Wind Integration In New England

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ISO New England

- Private not-for-profit; created in 1997 located in western MA
- Regulated by FERC
- Independent System Operator
- Major responsibilities:
  - Reliable system operations
  - Administer competitive wholesale electricity markets
  - Comprehensive system planning

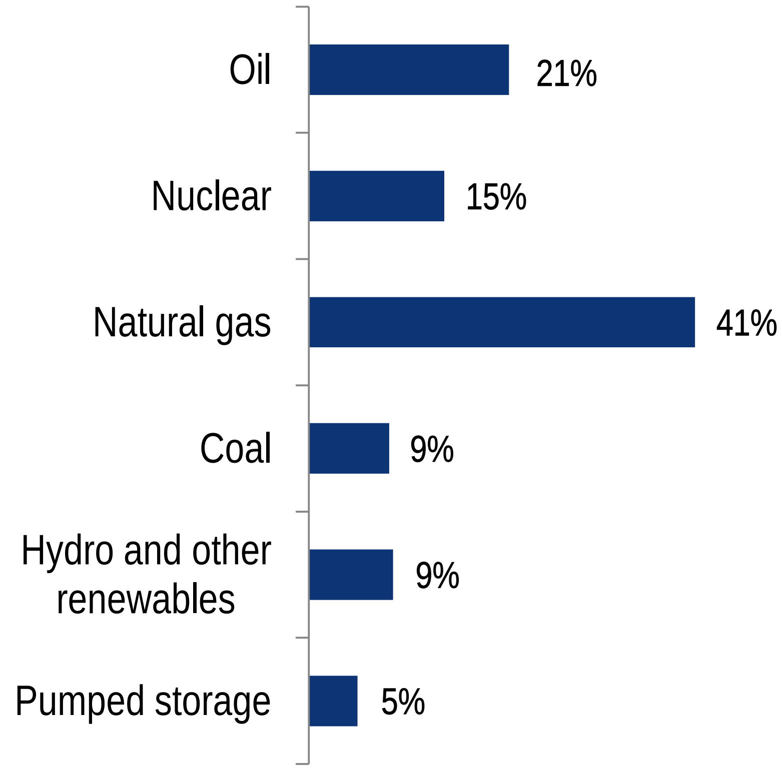
Regional System

- Population 14 million
- 6.5 million residents/businesses
- > 350 generators
- > 5,000 demand assets
- 32,000 MW of total supply
- > 2,750 MW of demand resources
- System peak:
  - Summer: 28,130 MW (Aug. ‘06)
  - Winter: 22,818 MW (Jan. ‘04)
- > 8,000 miles high-voltage transmission
- 13 interconnections
  - New York, New Brunswick, Quebec

Background

- New England's power system likely to undergo changes in the coming years to integrate renewables, demand response, smart grid and other new technologies
  - Currently
    - About 525 MW of wind on transmission system
    - Estimate 125 MW of solar PV embedded in distribution system
- Good planning helps overcome integration challenges

Regional Generation Capacity 2010



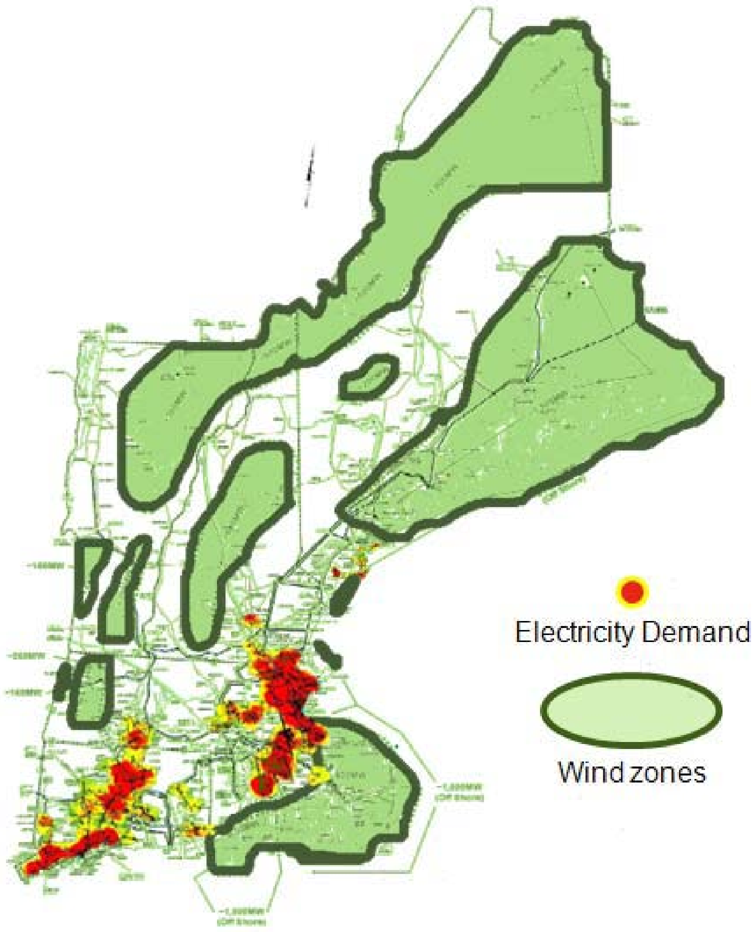
New England's Wind Potential

- New England has abundant wind energy potential
  - Predominant wind in region is in northern areas and off-shore
  - Up to 200,000 MW theoretically possible
- Wind could be well positioned for large-scale growth in region
  - 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

Connecting Wind Energy to Load Centers

- Population and electric demand concentrated along coast and in southern New England

- Large-scale wind development will require significant transmission upgrades



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

- ISO needed a New England-focused wind integration analysis

- New England Wind Integration Study
  - Performed over two years (2008-2010)
  - 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

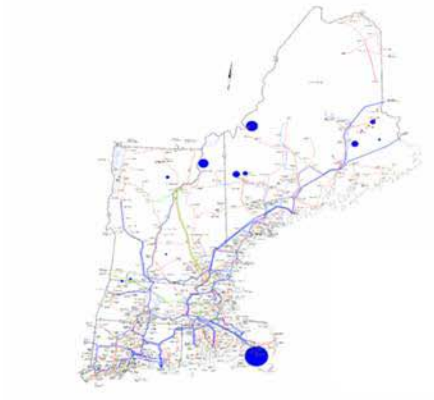
- **Develop interconnection requirements (Task 2 Report)**
  - Grid support functions
  - "Best practices" capacity value determination for wind power
    - Both for the entire region and for incremental wind power
  - Data/telemetry requirements
  - Wind forecasting

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

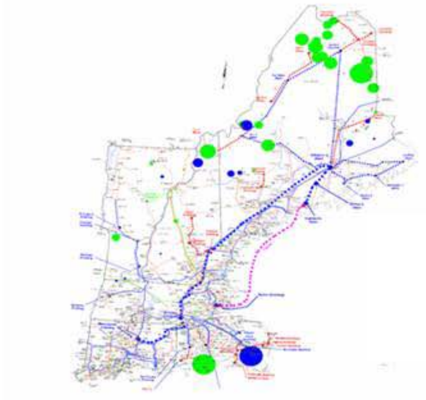
- **Several levels of review**
  - Stakeholder feedback
  - Internal ISO-NE review
  - Independent Technical Review Committee (TRC) of recognized experts

