The 20% Wind Energy Scenario: System Operation and Transmission Needs

2008 IEEE PES Meeting

Pittsburgh, PA

July 22, 2008
8:00 am – noon

UWIG
Utility Wind Integration Group

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UWIG

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What is UWIG?

- Non-profit corporation established by 6 utilities in 1989 with support from EPRI and DOE/NREL
- Current membership in excess of 120, including utilities, developers, manufacturers, consultants, government organizations
- Focus on technical issues
- Mission: To accelerate the development and application of good engineering and operational practices supporting the appropriate integration of wind power into the electric system

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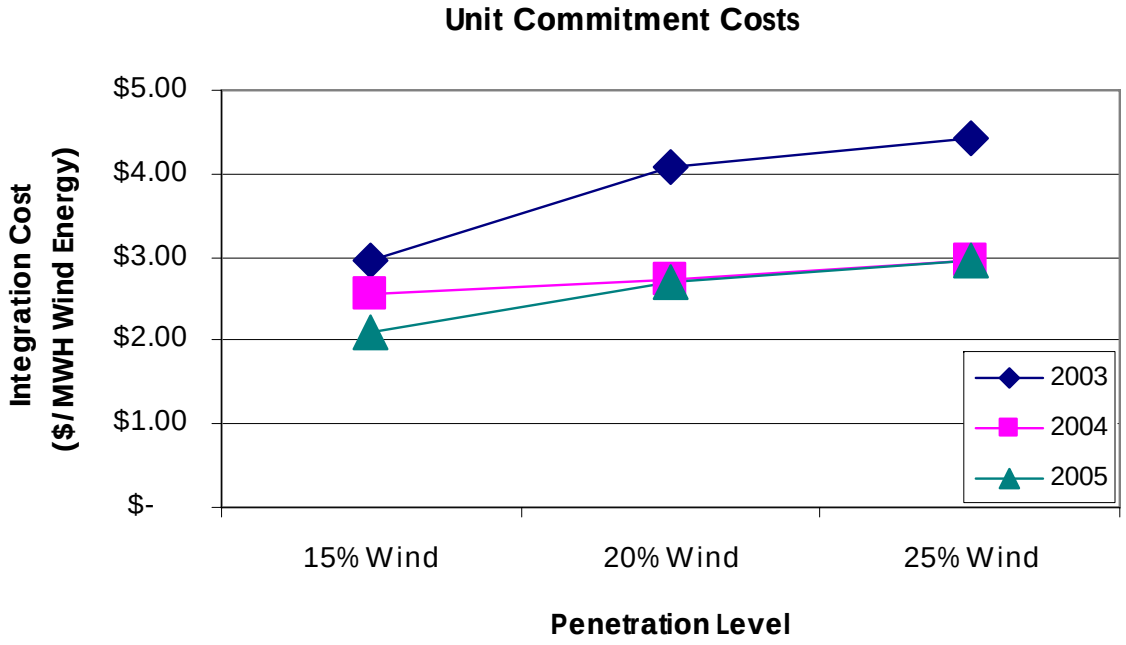
Outline of Topics

- Lessons from Recent Studies and Experience Dealing With High Wind Penetration
- Transmission Issues
- Recommendations
- Conclusions

