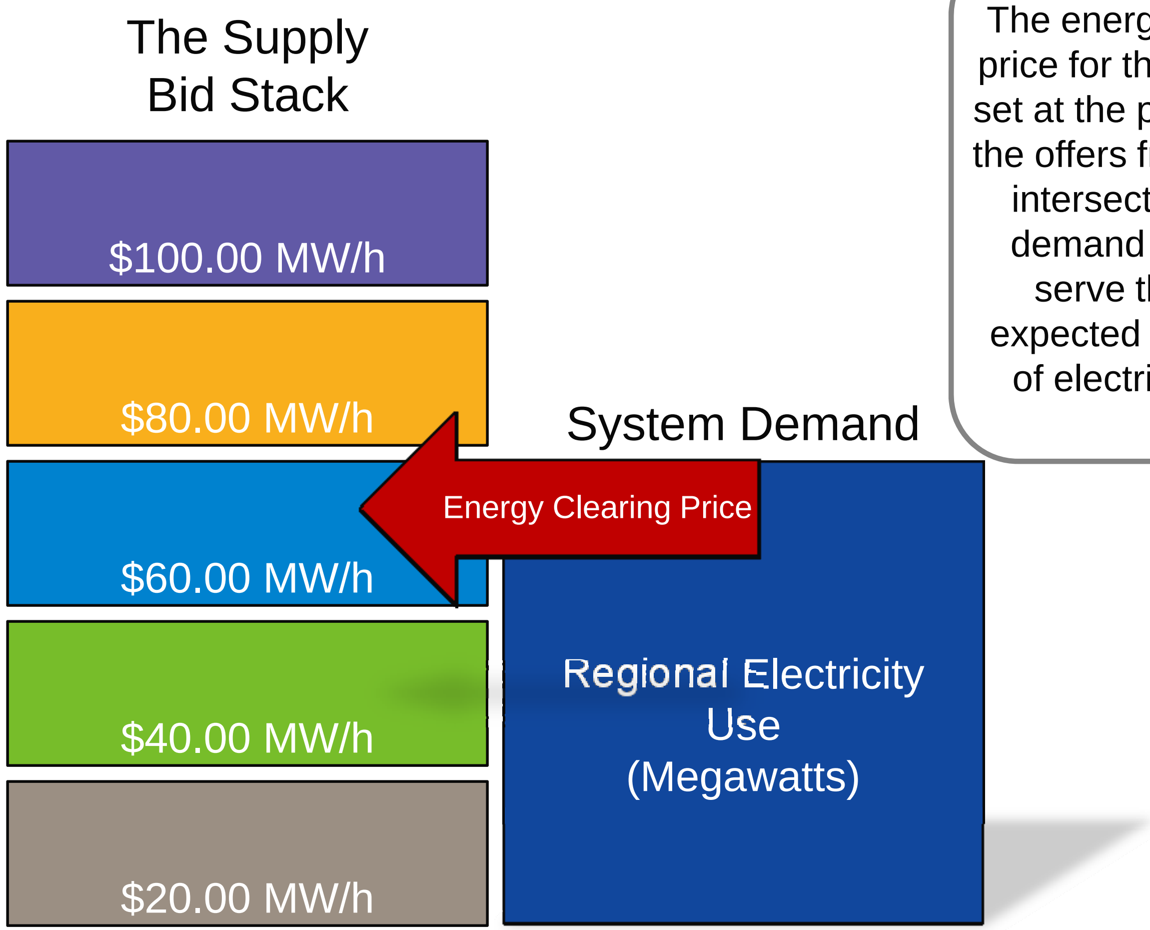
Selects Lowest Cost Resources to Meet Demand

- 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

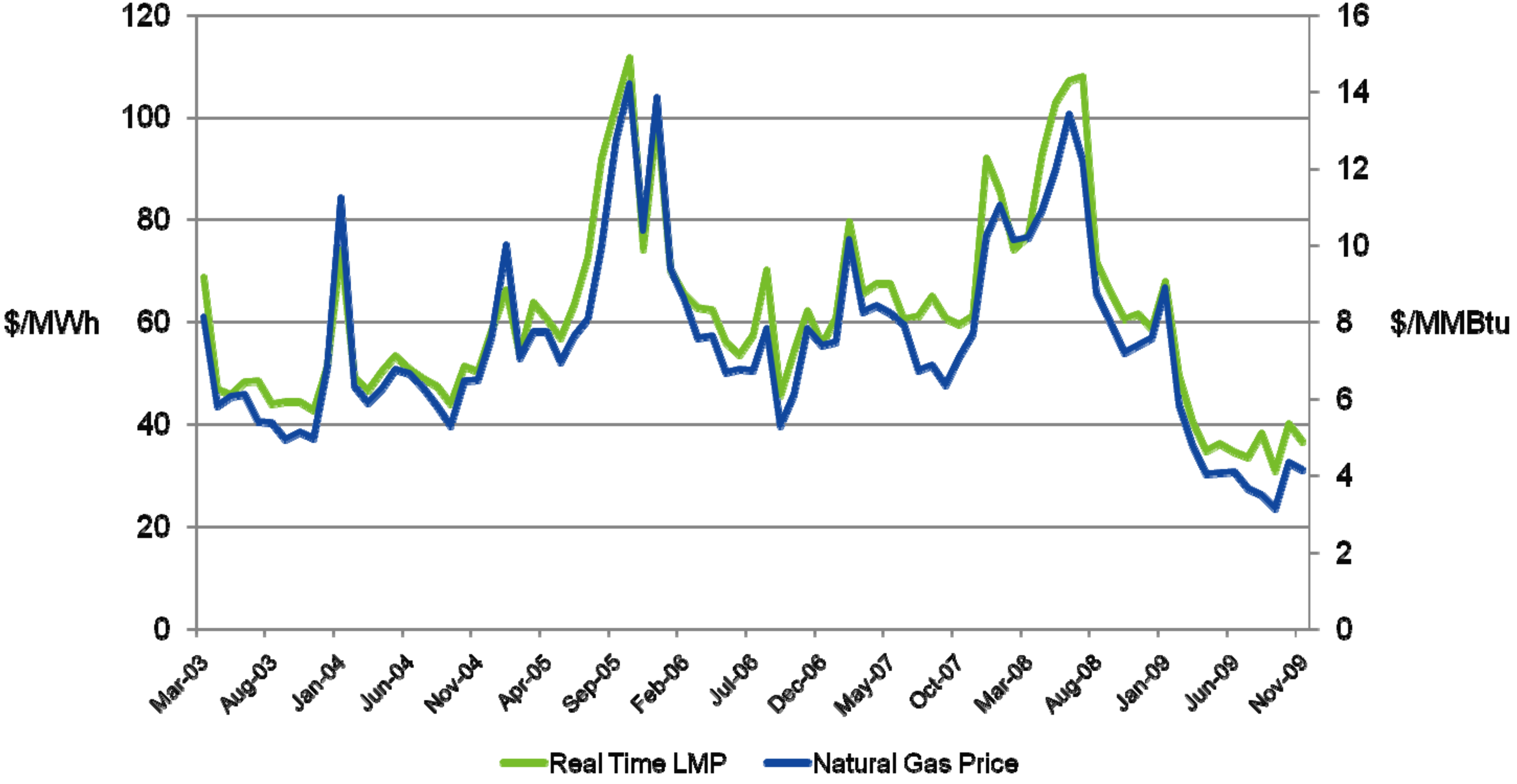
Each resource submits an offer that specifies its incremental cost of producing energy and represents the price at which it is willing to run. These offers are stacked from highest to lowest.



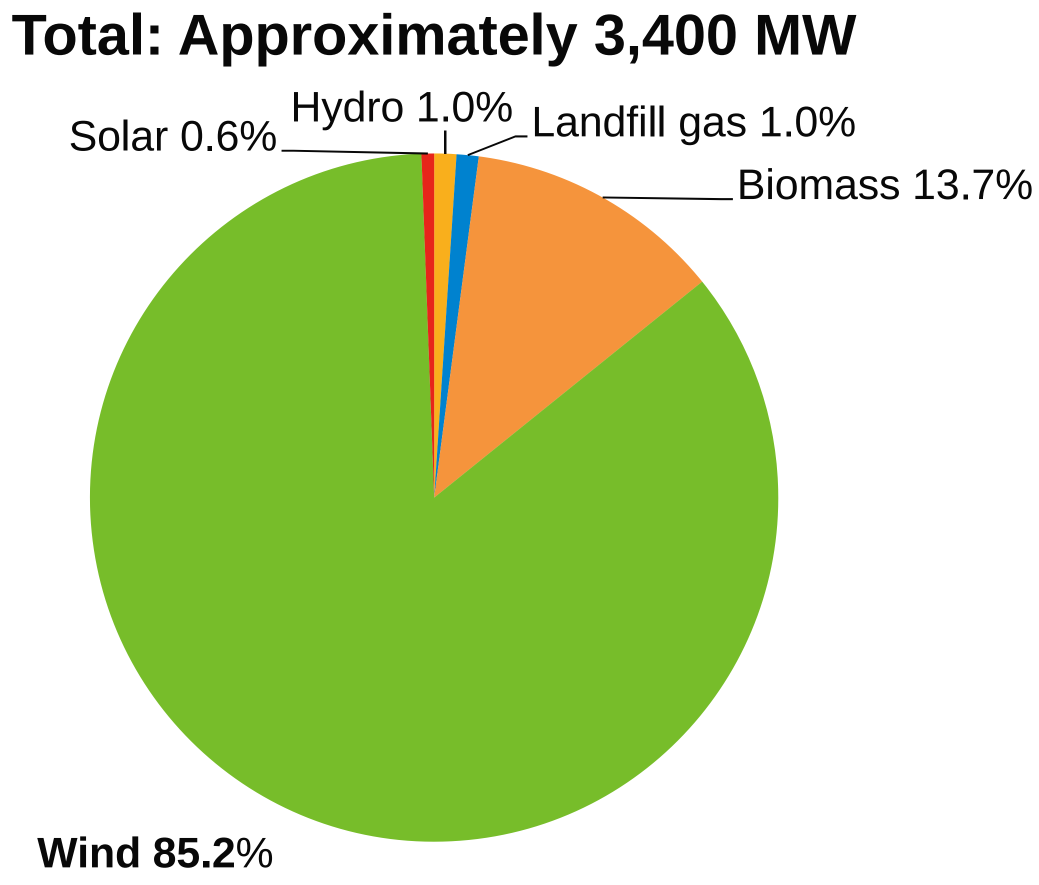
The energy clearing price for the region is set at the point where the offers from supply intersect with the demand levels to serve the next expected megawatt of electricity use.