New England Wind Integration Study (NEWIS)

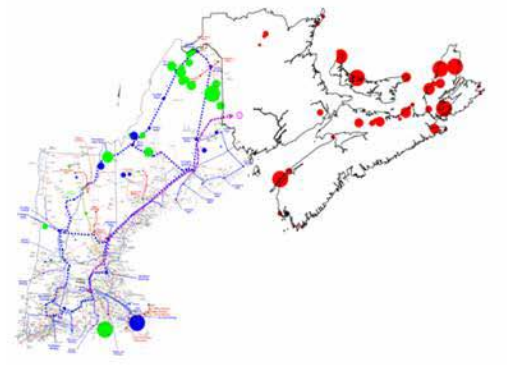
- Studied varying amounts of wind & different siting scenarios
  - Up to 12 GW of wind (24% of annual energy demand)



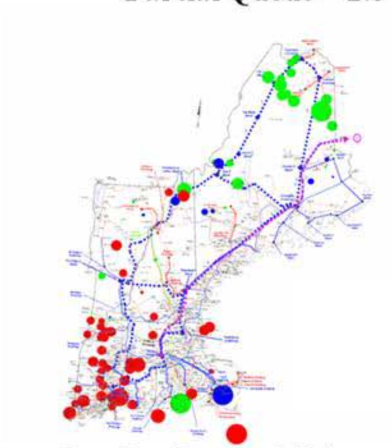
Partial Queue – 2.5%



Full Queue – 9%

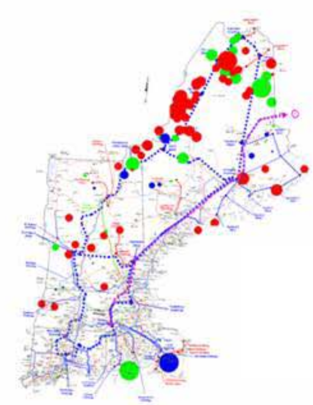


Maritimes – 20%

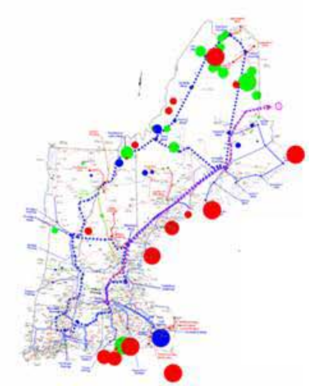


Best By State – 20%

Best Offshore – 20%



Best Onshore – 20%



Balance Case – 20%

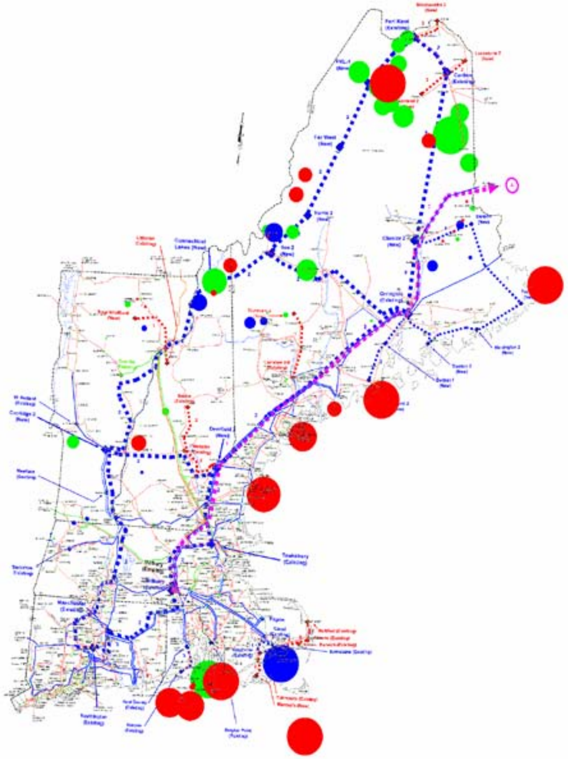
Major Findings of NEWIS

- Large-scale wind integration in New England
  - Maximum studied: 24% is achievable under certain conditions
- When available to provide energy, wind resources could reduce fossil-fueled generation as an energy resource
  - Primarily reduce natural-gas-fired generation
  - Almost fully reduce use of oil-fired generation
- Large-scale wind integration will require:
  - Significant transmission upgrades
  - Continued availability of supply- and demand-side resources plus new resources
  - Increases in regulation and operating reserves
  - Technical interconnection requirements for wind generation
    - See link to Task 2 report in Appendix

Major Findings of NEWIS (continued)

- Large-scale wind integration can result in emission reductions
  - Potential Results 20% Wind Penetration

Pollutant	Approximate annual reduction	Approximate reduction vs. no wind
NO_x	6,000 tons	26%
SO_x	4,000 tons	6%
CO_2	12,000,000 tons	25%



20%
Balance Scenario

Major Findings of NEWIS (continued)

- The region needs to maintain a system with flexible resources to manage variability
  - Natural gas fleet provides flexibility
  - Wind is at its lowest levels in the summer, when demand is peaking
  - Market design may need to evolve to maintain 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
  - Capacity factors and values are higher for off-shore than on-shore wind sites

Major Findings of NEWIS (continued)

- Centralized wind power forecasting 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

Centralized Wind Power Forecasting

- Operators accustomed to uncertainty in load
- Weather-driven generation imposes another layer of uncertainty

	MAE – Day Ahead	MAE – Hour Ahead
Load Forecast	1% to 3%	0.5%
Wind power forecast	10% to 20%	~2%

- Actually need a "net load" forecast
- Accurate wind power forecast is critical to integrating wind
  - Uncertainty needs to be managed
    - "Unexpected events" → reserves
    - Short-term forecast error is main driver of increased regulation req'mts
  - System-wide benefits across all timeframes
    - Fuel cost savings due to more efficient unit commitment
    - Reduction in additional regulation/reserves requirements due to wind

