



Wind Energy and the Power System: An Interactive FAQ

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Wind Energy and the Power System: *Wind Power Myths Debunked*, from IEEE Power and Energy Magazine, Nov/Dec 2010

Webinar Jan 2010

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IEEE

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for electric power professionals



It's Growing Like Trees

An Update on Wind Integration

Wind & the Grid
The Challenges of Integration

Bold Effort in Vermont
1941 Smith-Putnam Wind Turbine



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- National Renewable Energy Laboratory
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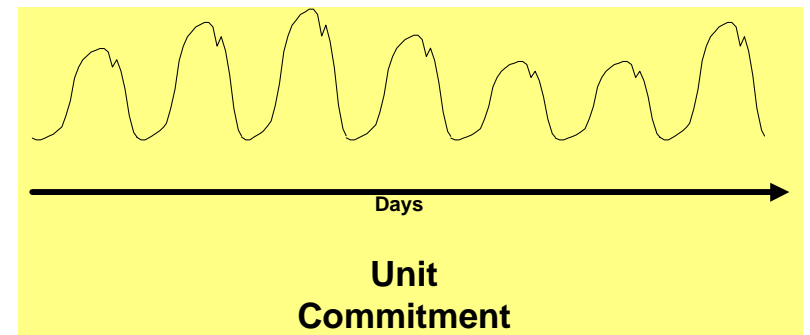
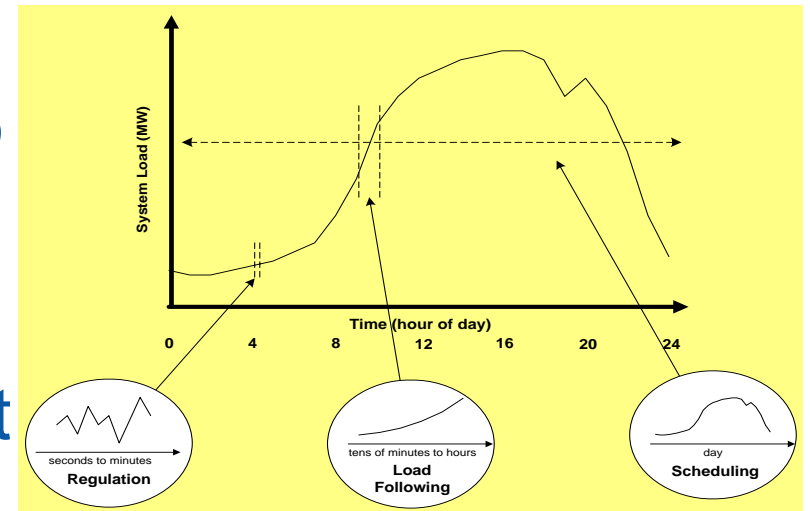
Large-Scale Wind Integration Studies

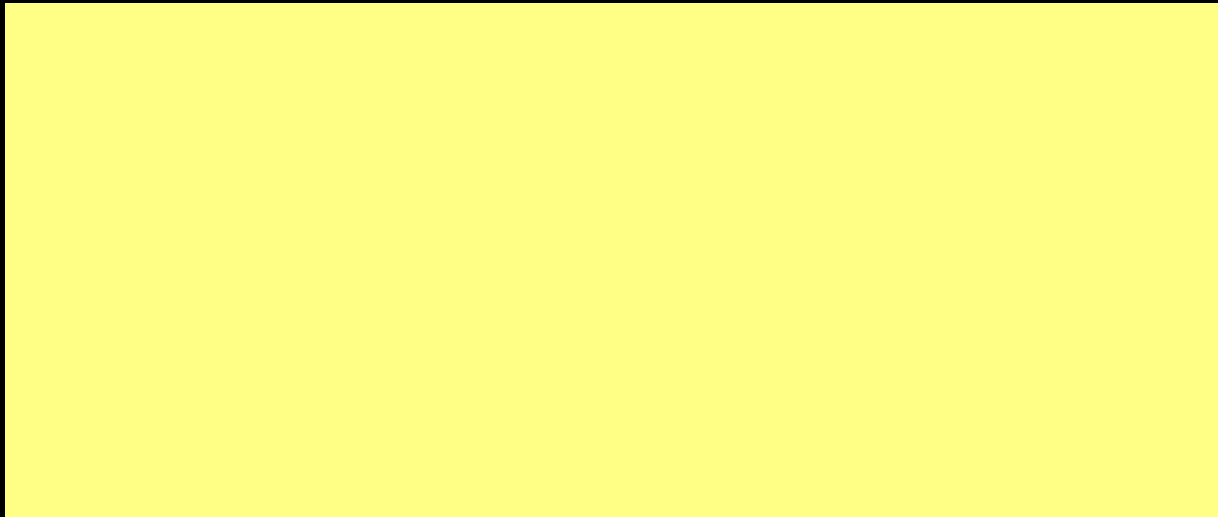
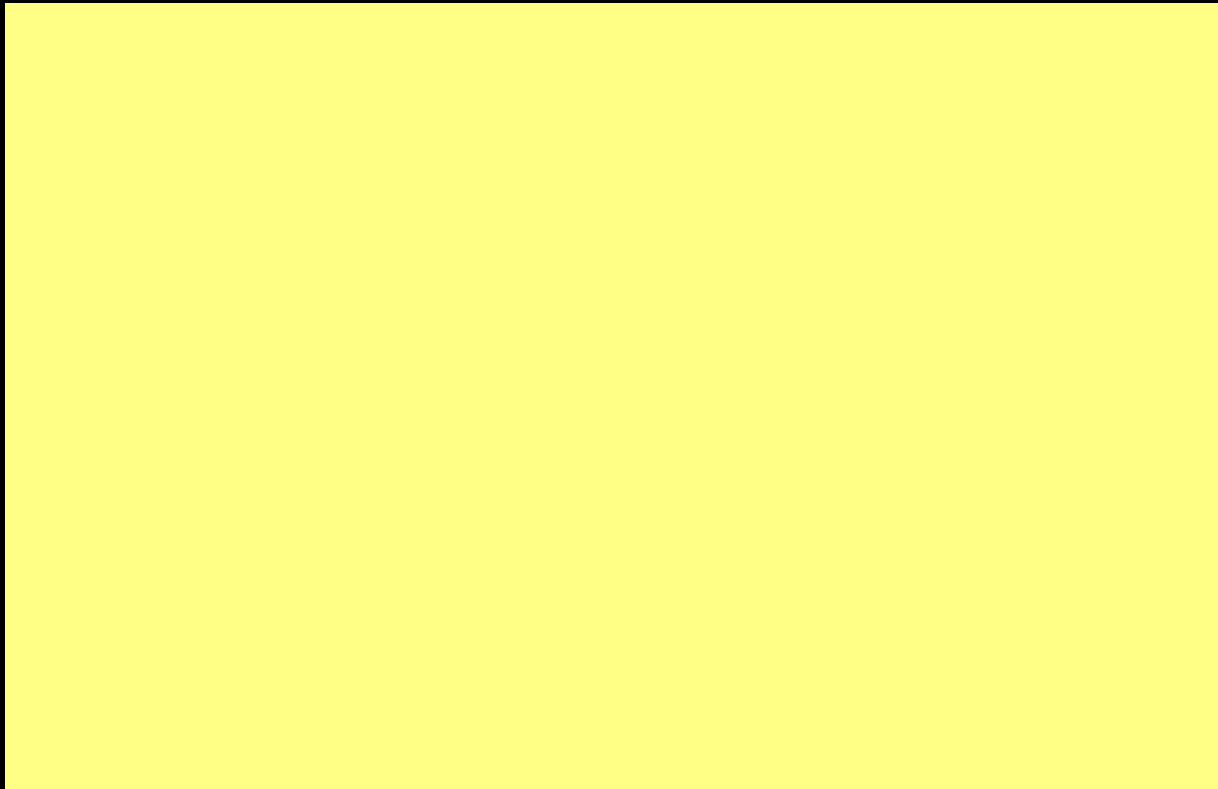
- Sponsored by US DOE, managed by NREL
- Eastern Wind Integration and Transmission Study, released Jan 20, 2010
- Western Wind and Solar Integration Study, to be released in Mar 2010

- Evidence from these studies is not included in the article or webinar, but supports the conclusions herein

Power System Basics

- Portfolio of different type of generators are managed so that the sum of all output = load at each moment
- Base-load generators run at constant output
- Intermediate/cycling units pick up daily load swings
- Peaking units are seldom run but provide peak capacity when needed

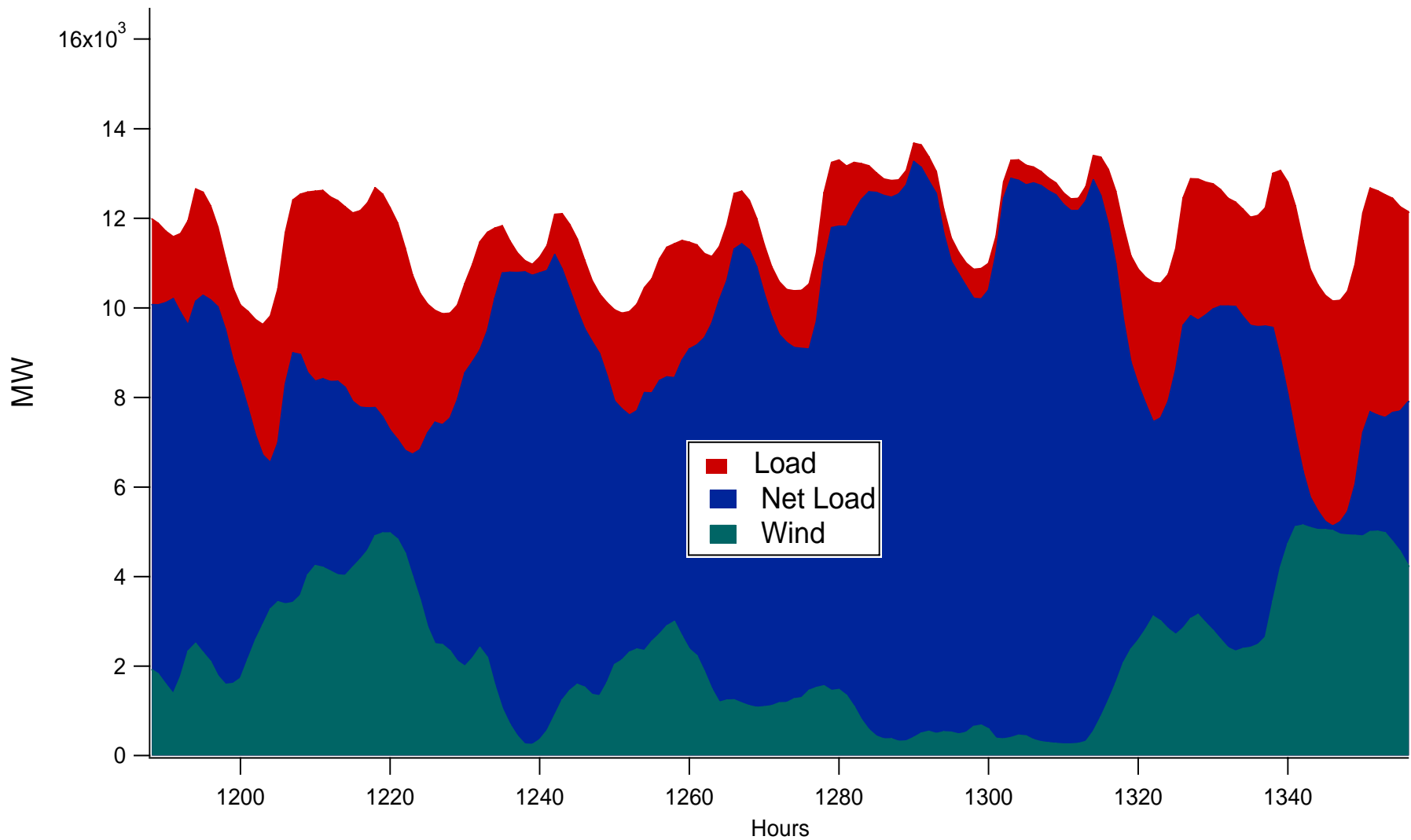




Power System Basics (cont)

