Wind Power Impacts on Electric System Operating Costs

UWIG 2003 Technical Wind Workshop
Utility Wind Integration
Seattle, Washington
October 24, 2003

we energies

We Energies Renewable Energy Commitment

- Target of 5% of our retail electric sales to come from renewable energy sources by 2011 (1,500 GWh/yr)
- Formation of “Renewable Energy Collaborative”
- Have signed Power Purchase Agreements for 214 MW of wind.

Contracts for 214 MW of Wind

- 20 year contracts signed in July 2003
- Navitas/GAMESA: 160 MW - 2 sites
- Midwest Wind Energy: 54 MW - 1 site
- 1.5 - 1.8 MW wind turbines
- Sites in southeast WI
- Projected on line in 2005

Key Issues For Wind Projects

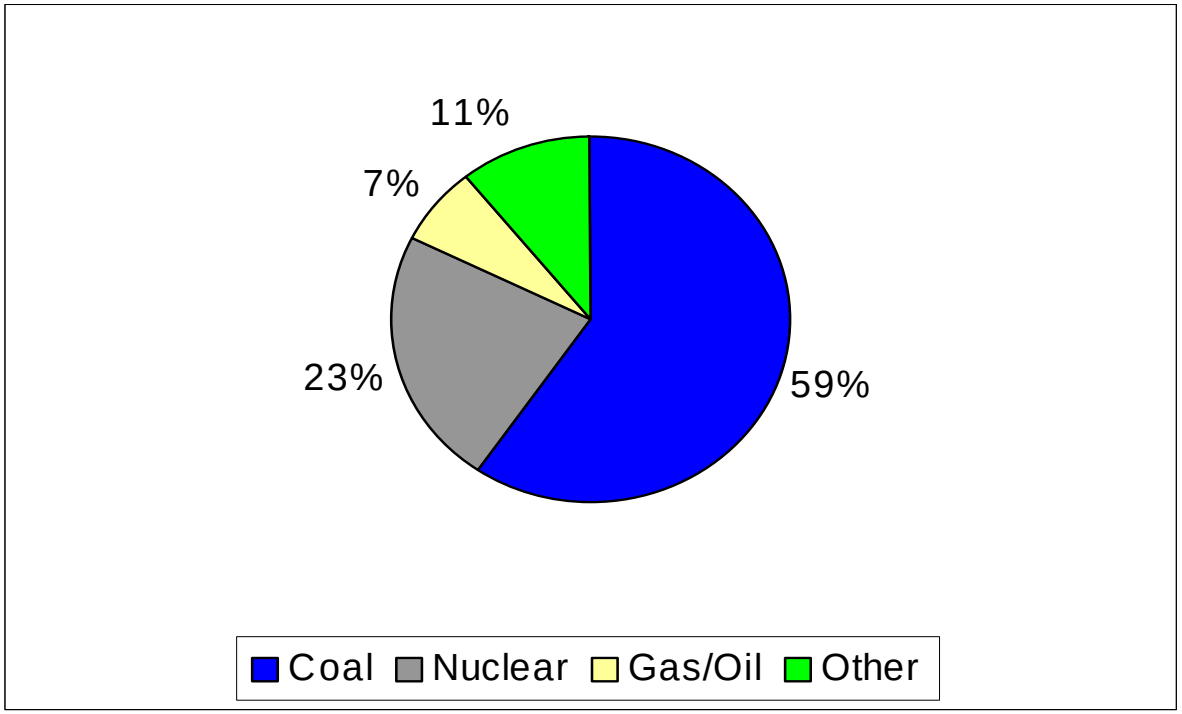
- Federal Production Tax Credit
- Transmission
- Siting Approval
- Price
- Capacity Value
- Wind Integration Issues

Electrotek Wind Integration Study June 2003

- Objective - to estimate impact on utility operating costs to support the integration of wind.
- Study 250, 500, 1000 and 2000 MW of wind in year 2012.
- Life cycle cost differences due to installing wind in place of coal or gas plants were evaluated separately.