Centralized Wind Power Forecasting, *cont'd*

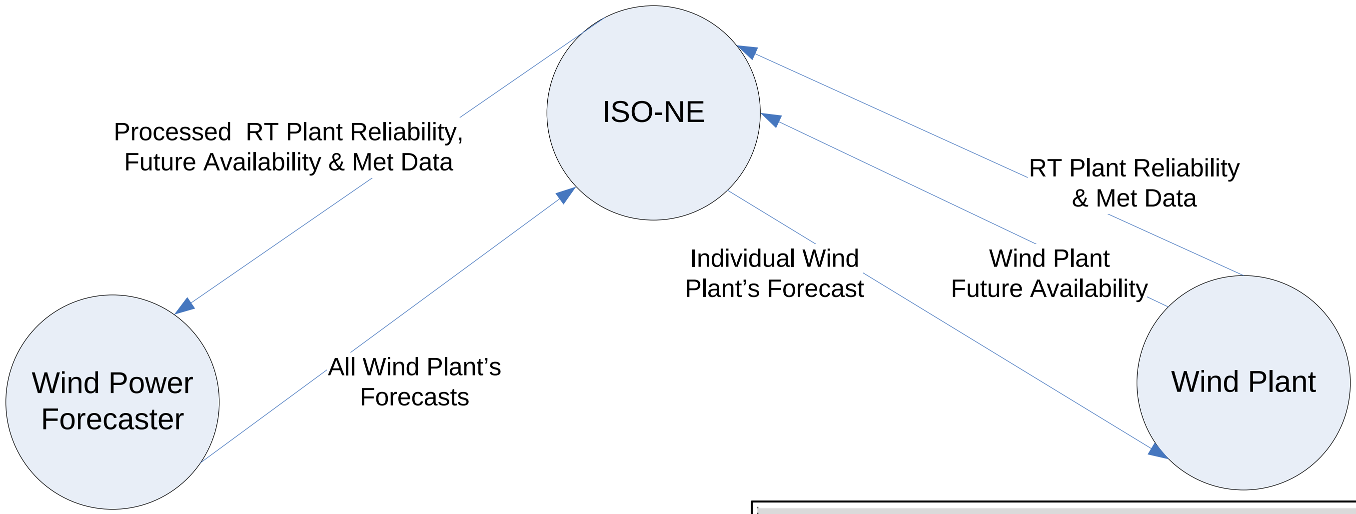
- RFP issued in July 2011
  - Selected vendor late-2011 → GL Garrad Hassan
- GL GH forecasting:
  - Very high resolution mesoscale modeling
  - Model and provide separate forecast for each wind plant
  - How much wind power and when? (deterministic)
  - Wind events – alert, characterization, and probability
  - Provide narrative summarizing expected weather conditions (situational awareness)
- Currently setting up and training model, developing real-time visualization tools for operators

Suite of Forecast Products

Forecast	Deadline	Frequency	Interval	Forecast Period	Used By
Short Term	5-minute clock intervals	5 minutes	5 minutes	T+5 minutes to 4 hours	• RAA Process (SCRA) • RT Dispatch • Operator Displays
Medium Term	Daily beginning at 00:00 EPT	3 hours	1 hour (clock hour)	T+4 hours to 48 hours	• RAA Process (SCRA) • Morning Report • Web Publishing
Long Term	9:00 EPT	Daily	1 hour (clock hour)	T+48 hours to 168 hours	• STOC • 7-Day Forecast • Web Publishing
Ramp Event (Plant)	5-minute clock intervals	5 minutes	5 minutes	T+5 minutes to 4 hours	• RAA Process • RT Dispatch • Operator Displays
Ramp Event (System)	Daily beginning at 00:00 EPT	3 hours	1 hour (clock hour)	T+4 hours to 48 hours	• RAA Process • RT Dispatch • Operator Displays
Distributed Generation	Daily beginning at 00:00 EPT	3 hours	1 hour (clock hour)	T+4 hours to 48 hours	• Load Forecasting (future)

Need Data For Effective Forecast & Operations

Conceptual Flow of Data Communications



Communications with Wind Plant

Wind Plant Parameter	Frequency
RTHOL and WHL	5-minutes
Plant reactive leading and lagging capability	4-seconds
Wind Turbine Status Counts which tell how many wind turbines are operating normally, out of service, etc.	5-minutes
Meteorological data such as wind speed, wind direction and temperatures	30-seconds
Wind Plant Future Availability for next 48 hours	Hourly
Wind Plant Future Availability for next 7 days	Daily

Additional Wind Integration Activities

- 2010/2011 Economic Study
  - Examining impact of relieving transmission constraints between wind project development areas and bulk power system in New England
- Strategic transmission analysis
  - Refine smallest transmission build out plan used in NEWIS to reliably integrate 4 GW of wind
- Market Development
  - Negative incremental energy offers
    - Energy offers currently limited by a floor price of $0/MWh
  - Intermittent resources on economic dispatch
    - System operators must manually curtail intermittent resources

Questions

Appendix

Additional Slides

References and Resources

NEWIS Task 2 Report, including review of recommended technical requirements for wind interconnection and the status of the NEWIS project
http://www.iso-ne.com/committees/comm_wkgrps/prtcpnts_comm/pac/mtrls/2009/nov182009/newis_slides.pdf

The NEWIS final report
http://www.iso-ne.com/committees/comm_wkgrps/prtcpnts_comm/pac/reports/2010/newis_report.pdf

New England 2030 Power System Study: Report to the New England Governors
http://www.iso-ne.com/committees/comm_wkgrps/prtcpnts_comm/pac/reports/2010/economicstudyreportfinal_022610.pdf

Recent Developments in the Levelized Cost of Energy from U.S. Wind Power Projects, LBNL/NREL, February 2012: http://eetd.lbl.gov/ea/ems/reports/wind-energy-costs-2-2012.pdf

US DOE/Alstom Grid, Inc., Strategies and Decision Support Systems for Integrating Variable Energy Resources in Control Room Centers for Reliable Grid Operations, Global Best Practices, Examples of Excellence and Lessons Learned: http://energy.gov/articles/new-report-integrating-variable-wind-energy-grid

New England Wind Integration Study (NEWIS) Wind Scenarios and Transmission Overlays
http://www.iso-ne.com/committees/comm_wkgrps/prtcpnts_comm/pac/mtrls/2010/jan212010/newis.pdf

References and Resources, *cont'd*

Operating Procedure 14, Appendix F - Wind Plant Operator Guide
http://www.iso-ne.com/rules_proceds/operating/isone/op14/op14f_rto_final.pdf

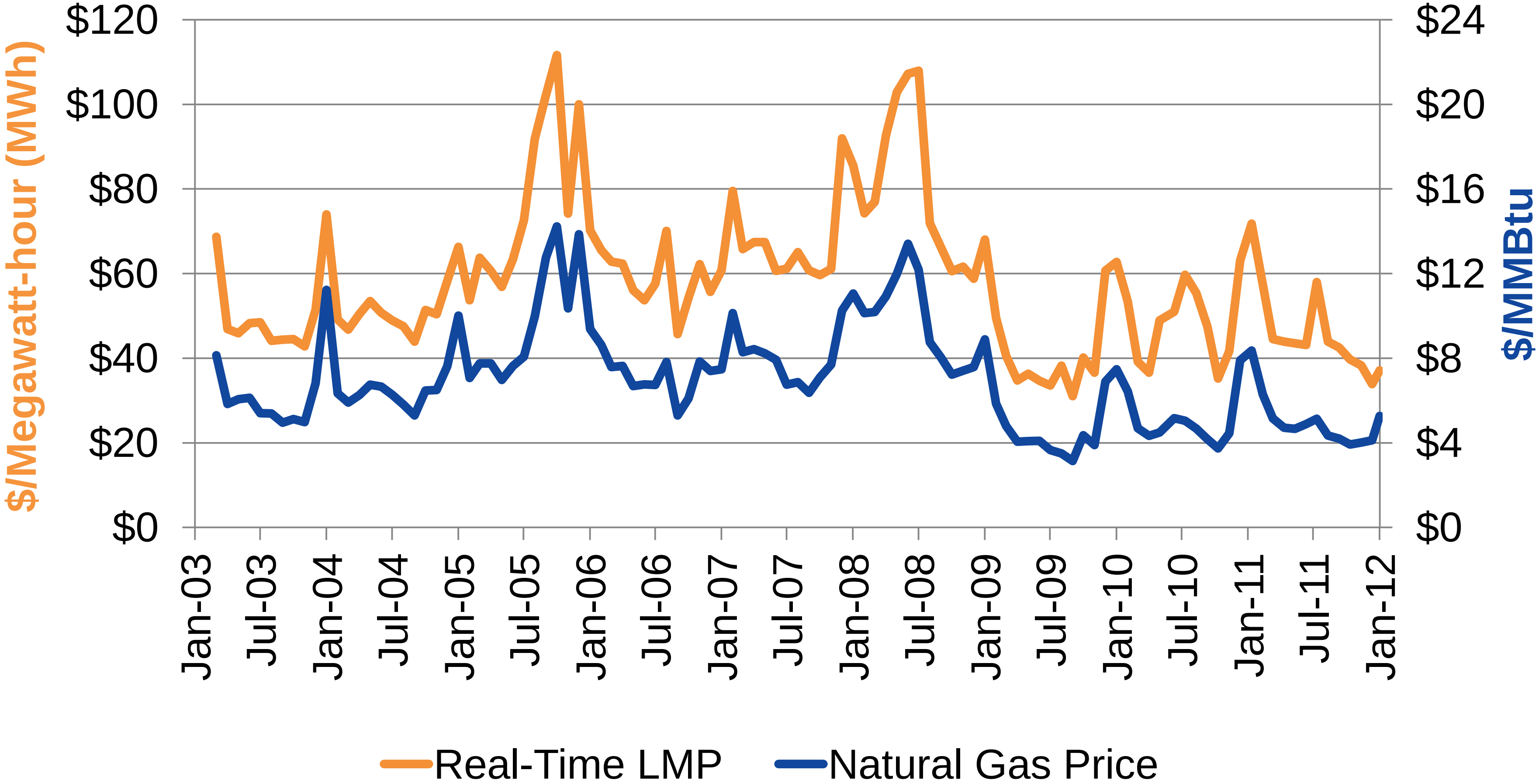
Negative Incremental Energy Offers, Markets Committee, March 6, 2012
http://www.iso-ne.com/committees/comm_wkgrps/mrkts_comm/mrkts/mtrls/2012/mar672012/a15_iso_presentation_03_07_12.ppt