- Extra generation – reserves – available in case of generator or transmission outage:
Contingency reserves
- Some generators can change output and are used to manage **variability** in load (demand)
- The demand for power is not known with certainty so may influence the level of reserves for managing this **uncertainty**
- Wind increases the level of **variability** and **uncertainty** that the power system operator must manage

Load-less-wind = net load



Wind Power Myths Debunked

- 1) Can grid operators deal with the continually changing output of wind generation?
- 2) Does wind have capacity credit?
- 3) Does the wind stop blowing everywhere at the same time?
- 4) To what extent can wind power be predicted?
- 5) Isn't it very expensive to integrate wind?

Wind Power Myths Debunked

- 6) Doesn't wind power need new transmission, and won't that make wind expensive?
- 7) Does wind power need back-up generation? Isn't more fossil fuel burned with wind than without, due to back-up requirements?
- 8) Does wind need storage?
- 9) Isn't all the existing flexibility already used up?
- 10) Is wind power is as good as coal or nuclear even though the capacity factor of wind power is so much less?
- 11) Is there a limit to how much wind can be accommodated by the grid?

Where did the questions come from?

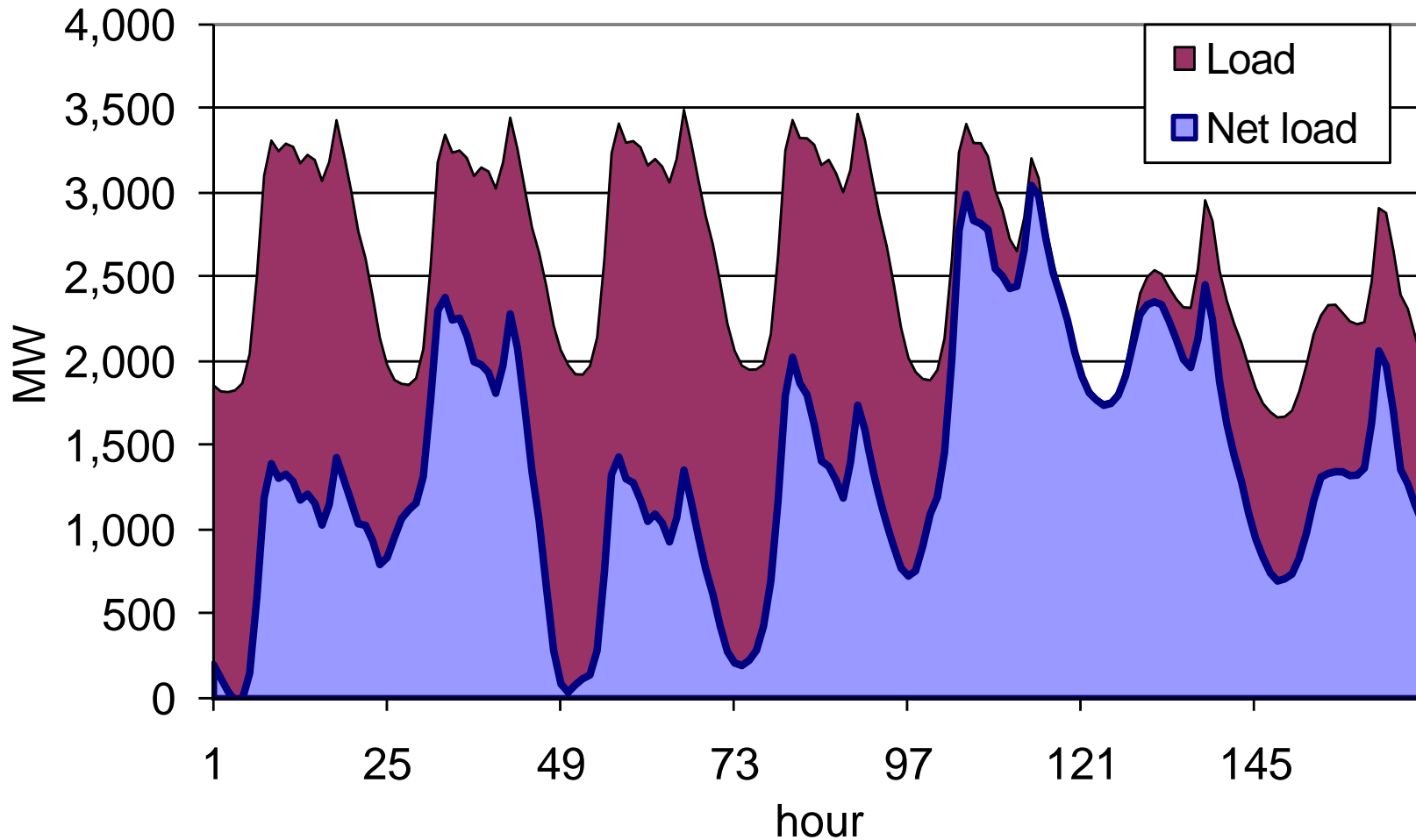
- International experience with wind integration
- Common questions

Where do the Answers Come From?

- Extensive analysis
 - Power system simulations that mimic real-time operations
 - Statistical analysis of wind and load data
 - Experience operating power systems with wind
- *International Energy Agency Task 25 Report: Design and operation of power systems with large amounts of wind power State of the art report.*
 - <http://www.vtt.fi/inf/pdf/tiedotteet/2009/T2493.pdf>
- Utility Wind Integration Group www.uwig.org
- NREL Systems Integration
 - <http://www.nrel.gov/wind/systemsintegration/>
 - <http://www.nrel.gov/publications>

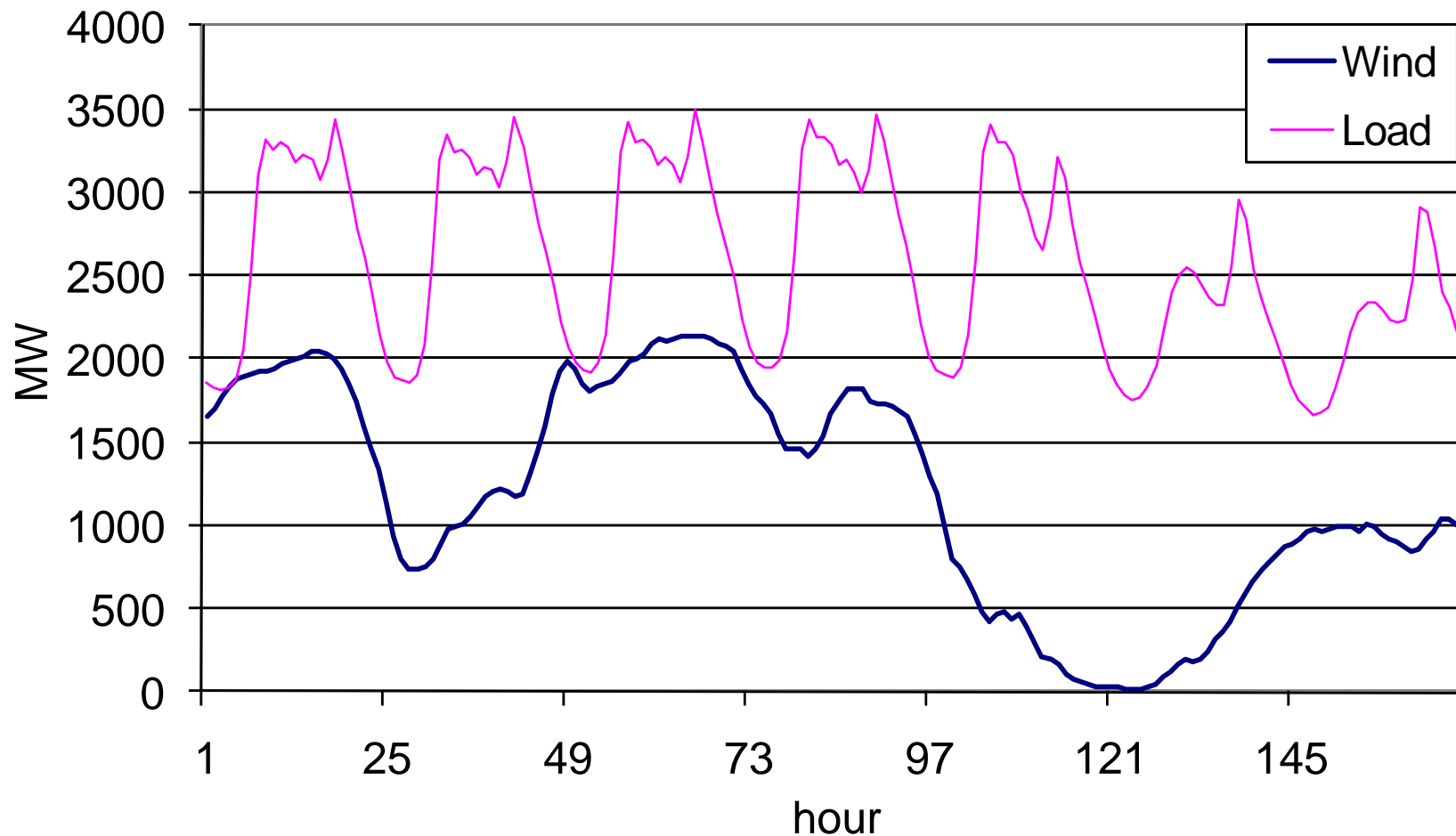
1) Can grid operators deal with the continually changing output of wind generation?