Wholesale Electricity Prices Track Natural Gas

Natural Gas and wholesale electricity prices have both recently declined

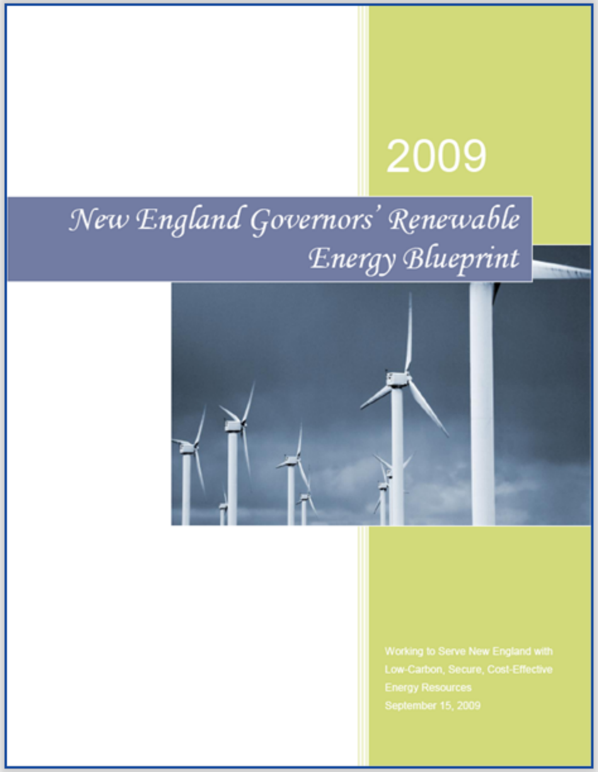


Proposed Renewable Resources in the ISO Interconnection Queue

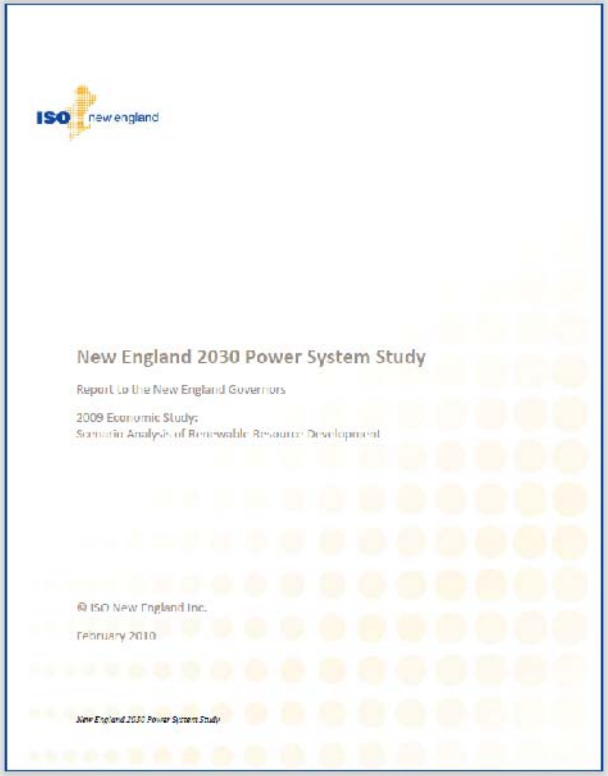


As of June 1, 2010

New England Governors Adopt Long-term Renewable Energy Vision



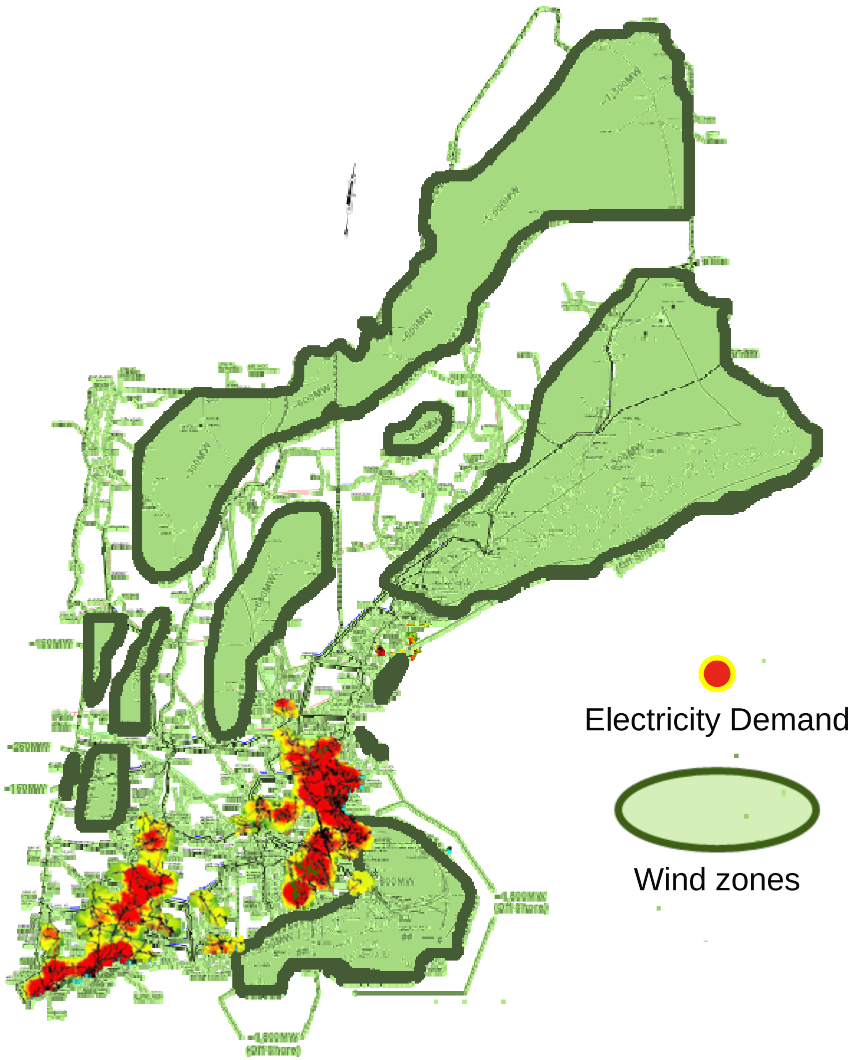
States' Blueprint as guiding policy and regulatory framework



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

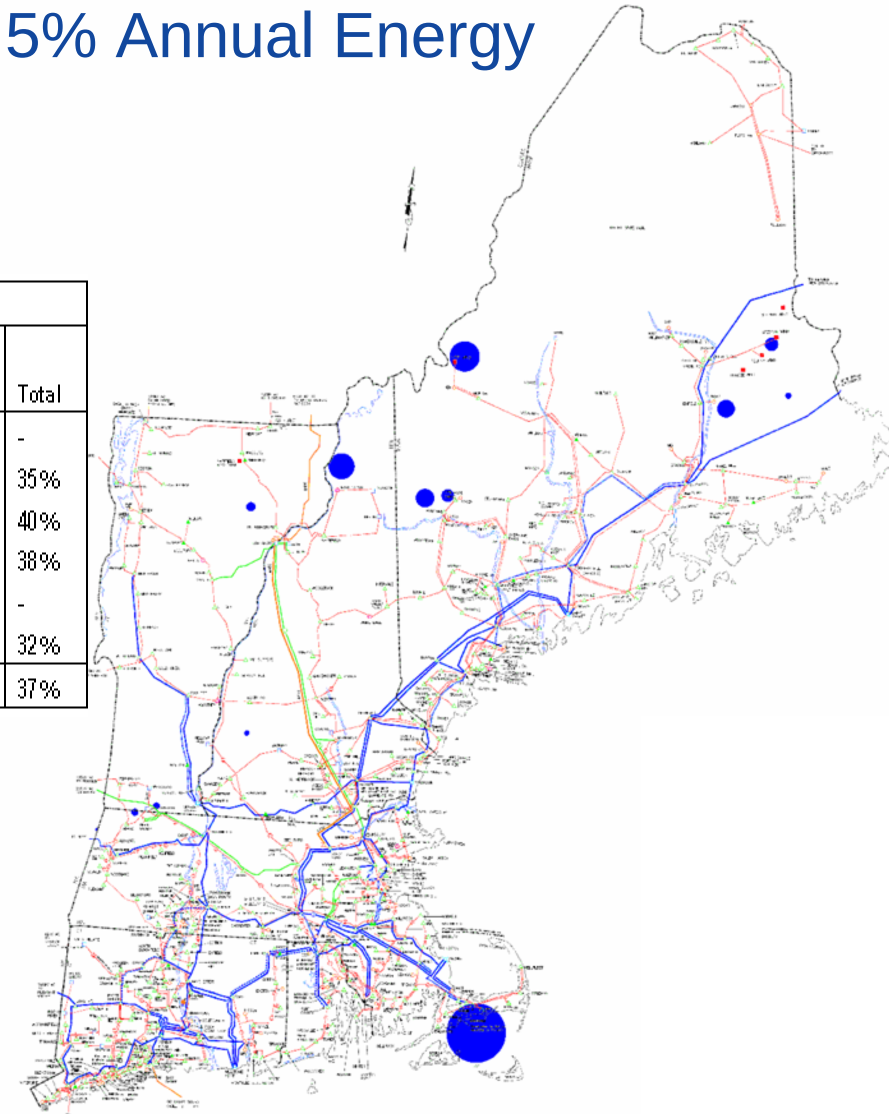
Different Scenarios Studied

- 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

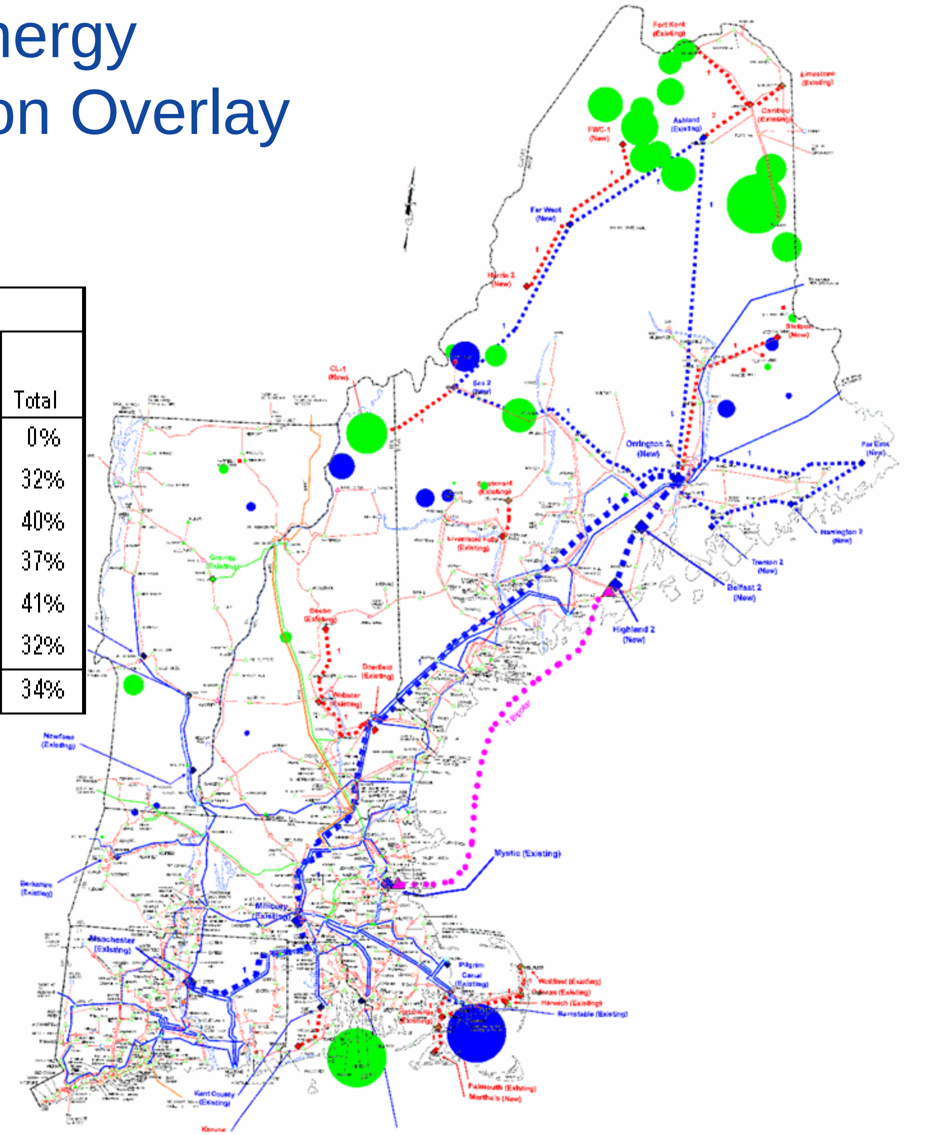
ST.	Onshore # of Sites	Onshore Name Plate (GW)	Onshore Energy (GWh)	Offshore # of Sites	Offshore Name Plate (GW)	Offshore Energy (GWh)	Total # of Sites	Total Name Plate (GW)	Total Energy (GWh)	Capacity Factor (%) Onshore	Capacity Factor (%) Offshore	Capacity Factor (%) Total
CT	-	-	-	-	-	-	-	-	-	0%	0%	-
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%