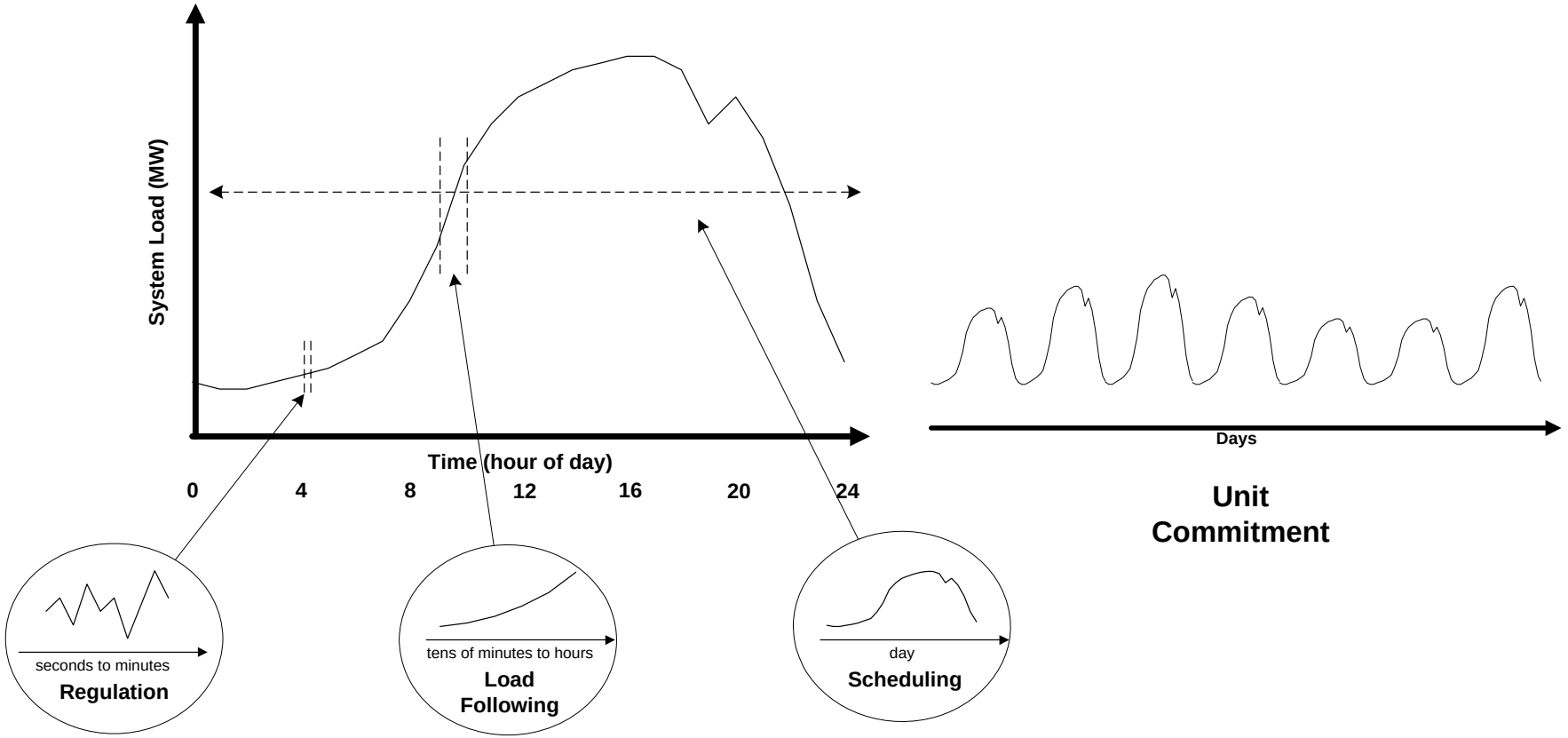
20% Wind Energy Can Be Managed



Wind integration costs for three penetration levels and pattern years.
Cost of incremental operating reserves is embedded.

Source:
MN DOC

Time Scales of Interest



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Summary of Wind Plant Ancillary Service Costs

Ancillary Services Cost Comparison

Date	Study	Wind Capacity Penetration (%)	Regulation Cost ($/MWh)	Load Following Cost ($/MWh)	Unit Commit-ment Cost ($/MWh)	Gas Supply Cost ($/MWh)	Total Operating Cost Impact ($/MWh)
May 03	Xcel-UWIG	3.5	0	0.41	1.44	na	1.85
Sep 04	Xcel-MNDOC	15	0.23	na	4.37	na	4.60
Dec 06	MN/MNDOC	33	na	na	na	na	4.41
July 04	CA RPS Multi-year Analysis	4	0.45	na	na	na	na
June 03	We Energies	4	1.12	0.09	0.69	na	1.90
June 03	We Energies	29	1.02	0.15	1.75	na	2.92
2005	PacifiCorp	20	0	1.6	3.0	na	4.6
April 06	Xcel-PSCo	10	0.20	na	2.26	1.26	3.72
April 06	Xcel-PSCo	15	0.20	na	3.32	1.45	4.97

Some Additional Reserves May Need to be Committed

Reserve Category	Base		15% Wind		20% Wind		25% Wind	
	MW	%	MW	%	MW	%	MW	%
Regulating	137	0.65%	149	0.71%	153	0.73%	157	0.75%
Spinning	330	1.57%	330	1.57%	330	1.57%	330	1.57%
Non-Spin	330	1.57%	330	1.57%	330	1.57%	330	1.57%
Load Following	100	0.48%	110	0.52%	114	0.54%	124	0.59%
Operating Reserve Margin	152	0.73%	310	1.48%	408	1.94%	538	2.56%
Total Operating Reserves	**1049**	**5.00%**	**1229**	**5.86%**	**1335**	**6.36%**	**1479**	**7.05%**

Estimated Operating Reserve Requirement for MN BAs – 2020 Load

Source: MN DOC

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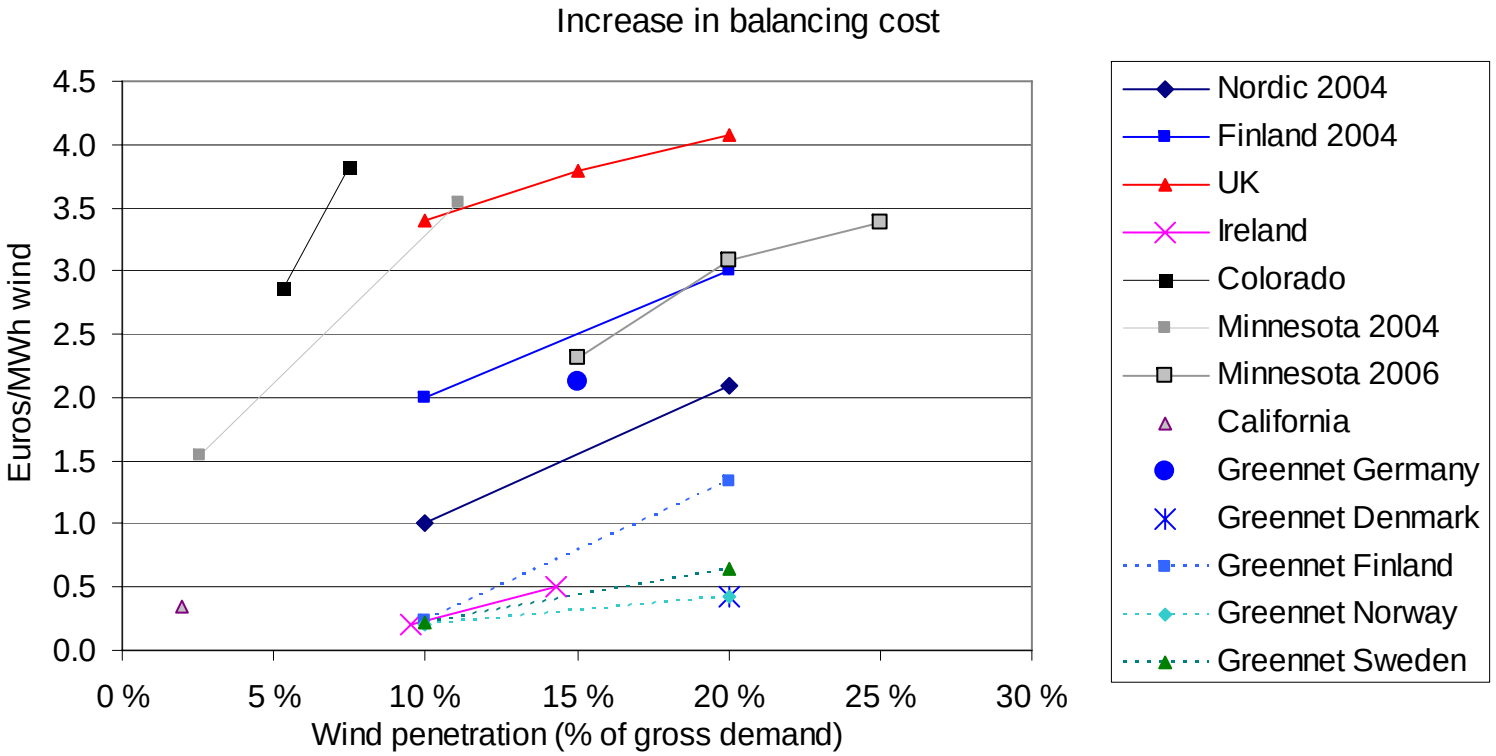
Increased Balancing Cost