West Denmark January 10-16, 2005

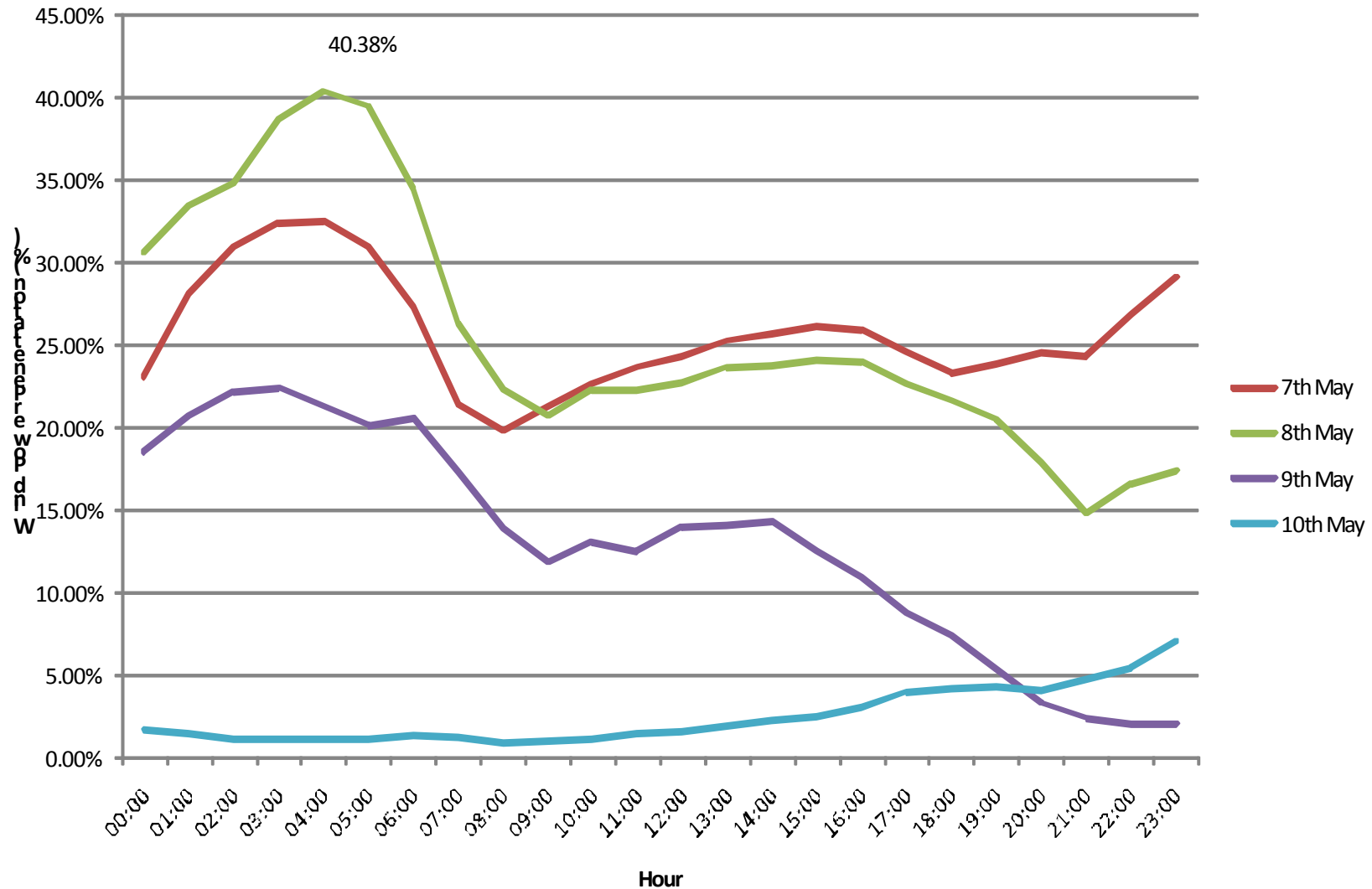


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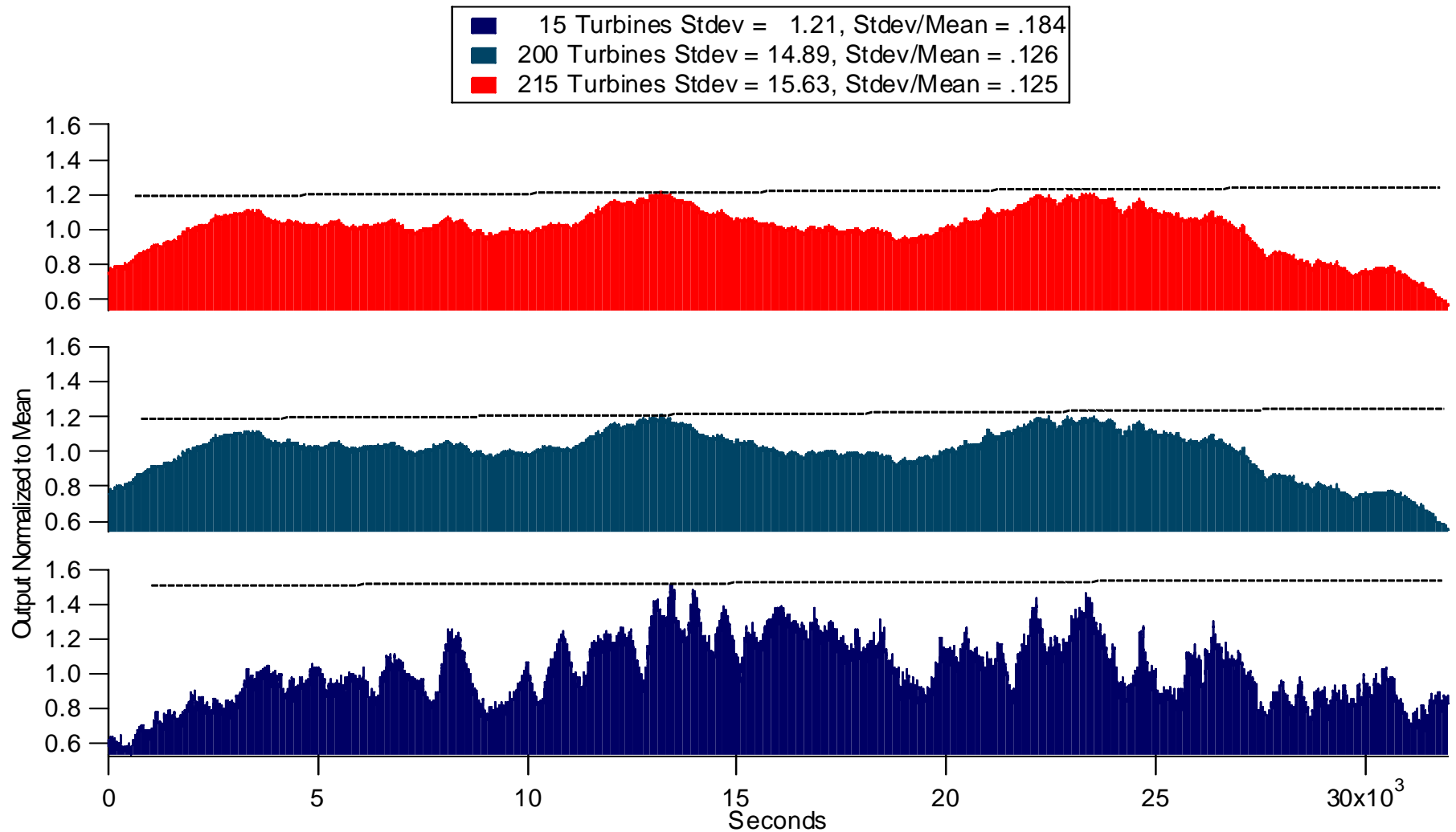
West Denmark January 10-16, 2005



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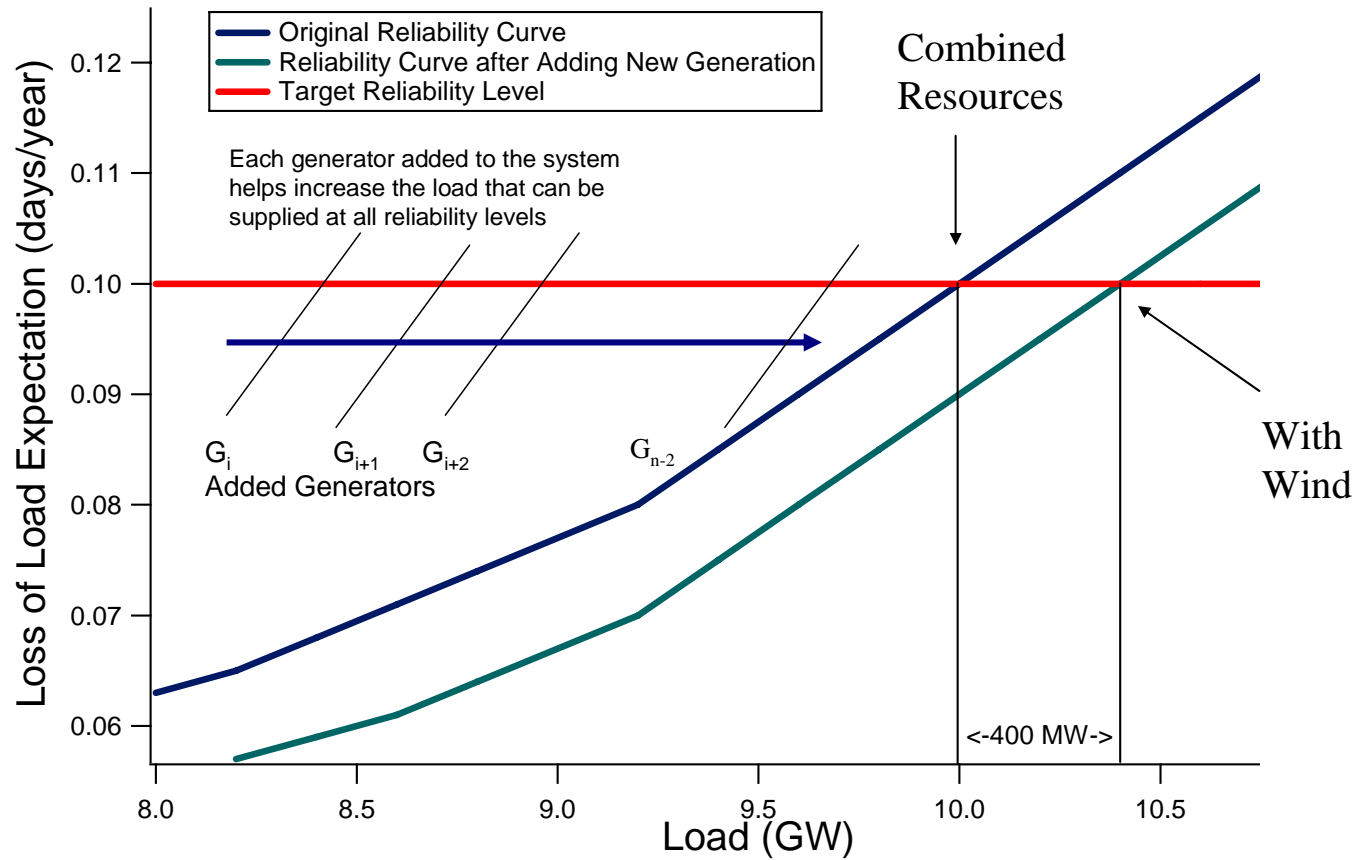


1) Can grid operators deal with the continually changing output of wind generation?