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%



Partial Queue

Additonal Queue

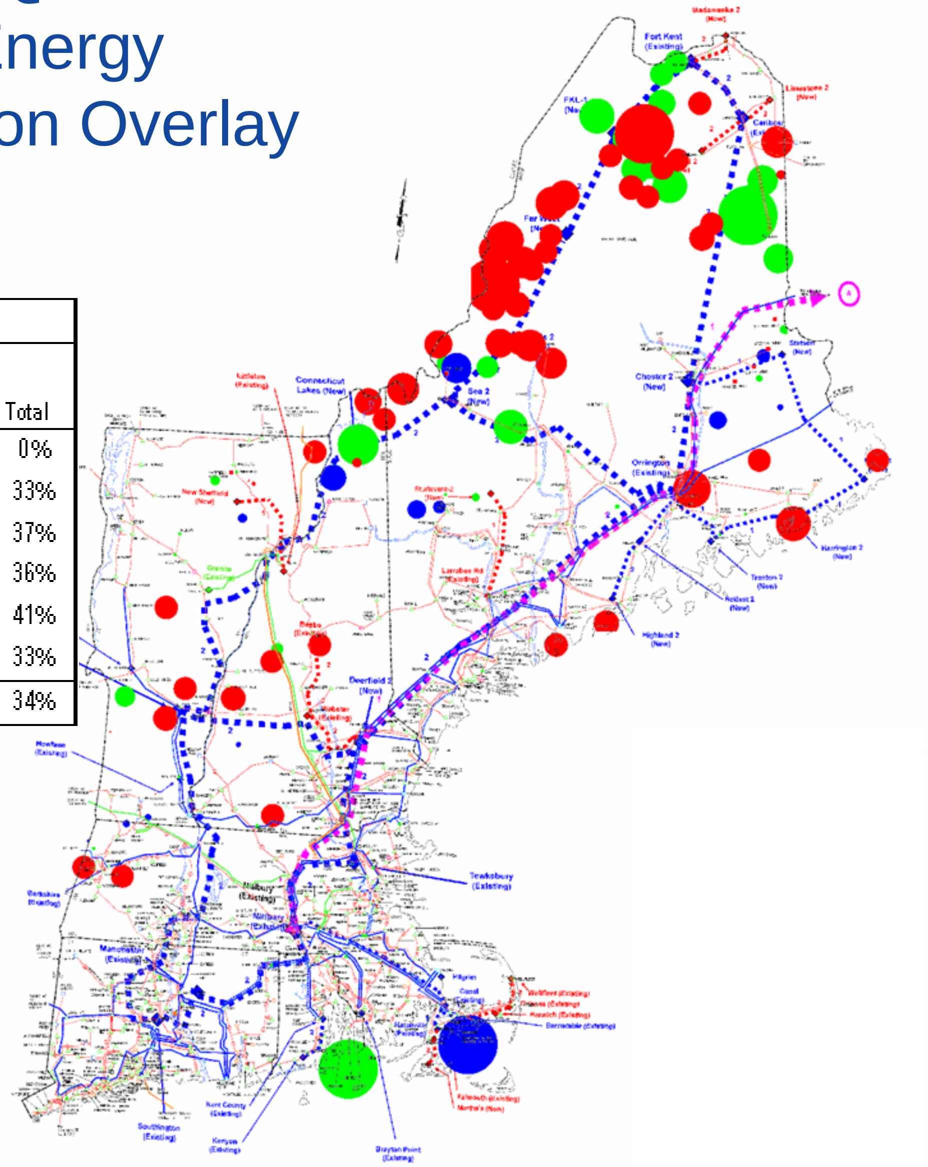
Additional to 20% Energy

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%

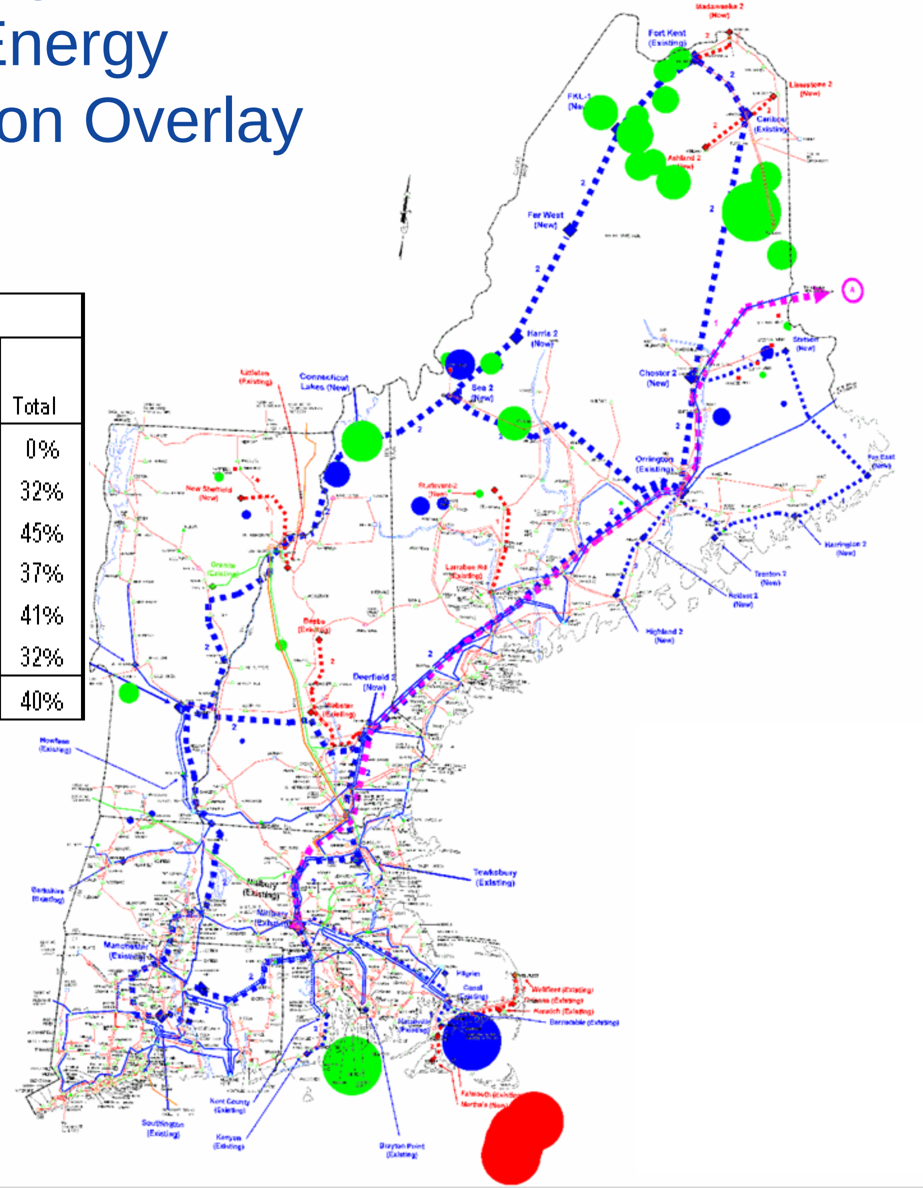


- Partial Queue
- Additonal Queue
- Additional to 20% Energy

Best Offshore + Full Queue

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

ST.	Onshore # 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	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

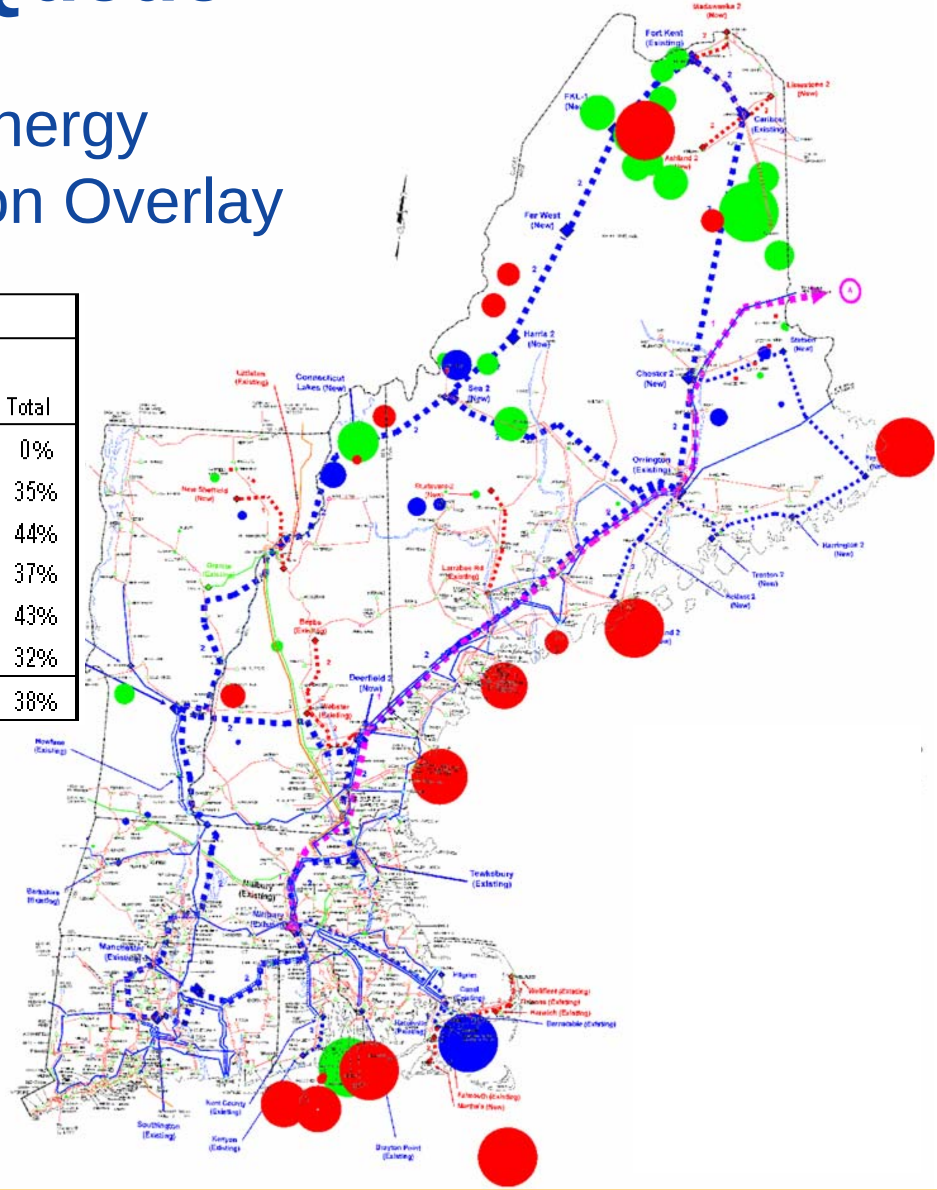
Balance Case + Full Queue

(aka. Best Sites)

Total: 8.80 GW 20% Annual Energy

Governors' 4 GW Transmission Overlay

	Onshore			Offshore			Total			Capacity Factor (%)		
ST.	# 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