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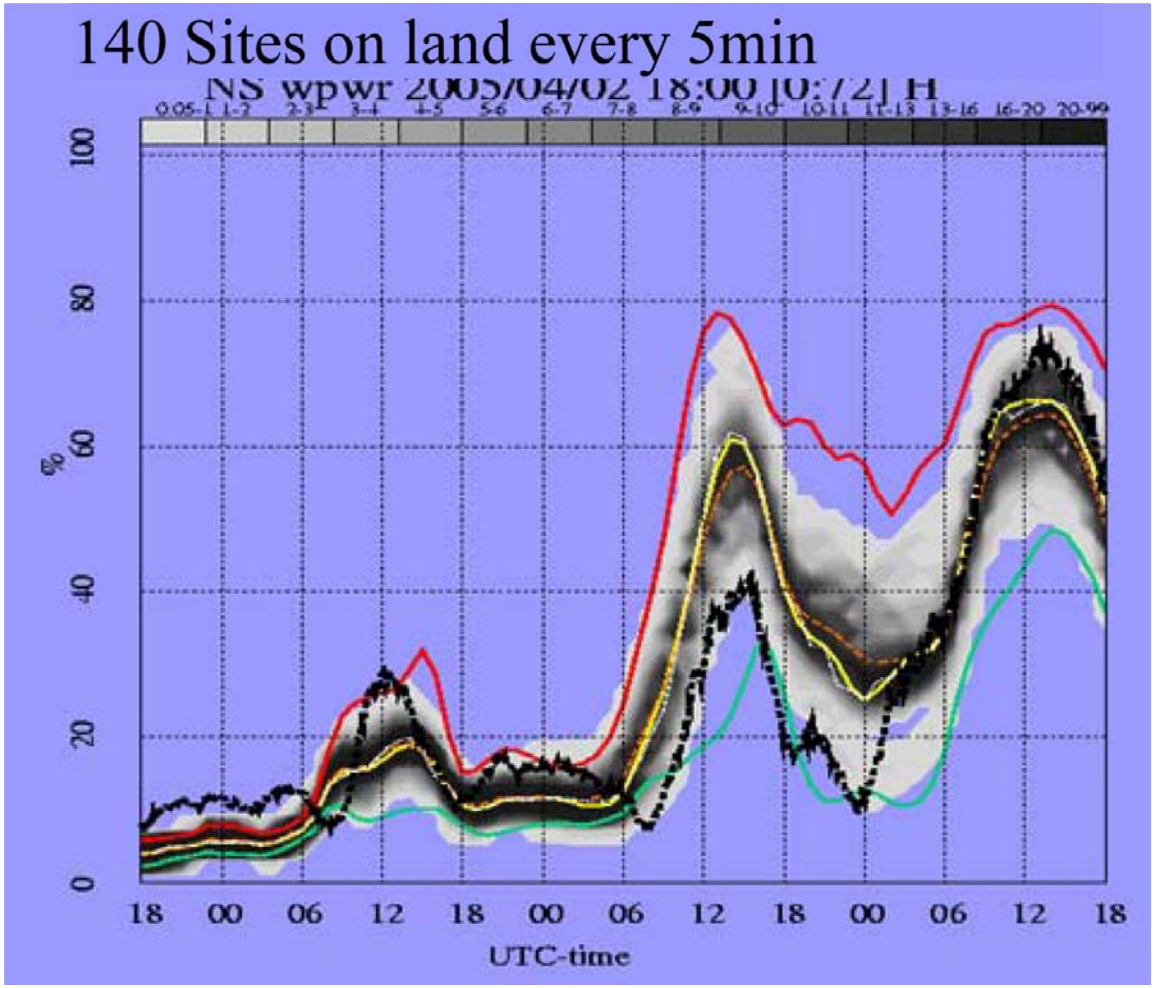
Forecasting and Balancing Markets Reduce Impacts



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Different Forecasts for Different Time Periods

- Situational awareness forecast: used for severe weather events (real-time)
- Hour ahead forecast: uses rapid update cycle to produce 10 min forecasts 4-6 hrs ahead, updated every hour
- Day ahead forecast: Hourly forecasts 2-4 days ahead, updated every 12 hours, uses national weather service models
- Nodal forecast: hourly forecast of transmission system nodal injections for managing transmission congestion
- Different performance metrics for different forecasts

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How Good is the Forecast?

- Wind plant output can be forecast within some margin of error, and forecasts are getting better

	Forecast Error	
	Single Plant	Large Region
Hour Ahead		
Energy (% actual)	10-15%	6-11%
Capacity (% rated)	4-6%	3-6%
Day Ahead		
Hourly Energy (% Actual)	25-30%	15-18%
Hourly Capacity (% Rated)	10-12%	6-8%

