Integrating Renewable: Implications for Grid Storage Needs

Large-Scale Storage Workshop
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About BPA

BPA established 1937
Service area size (square miles) 300,000
Transmission line (circuit miles) 15,397
BPA substations 284
Generation Capacity (MW) 15,900

BPA is a Federal Power Marketing Administration and is part of the U.S. Department of Energy
Introduction to BPA:

System Map

McNary
Dworshak
Anderson Ranch
Palisades
Ice Harbor
Grand Coulee
Revelstoke
Lower Monumental
Little Goose
John Day
The Dalles
Minidoka
Lower Granite
Chandler
Rosa
Albeni Falls
Black Canyon
Boise Diversion
Mica
Keenleyside
Duncan

BPA Service Area

Congress created the Bonneville Power Administration (BPA) in 1937 to market and transmit the power produced by Bonneville Dam. Today, BPA markets power and transmission services from 31 Federal dams, one non-federal nuclear plant, and 75% (15,000 miles) of the high-voltage lines in the Pacific Northwest.

The dams and the electrical system are known as the Federal Columbia River Power System (FCRPS)

BPA sells wholesale power to publicly owned and investor-owned utilities, as well as to some large industries. BPA also sells or exchanges power with utilities in Canada and other parts of the Western United States

BPA is a self-funded, not-for-profit federal agency within DOE
BPA has substantial wind energy experience

- Over 3,000 MW of wind in its 10,500 MW peak load balancing area
- 25 wind farms interconnected
- More than 1,800 wind turbines on line
- Five new substations for wind farms
- Six new taps for wind farms
- Approximately 85% of the wind serves load outside of the BPA balancing area
- In 2010, approximately 65% of wind serves loads in California balancing areas
- 7,080 MW, (60 percent) of committed requests under BPA’s 2008, 2009, and 2010 Network Open Seasons are for wind generation.
Wind power is growing fast

Wind Generation Capacity in the BPA Balancing Authority Area
Sequential Increases in Capacity, Based on Date When Actual Generation First Exceeded 50% of Nameplate Capacity

<table>
<thead>
<tr>
<th>Plant</th>
<th>Nameplate Capacity MW</th>
<th>Date When Actual Generation First Exceeded 1/2 of Current Nameplate Capacity</th>
<th>Cumulative Nameplate Capacity MW</th>
</tr>
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<tbody>
<tr>
<td>Stateline</td>
<td>90</td>
<td>12/18/2001</td>
<td>115</td>
</tr>
<tr>
<td>Klondike I</td>
<td>24</td>
<td>1/16/2002</td>
<td>139</td>
</tr>
<tr>
<td>Gordon</td>
<td>50</td>
<td>6/18/2002</td>
<td>189</td>
</tr>
<tr>
<td>Klondike II</td>
<td>76</td>
<td>6/28/2005</td>
<td>265</td>
</tr>
<tr>
<td>Hapkins Ridge</td>
<td>157</td>
<td>8/10/2006</td>
<td>422</td>
</tr>
<tr>
<td>Leaning Juniper</td>
<td>100</td>
<td>11/25/2005</td>
<td>522</td>
</tr>
<tr>
<td>Big Horn</td>
<td>200</td>
<td>10/4/2006</td>
<td>722</td>
</tr>
<tr>
<td>White Creek</td>
<td>200</td>
<td>10/5/2007</td>
<td>922</td>
</tr>
<tr>
<td>Klondike III</td>
<td>226</td>
<td>10/15/2007</td>
<td>1148</td>
</tr>
<tr>
<td>Biglow Canyon</td>
<td>126</td>
<td>11/17/2007</td>
<td>1274</td>
</tr>
<tr>
<td>Nine Canyon @ 28%</td>
<td>27</td>
<td>11/26/2007</td>
<td>1301</td>
</tr>
<tr>
<td>Goodnoe Hills</td>
<td>96</td>
<td>4/29/2008</td>
<td>1397</td>
</tr>
<tr>
<td>Nine Canyon @ 52%</td>
<td>24</td>
<td>5/10/2008</td>
<td>1421</td>
</tr>
<tr>
<td>Klondike 3a</td>
<td>75</td>
<td>6/6/2008</td>
<td>1496</td>
</tr>
<tr>
<td>Arlington</td>
<td>103</td>
<td>12/7/2008</td>
<td>1599</td>
</tr>
<tr>
<td>Willow Creek</td>
<td>72</td>
<td>1/1/2009</td>
<td>1671</td>
</tr>
<tr>
<td>Pebble Springs</td>
<td>100</td>
<td>1/27/2009</td>
<td>1771</td>
</tr>
<tr>
<td>Hay Canyon</td>
<td>100</td>
<td>2/12/2009</td>
<td>1871</td>
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<tr>
<td>Westfield</td>
<td>97</td>
<td>3/22/2009</td>
<td>1968</td>
</tr>
<tr>
<td>Tuolumne</td>
<td>137</td>
<td>5/1/2009</td>
<td>2105</td>
</tr>
<tr>
<td>Biglow Canyon Phase 2</td>
<td>149</td>
<td>8/6/2009</td>
<td>2254</td>
</tr>
<tr>
<td>Windy Flats Dooley (phase 17)</td>
<td>30</td>
<td>9/21/2009</td>
<td>2284</td>
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<tr>
<td>Windy Flats Dooley (phase 23)</td>
<td>233</td>
<td>11/30/2009</td>
<td>2517</td>
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<tr>
<td>Harvest</td>
<td>100</td>
<td>12/16/2009</td>
<td>2617</td>
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<tr>
<td>Combine Hills</td>
<td>63</td>
<td>1/1/2010</td>
<td>2680</td>
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<tr>
<td>Star Point</td>
<td>100</td>
<td>1/15/2010</td>
<td>2780</td>
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<tr>
<td>Linden Farm</td>
<td>50</td>
<td>6/6/2010</td>
<td>2830</td>
</tr>
<tr>
<td>Coastal Energy</td>
<td>6</td>
<td>6/30/2010</td>
<td>2836</td>
</tr>
<tr>
<td>Biglow Canyon Phase 2 (add’l)</td>
<td>14</td>
<td>8/11/2010</td>
<td>2850</td>
</tr>
<tr>
<td>Biglow Canyon Phase 2</td>
<td>162</td>
<td>8/11/2010</td>
<td>3011</td>
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</tbody>
</table>
Wind farms are clustered along the Columbia River near existing BPA transmission and new transmission projects.
Wind Generation Capacity Connected to BPA’s Transmission System is Growing