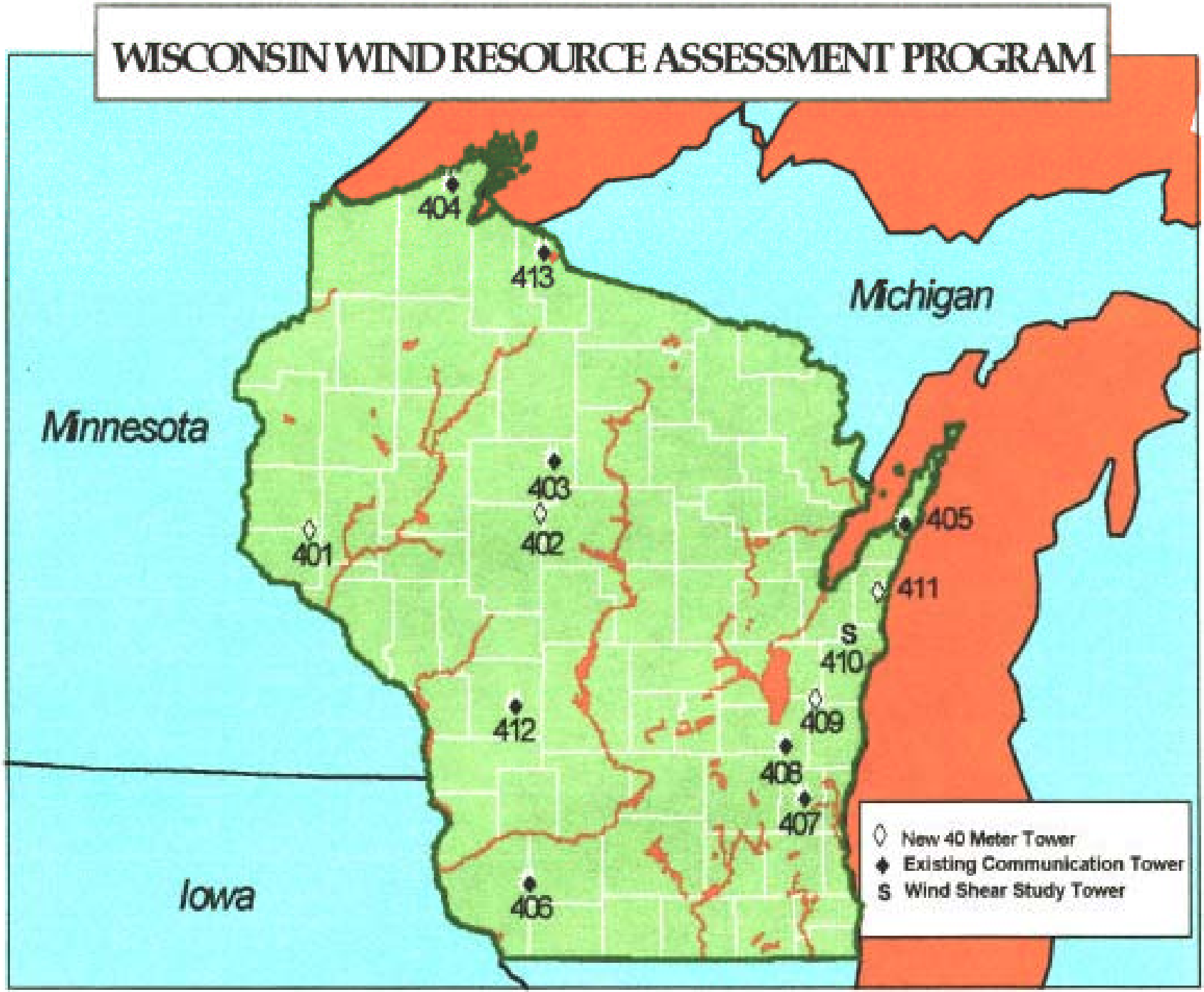
We Energies System Background

- Projected peak in 2012: 7045 MW
- MAIN requirements: 75 MW spinning and 75 MW non-spinning reserve.