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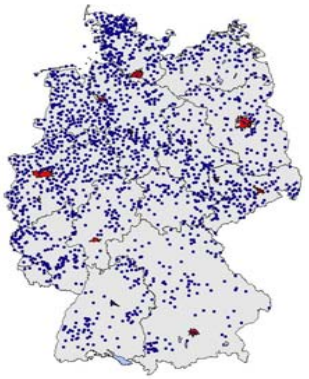
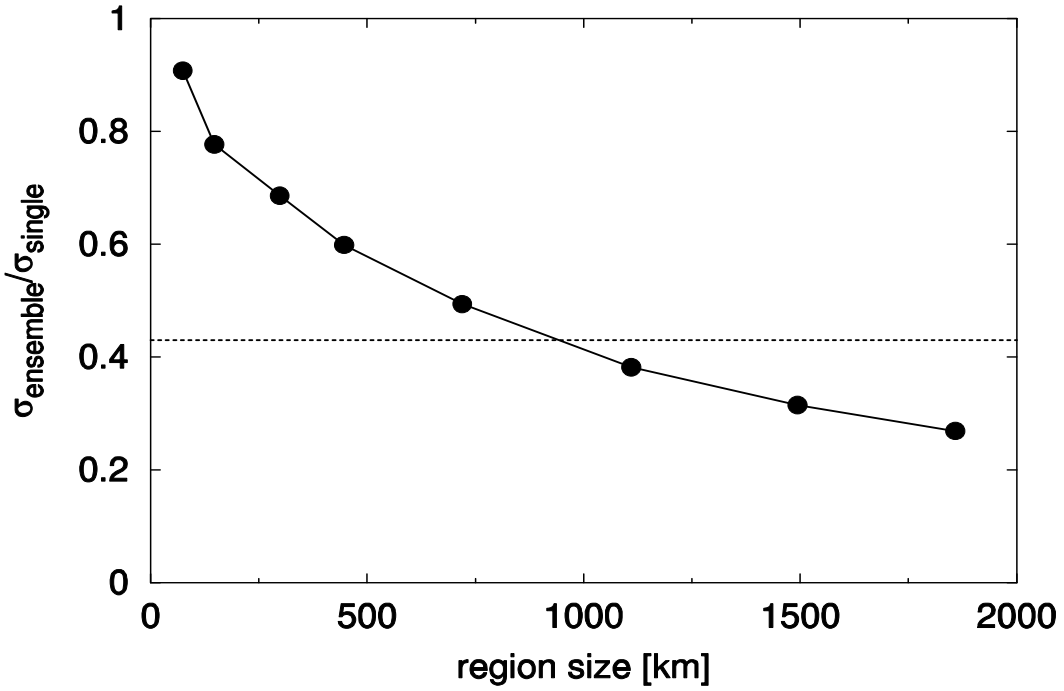
Error Decreases with Region Size





- Error decreases with increase of region size
- Regional smoothing depends only on region's size, not on number of sites
- Error is reduced in Germany to 42 % compared to single forecast

Source: Energy and Meteo Systems

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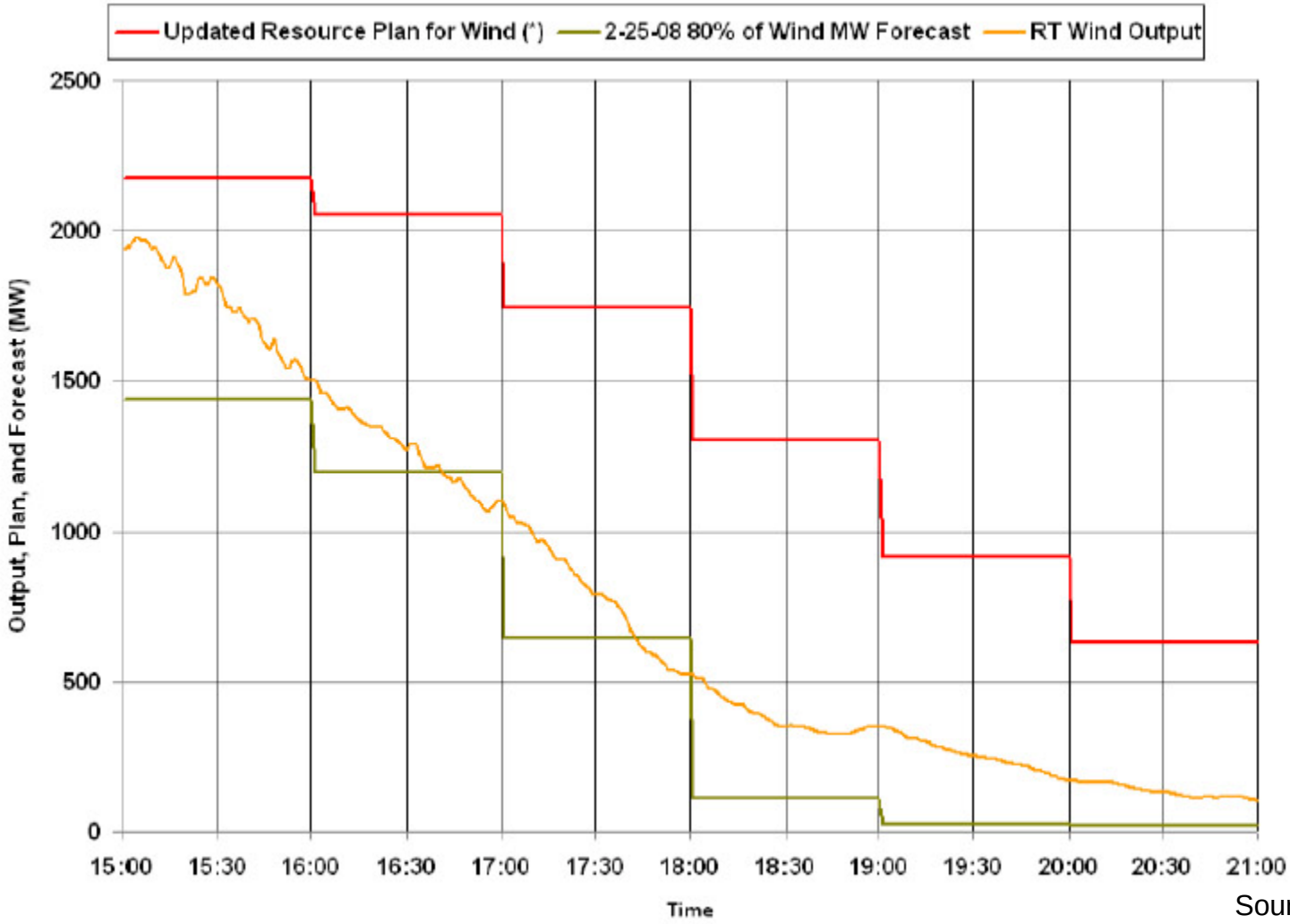
ERCOT Wind Generation – Feb. 26, 2008