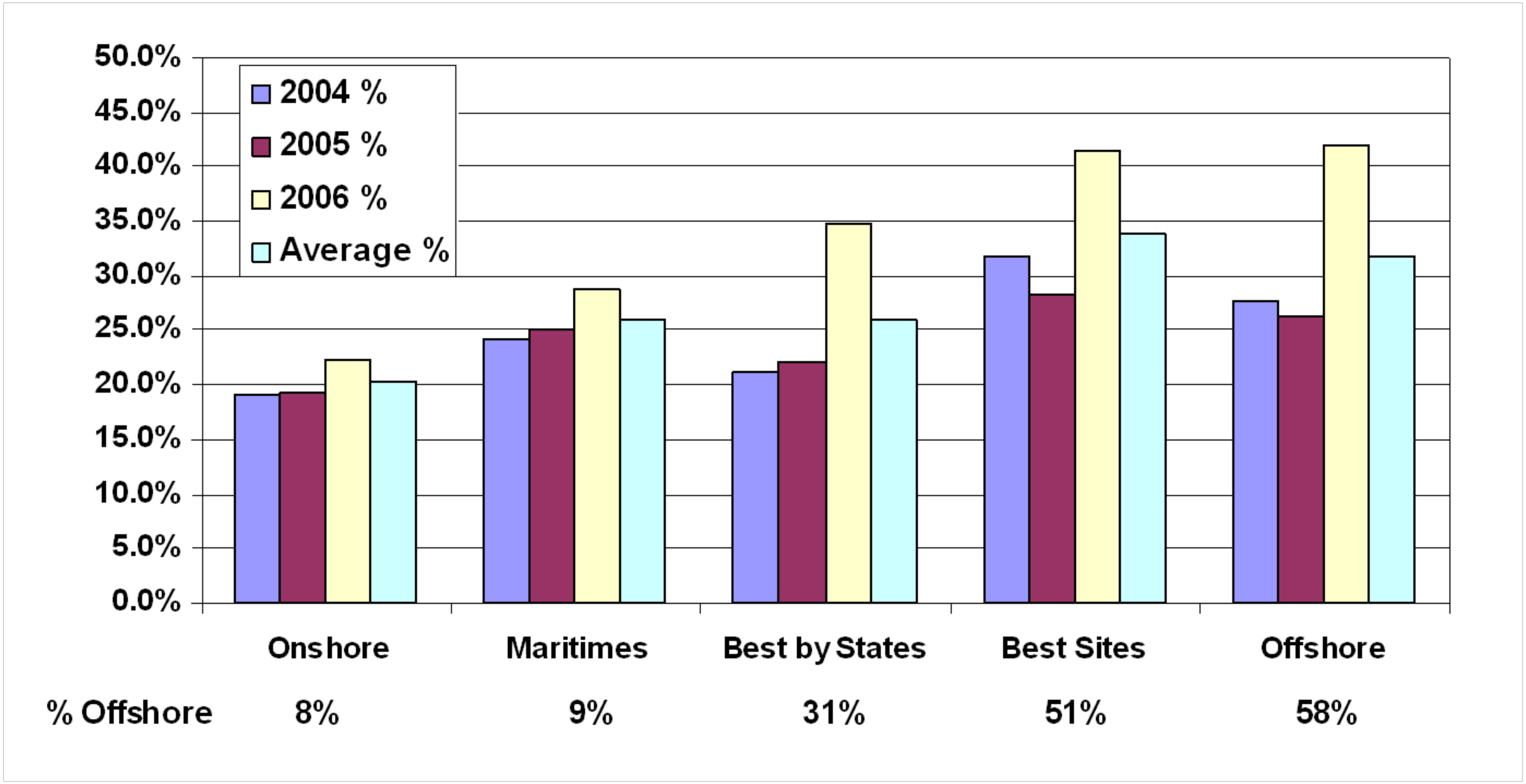
Additonal Queue

Additional to 20% Energy

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

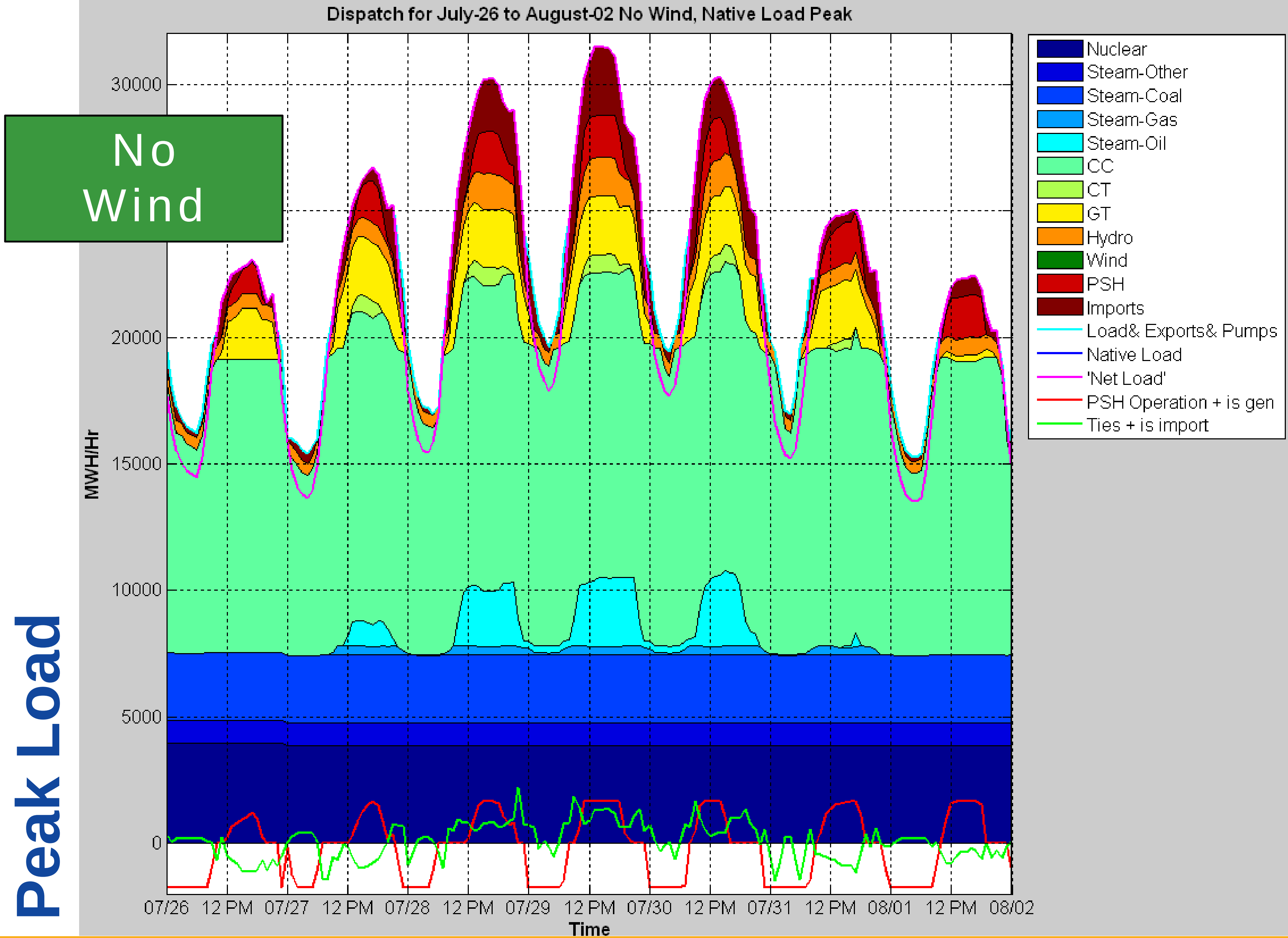
20% Energy Scenario: Capacity Values



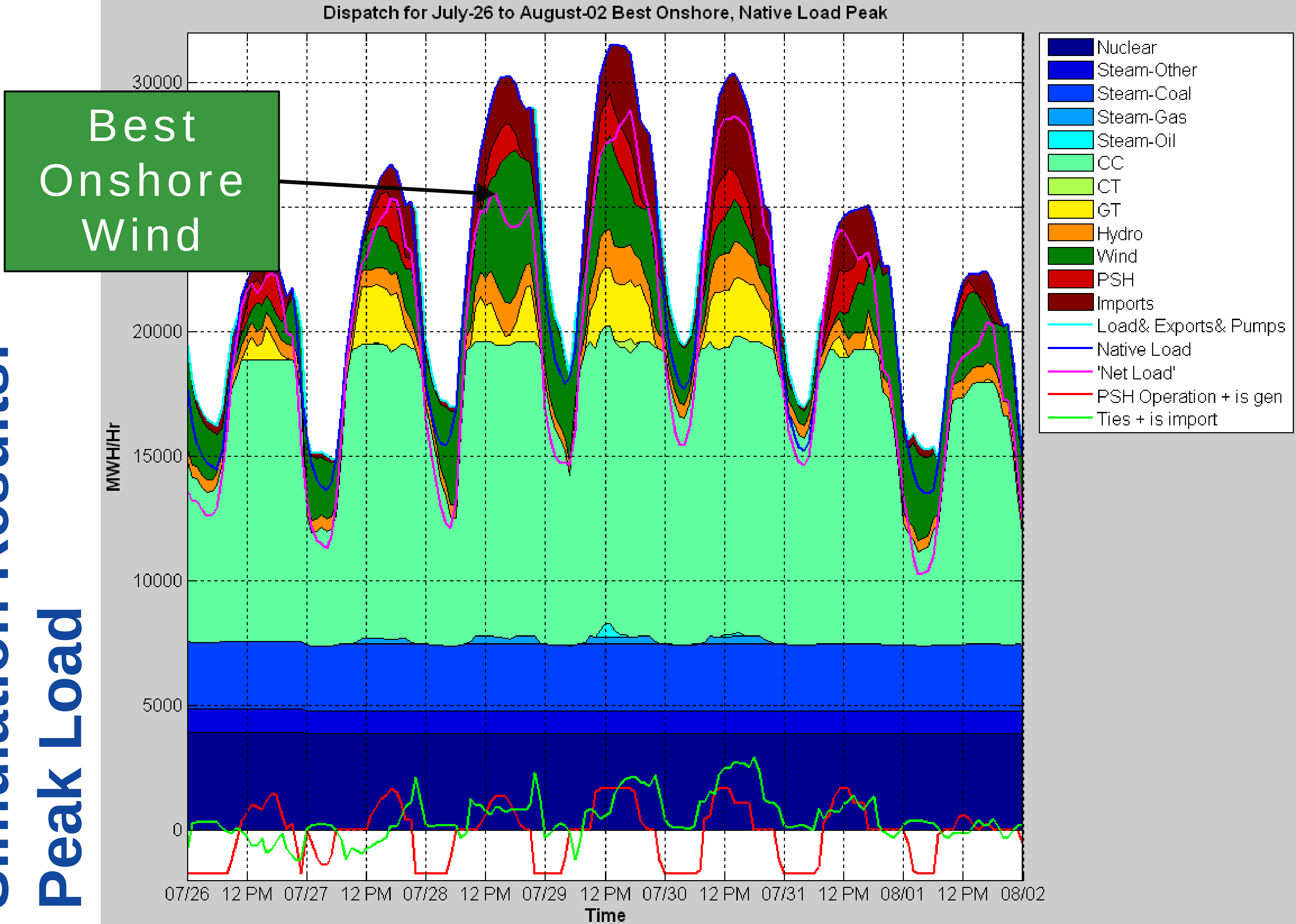
Next Four Slides: Operational Simulation

- 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

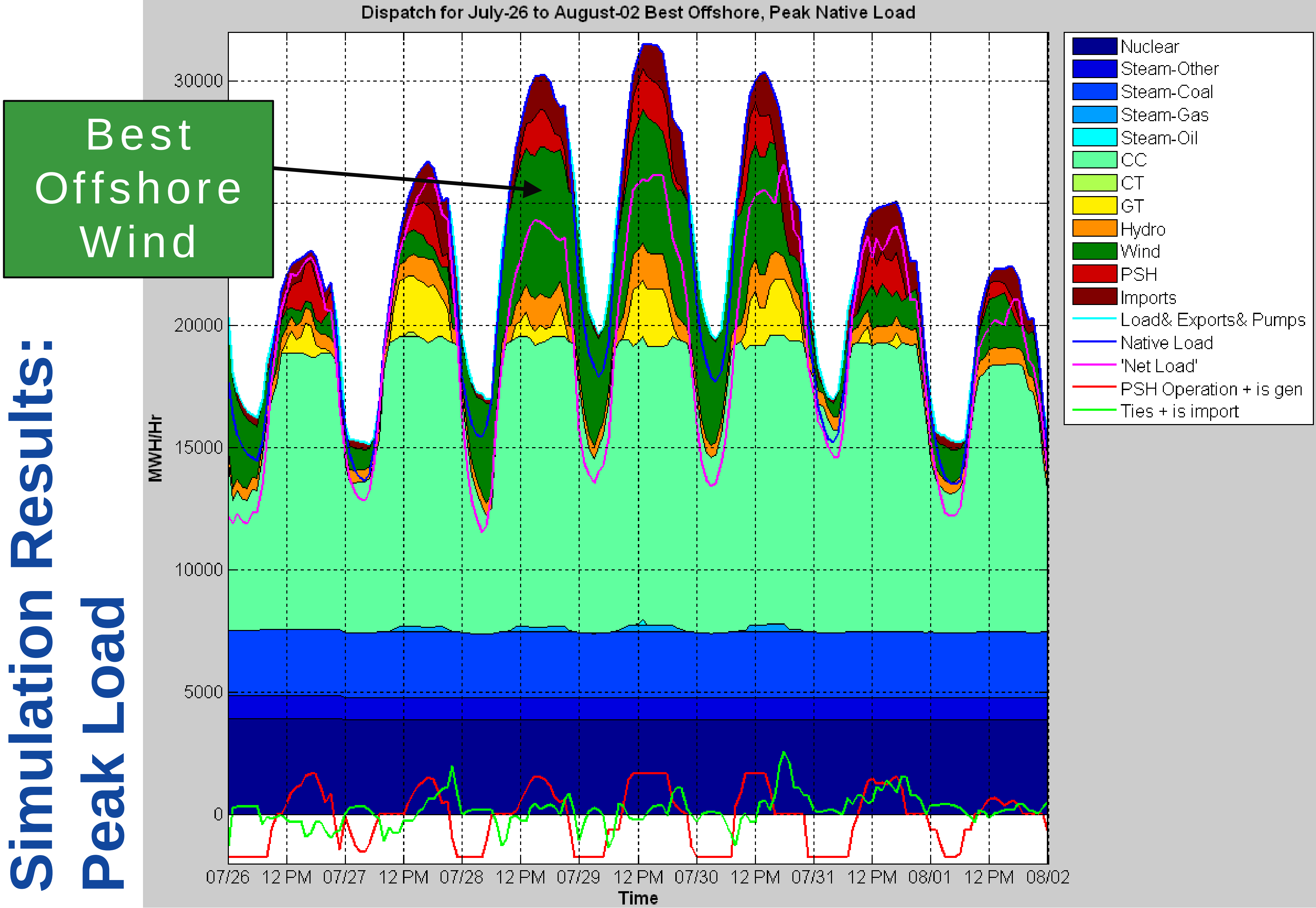
Simulation Results: Peak Load



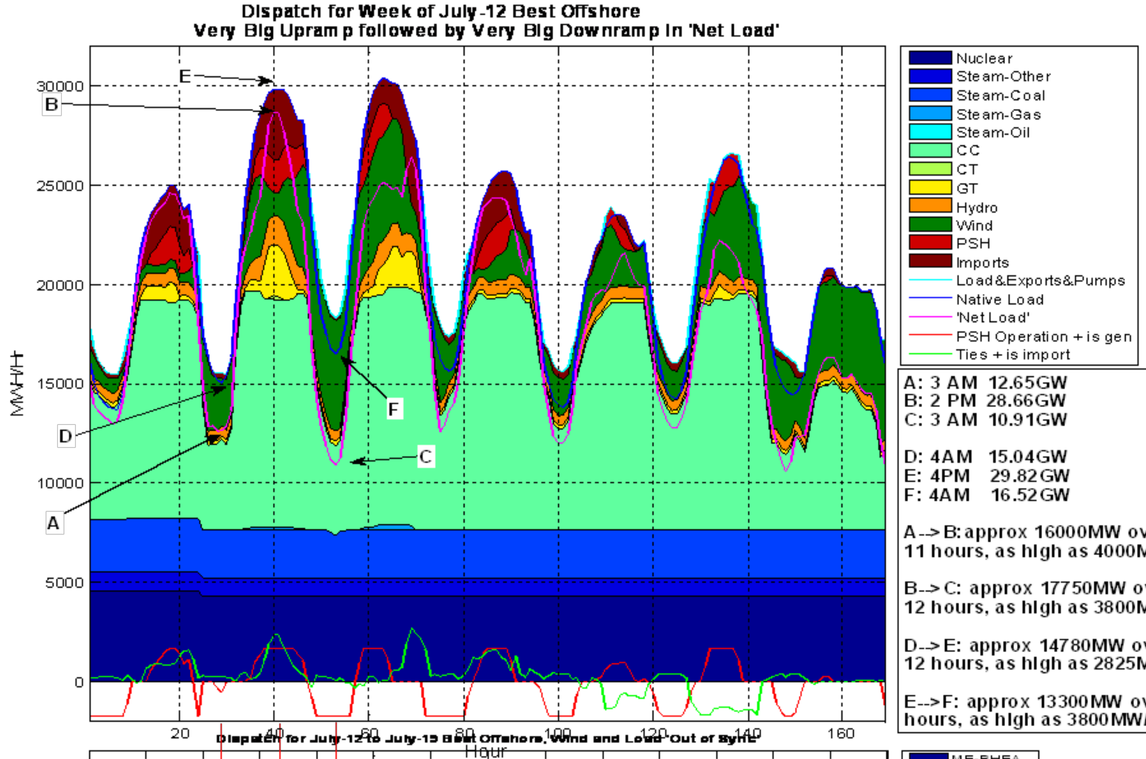
Simulation Results: Peak Load



Simulation Results: Peak Load



Simulation Results: An Interesting Week!



