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

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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 100, including utilities, developers, manufacturers, consultants, government organizations
- Focus on technical issues
- Mission: To accelerate 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

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European Experience

(data for 2005-2006)	Denmark (W)	Spain	Germany	Ireland
Peak Load (MW)	3,700	44,000	78,000	4,800
Minimum Load (MW)	1,200	17,000	38,000	1,800
Wind Capacity (MW)	2,400	10,000	18,000	600
Wind, % Peak Load	65%	23%	23%	12%
Wind, % Minimum Load	200%	59%	50%	33%
Wind, % Total Energy	24%	7%	5.5%	6%
Capacity Goal by 2010 (MW)	3,600	20,000	25,000	1,200

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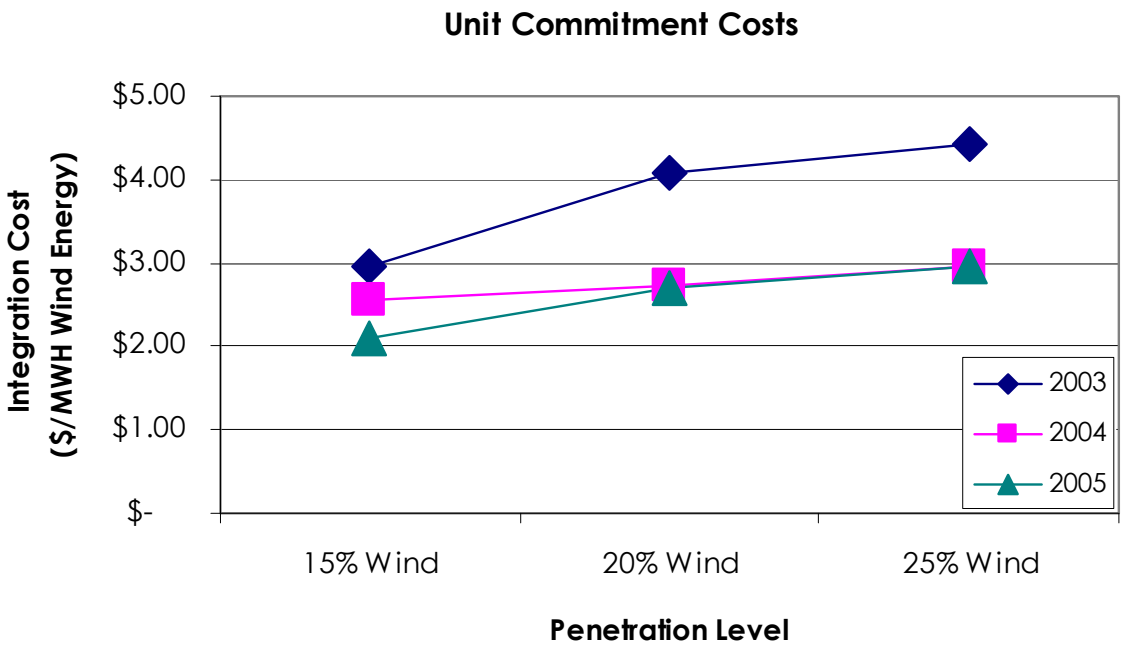
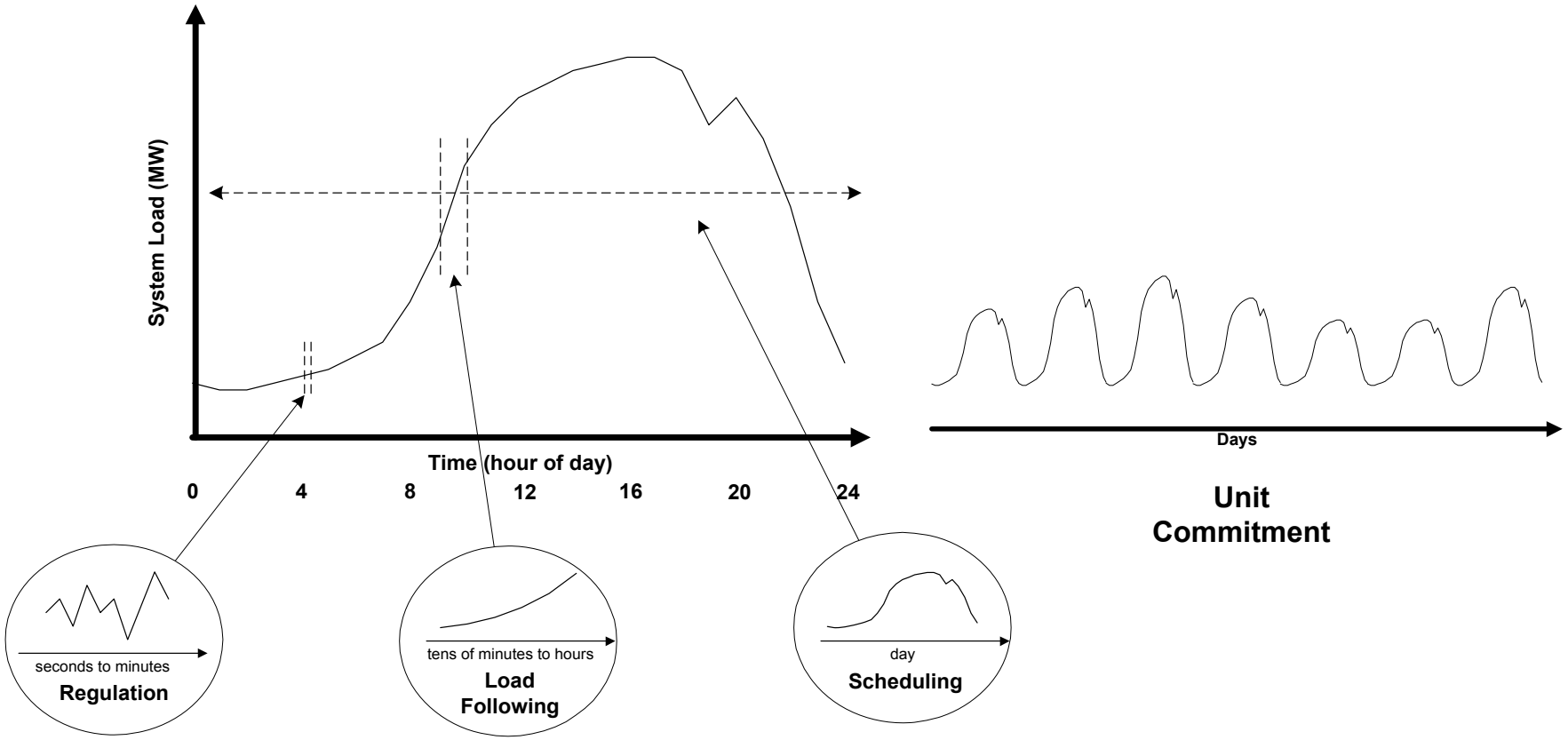
20% Wind Energy Can Be Managed



