Integrating Variable Energy Resources

Northwest Energy Systems Symposium – Seattle, WA

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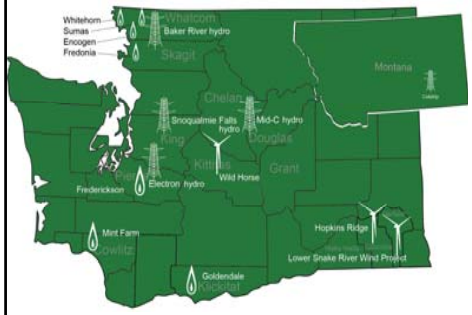
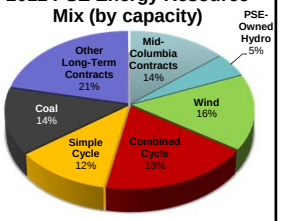
Objectives

- Puget Sound Energy Overview
- Overview of Wind Development in the N.W.
- Challenges of Integrating Wind
- Impact of Wind on PSE operations
- Next steps from a regulated utility perspective

Puget Sound Energy at a Glance





- PSE serves over 1 Million electric and over 750,000 natural gas customers

Leaders in Renewable Energy Development

- Second-largest utility owner of wind energy in United States (773 MW capacity)
- 157 MW Hopkins Ridge – 2005
- 229 MW Wild Horse – 2006
- 500 kW Wild Horse solar demonstration – 2007
- 44 MW Wild Horse Expansion – 2009
- 343 MW Lower Snake River - 2012

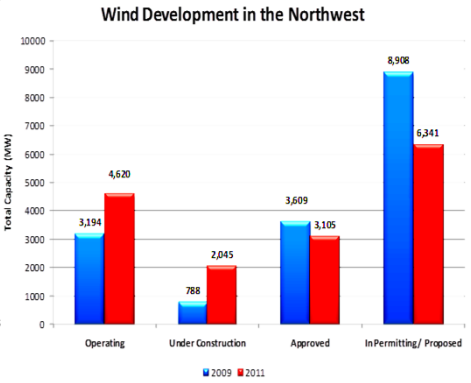
Wind Development In the Northwest

Why Renewable Resources?

- In some cases, wind has proven to be the least cost option (Hopkins Ridge)
- Meet state mandated Renewable Portfolio Standard (RPS)
  - 3% by 2012
  - 9% by 2016
  - 15% by 2020

Wind Development in N.W.

- 45% Increase in operating wind capacity over the past two years
- Over 11,000 MW either under construction or in various stages of approval



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Let's define reserves

Reserves	Operating Reserves Definitions
Net Load **Regulation**	Automatic Generation Control (AGC) that balances fast variations in load/wind with generation over short time frames of seconds to minutes.
Net Load **Following**	Balance the natural volatility of wind generation and forecast error over longer time intervals of several minutes to hours.
Contingency	Spinning & non-spinning reserves used in the event of a system contingency such as a loss of a generating capacity. 5% of Hydro + 5% of Wind + 7% of Thermal generation
Total	Regulation + Following + Contingency

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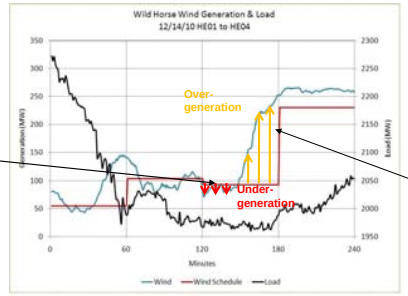
Wind introduces additional uncertainty and variability to the system, and can impact the reserves need in every hour, not just peak hours.

- Uncertainty – what level of generation will be observed in the future?
- Variability – even with a perfect forecast, wind generation can still fluctuate within an hour
- Not static – reserves level varies by time of day, season, and wind forecast

Wind generates <u>less</u> than schedule; therefore other system generation must be <u>increased</u>.



Wind generates <u>more</u> than schedule; therefore other system generation must be <u>reduced</u>.

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Challenges of Integrating Wind

- PSE Operates in a Bi-lateral Energy Market
  - No reliable short-term capacity market
  - Market transactions occur on an hourly basis
  - Lack of a consolidated scheduling entity or transmission provider increases wind balancing complexity and reduces the diversity benefits associated with geographically distinct wind plants and load centers
- Over-generation Has Become an Issue in the Pacific Northwest
  - High water events coupled with increasing wind penetrations levels, lack of market flexibility, and a constrained transmission system are the primary drivers
  - High water events have lead to significant wind curtailments

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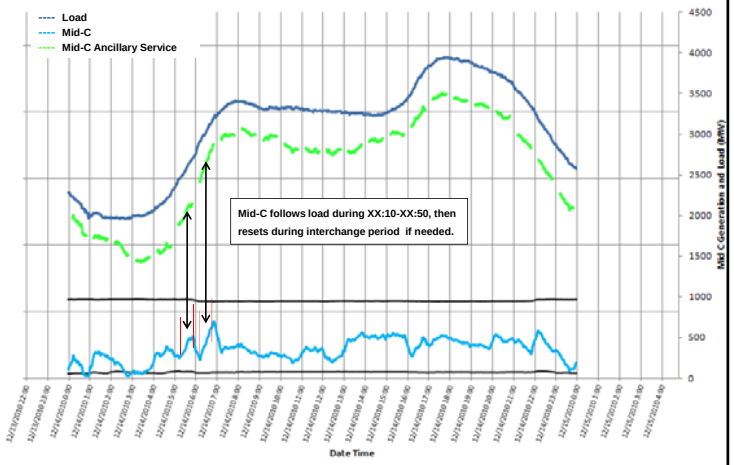
Ancillary Services – 12/14/2010 - no wind