Modeling of System Impacts

- PROSYM production cost model.
- Hourly commitment simulations for 2012.
- Wisconsin Wind Resource Assessment Program (WRAP) - monitored wind at 13 sites for 3 years.
- Identified 4 representative sites with 20% - 25% capacity factors.


WISCONSIN WIND RESOURCE ASSESSMENT PROGRAM
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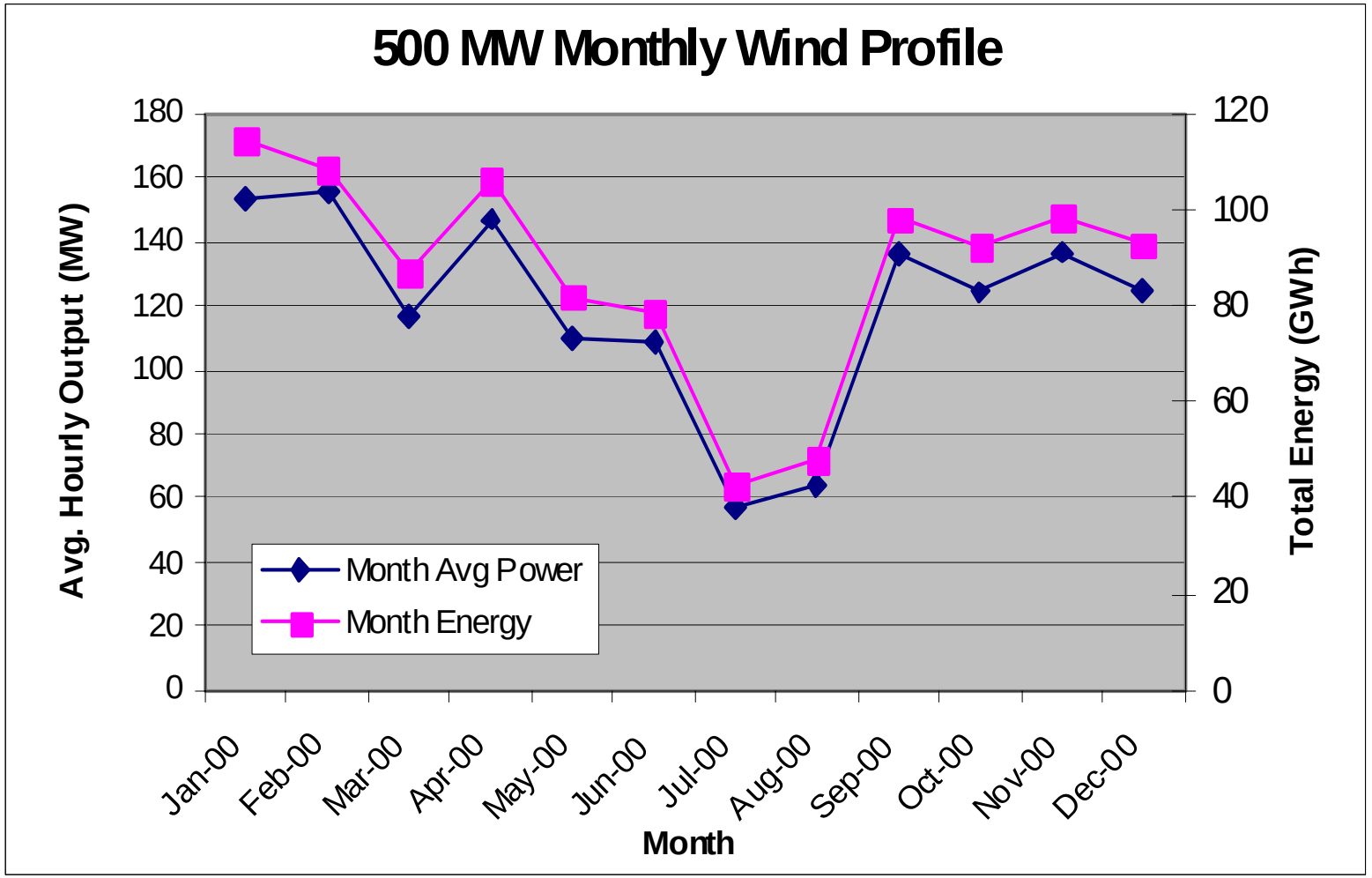
New 40 Meter Tower
Existing Communication Tower
S Wind Shear Study Tower