Source: ERCOT

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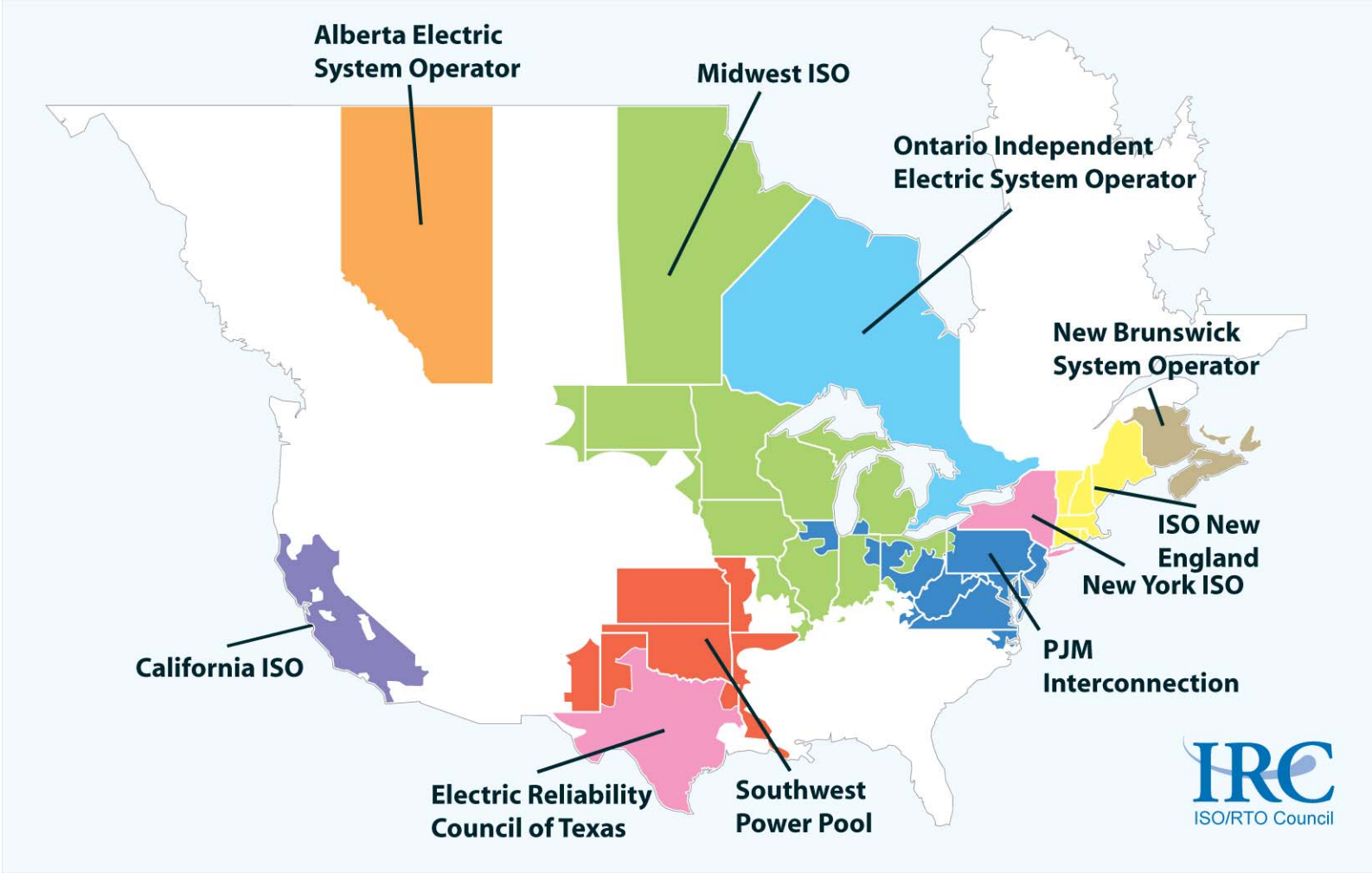