(Approximately 8 hours)

2) Does wind have capacity credit?

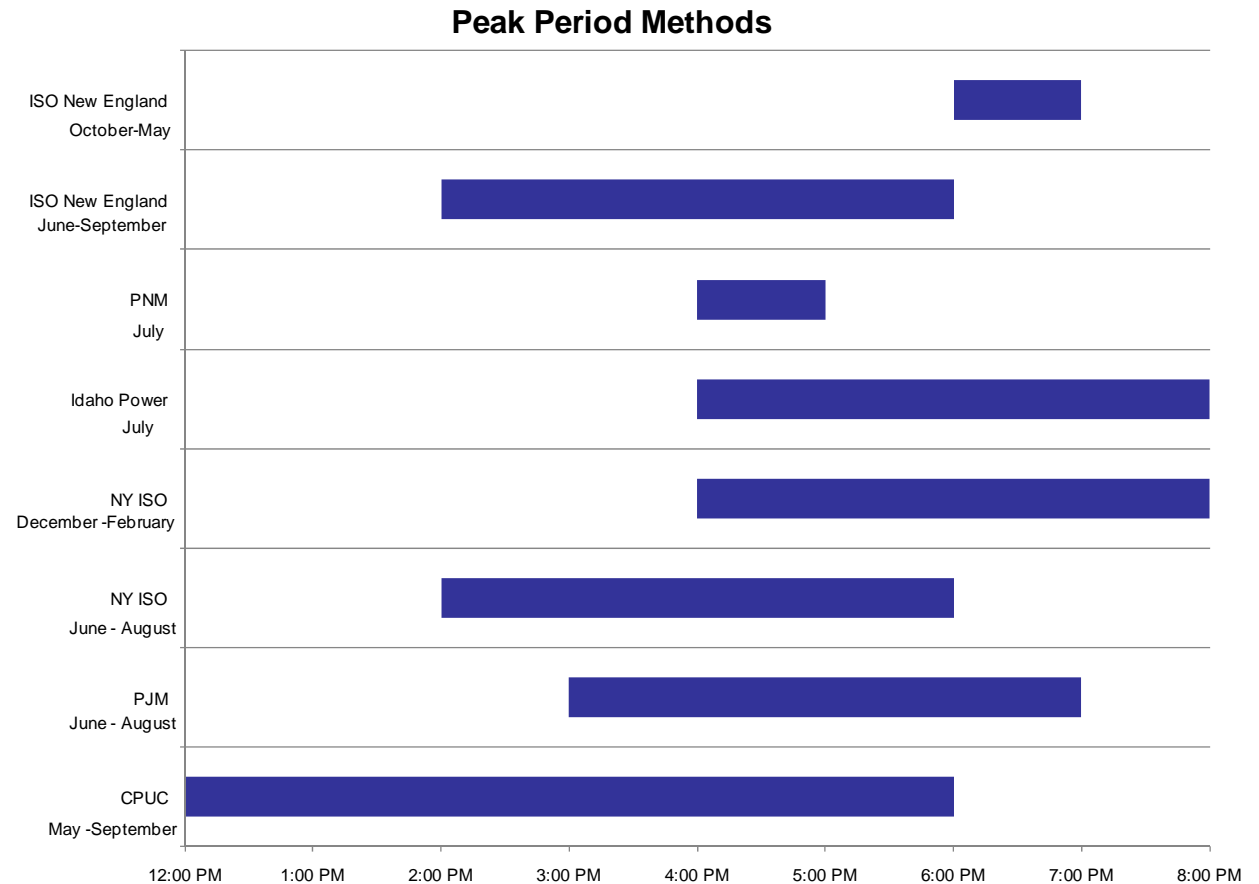


2) Does wind have capacity credit?

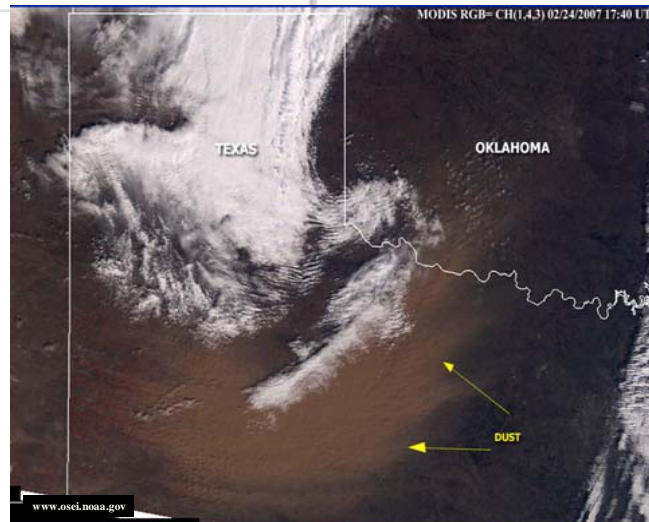
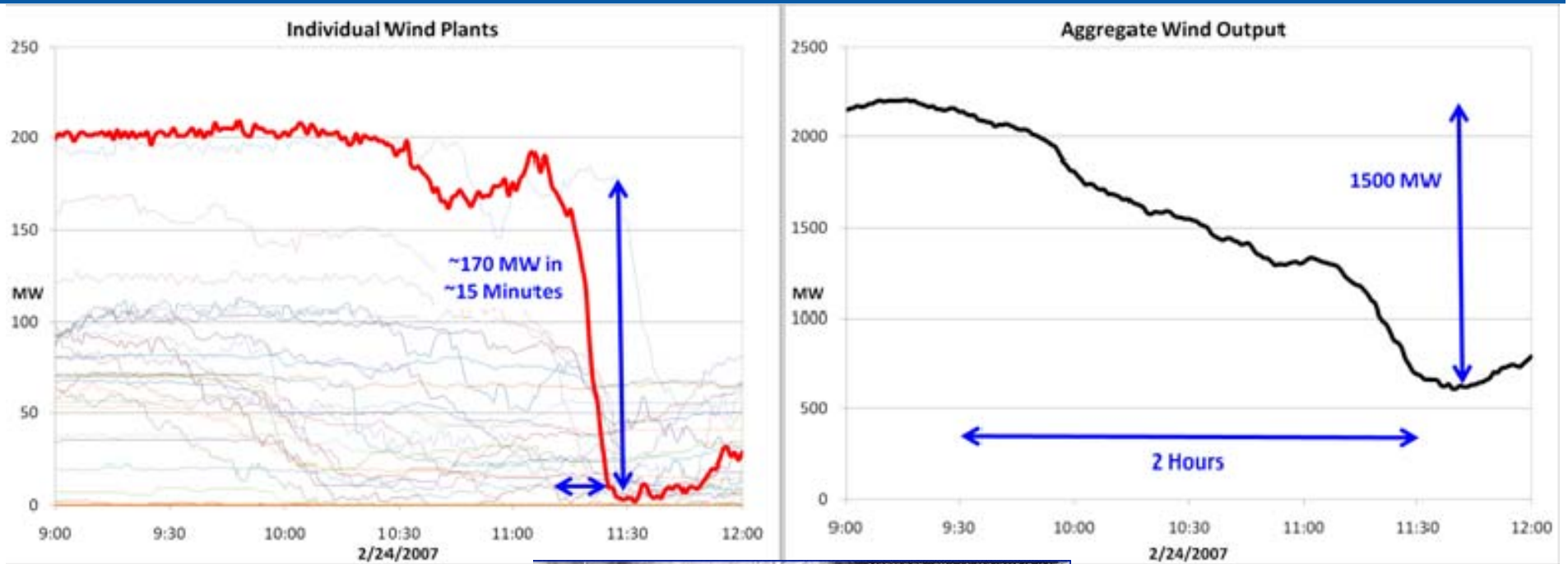
Wind is primarily an energy resource, but can make a small contribution to planning reserves

Depends on timing of wind energy vs. load characteristics

Range in the U.S. approximately 5%-40% of rated capacity

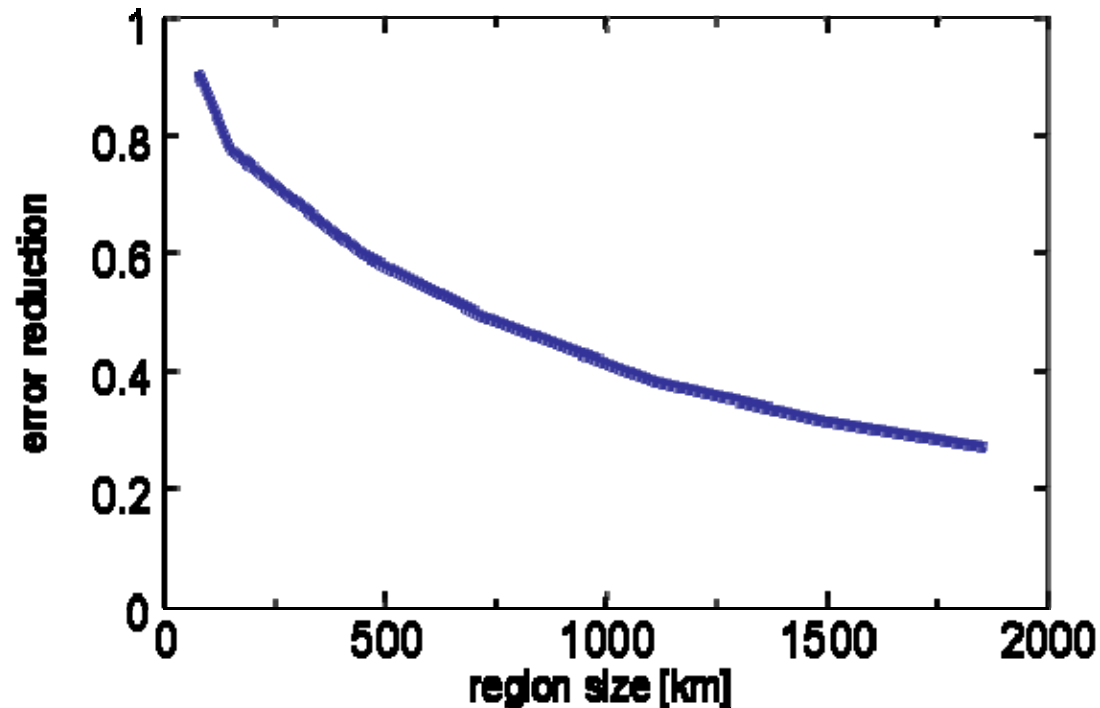


3) How often does the wind stop blowing everywhere at the same time?