NOTES:
1. Projections beyond FY11 may be impacted or delayed due to a need for Transmission system expansion.
2. Projected totals based on previous experience and present growth factors including Production Tax Credits and RPS Demand.
3. Total Renewable Projects / Oil Study Requests: 21,511 Megawatts
4. Wind generation shown is interconnected to BPA-T; amount within BPA Balancing Authority Area is not estimated.
5. Graph FY assumption based on estimate of commercial operation of wind projects.
Much of the Wind Resource Serving Load Outside BPA Balancing Authority (BA)

<table>
<thead>
<tr>
<th>Year</th>
<th>Wind Generation Inside BPA Balancing Authority</th>
<th>Location of Load Being Served</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>BPA BA</td>
</tr>
<tr>
<td>2010</td>
<td>3,600</td>
<td>475</td>
</tr>
<tr>
<td>2012</td>
<td>5,950</td>
<td>800</td>
</tr>
<tr>
<td>2020 Scenario</td>
<td>9,800</td>
<td>1,200</td>
</tr>
</tbody>
</table>
Understanding wind energy

Wind is primarily an \textit{energy}, rather than a \textit{capacity} resource

- High value, similar to hydro electricity’s value. Both reduce carbon emissions and offer low, stable fuel price.

- Variability and supply uncertainty also similar to hydro, but differs in three ways:
  - Hydro can be stored, wind can not
  - Time scale of the variability
    - Hydro’s variability is measured in years, months and weeks
    - Wind’s variability is measured in days, hours and minutes
  - Level of variability
    - Hydro runoff has varied from 88.7 to 190.8 million acre-feet in a year
    - Wind can vary from zero to nameplate capacity in a few hours

- Wind power increases need for balancing reserves

- Wind power requires changing system operations and trying innovative approaches
BPA Balancing Authority Total Wind Generation and Wind Basepoint

BPA Balancing Authority Load & Total Wind, Hydro, and Thermal Generation, Last 7 days
09Jul2010 - 15Jul2010 (last updated 15Jul2010 15:06:42)

Based on 5-min readings from the BPA SCADA system for points 45583, 79687, 79682, and 79685
Balancing Authority Load in Red, Wind Gen. in Blue, Hydro Gen. in Green, and Thermal Gen. in Brown
Installed Wind Capacity=2636 MW
BPA Technical Operations (TOT-OpInfo@bpa.gov)
BPA Balancing Authority Total Wind Generation and Wind Basepoint