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

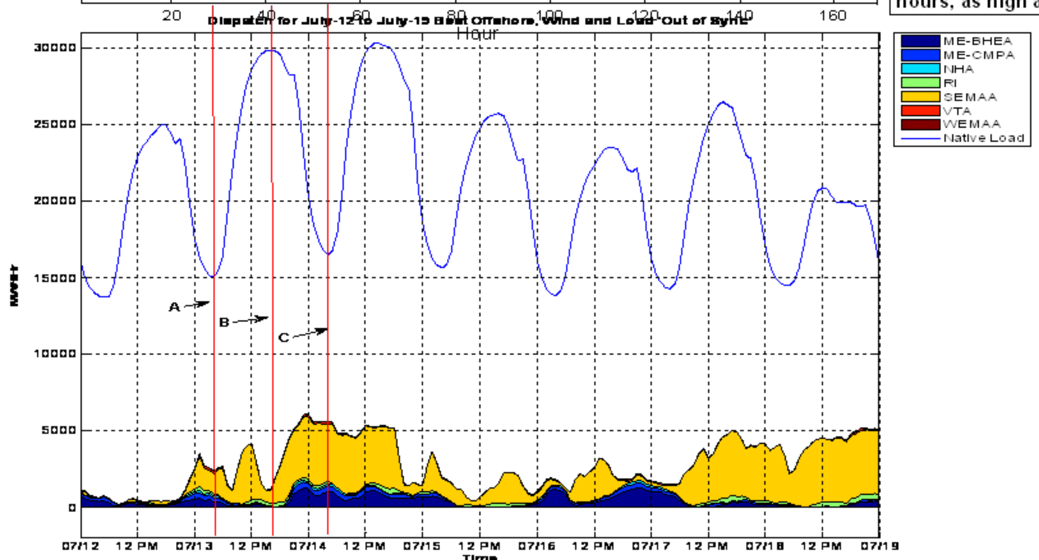
D: 4AM 15.04GW
E: 4PM 29.82GW
F: 4AM 16.52GW

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

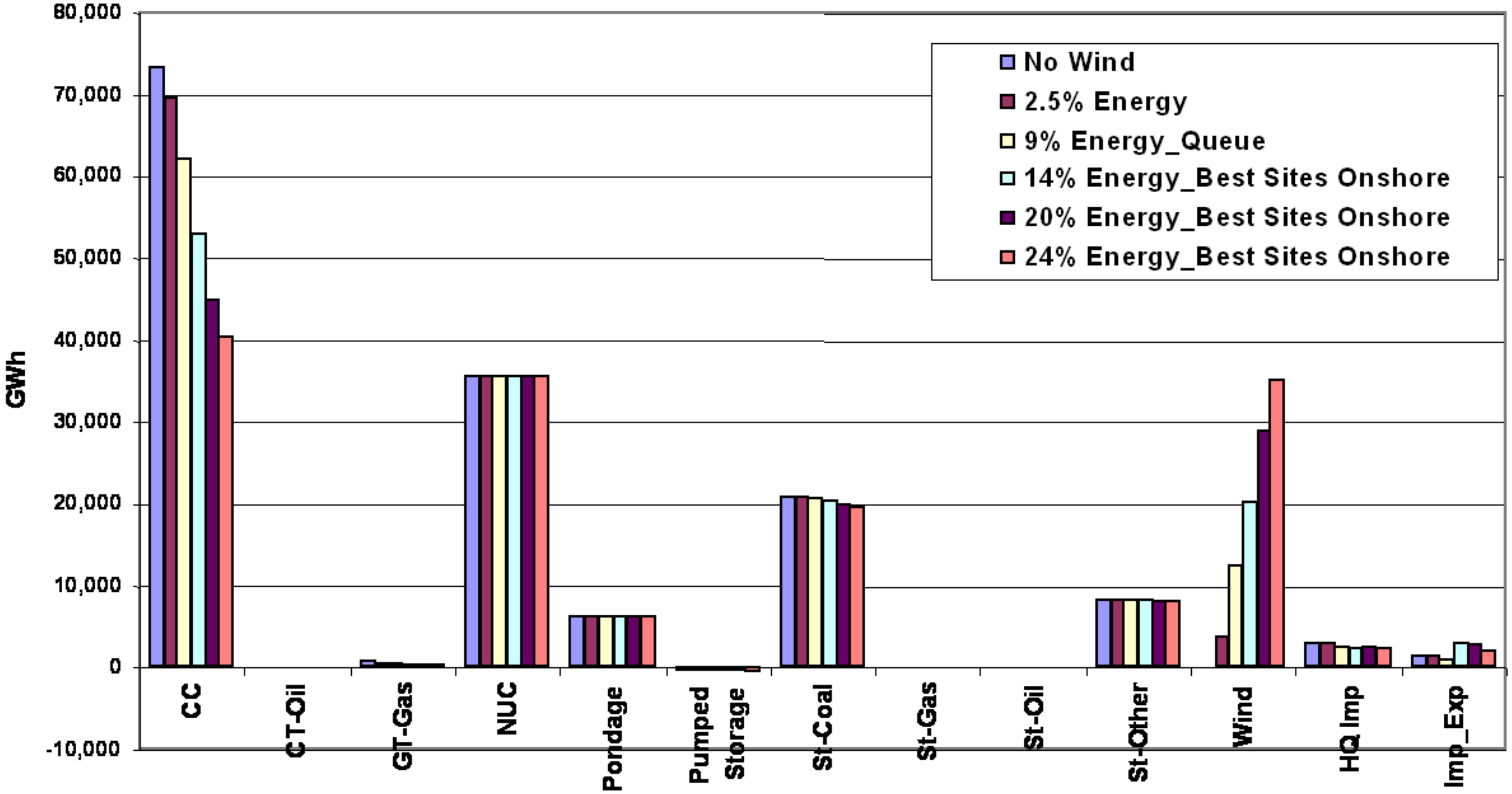
B-> C: approx 17750MW over 12 hours, as high as 3800MW/Hr

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

E->F: approx 13300MW over 12 hours, as high as 3800MW/Hr

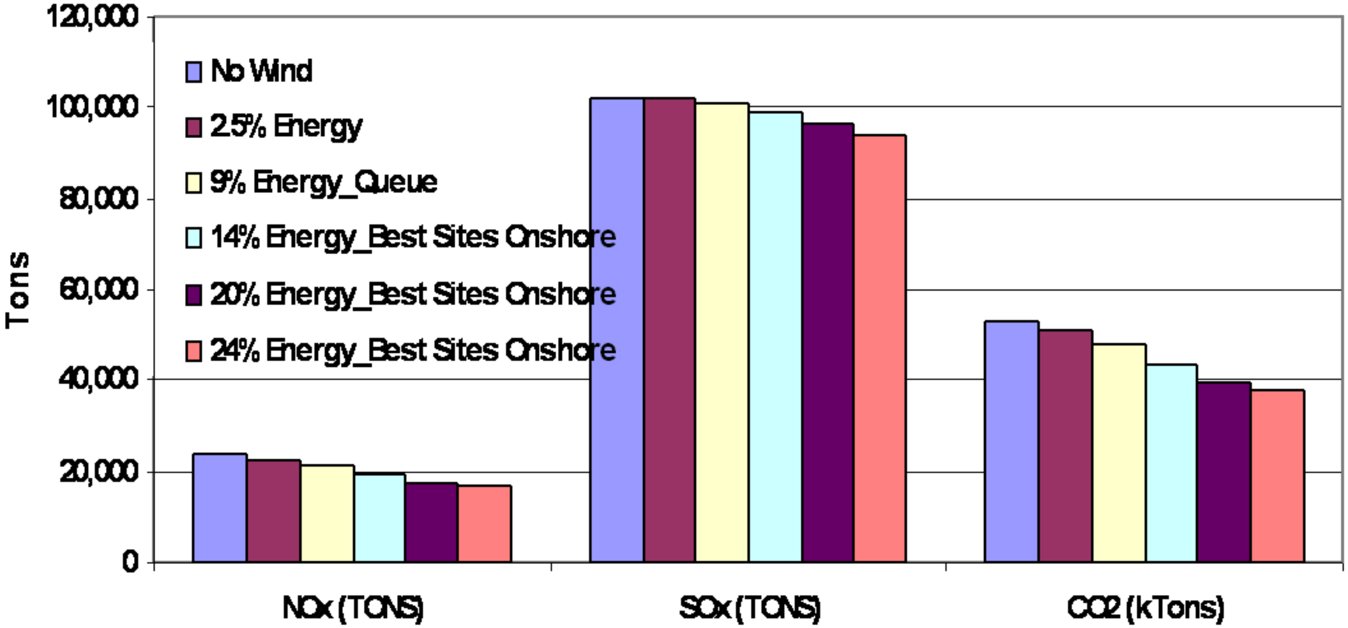


Annual Energy By Fuel Type



Wind displaces mostly natural gas, and oil, and some coal too.

Annual Emissions for ISO-NE



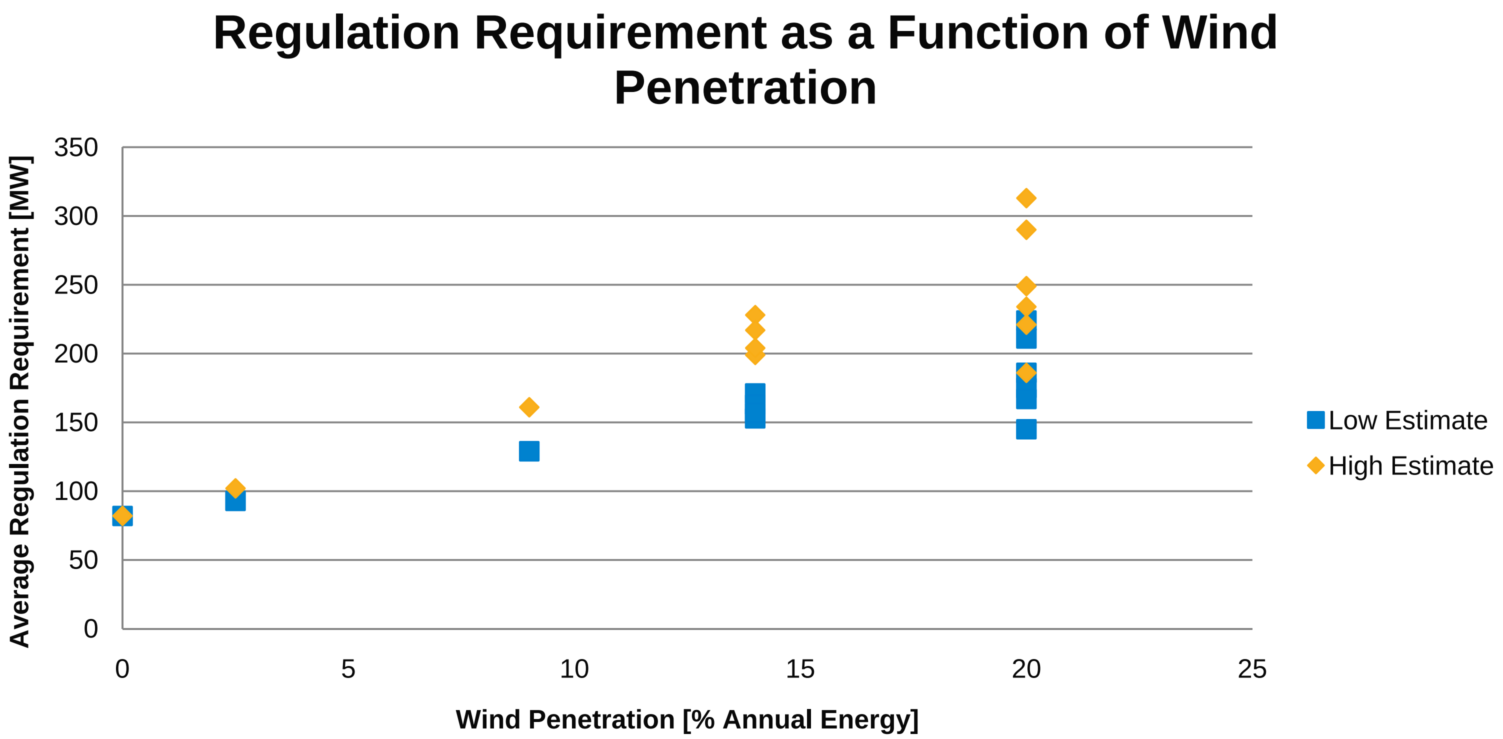
Wind Penetration (Energy)	CO2 Reduction
2.5%	2.5%
9%	9%
14%	17%
20%	25%
24%	30%