4) To what extent can wind power be predicted?

- Easier to predict wind for short time steps
 - Errors ~5-7% MAE based on rated wind capacity
- More difficult day-ahead
 - Errors ~20% MAE
- Relative forecast errors are reduced for large geographic footprints (energy & meteo)



5) Isn't it very expensive to integrate wind?

Date	Study	Wind Capacity Penetration (%)	Regulation Cost (\$/MWh)	Load Following Cost (\$/MWh)	Unit Commitment Cost (\$/MWh)	Gas Supply Cost (\$/MWh)	Tot Oper. 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
June '06	CA RPS	4	0.45*	trace	na	na	0.45
Feb '07	GE/Pier/CAIAP	20	0-0.69	trace	na***	na	0-0.69***
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	4.60
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
Dec '06	MN 20%	31**					4.41**
Jul '07	APS	14.8	0.37	2.65	1.06	na	4.08

* 3-year average; total is non-market cost

** highest integration cost of 3 years; 30.7% capacity penetration corresponding to 25% energy penetration; 24.7% capacity penetration at 20% energy penetration

*** found \$4.37/MWh reduction in UC cost when wind forecasting is used in UC decision

5) Isn't it very expensive to integrate wind?

- Primary cost comes from additional operating reserve and impacts on non-wind generation operations
- Additional reserve is not constant throughout the year: it depends on what the wind and load are doing
- Wind's variability combines with the variability of load
- Small balancing areas will normally find it more difficult and costly to integrate wind than larger balancing areas
- Sub-hourly energy markets can help manage variability

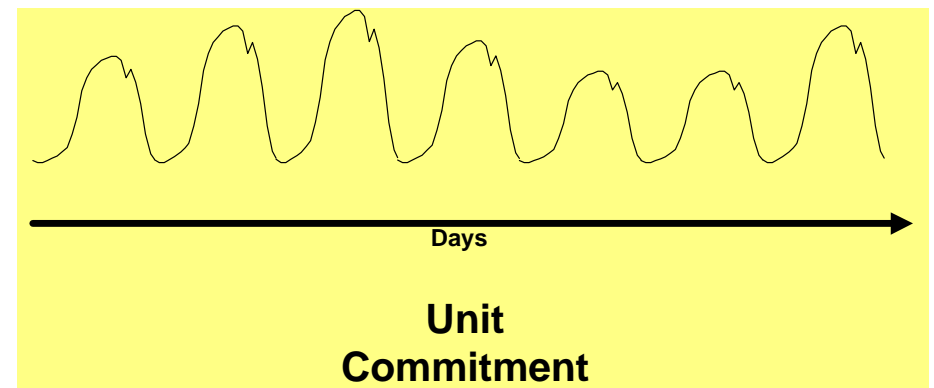
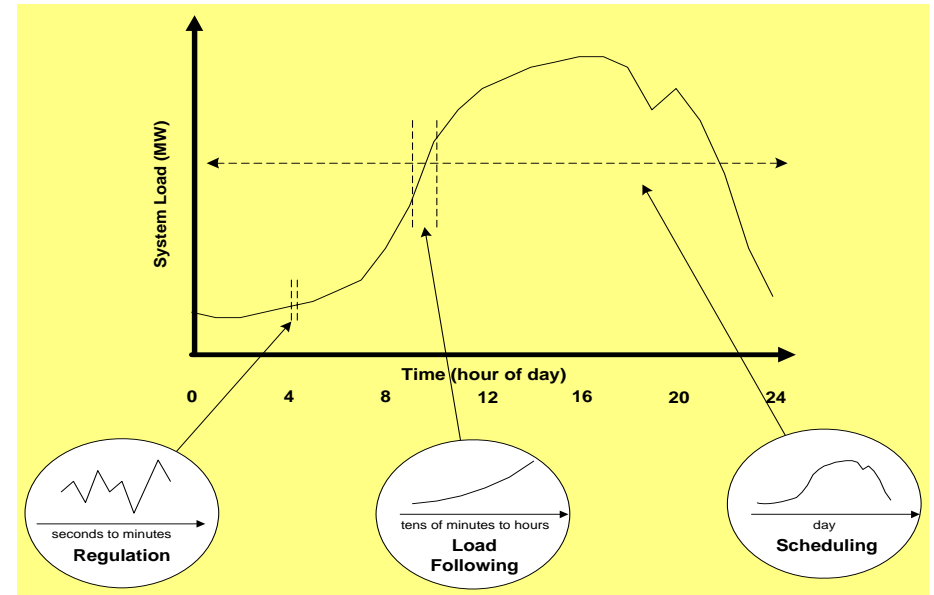
6) Doesn't wind power need new transmission, and won't that make wind expensive?

- Transmission is needed for most new generation sources
- Joint Coordinated System Plan found benefit/cost ratio of 1.7/1 for transmission that would support a 20% wind energy penetration. Transmission was 2% of the wholesale energy cost.
- Consumers often will benefit by lower energy costs
- Transmission build-out can reduce the need for new generation



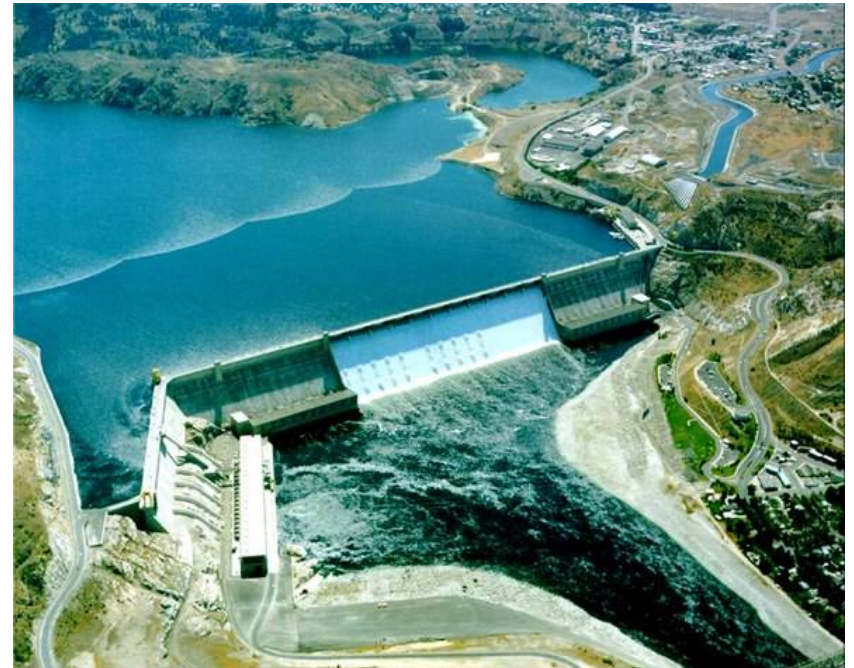
7) Does wind power need back-up generation? Isn't more fossil fuel burned with wind than without, due to back-up requirements?

- Total load must be met by a combination of generation
- Individual generators are not backed up: but reserves are provided on a system basis
- Wind will displace generation, freeing up that generation to provide reserves (if economic)
- Generators that change dispatch as a result of wind may have reduced efficiency, but total fuel burn and emissions will decrease



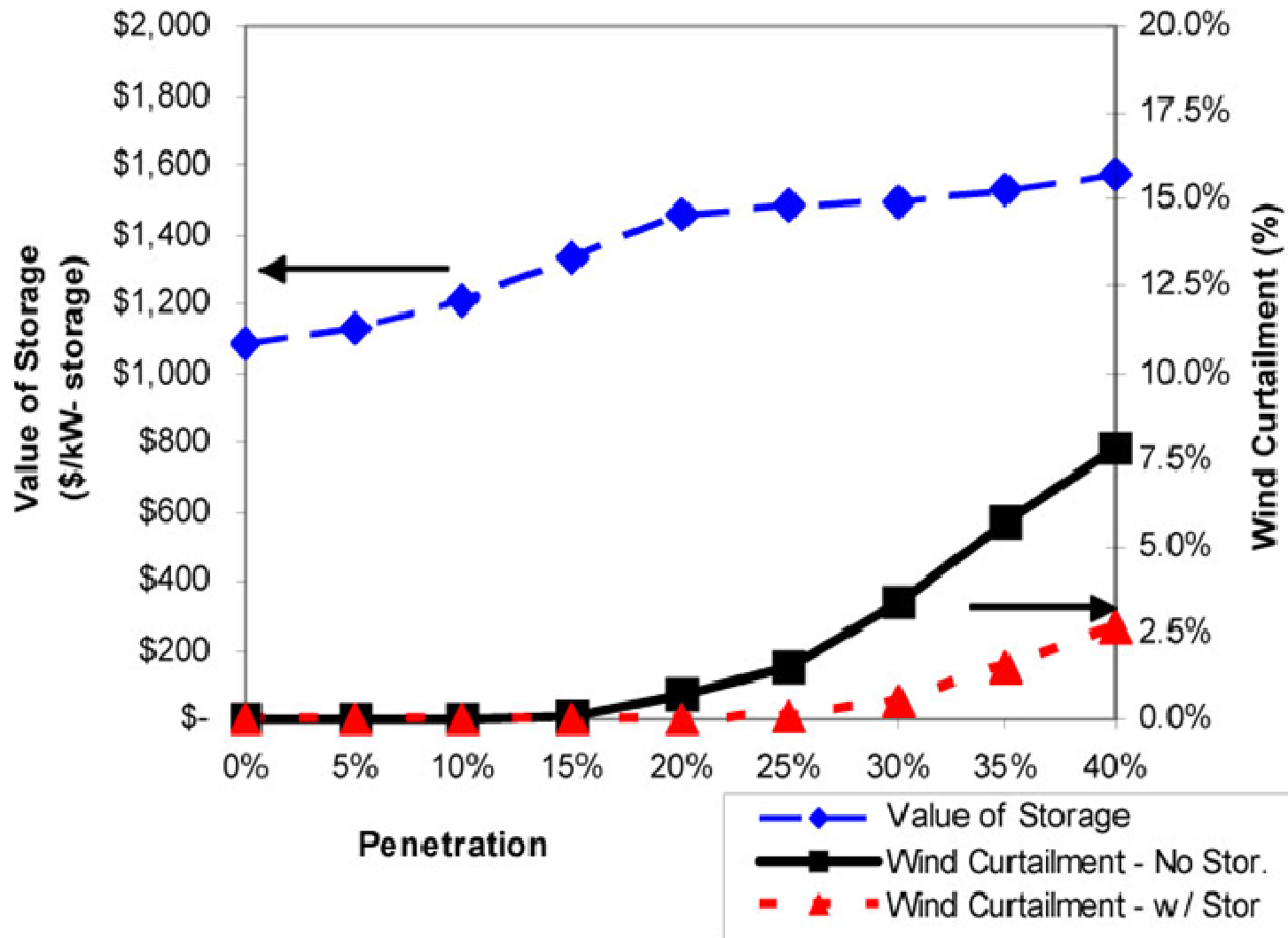
8) Does wind need storage?