Unit commitment 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

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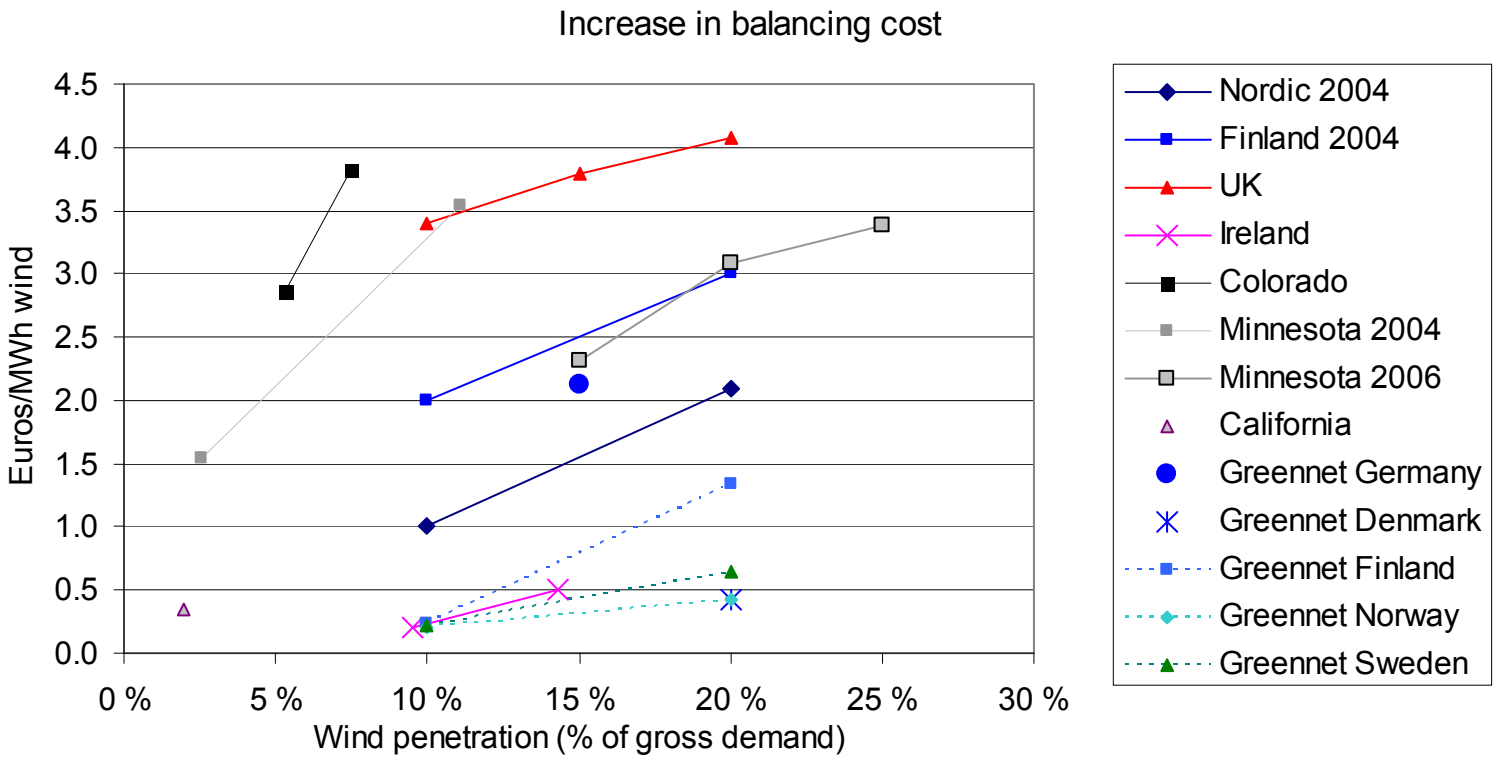
Some Additional Reserves May Need to be Committed