Variability of Wind by Month



System Cost Impact Components Evaluated

- Regulation - additional reserve needed for short term variability of wind
- Load Following - additional reserve needed for variability of wind over the course of the day
- Forecast Uncertainty - additional costs due to uncertainty of wind speed forecast, irrespective of wind variability

System Cost Impact
Regulation Reserve

- Regulation - cost of tracking minute by minute short term random fluctuations of load, such as turning lights on and off.
- Due to variability of wind, regulation reserve needs to be increased for increasing amounts of wind generation.
- Price of regulation reserve is based on capacity markets. Energy cost is assumed negligible.
- Cost for regulation reserve: $1.02 - $1.12/MWh

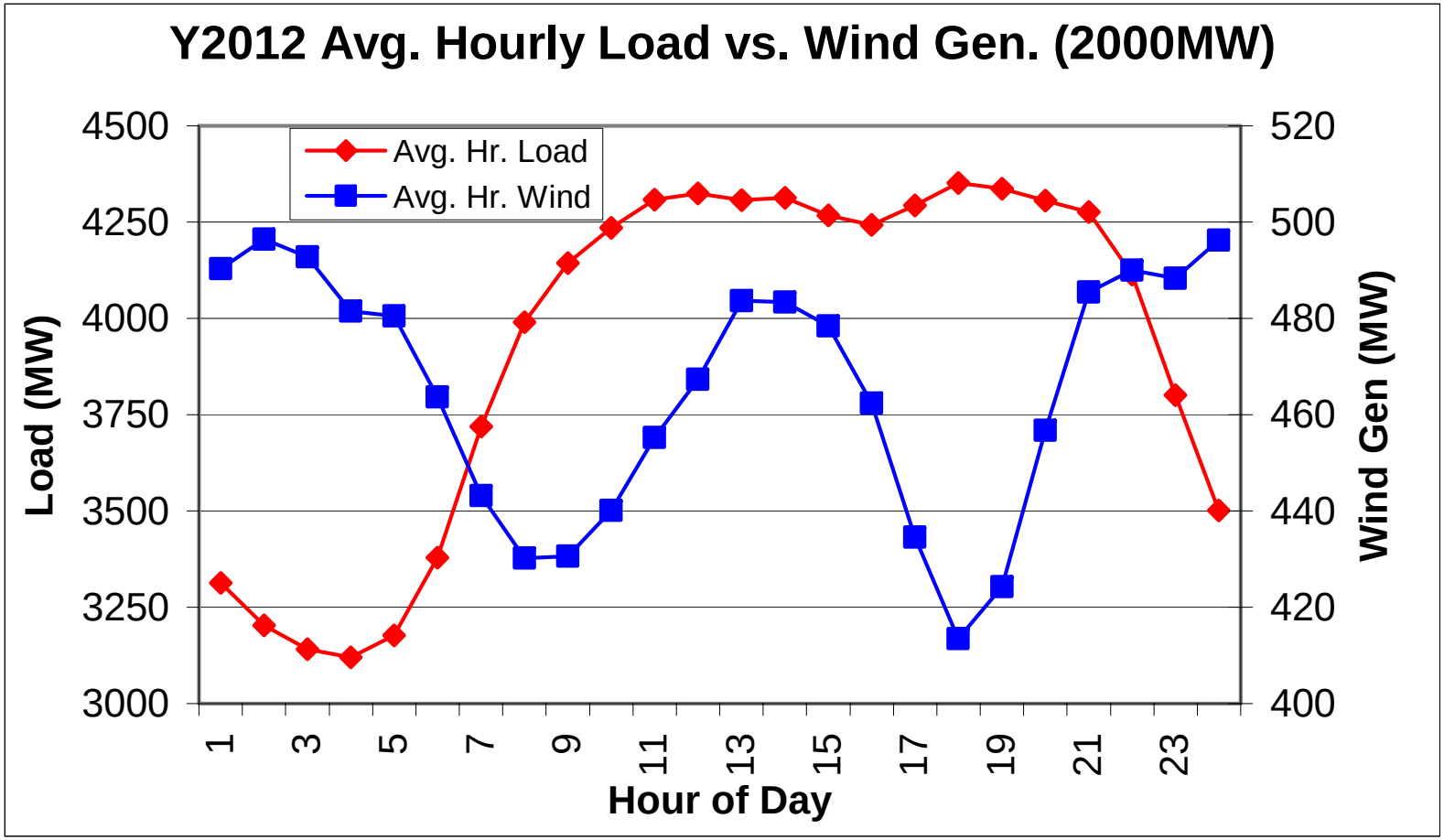
System Cost Impact
Load Following Reserve