- Storage is always useful, but may not be economic
- Detailed simulation of power system operation find no *need* for storage up to 30% penetration
- Experience with more than 31,000 MW of installed wind in the US shows no *need* for storage
- However: storage is very beneficial with and without wind
- Depends on cost-benefit

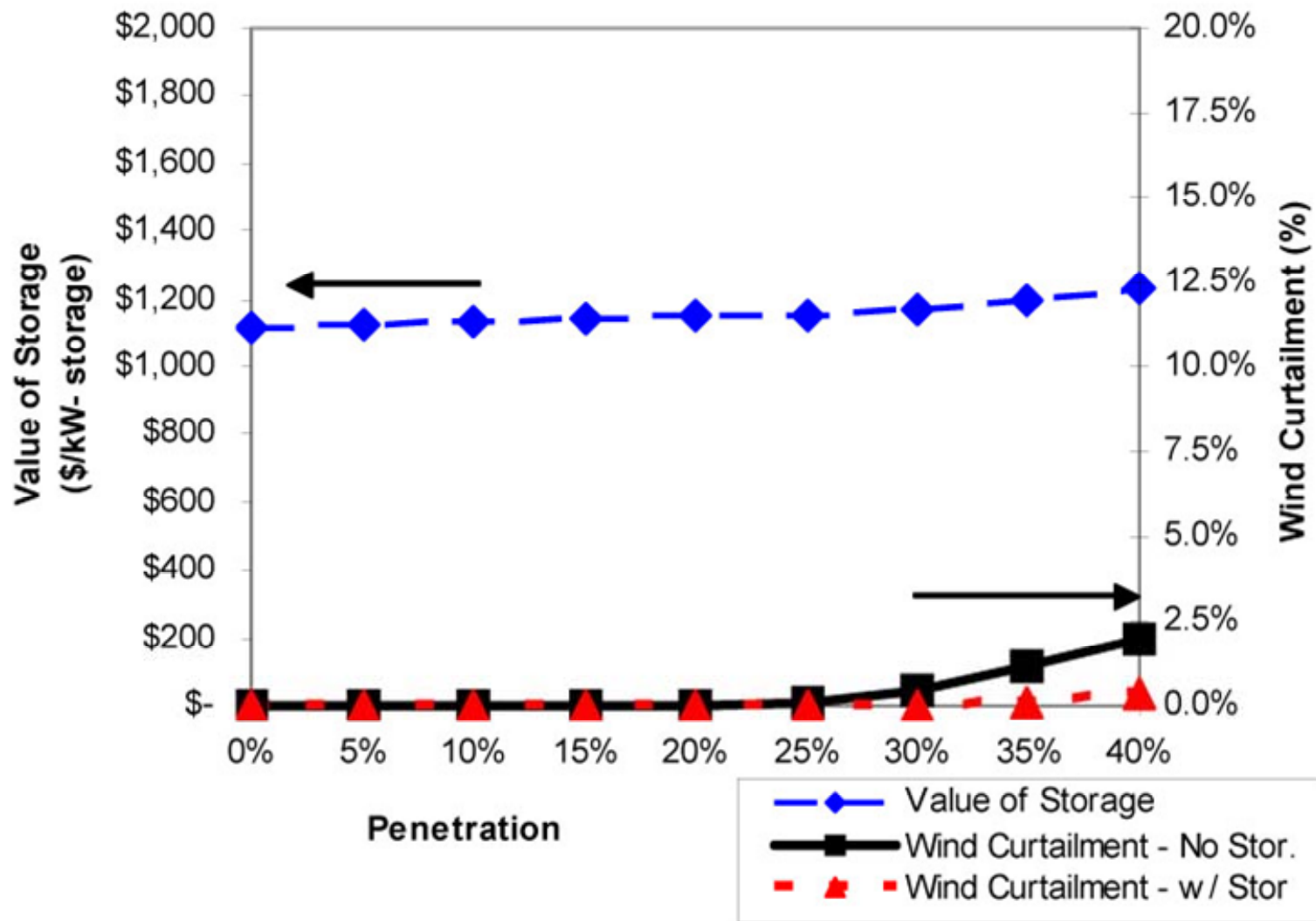


Large-scale studies (EWITS and WWSIS) do not find a need for storage at wind penetrations up to 30% of all electricity, although storage does have value

8) Does wind need storage?



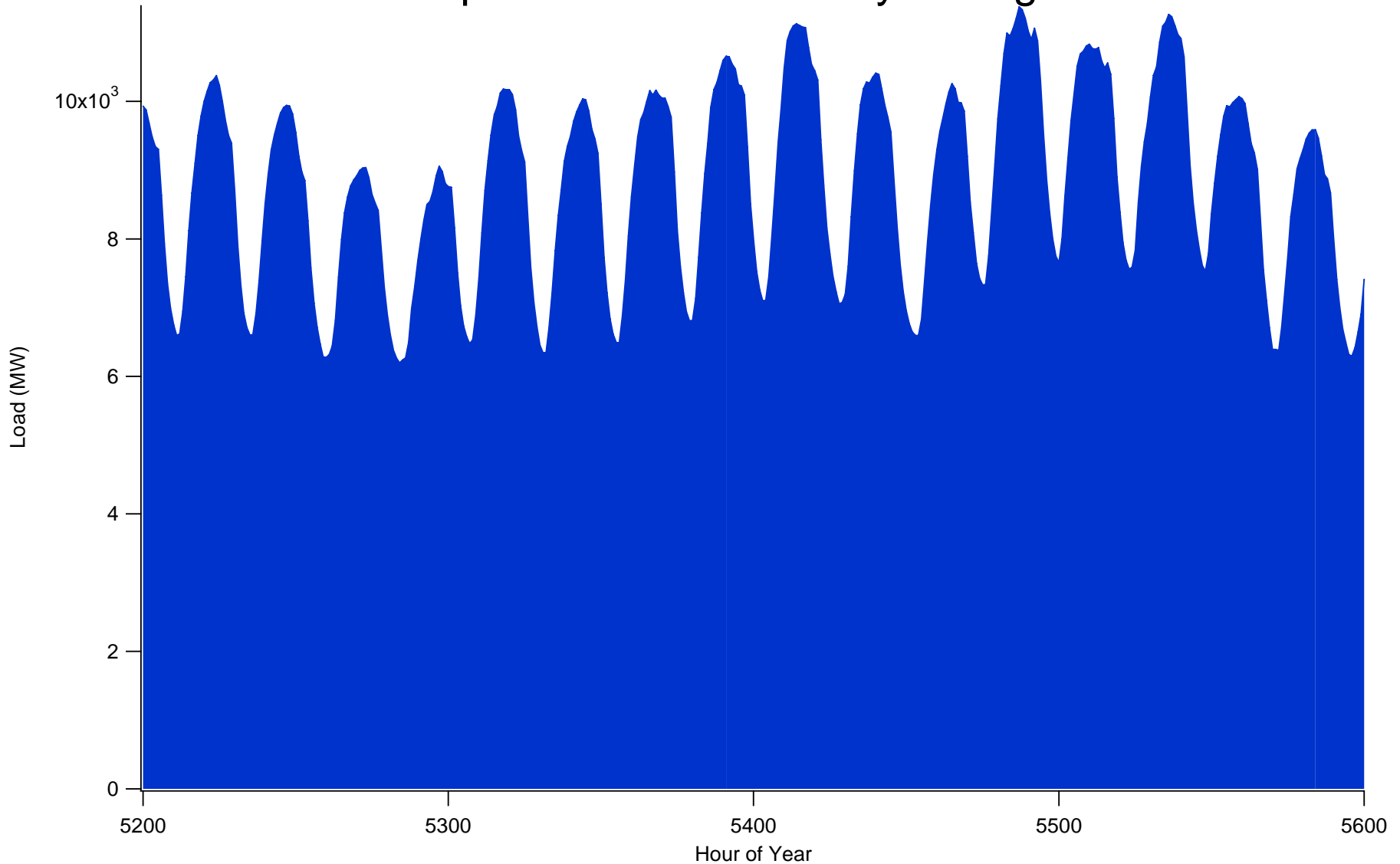
Value of storage with current resource mix.



Value of storage with new flexible resource mix.

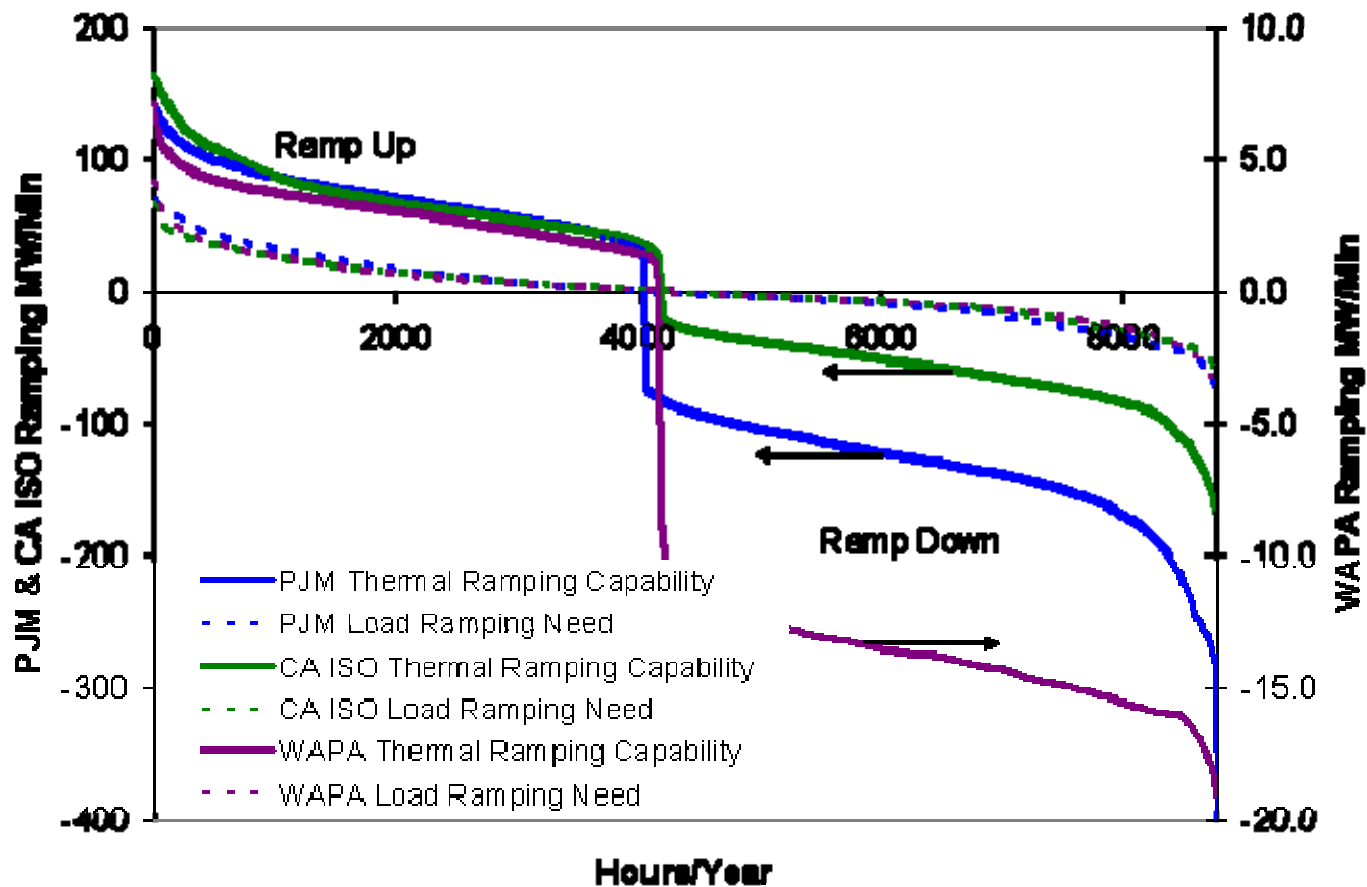
9) Isn't all the existing flexibility already used up?