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)

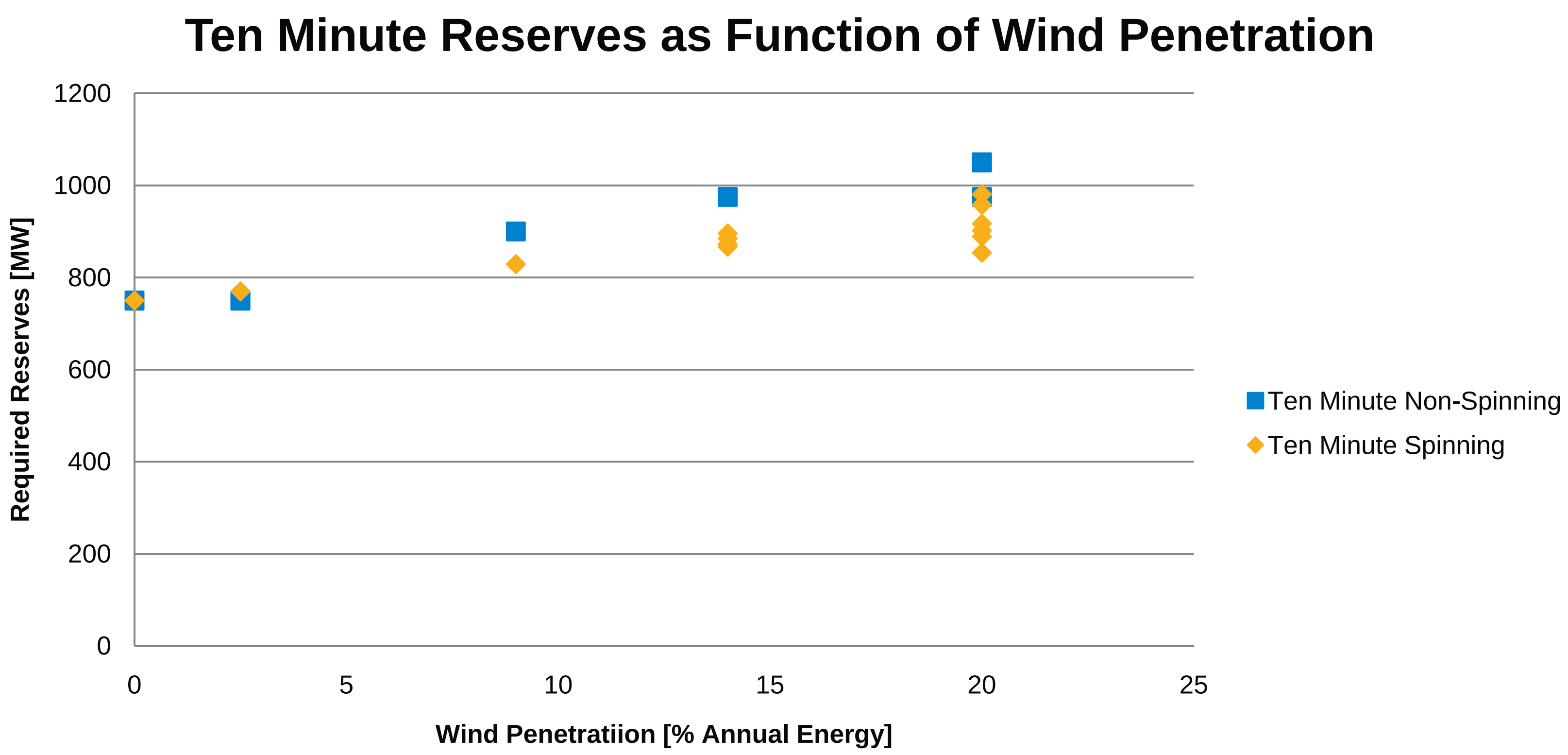


Required regulation capacity increases with wind penetration

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

NEWIS Reserves Analysis (Preliminary)



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

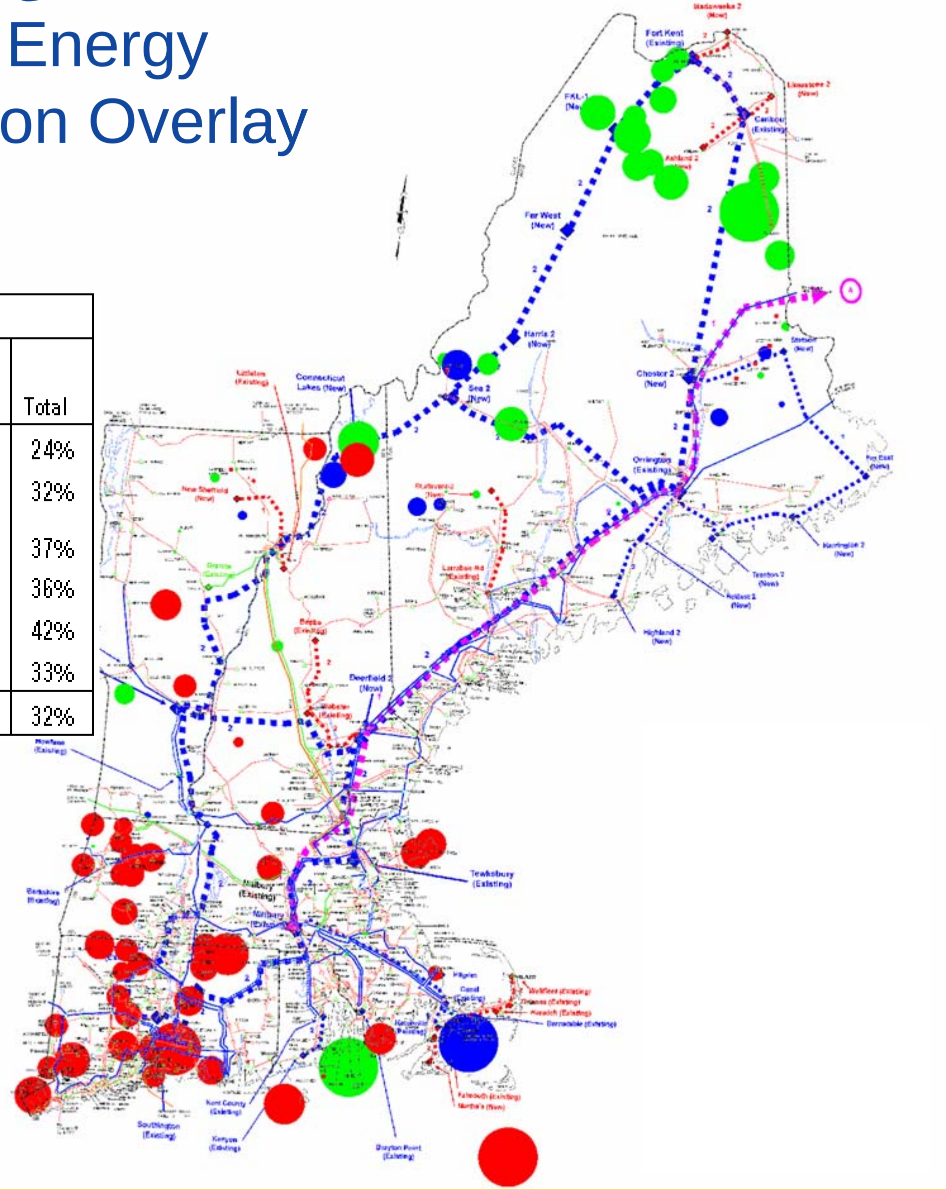
Questions?

Bonus Material

Best By State + Full Queue

Total: 10.24 GW 20% Annual Energy
Governors' 4 GW Transmission Overlay

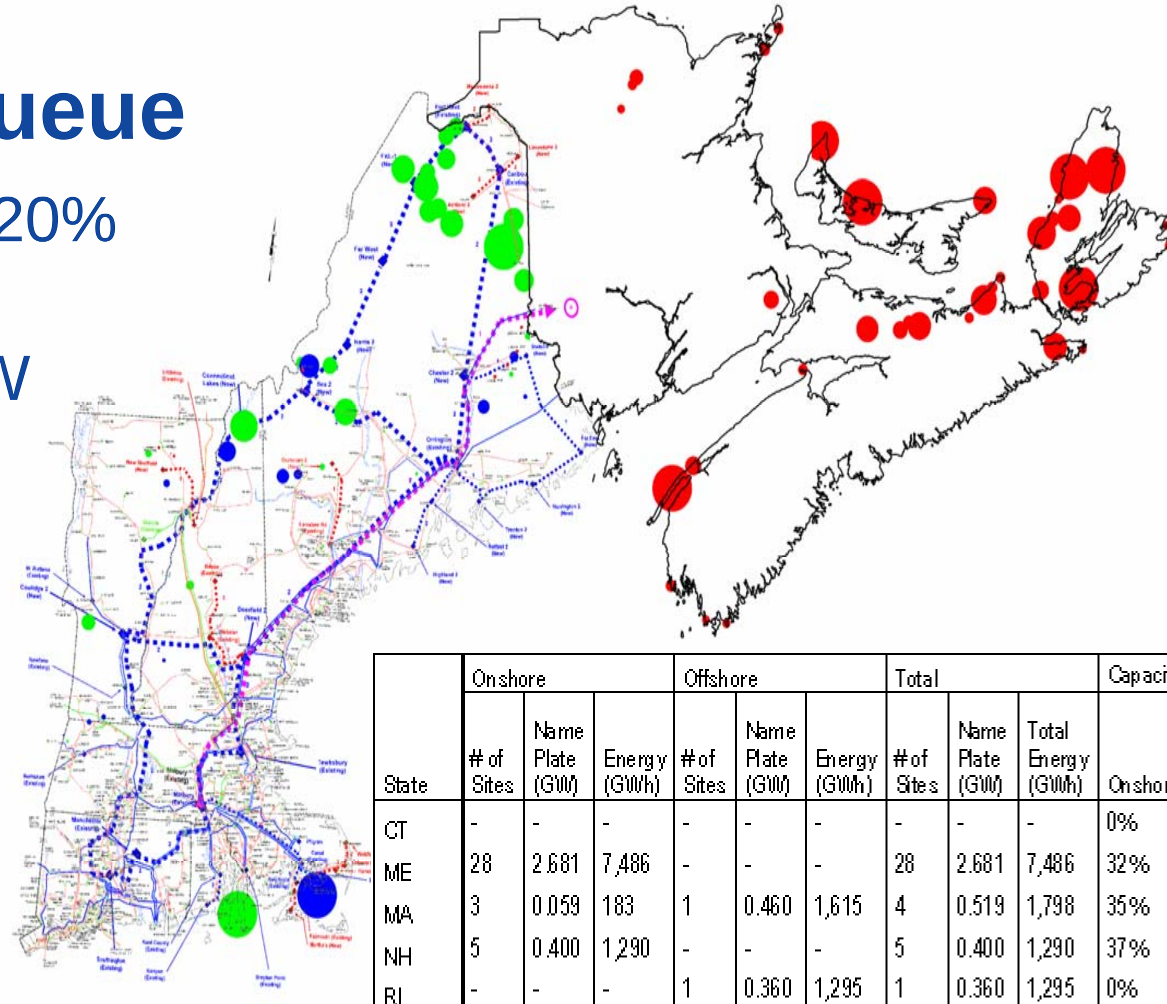
ST.	Onshore			Offshore			Total			Capacity Factor (%)		
	# of Sites	Name Plate (GW)	Energy (GWh)	# of Sites	Name Plate (GW)	Energy (GWh)	# of Sites	Name Plate (GW)	Total Energy (GWh)	Onshore	Offshore	Total
CT	20	2.642	5,604	-	-	-	20	2.642	5,604	24%	0%	24%
ME	28	2.681	7,486	-	-	-	28	2.681	7,486	32%	0%	32%
MA	22	1.619	4,353	2	1.498	5,800	24	3.117	10,153	31%	44%	37%
NH	8	0.691	2,208	-	-	-	8	0.691	2,208	36%	0%	36%
RI	-	-	-	3	0.555	2,019	3	0.555	2,019	0%	42%	42%
VT	9	0.549	1,591	-	-	-	9	0.549	1,591	33%	0%	33%
Tot.	87	8.182	21,241	5	2.053	7,818	92	10.235	29,060	30%	43%	32%



