Integrating Variable Energy Resources

Puget Sound Energy at a Glance

Leaders in Renewable Energy Development

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

Let’s define reserves

<table>
<thead>
<tr>
<th>Reserves</th>
<th>Operating Reserves Definitions</th>
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</thead>
<tbody>
<tr>
<td>Net Load</td>
<td>Automatic Generation Control (AGC) that balances fast variations in load and wind generation over short time frames of seconds to minutes.</td>
</tr>
<tr>
<td>Regulation</td>
<td>Balance the natural volatility of wind generation and forecast error over longer time intervals of several minutes to hours.</td>
</tr>
<tr>
<td>Following</td>
<td>Spinning &amp; non-spinning reserves used in the event of a system contingency such as a loss of a generating capacity.</td>
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<tr>
<td>Contingency</td>
<td>5% of Hydro + 5% of Wind + 7% of Thermal generation</td>
</tr>
<tr>
<td>Total</td>
<td>Regulation + Following + Contingency</td>
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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
Ancillary Services – 12/14/2010 - no wind

- Load
- Mid-C
- Mid-C Ancillary Service

Mid-C follows load during XX:10-XX:50, then resets during interchange period if needed.

Ancillary Services – 12/14/2010 – wind added

- Load
- Mid-C
- Mid-C Ancillary Service
- Net Load
- Wind Farm #1
- Wind Farm #2

Unanticipated drop in wind generation increases net load ramp rate. Load-only ramp rate of 7.4 MW/min, net load ramp rate of 11.6 MW/min over the 48 minute period.

Stronger than forecasted wind ramp forces Mid-C temporarily below min generation limit.

Ancillary Services in Spring time

- Load
- Mid-C
- Mid-C Ancillary Service
- Net Load
- Wind Farm #1
- Wind Farm #2

1 Coal unit and 2 SCCTs used for load following and spinning reserve.

Flat heat rate 3,790
Off-peak power -$4.27 / MWh
Both CTs run for 18 hours

Example Peaker Start Results from PSE Wind Study

Total Peaker Starts v Hourly Following Capacity

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.
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?

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

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.

Balancing Reserve Conclusions

- 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
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

Questions?