Load requires a lot of flexibility from generators



9) Isn't all the existing flexibility already used up?

Analysis of 3 different balancing areas showed that all 3 have excess load-following capability inherent in the conventional thermal generation mix

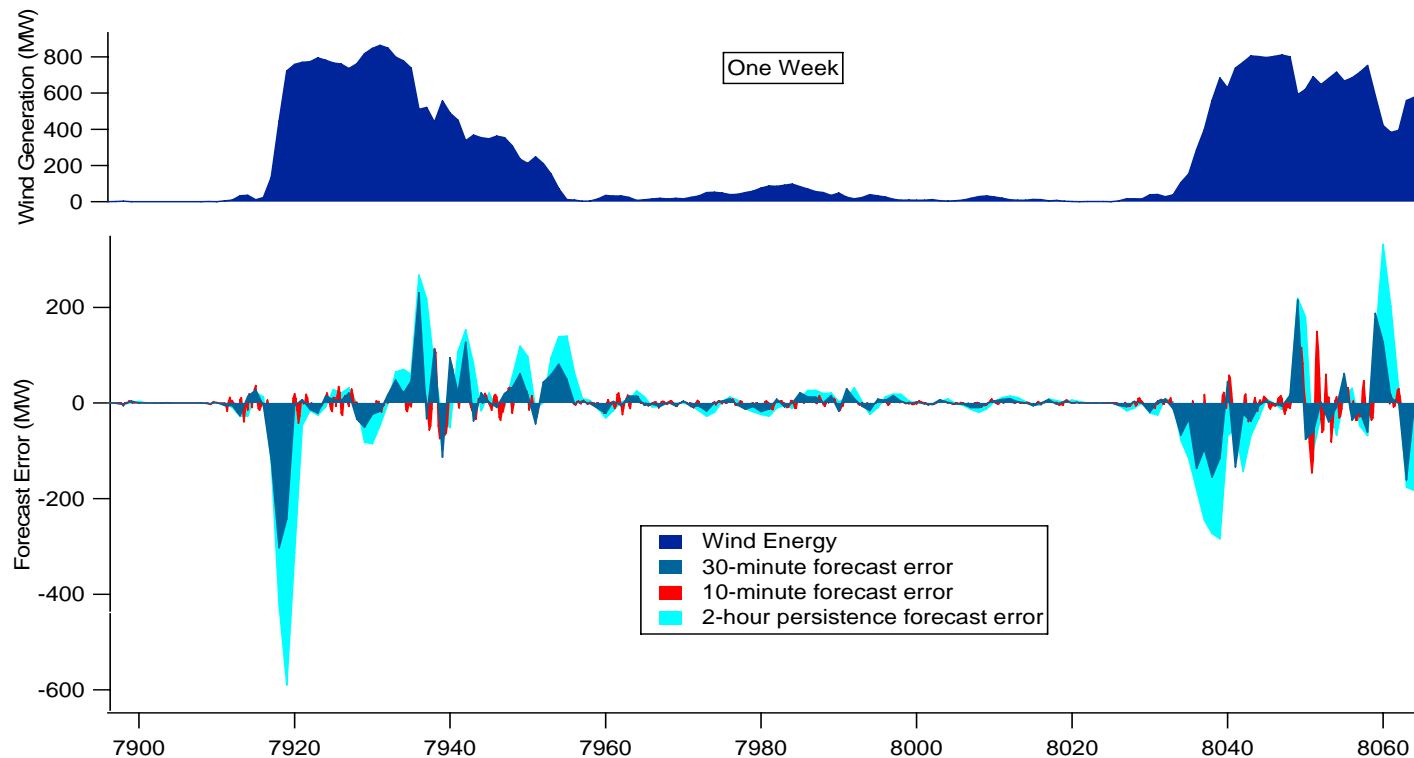


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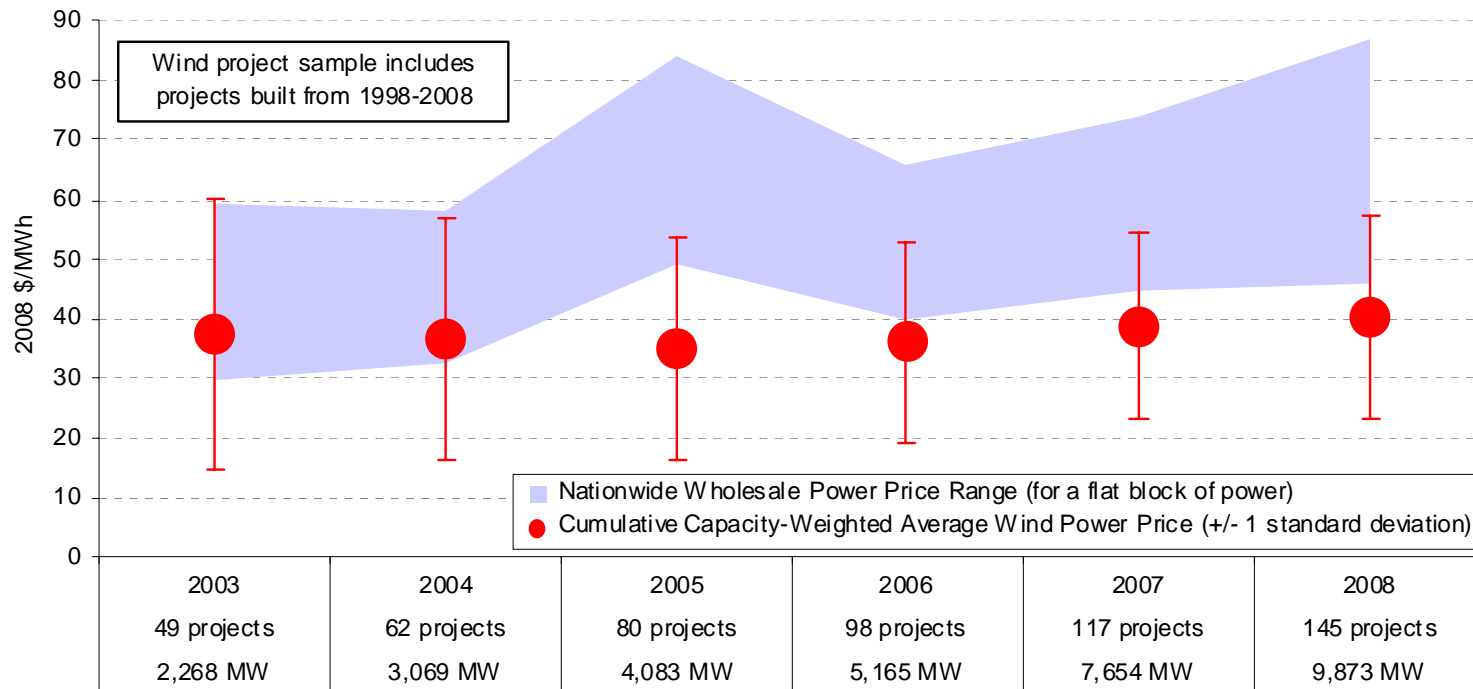
- Additional sources of flexibility may be needed at high penetration rates
 - newer types of generation: CTs, reciprocating engines
- Institutional flexibility
 - Fast energy markets
 - Sub-hourly scheduling protocols with neighboring balancing areas
- Demand response
- Plug-hybrid vehicles in the future

9) Isn't all the existing flexibility already used up?

- Impact of Inter-BA Wind With Slow Schedule Response
- Extra installed capacity is required in the host BA, increasing costs for all
- Larger imbalances and costs will be incurred
- Scheduling inefficiencies restrict units that can respond
- ***Solution: fast scheduling (~5 minutes) between balancing areas***