Wind Forecasting and Real-Time Dispatch, Markets Committee, March 6, 2012
http://www.iso-ne.com/committees/comm_wkgrps/mrkts_comm/mrkts/mtrls/2012/mar672012/a14_iso_presentation_03_07_12.ppt

Strategic Transmission Analysis Update, Planning Advisory Committee, March 14, 2012
http://www.iso-ne.com/committees/comm_wkgrps/prtcpnts_comm/pac/mtrls/2012/mar142012/strat_trans_analysis.pdf

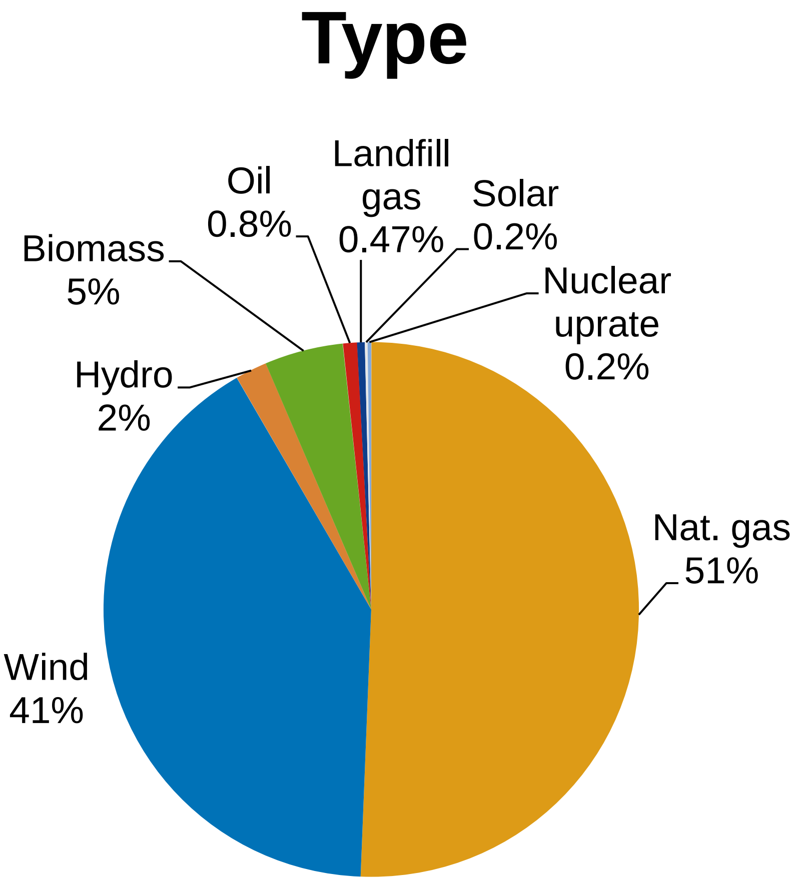
Economic Studies Update – Preliminary Results, Planning Advisory Committee, February 15, 2012
http://www.iso-ne.com/committees/comm_wkgrps/prtcpnts_comm/pac/mtrls/2012/mar8122012/eco_studies_update.pdf

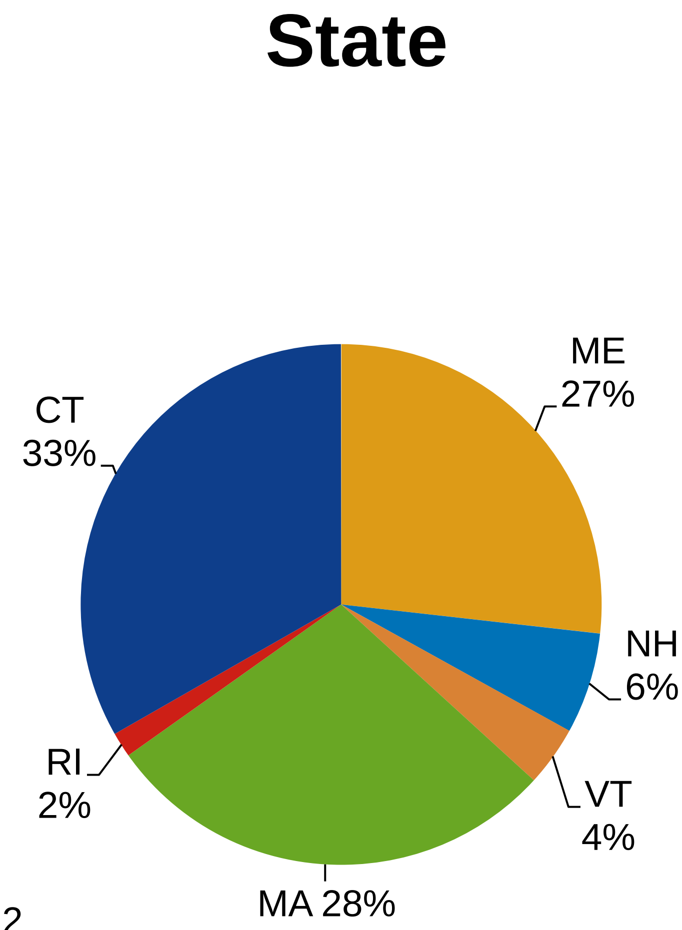
New England Wholesale Electric Energy Costs Track Natural Gas Prices