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

Maritimes Plus Full Queue

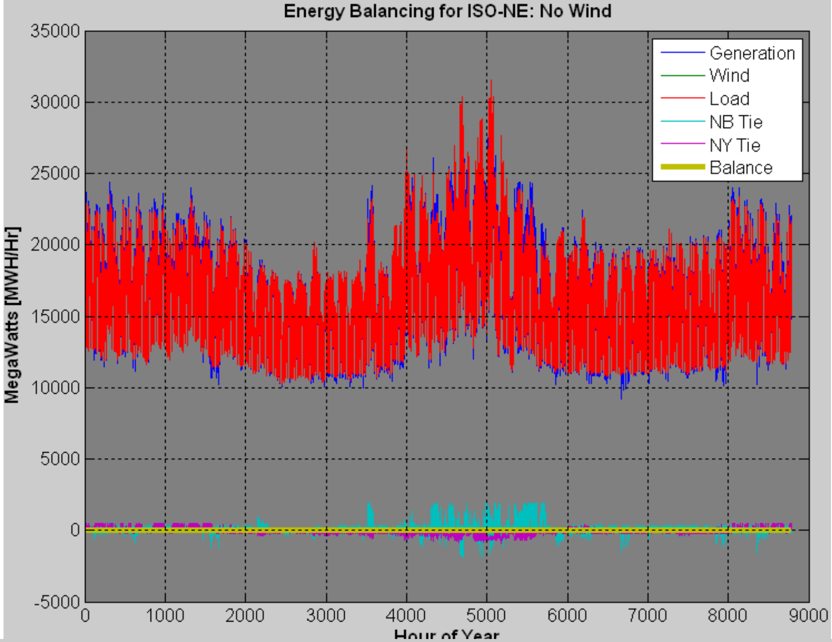
Total: 8.96 GW 20% Annual Energy Governors' 4 GW Transmission Overlay

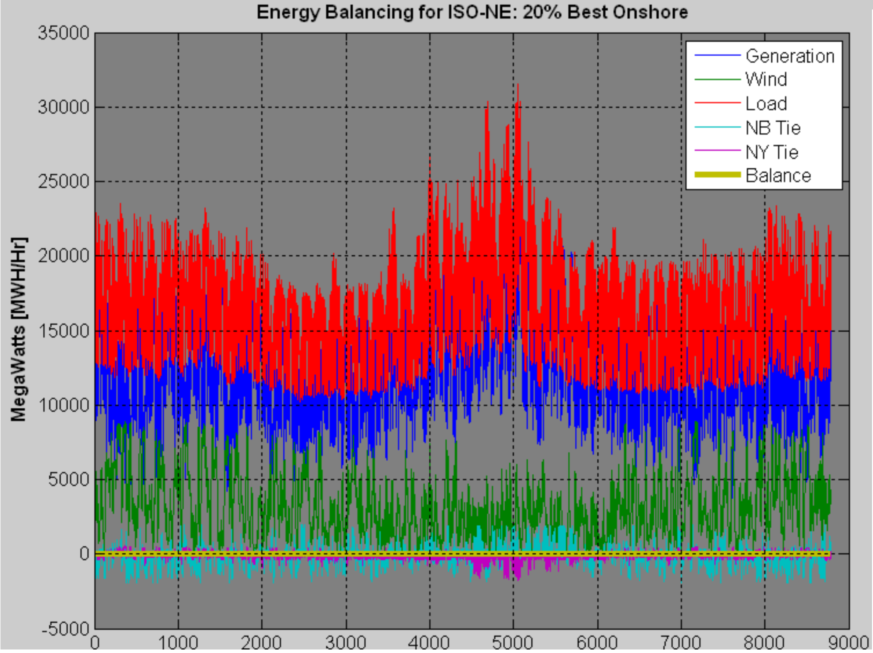


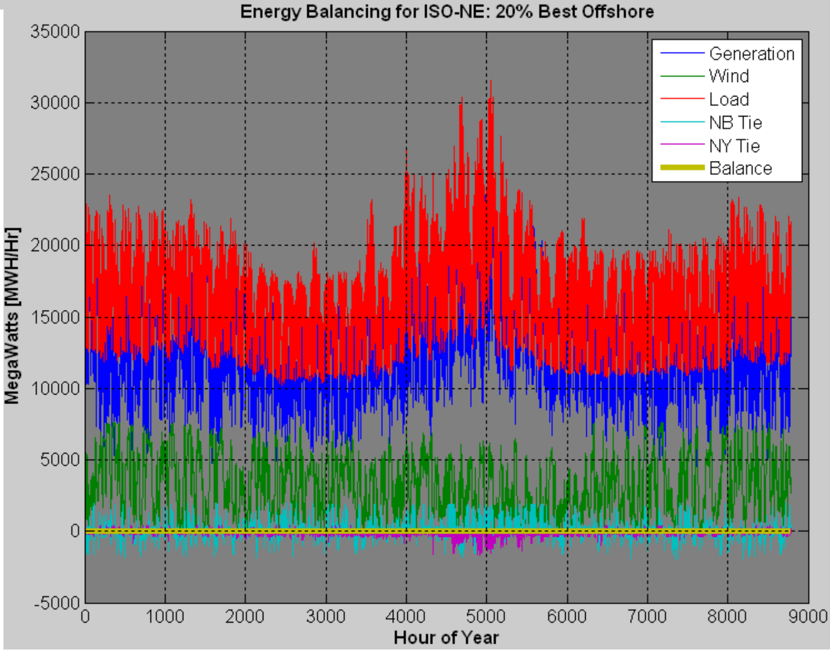
- Partial Queue
- Additonal Queue
- Additional to 20% Energy

State	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	1	0.460	1,615	4	0.519	1,798	35%	40%	40%
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%
NB, NS, PEI	35	4.787	16,607	-	-	-	35	4.787	16,607	40%	0%	40%
Total	76	8.136	26,150	2	0.820	2,910	78	8.956	29,060	37%	41%	37%