- System has definite daily load shape (day time peak) which requires scheduling capacity to meet ramping requirements.
- Load Following Reserve is capacity that is required within the hour to meet future load changes.
- When scheduling - we get sub-optimal dispatch because of the ramping requirements needed for the next hour.

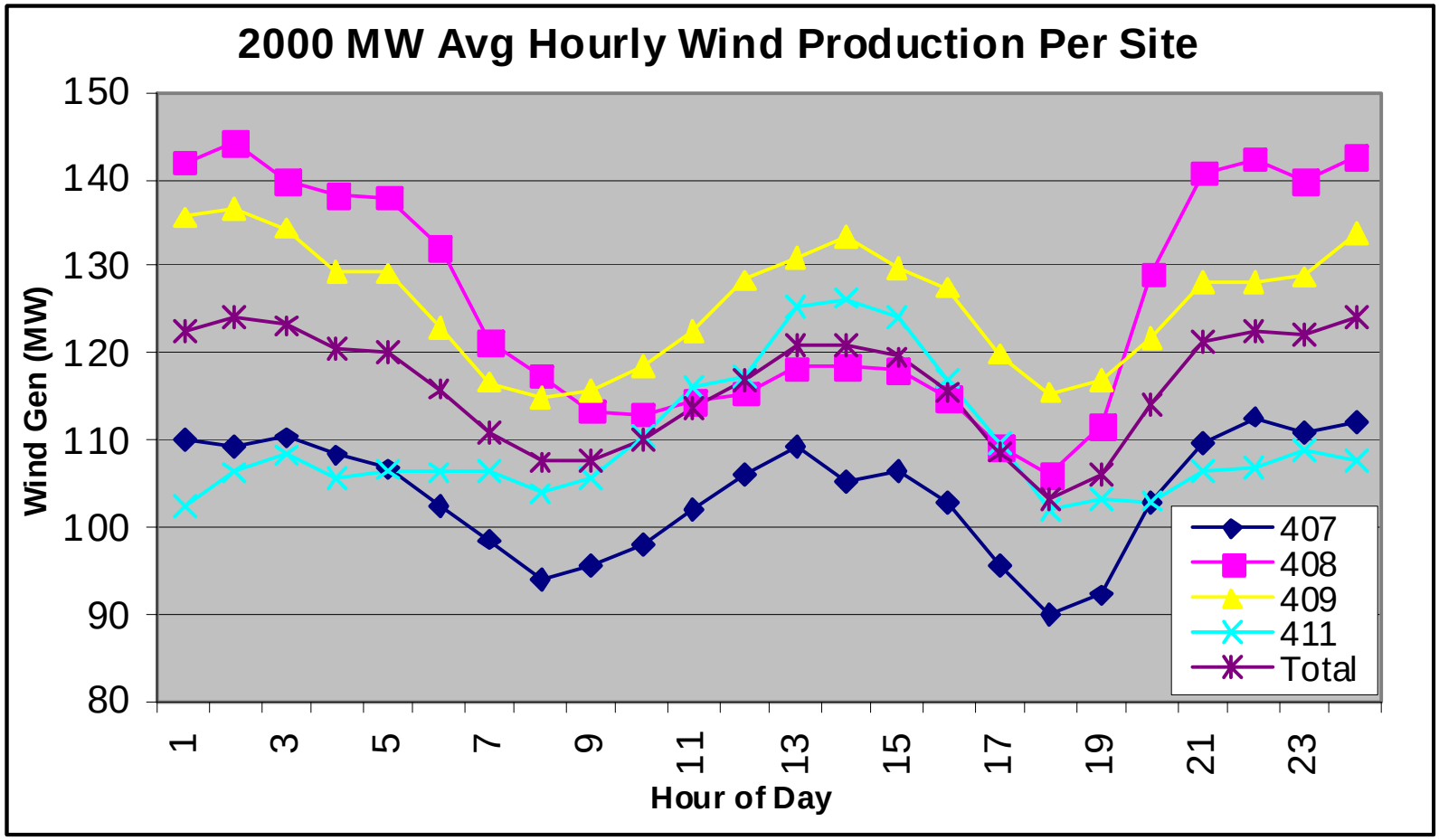
System Cost Impact
Load Following Reserve