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%**

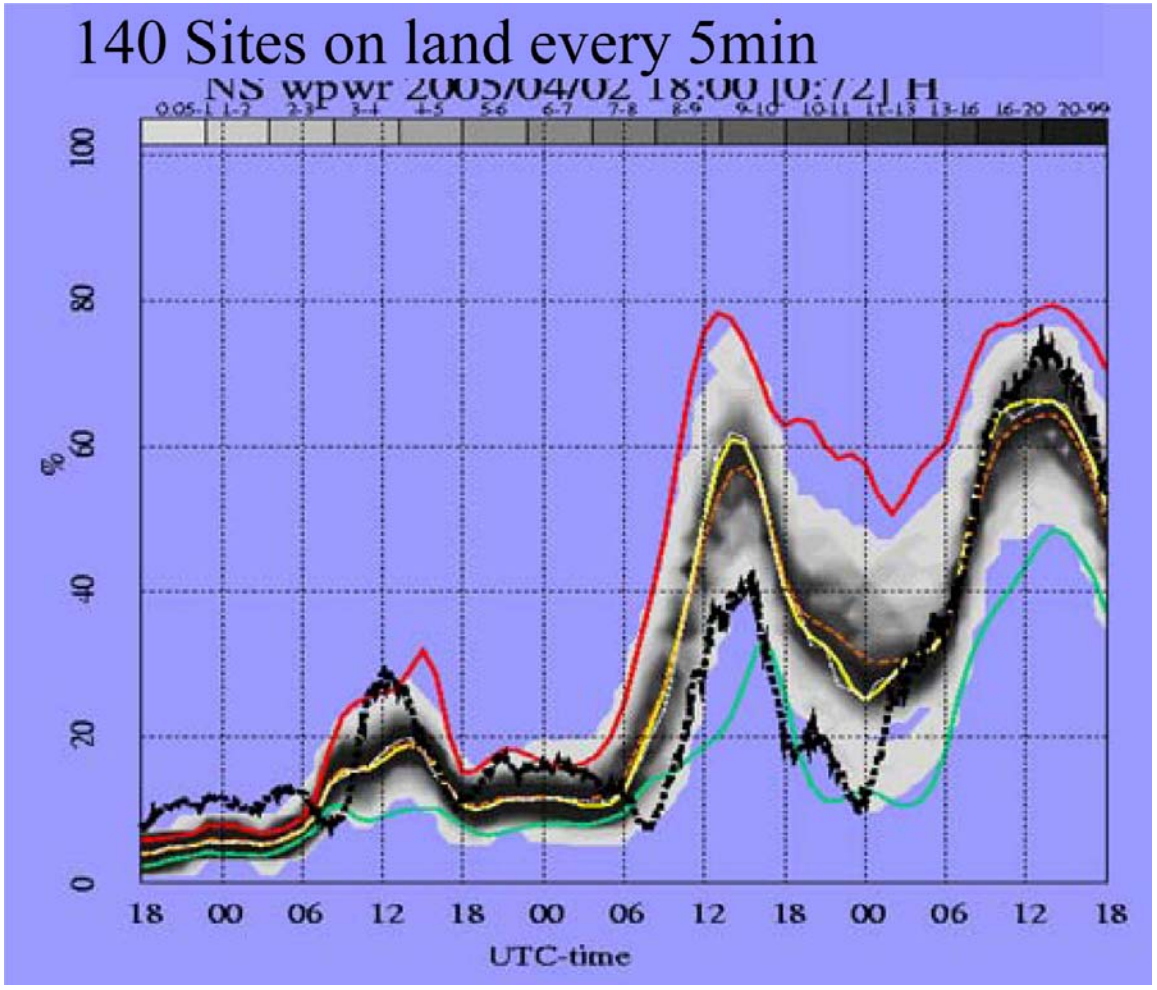
Estimated Operating Reserve Requirement for MN BAs – 2020 Load