Generator Proposals in the ISO Queue

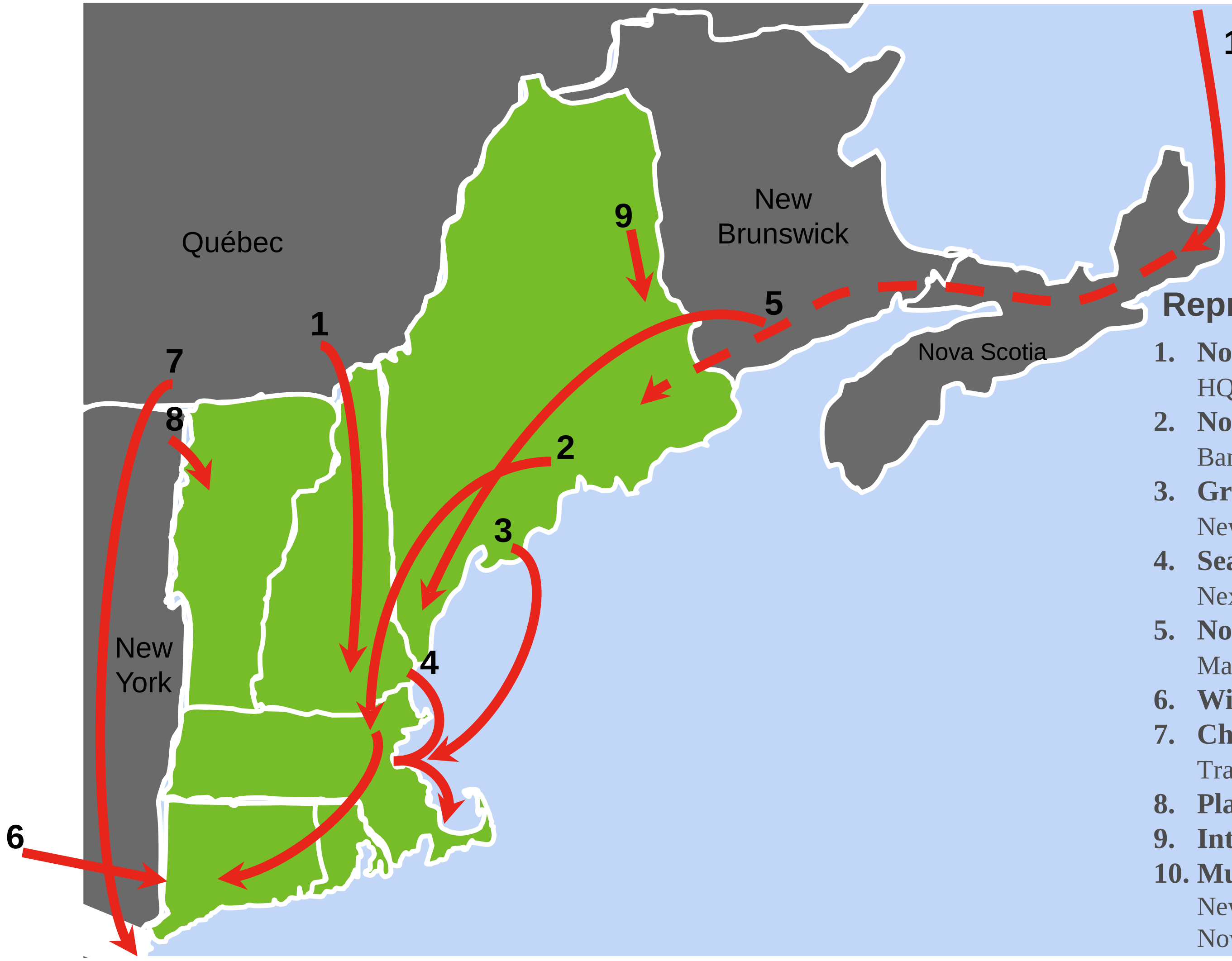
Approximately 6,000 MW





As of Jan. 1, 2012

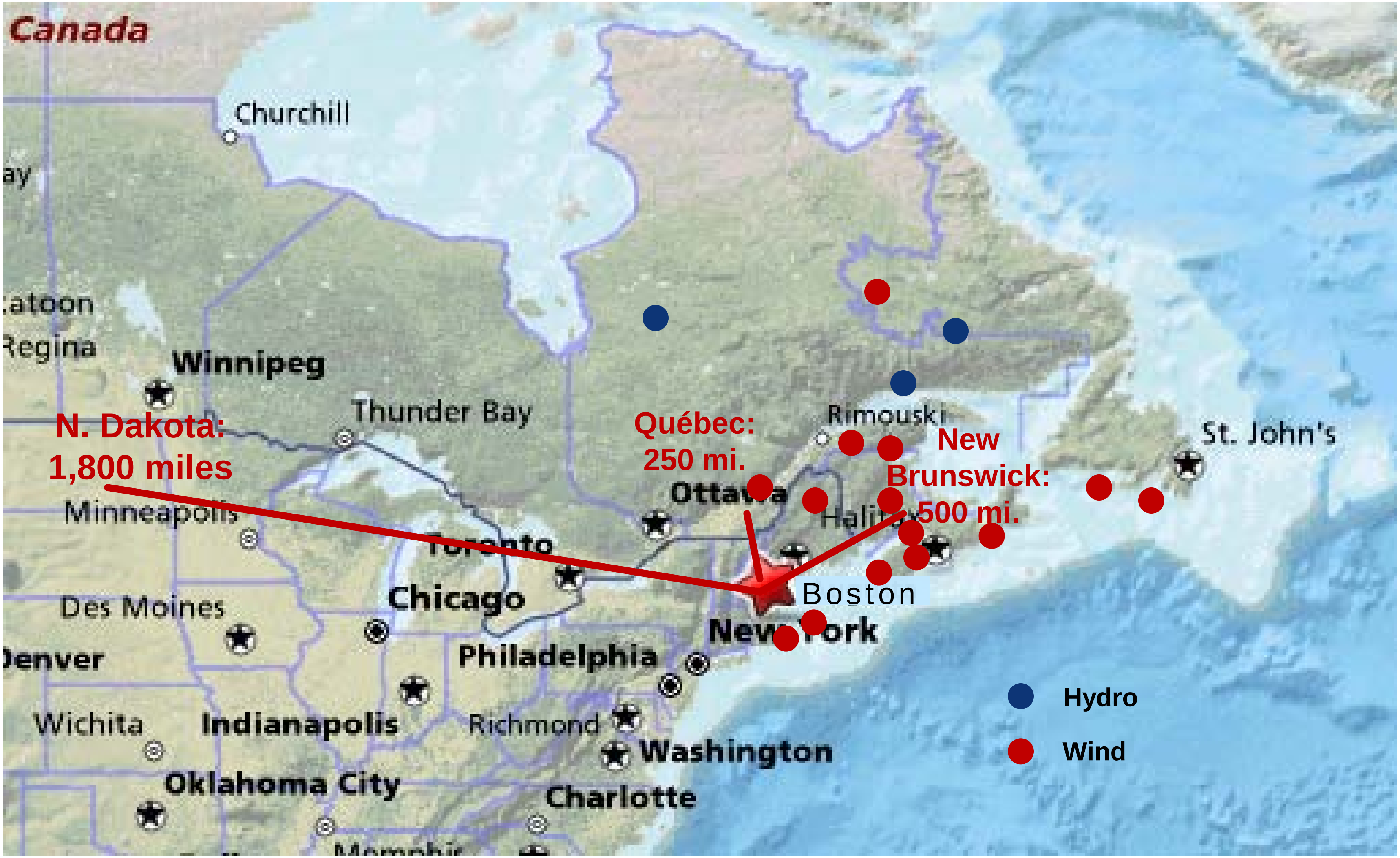
On- and Off-shore Transmission Projects Vying to Move Renewable Energy to New England Load Centers