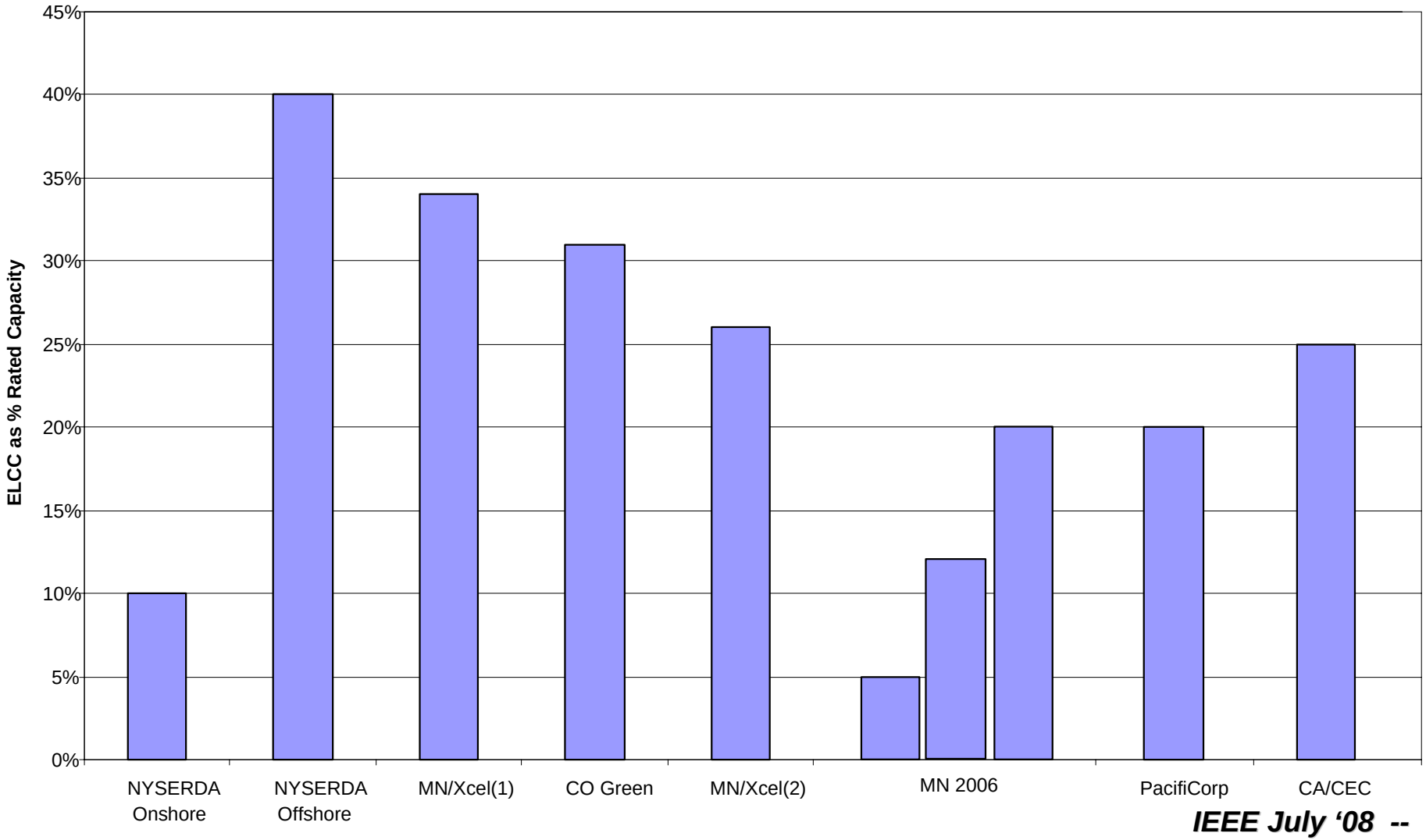
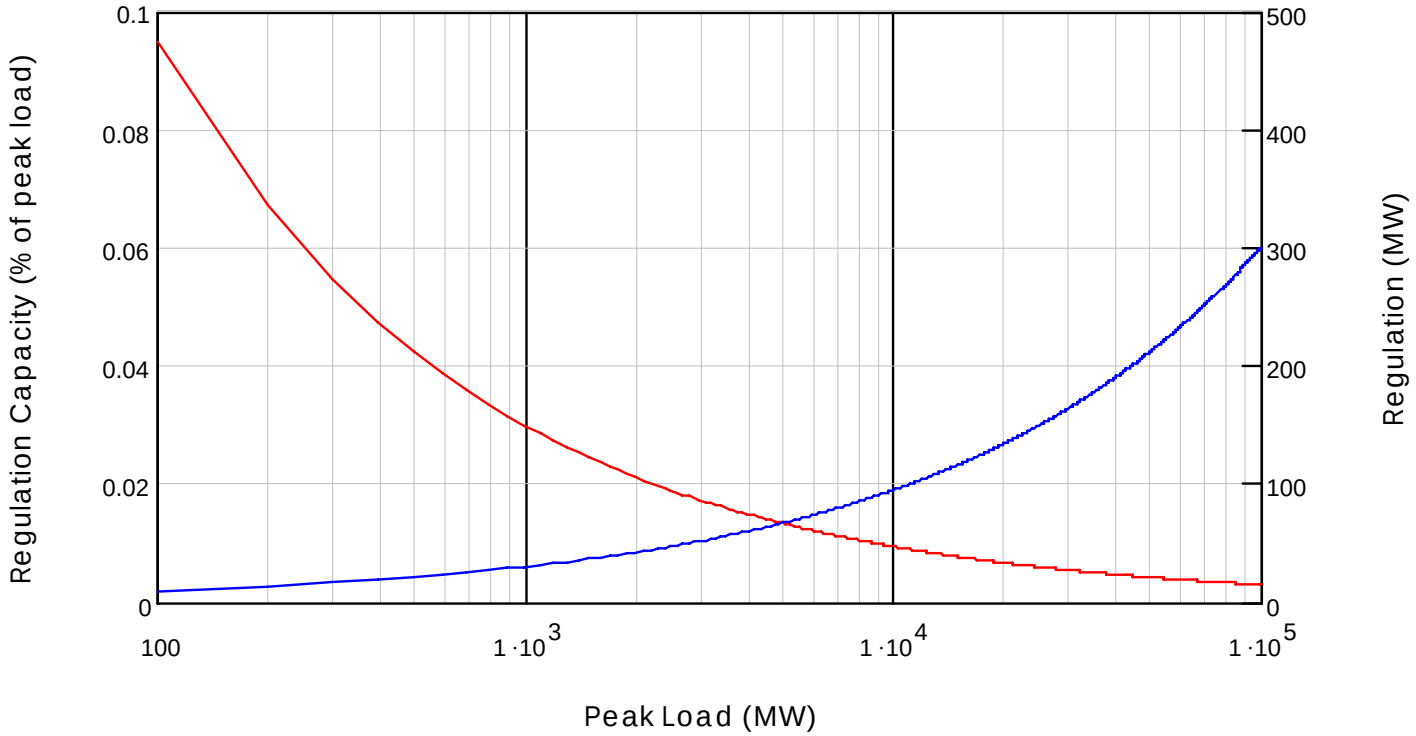
ISOs/RTOs in North America