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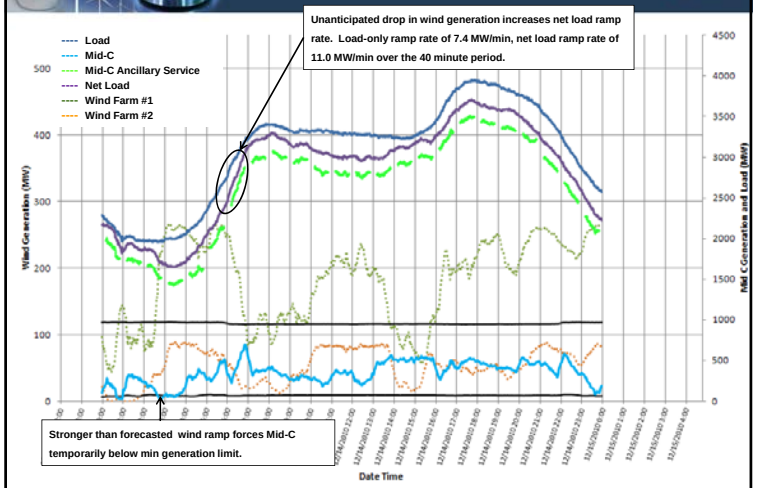
Ancillary Services – 12/14/2010 – wind added



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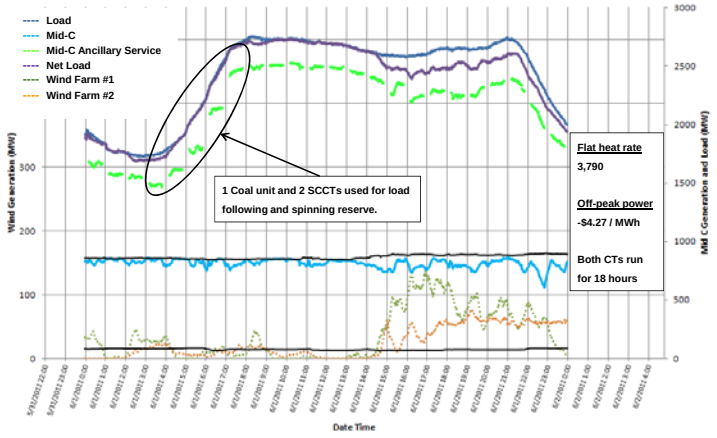
Ancillary Services in Spring time



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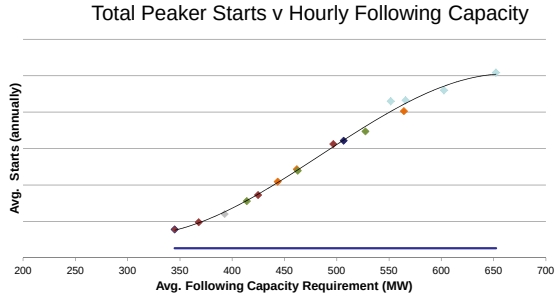
Example Peaker Start Results from PSE Wind Study



- The above example illustrates the results of a study designed to simultaneously analyze the impact of various wind penetration configurations and capacities on the PSE Peaker fleet.

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Future Ancillary Service Capability

- PSE's future resource portfolio:
  - Less hydroelectric generation
  - More gas-fired generation
  - More wind generation
- Meeting Future Ancillary Service Requirements:
  - As hydro capacity decreases, more following will be met by combined and simple cycle gas turbines.
  - Altered operations will increase O&M costs

How is PSE quantifying future ancillary service requirements and costs?

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Ancillary Valuation Model

- Iterative SAS-based model capable of determining:
  - Opportunity cost of balancing variable resources
  - Operational impacts of balancing additional variable resources
    - Unit starts
    - Unit generation
    - Unit run-times (hours of operation)
    - Unit cost
  - Distribution of possible cost and operational impacts

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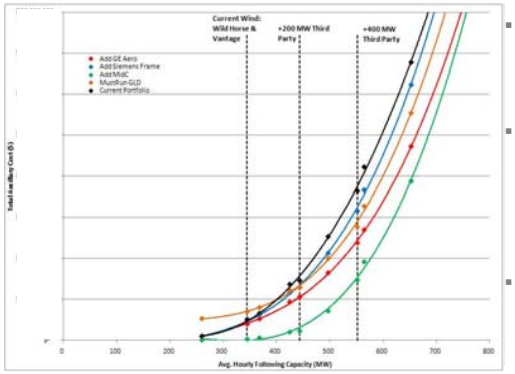
Example Ancillary Valuation Model Study Results



- Expected ancillary cost does not increase linearly with following reserve requirement.
- Present wind balancing obligations fall to left portion of curves, where system is not overly constrained.
- Remember: ancillary cost includes both load and wind following.

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Balancing Reserve Conclusions

Balancing Reserves	Drivers	Impacts of More Wind
• Regulation	• Regulation is driven by the natural volatility of wind and load as well as the turbine power curve	• Increase in the need for both regulation and following
• Following	• Following is driven by the magnitude of the forecast error	• Improvement in wind forecasting will reduce following requirements

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Initiatives Intended to Facilitate Wind Integration

- BA reconfiguration/coordination/expansion to enhance the benefits of geographic diversity
- Transmission development
- Dynamic scheduling out of the source balancing authority
- Develop a functioning within hour balancing market
- Improve wind forecasting capabilities

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Questions?

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