Representative Projects

1. **Northern Pass**
   HQ/Northeast Utilities/NSTAR
2. **Northeast Energy Link**
   Bangor Hydro/National Grid
3. **Green Line**
   New England ITC
4. **Seabrook-Boston-Cape Cable**
   NextEra Energy (formerly FPL)
5. **Northeast Energy Corridor**
   Maine/New Brunswick
6. **Wind from the Midwest**
7. **Champlain Hudson Express**
   Transmission Developers Inc. (TDI)
8. **Plattsburgh, NY–New Haven, VT**
9. **Interconnect Northern Maine**
10. **Muskrat Falls/Lower Churchill**
    Newfoundland and Labrador (Nalcor) and Nova Scotia (Emera)

Distances to Access Renewable Resources



EXTRA NEWIS SLIDES

The NEWIS Team

- Team GE
  - GE Energy and Systems Engineering
    - NYSERDA (‘04, ‘05) through to CAISO (’07) and WSIS2 (’12)
  - EnerNex
    - Minnesota (‘04) through to EWITS and more (‘10)
  - AWS Truepower
    - NYSERDA through to EWITS and more

- Technical Review Committee
  - J. Charles Smith: UWIG, AWEA
  - Michael Milligan, Brendan Kirby: National Energy Labs
  - Mike Jacobs: Developers/Transmission
  - Utama Abdulwahid: UMass Wind Energy Center
  - Warren Lasher: ERCOT

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

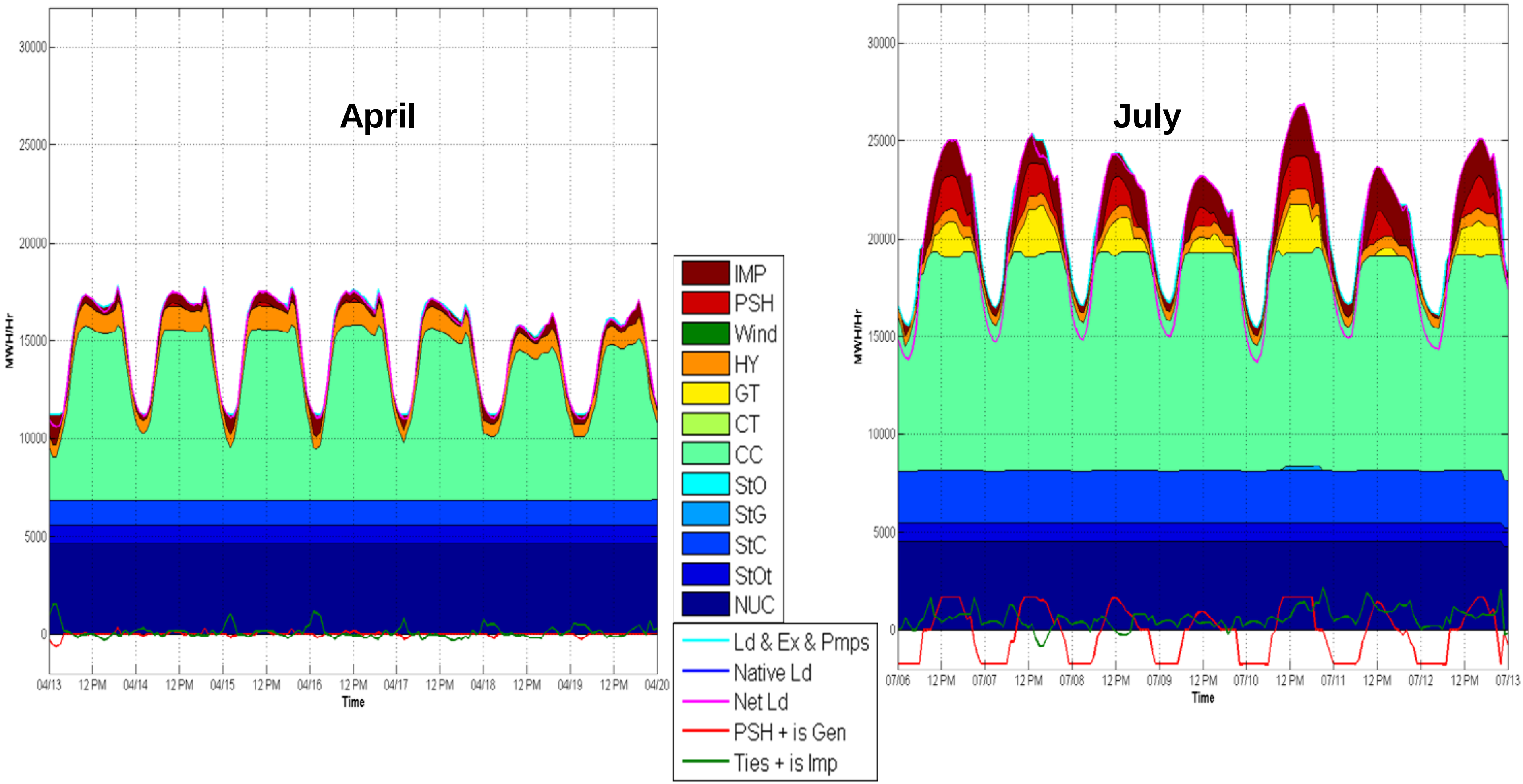
- These changes would require additional analysis for increasing levels of wind penetration and for issues identified within New England, or beyond, as system operators gain experience with wind energy

- The development, implementation, and operating costs associated with these changes are not accounted for in this study