An Energy Resource in a Capacity World



Large Balancing Areas Reduce Reserve Requirements



Approximate regulating requirements for a BA as a function of peak demand.

Source: MN DOC

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A Comparison of Regulating Reserves

Balancing Authority	*Peak Load*	*Regulating Requirement (from chart)*	*Regulating Requirement (% of peak)*
GRE	3443 MW	56 MW	1.617%
MP	2564 MW	48 MW	1.874%
NSP	12091 MW	104 MW	0.863%
OTP	2886 MW	51 MW	1.766%
Sum of Regulating Capacity		**259 MW**	
Combined	20984 MW	**137 MW**	**0.655%**

Estimated Regulating Requirements for MN BAs - 2020

Source:
MN DOC

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What About Energy Storage?

- Valuable component of a power system, can provide many benefits
- Greatest value when operated for benefit of entire system, not dedicated to a single resource
- One of many sources of flexibility available to the system
- Expensive, and benefits accrue to different parties, i.e. generation owner, trans. system operator, power marketer
- Seldom sufficient value in revenue stream for any single party to justify the investment
- Integration studies do not show need for storage at 20% wind except possibly on small, isolated systems

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Current Transmission Situation

- Current system maintained at minimum level necessary to meet reliability criteria
- System is reliable, but heavily stressed
- System is congested for energy market purposes and inter-regional energy transfers
- System not designed to operate with energy markets or large energy resources like wind
- Results in high-cost load pockets and low-cost generation pockets, with economical energy transfers limited by transmission congestion

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Evolving Transmission Situation

- Recent studies indicate an opportunity to significantly expand the transmission system to serve both the energy markets and wind generation potential
  - MTEP 06, MTEP 08
  - Joint Coordinated System Plan (JCSP)
  - DOE 20% by 2030
- DOE 20% scenario stimulated conceptual 765 kV EHV overlay examined by AEP
  - Investment of $60 billion over next 20 years for 19,000 mi of line to deliver additional 200-400 GW
  - Current transmission investment $8 billion/yr and growing
- Building an inter-regional high voltage overlay to address the needs identified in recent studies is unprecedented
- No previous investigation or understanding established through business models, energy policy, or federal or state policy or regulation

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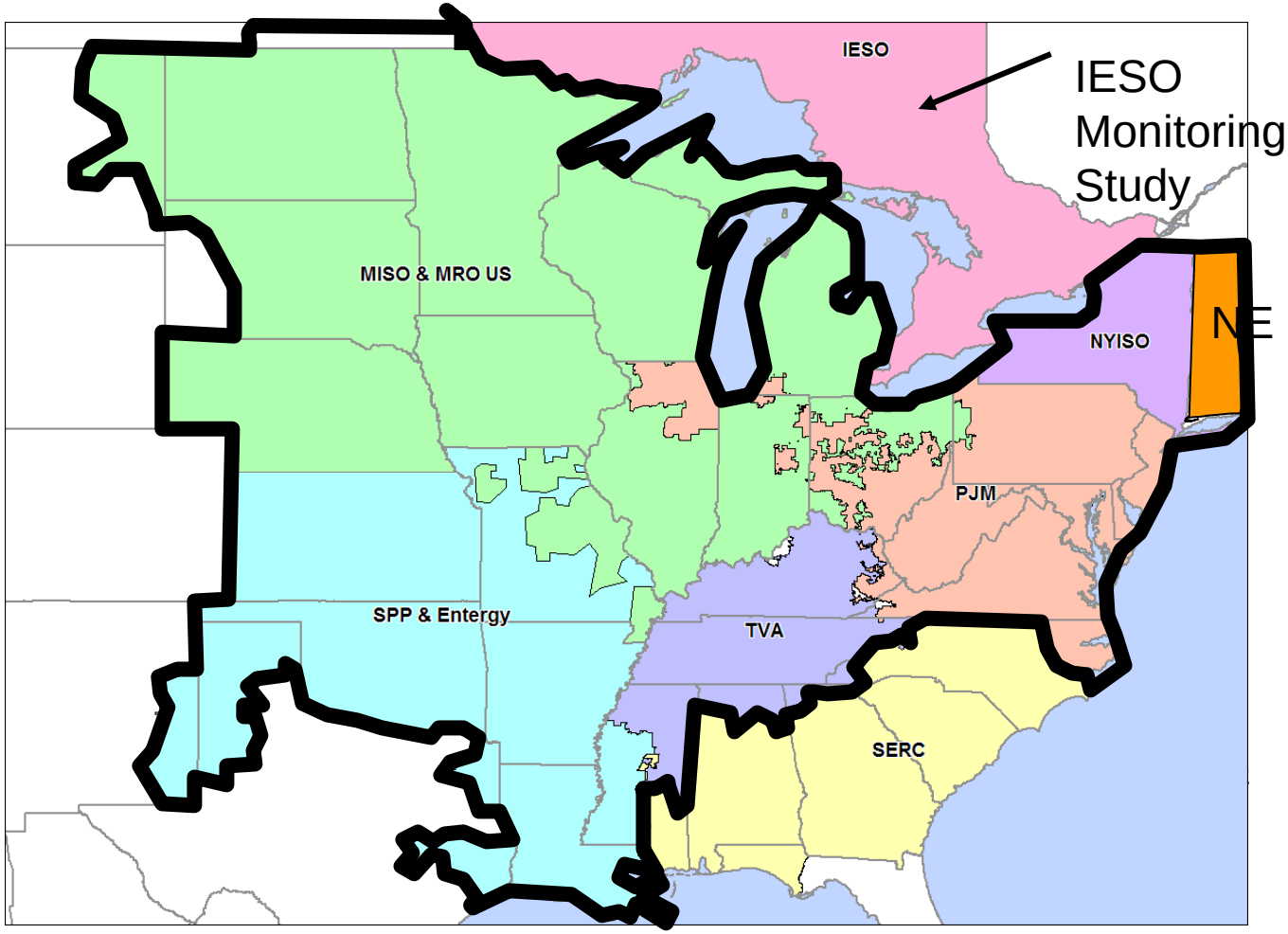
JCSP Study Regions



Source: MISO

What's Driving Transmission Planning for Wind Energy

- Total potential congestion for the Eastern Interconnection from MTEP '08 20% Renewable Scenario- $24B/yr in 2021$
  - Reduction of only about half will be achievable
  - Requires high power transfer capability, low delivery cost with multiple lines self-providing for contingencies
- Transmission planning must take place on a broad regional basis- link lowest cost areas to highest priced areas
- Economies of scale in transmission necessary to realize the benefits
- Revenue from energy transactions pays for the cost of the line
- Techniques pioneered in MISO Transmission Expansion Plan (MTEP) and JCSP (20% wind energy in Eastern Interconnection)