- Wind has its own daily ramping pattern which doesn't match daily hourly load pattern.
- Wind increases the load following reserves required. This is dampened by multiple diverse sites
- Cost of load following reserve for wind integration is: $0.09 - $0.15 per MWh

Hourly System Load vs. Hourly Wind Generation



Variability of Wind by Hour



System Cost Impact Forecast Uncertainty

- Utilities schedule generating units based on load forecast. Spinning reserve is also scheduled in case of forecast error.
- Load Forecast Uncertainty - additional cost to accommodate uncertainty of load forecast.
- Wind Forecast Uncertainty - additional costs due to uncertainty of wind speed forecast, irrespective of wind variability

System Cost Impact Forecast Uncertainty

- Included cost impact for reserves, imbalance energy and under-forecast
- Impact of wind forecast uncertainty is considerably less when aggregated with load forecast uncertainty.
- Forecast uncertainty cost impact at 95% confidence level: $0.60 -$1.75 per MWh

Total Ancillary Service Cost Impact for Wind Integration

Wind Capacity MW	Regulation Reserve $/MWh	Load-Following Reserve $/MWh	Forecast Uncertainty $/MWh	Total Ancillary Service $/MWh
250	1.12	0.09	0.69	1.90
500	1.14	0.10	1.23	2.47
1000	1.08	0.14	1.60	2.82
2000	1.02	0.15	1.75	2.92

Summary of Other Wind Integration Study Results

		$/MWh			
Study	Wind Amount	Regu-lation	Load Following	Forecast Uncertainty	Total
Xcel	3.5%	0	0.41	1.44	1.85
PacifiCorp	20%	0	2.50	3.00	5.50
BPA	7%	0.19	0.28	1.0 – 1.80	1.47 - 2.27
Hirst	0.06 - 0.12%	0.05 - 0.30	0.70 – 2.80	NA	NA
WeEnergies 250 MW	4%	1.12	0.09	0.69	1.90
WeEnergies 2000 MW	29%	1.02	0.15	1.75	2.92

Conclusions

- Studied system cost impacts for integrating 250 MW to 2000 MW of wind.
- Total incremental ancillary service costs for wind integration ranged from $2 to $3 per MWh.
- Other studies ancillary service costs for wind integration ranged from $1.50 to $5.50 per MWh.

Other Wind Integration Issues

- Study provides a general indication of the magnitude of system cost impacts.
- Other issues and costs include:
  - Dispatchability
  - Capacity value
  - Minimum system load scenarios
  - Wind forecasting improvements

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