Hourly Operations: System Dispatch

Week of April 13 & July 6

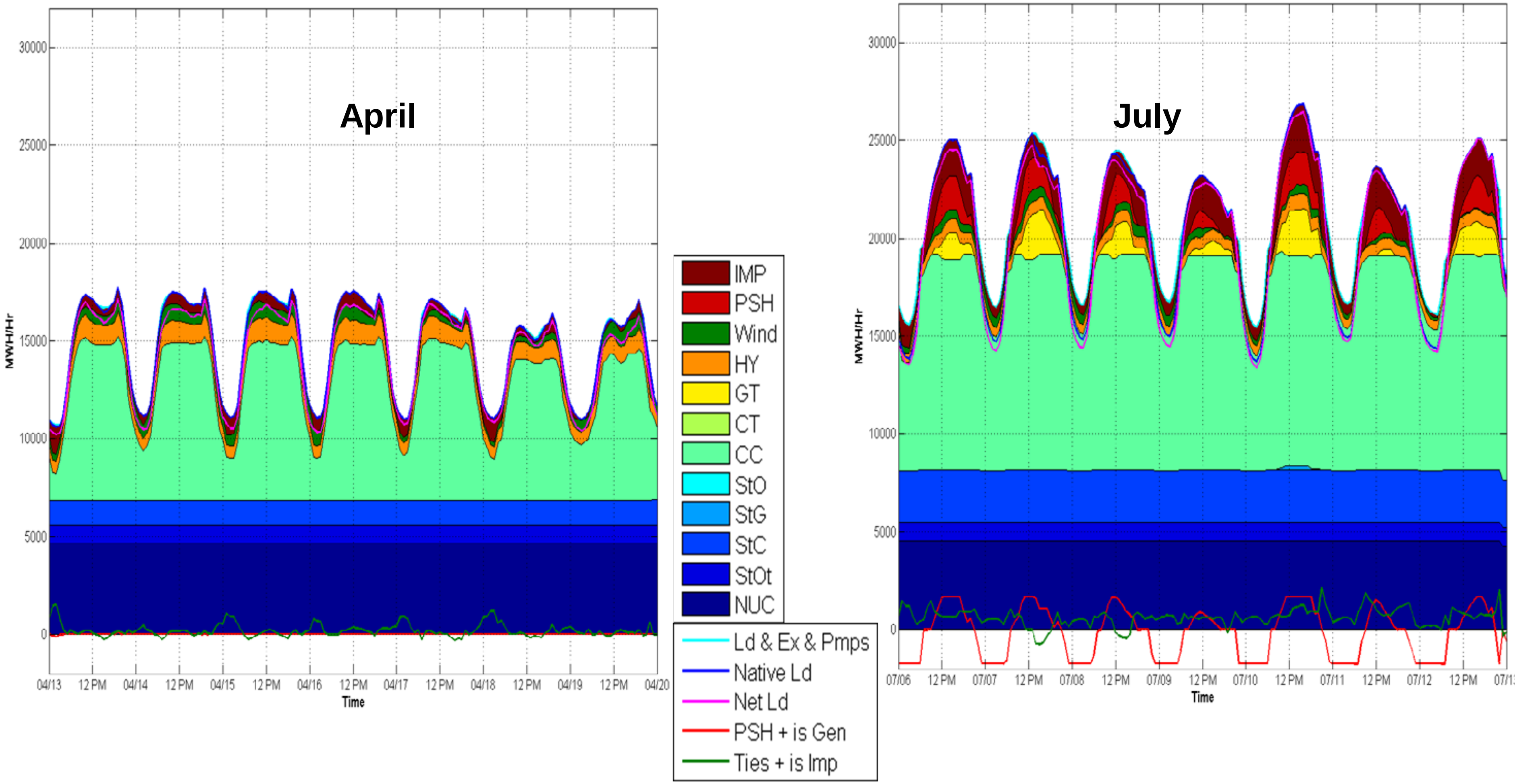
No Wind



Hourly Operations: System Dispatch

Week of April 13 & July 6

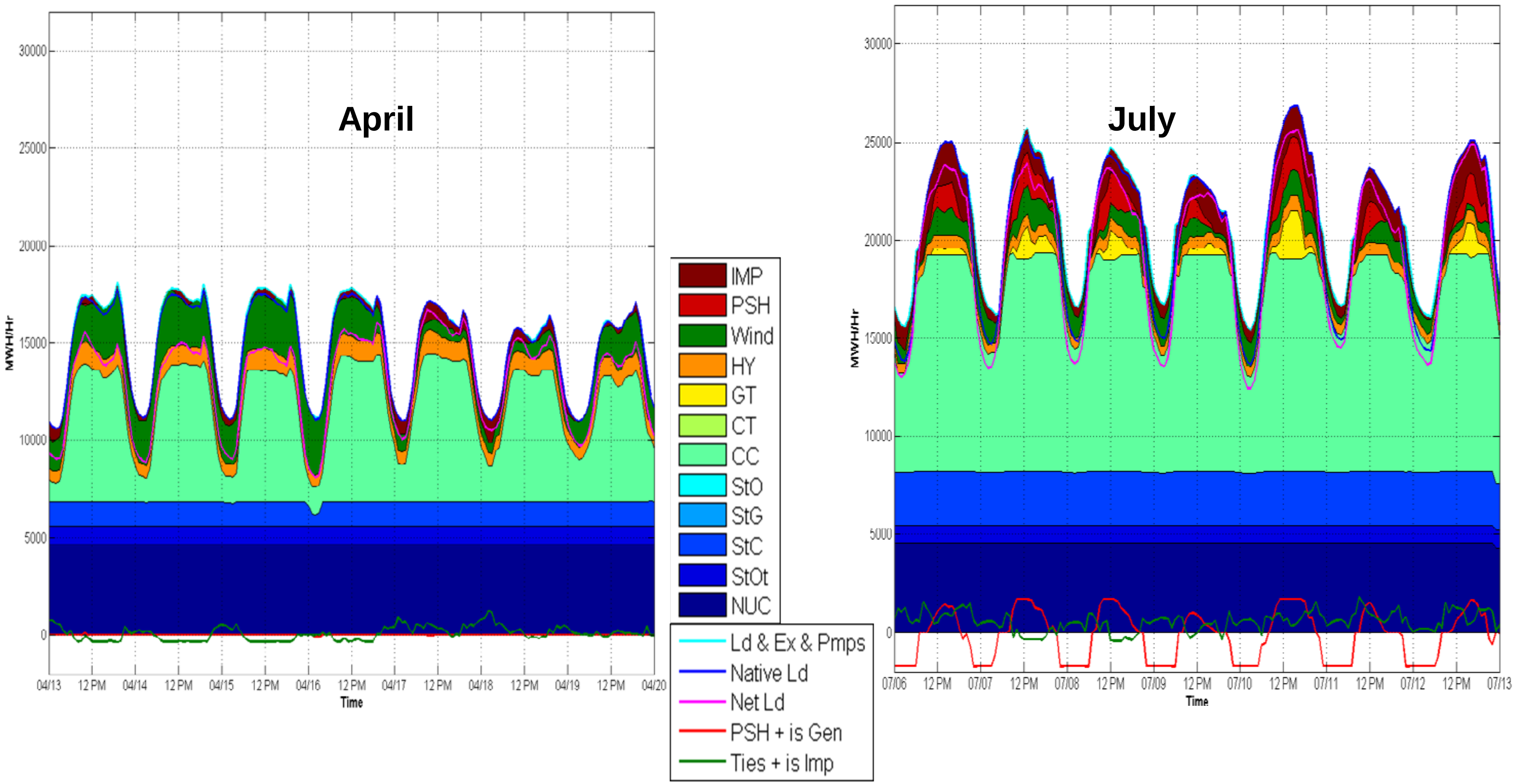
2.5% Energy



Hourly Operations: System Dispatch

Week of April 13 & July 6