Source: MN DOC

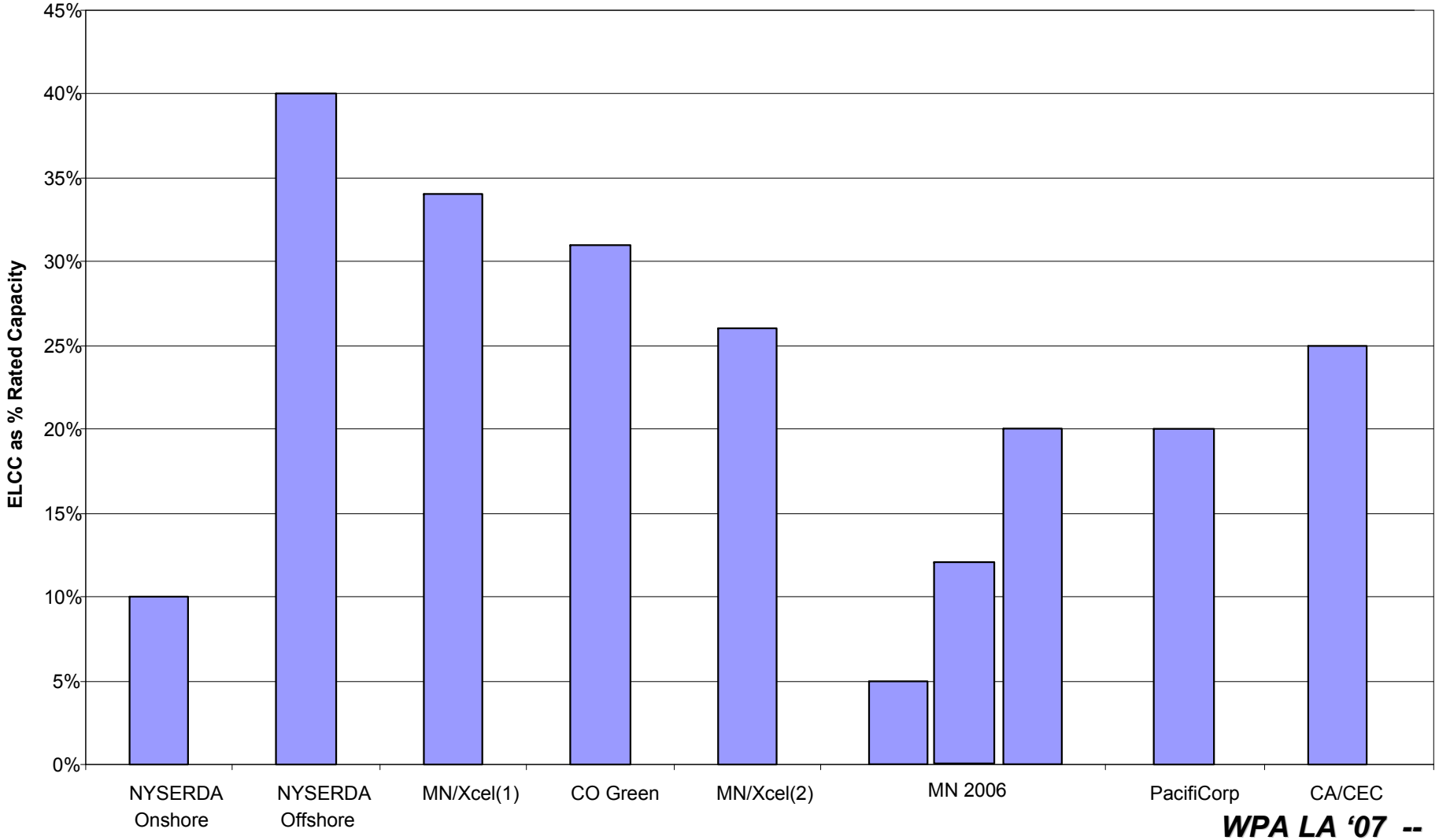
Increased Balancing Cost



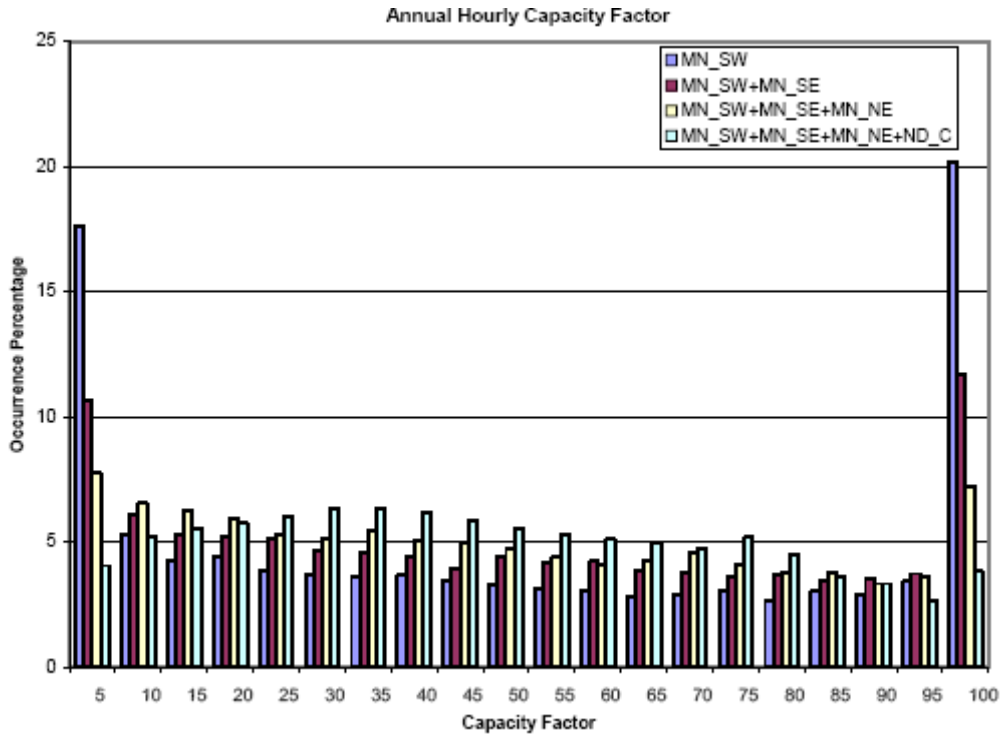
Forecasting and Balancing Markets Reduce Impacts