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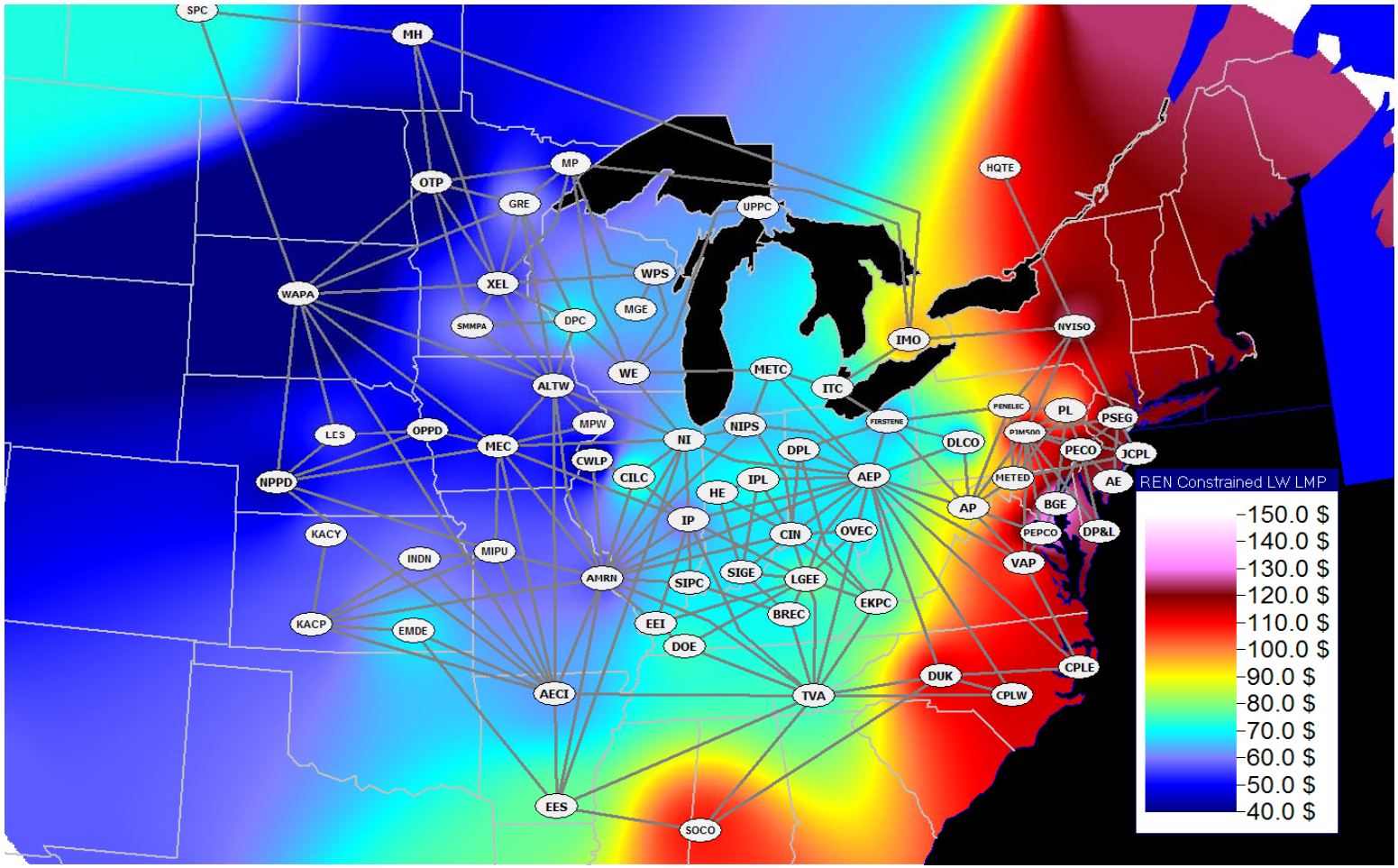
Full Constrained Case Annual Load Weighted LMP



Source: MISO

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Example of Opportunity

- With significant wind under RPS policy:
  - A three line 800 kV HVDC and 765 kV AC overlay system appears to have the potential for a 15,000 MW delivery system for energy from the wind areas in western MISO to the east coast for about $30/MWH
  - The average cost of this energy is about $65/MWH including losses
  - The delivered cost of energy would then be about $95/MWH
  - This is less than the $110/MWH or higher price on much of the east coast
- Planning techniques pioneered in MISO Transmission Expansion Plan (MTEP) and JCSP

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System Planning and Operation Recommendations

- Perform detailed wind integration studies
- Deploy more flexible generation and load technologies
- Improve wind plant output forecasting tools
- Improve grid codes and wind plant models
- Aggregate wind plant output over large regions
- Improve balancing area consolidation and ACE sharing
- Ongoing forums to share operating experience

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Transmission Planning Recommendations

- Develop adequate transmission capacity through planning process for energy resources
- Comprehensive regional planning processes
- Federal leadership in developing high-voltage transmission in support of national energy policy
- Reassessment of transmission financing approach
  - Customers in remote regions can't afford it
  - load pays in the end
- More certainty of transmission cost recovery
- More robust and flexible "smart" grid

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Market Operation and Transmission Policy Recommendations

- Develop well-functioning real-time, hour-ahead and day-ahead energy and price responsive load markets and expand access to those markets
- Adopt market rules and tariff provisions that are more appropriate to weather-driven resources
- Make better use of physically (in contrast with contractually) available transmission capacity
- Eliminate pancaked rates

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and the conclusion is…

- There are no fundamental technical barriers to the integration of 20% wind energy into the nation's electrical system, but…

- There needs to be a continuing evolution of transmission planning and system operation policy and market development for this to be achieved.

For More Information

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