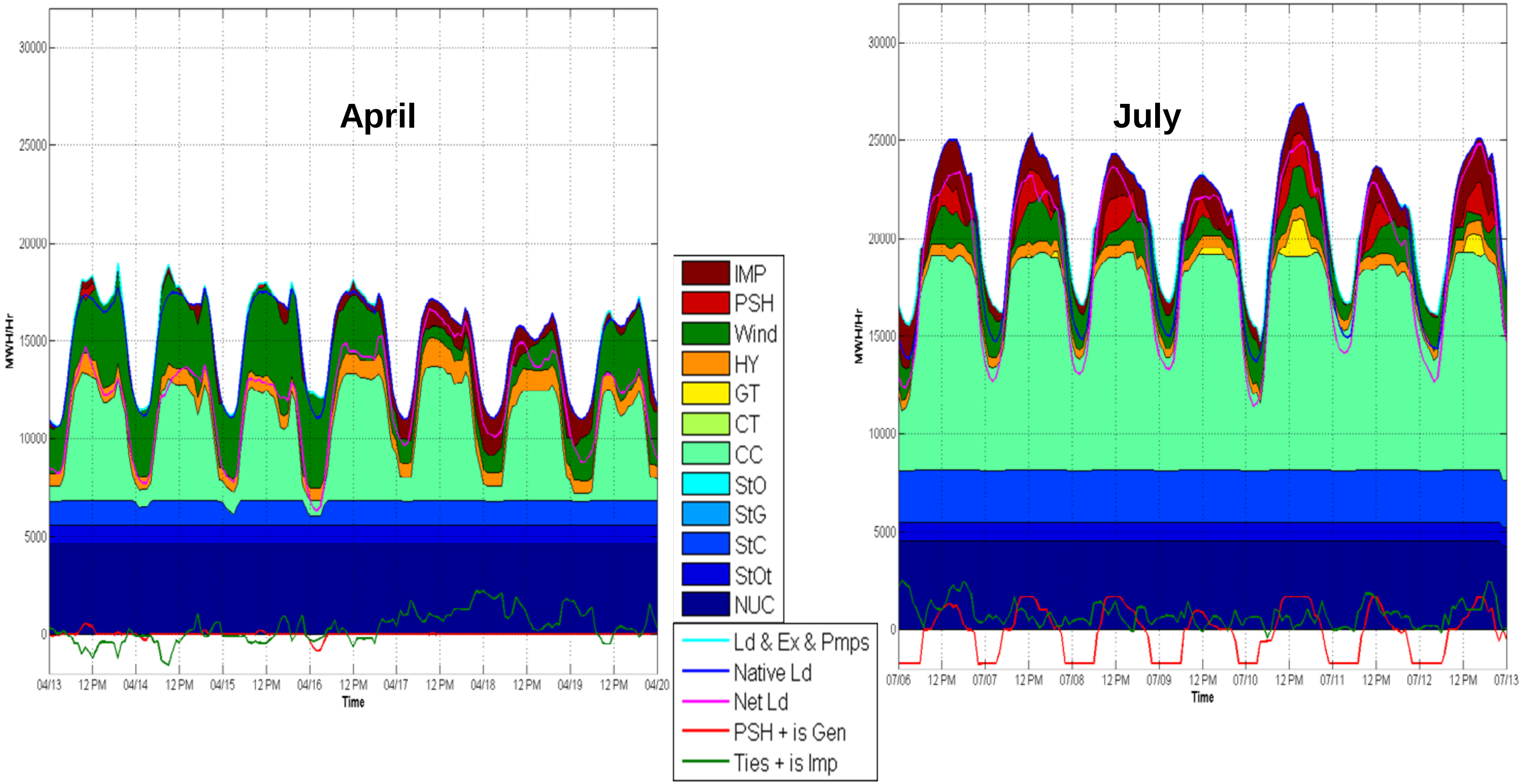
Full Queue



Hourly Operations: System Dispatch

Week of April 13 & July 6

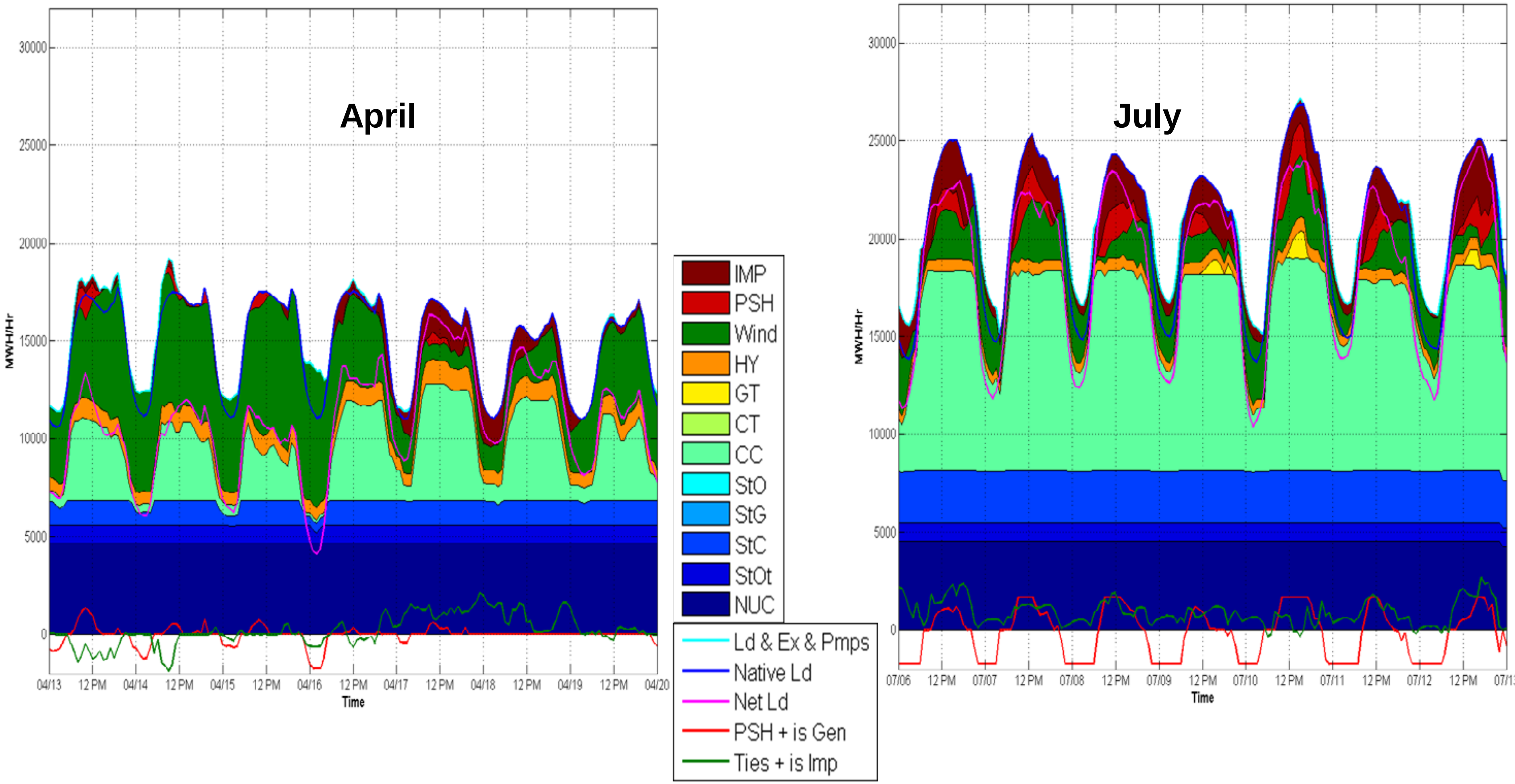
14% Energy



Hourly Operations: System Dispatch

Week of April 13 & July 6

20% Energy



Hourly Operations: System Dispatch

Week of April 13 & July 6

24% Energy