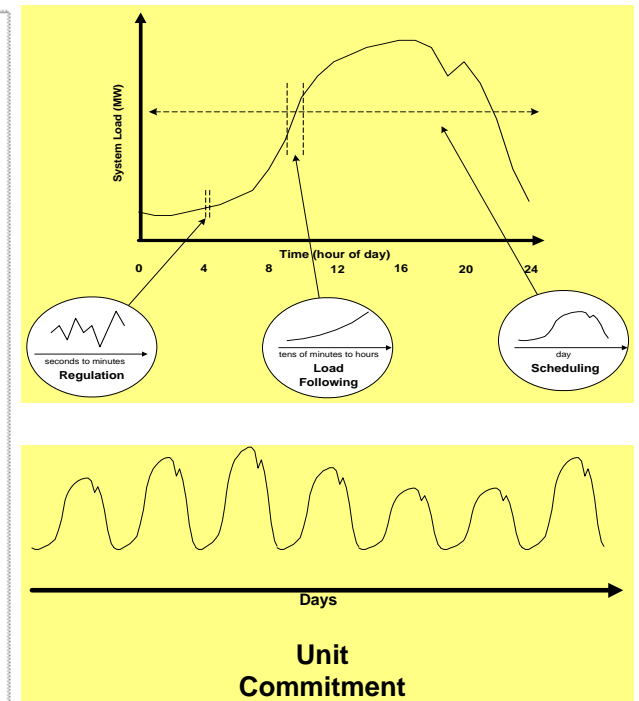
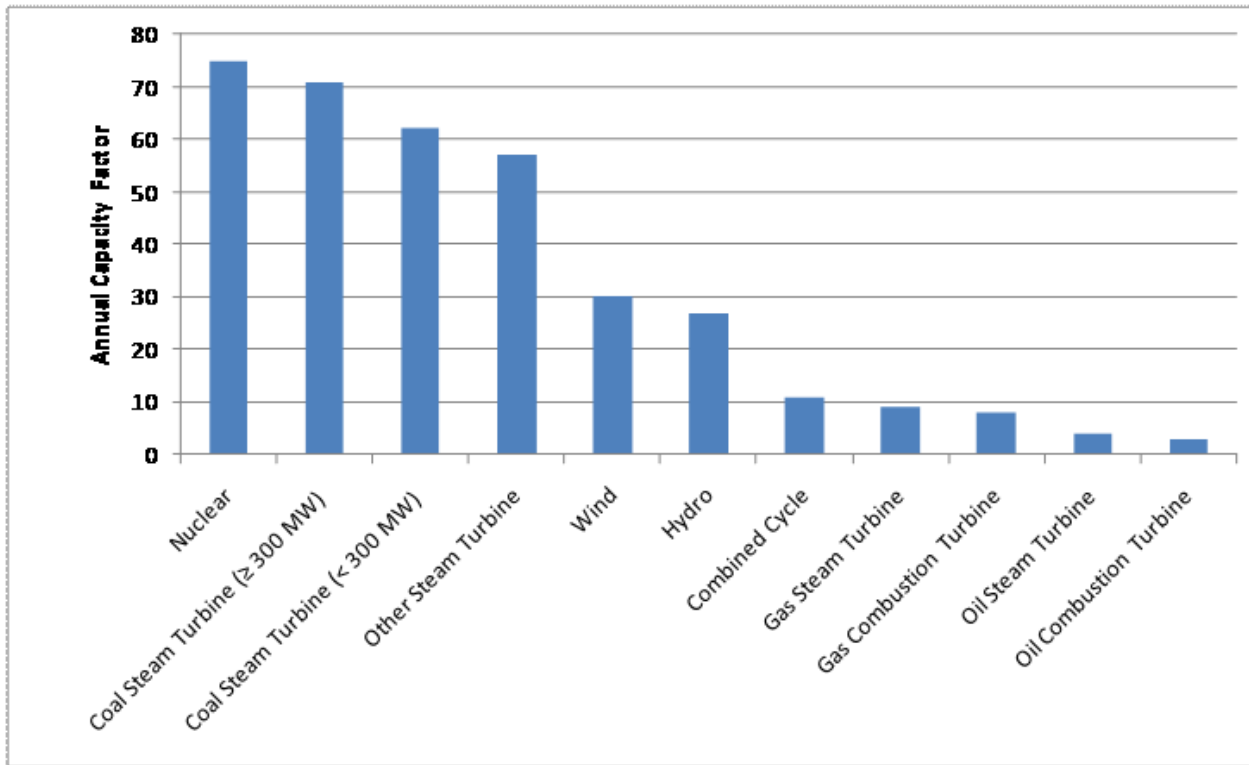


10) Is wind power is as good as coal or nuclear even though the capacity factor of wind power is so much less?



Average Cumulative Wind and Wholesale Power Prices Over Time. Source: Wisner, Ryan and Mark Bolinger. *Annual Report on U.S. Wind Energy Markets: 2008*. U.S. Department of Energy, <http://www1.eere.energy.gov/windandhydro/pdfs/46026.pdf>.

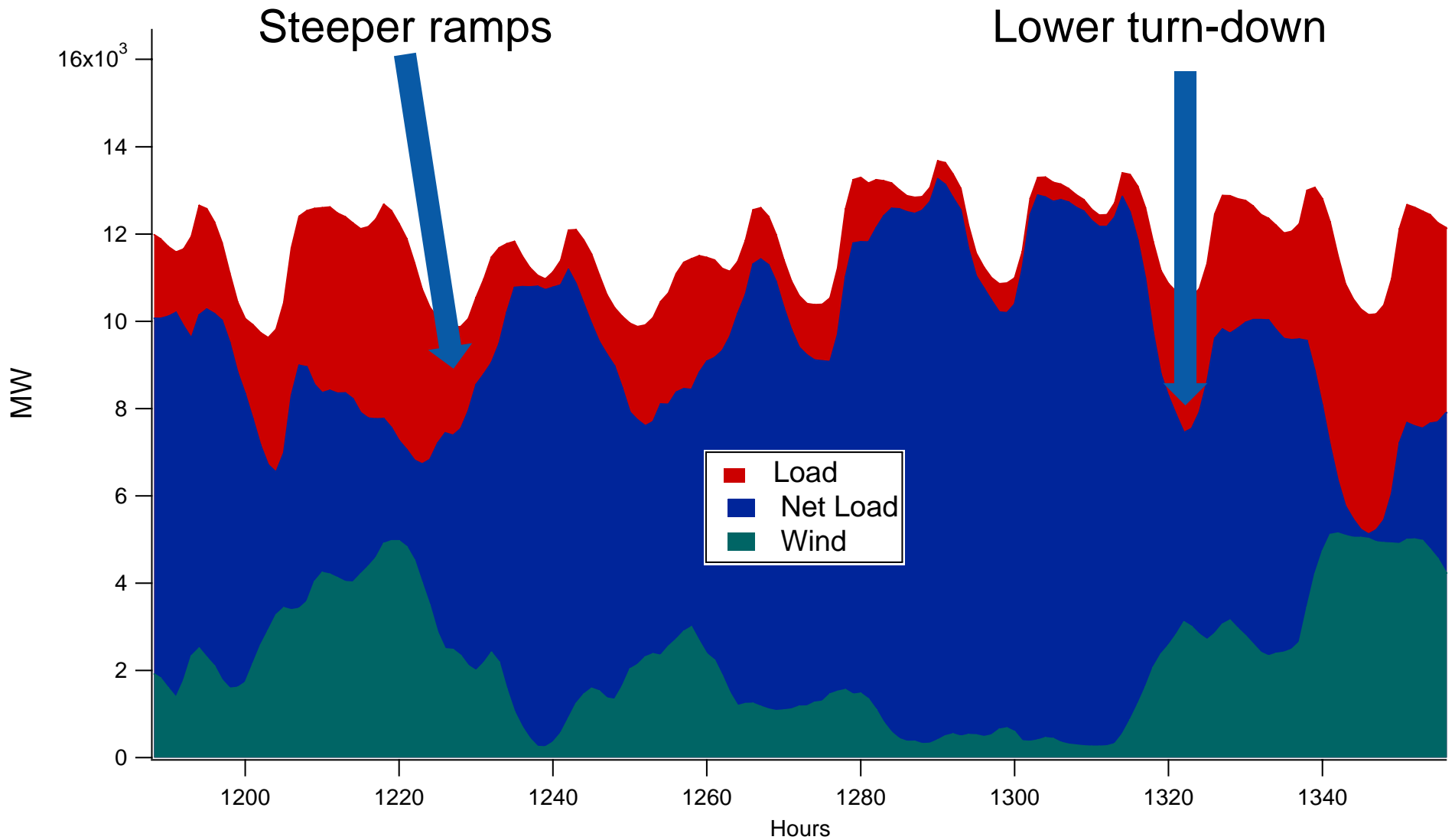
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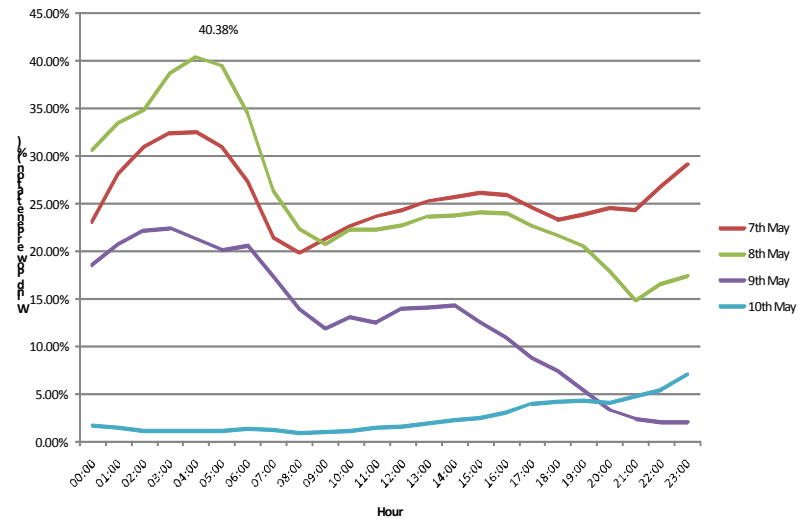
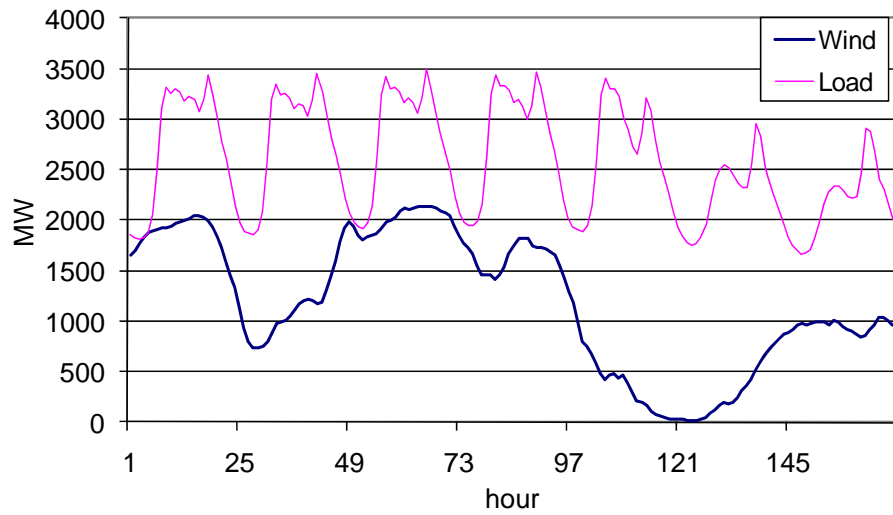
Midwest ISO Plant Capacity Factor by Fuel Type (June 2005–May 2006)

11) Is there a limit to how much wind can be accommodated by the grid?

- Studies done so far in the U.S. have not identified a physical limit, up to 30% energy penetration
- However, changes in standard operational and planning techniques may need to change
 - Larger electrical footprints for system balancing
 - Sub-hourly dispatch within balancing areas
 - Sub-hourly scheduling *between* balancing areas
 - More flexible generating technology
 - Fast ramp
 - Low turndown
 - Quick startup
 - Responsive load
 - Incorporation of wind forecasts into standard operations



West Denmark January 10-16, 2005



Summary

- Wind energy adds additional variability and uncertainty to power systems operations
- New methods for planning and operating the system may be needed to achieve higher penetration rates
- Much analysis is ongoing to address operational and planning issues

Questions?





Thank You!

Please submit your questions on the toolbar on your screen.

Note: The presentation will be made available after the webinar.