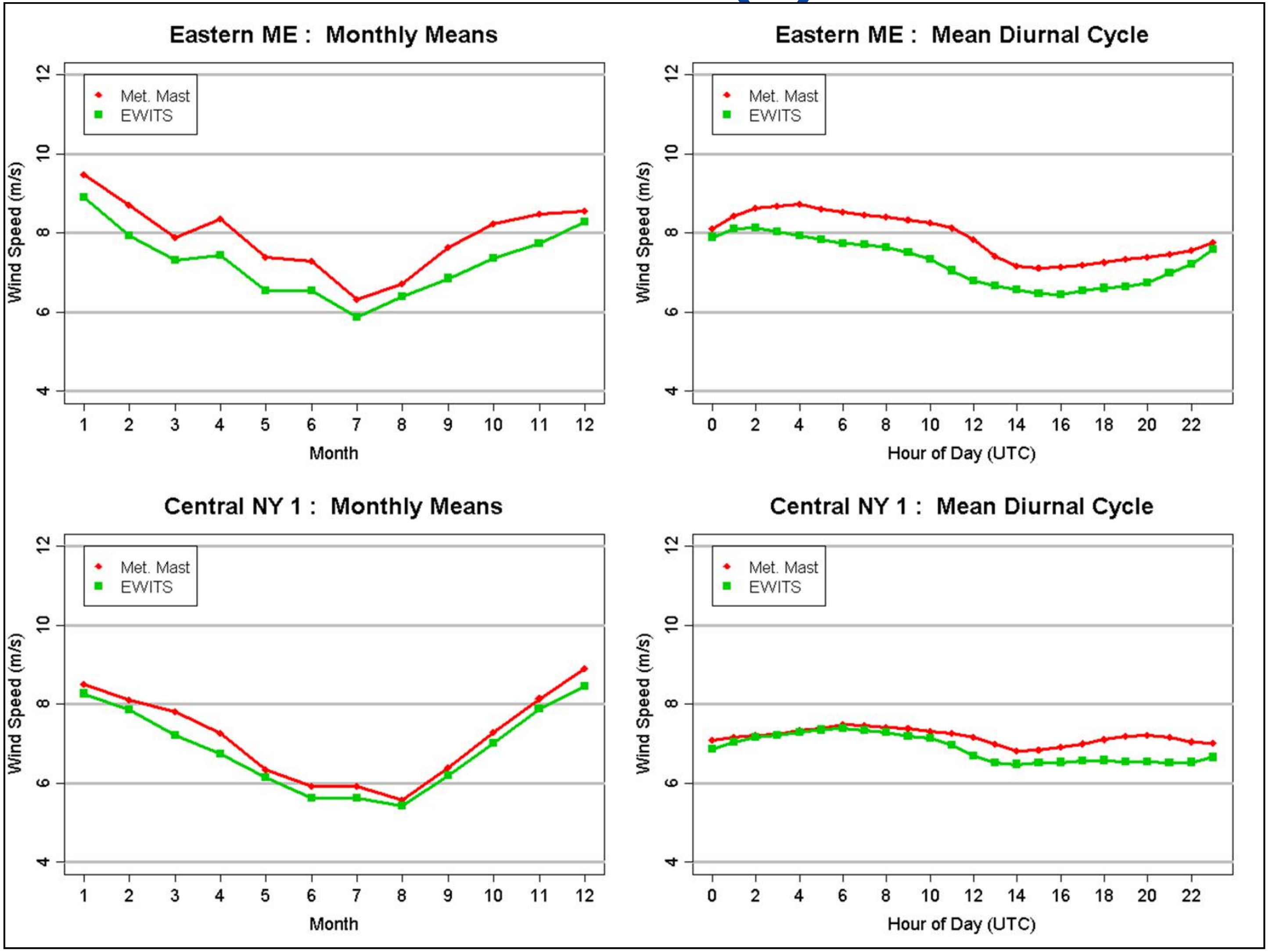
Energy Balance For ISO-NE



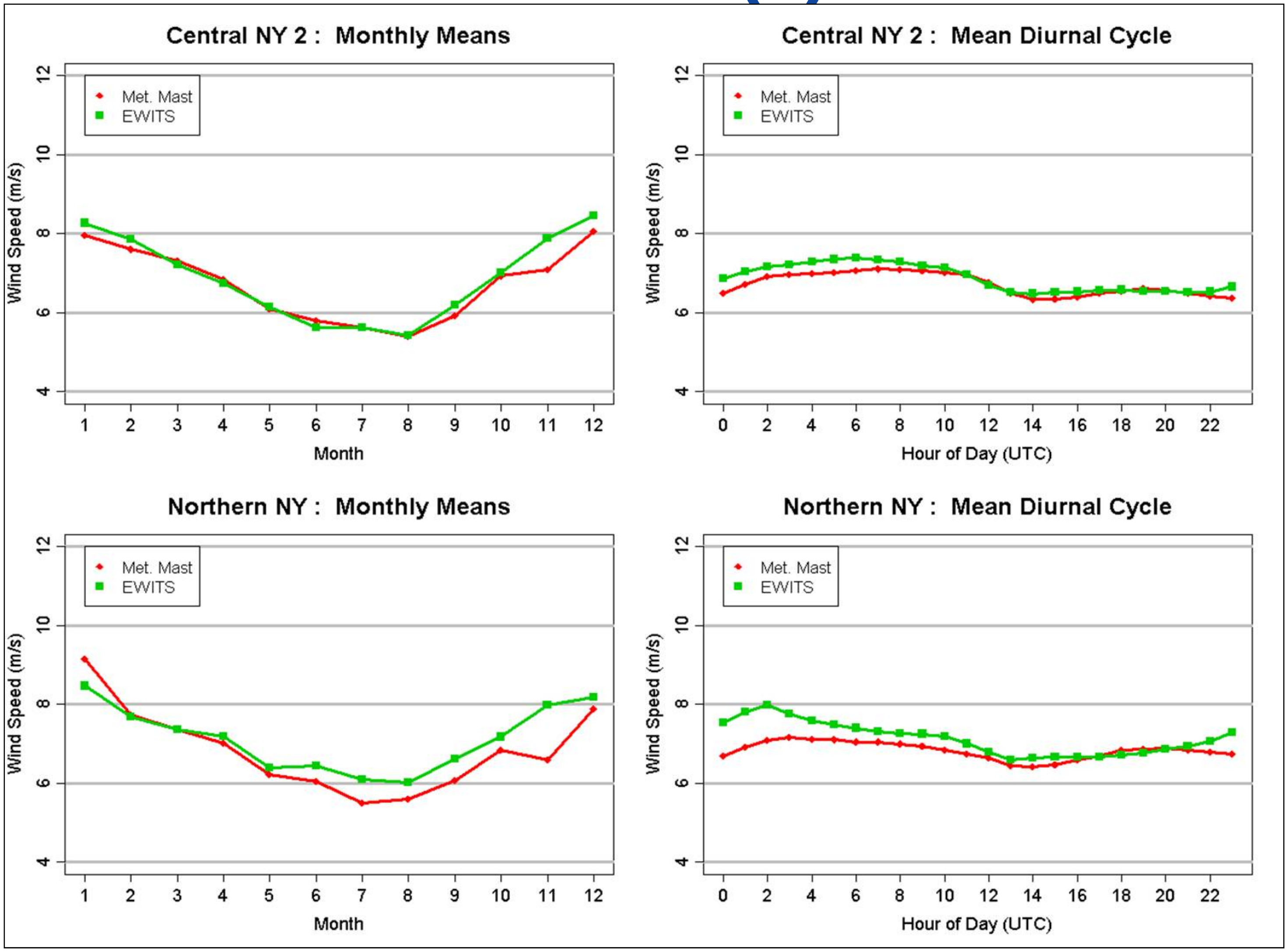




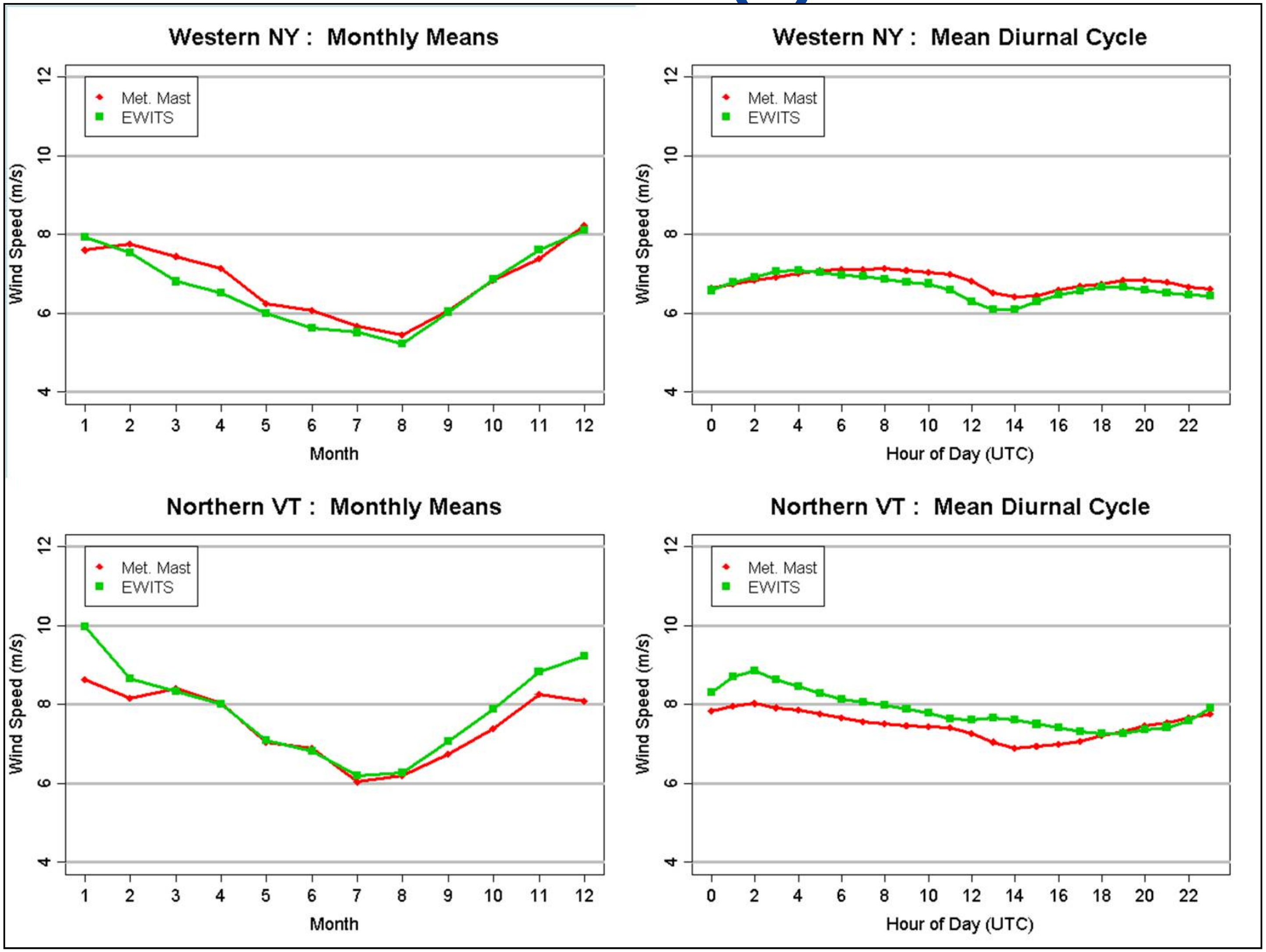
Wind Model Validation (1)



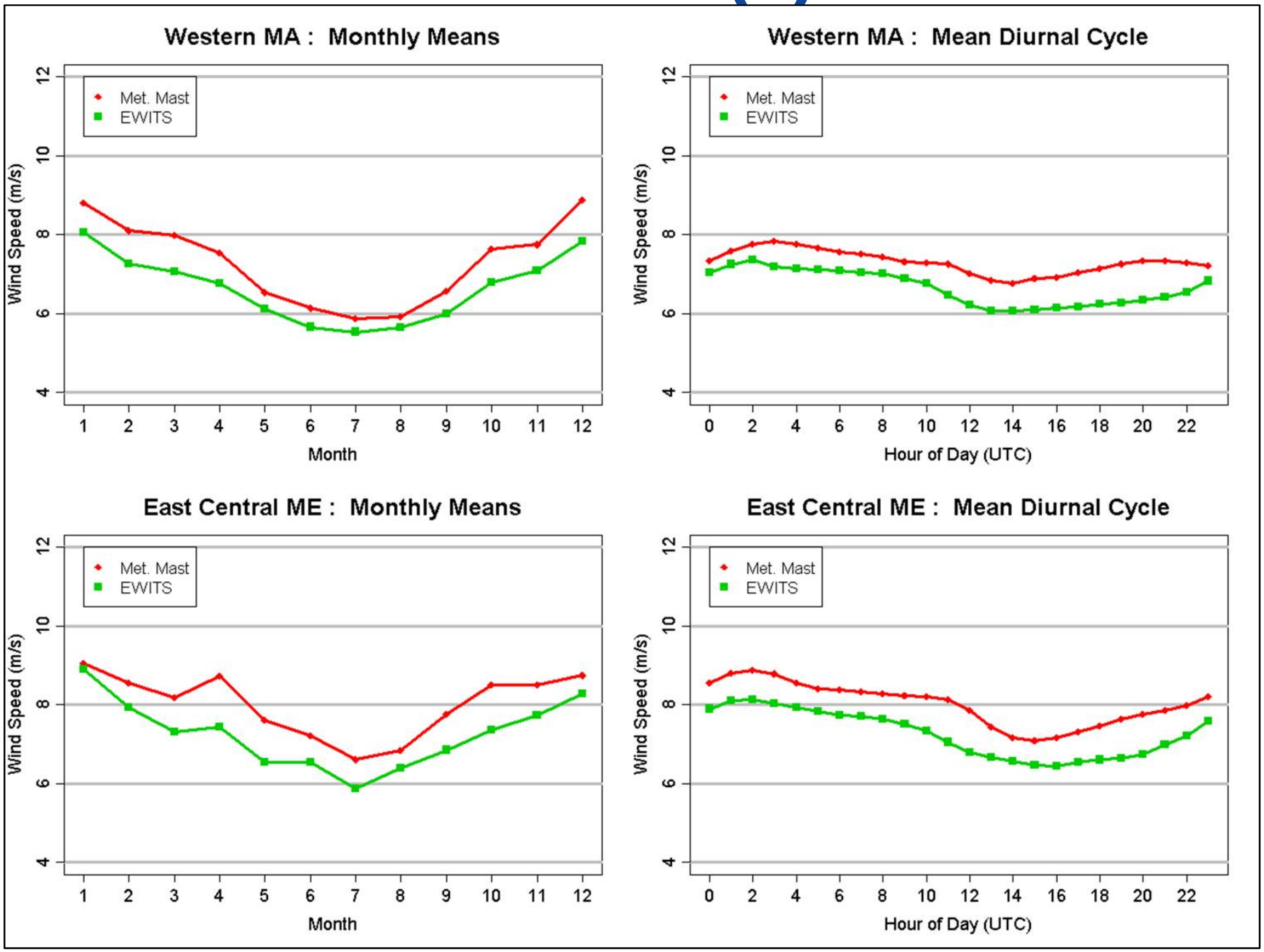
Wind Model Validation (2)



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

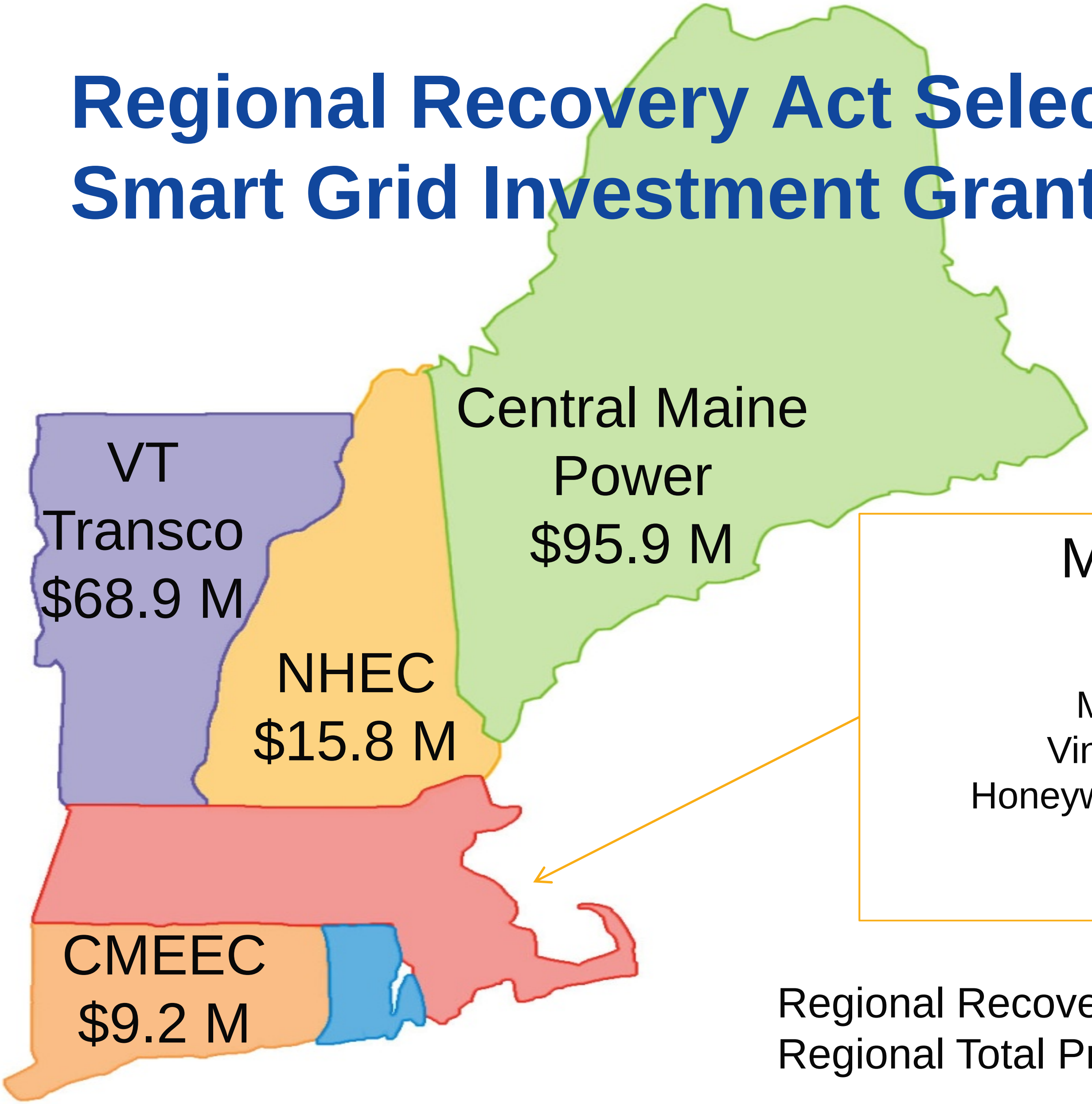
- ***Energy Independence and Security Act of 2007 (EISA)*, Section XIII**
  - Founding document for smart grid implementation

- ***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



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 $40M

Regional Recovery Grant Funding: $230 M
Regional Total Project Costs: $470 M

Smart Grid Progress at ISO New England

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

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