An Energy Resource in a Capacity World



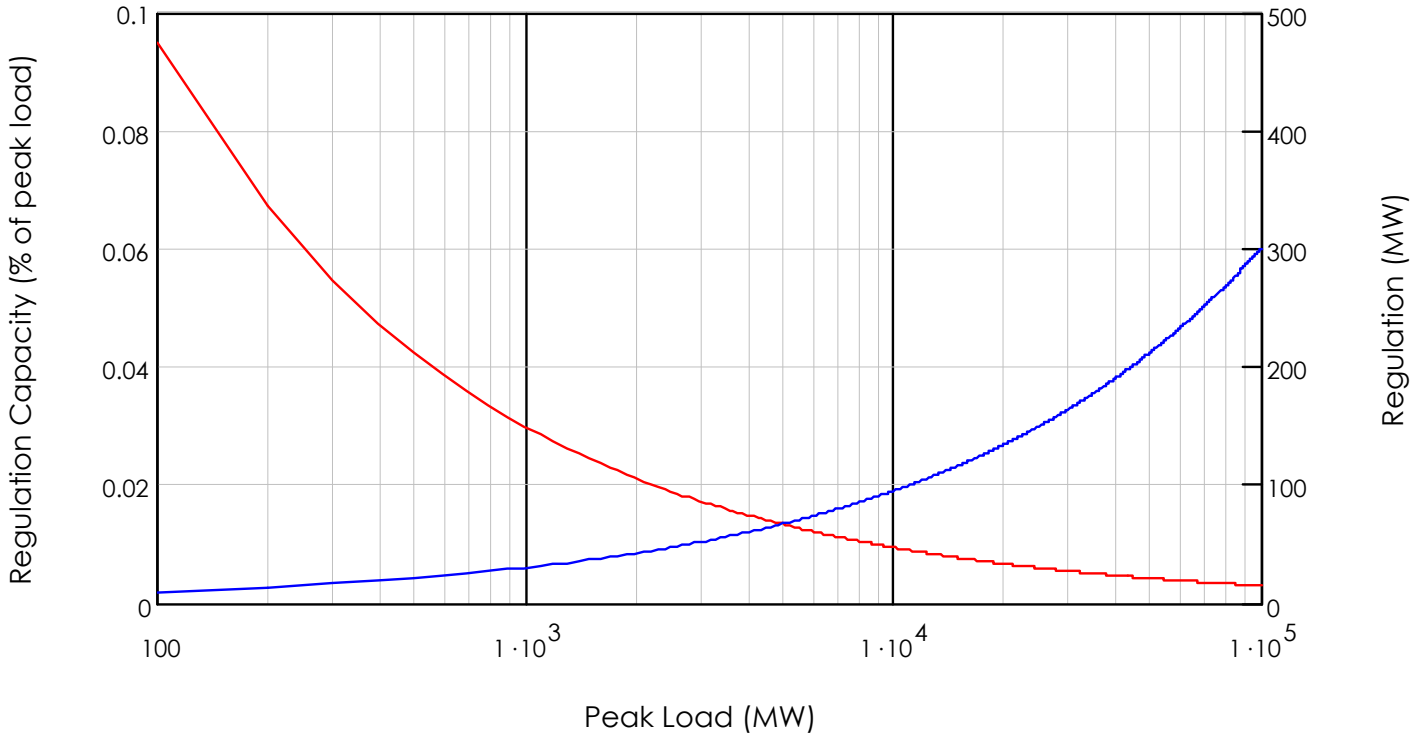
Aggregation Reduces Variability and Uncertainty



Annual histogram of hourly capacity factor for four levels of geographic dispersion.

Source: MN DOC

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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Transmission Issues

- Existing transmission system infrastructure is inadequate to achieve the vision
  - Insufficient capacity
  - Aging and congested
  - Reliability and operational flexibility concerns
- Current situation leads to inadequate generation competition
- 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 $7 billion/yr and growing

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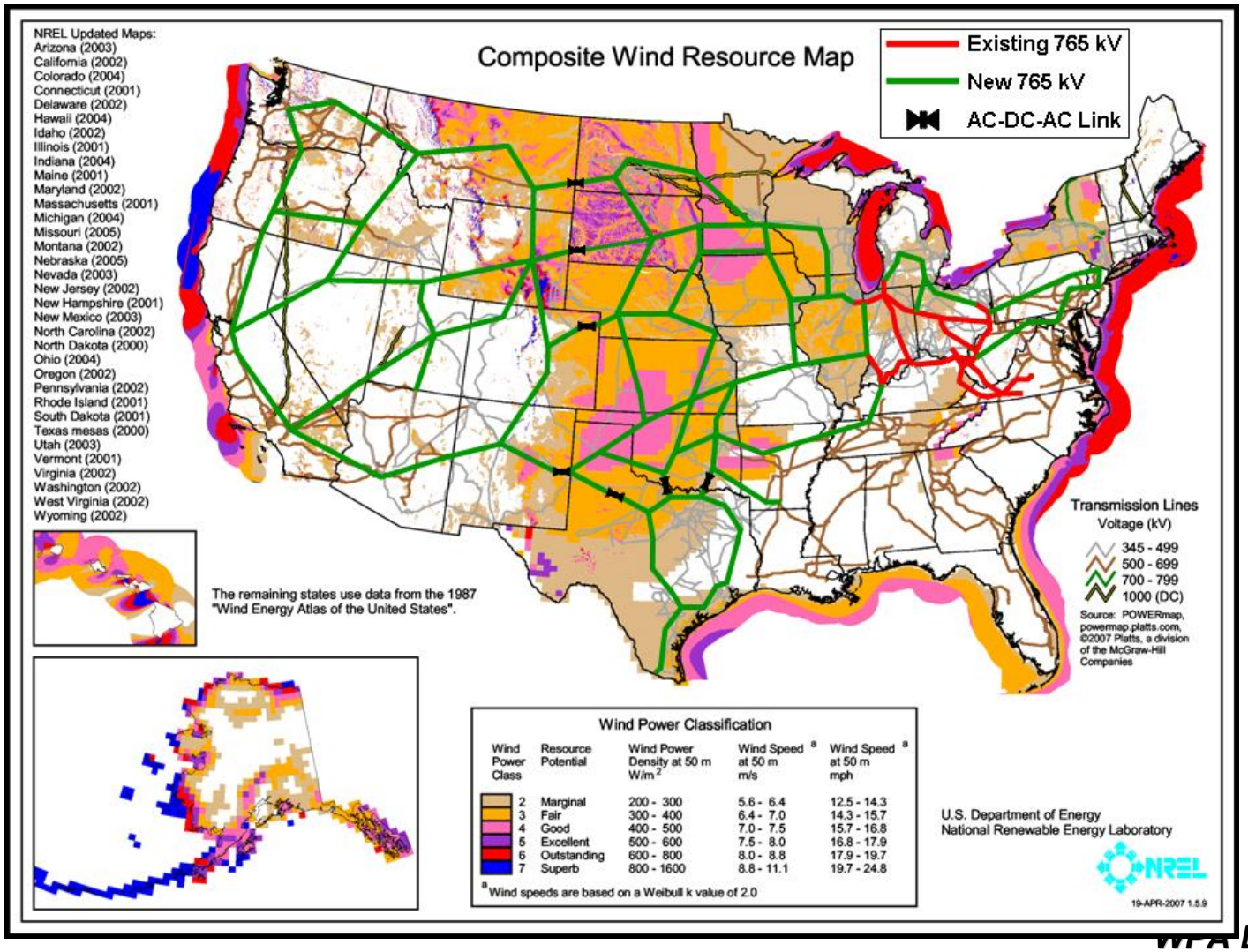
Conceptual EHV Transmission Overlay



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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
- Comprehensive regional planning processes
- Federal leadership in developing transmission in the national interest
- 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 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.