Based on 5-min readings from the BPA SCADA system for points 79687, 103349
Balancing Authority Wind Generation in Blue, Wind Basepoint in Red; Installed Wind Capacity = 1592 MW
BPA Technical Operations (TDT-OpInfo@bpa.gov)
Within Hour balancing

Hour 16 of May 26, 2010
Wind Generation on BPA's System

- **Generation Imbalance** – difference between the hourly schedule and the average hourly generation

**Chart:**
- **Y-axis:** MWs
- **X-axis:** Minutes
- **Legend:**
  - Schedule
  - Actual Gen
  - Generation Imbalance

**Graph Highlight:**
- Following
FCRPS is a Large Storage Machine

- Demands on federal hydro power system:
  - Serve load
  - Meet ESA requirements
  - Meet non-power requirements
  - Support variable generation

- BPA uses FCRPS to supply Balancing Reserves required to integrate wind generation

- With traditional tools, FCRPS could have supported only 3,000 – 3,500 MW of wind
BPA Wind Integration Support Actions

- Transmission Network Open Season Offered
- Conditional Firm Service Offered
- Area Control Error (ACE) Diversity Interchange
- New transmission construction financed
- Automatic Generation Control improved
- Spring 2009: New Wind Integration Initiatives Announced
  - New Operating Protocols (DSO 216)
  - Intra-Hourly Scheduling
  - Dynamic Transfer Offering
  - Wind Generation Forecasting
  - Customer-Supplied Generation Imbalance
Thinking Long-Term

Wind is a valuable addition to the Pacific Northwest renewable generation mix and it will continue to grow rapidly.

Successfully integrating renewable variable-generation resources will take coordination among utilities in the Northwest

1. Expand on the existing initiatives involving wind forecasting and new operational protocols and business practices
2. Plan and Build Transmission
3. Implement New Technologies, including Storage
4. Explore New Market Designs
5. Explore Consolidation of Balancing Authorities
Summary of Top Storage Application that BPA Needs

- **Transmission Frequency Regulation Storage**
  - Benefit: Replace overly conservative special protection schemes, and contribute toward the oscillation damping and area control.
  - Risk: Should be more competitive than hydro currently providing the resources.

- **Contingency Service Storage**
  - Benefit: Free up units supplying reserves, inter area oscillations damping, frequency and reactive support.
  - Risk: high cost, who pays.

- **Intermittency Management Storage**
  - Benefit: Within hr balancing, and wind integration rate.
  - Risk: Cost storage vs. generation, Ownership (BPA vs. wind plants).

- **Commodity Storage**
  - Benefit: Very reliable and proven resource maximizing value of energy, fill in behind the current variable generation (VG).
  - Risk: High capital cost (impact on rates), ownership & beneficiary.

- **Other Non-Power Related Needs**
  - Fishery and water management.
3. Within hour balancing *(the power is depending on wind on the system)

4. Commodity Storage

Upgrading Pump/Gen. of Grand Coulee Operation

2 months

7 days

16.6 hour

1.7 hour

10 minute

1 minute

6 second

0.6 second

60 millisecond

300-1500 MW

Source of the Generation Applications:
BPA Applications and Current Technologies

1. Frequency controls
2. Oscillation Damping Control
3. Within hour Balancing *(the power is depending on wind on the system)*
4. Commodity Storage

Source of the Current Technologies:
**Example of 100 MWs Inc and Dec Balancing Reserves from Natural Gas Fired Generator**

### Illustrative purposes only

<table>
<thead>
<tr>
<th><strong>LLH Dec’ing</strong></th>
<th><strong>HLH Inc’ing</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pricing Methodology</strong></td>
<td><strong>Pricing Methodology</strong></td>
</tr>
<tr>
<td>Capacity Reservation Charge = $1.50/kw/Month * Billing Determinant</td>
<td>Capacity Reservation Charge = $20/kw/Month * Billing Determinant</td>
</tr>
<tr>
<td>Above Market Dispatch costs =</td>
<td>Variable Dispatch Charge = 110% of daily gas index * unit heat rate</td>
</tr>
<tr>
<td>cost of production at full output vs. Hourly power prices</td>
<td>Assume that inc is use 25% of HLHs on average</td>
</tr>
<tr>
<td>Variable Dispatch Charge = based on heat rate increase caused by dec</td>
<td>Capacity Reservation Charge = $24 million</td>
</tr>
<tr>
<td>Pay BPA for energy used to meet load =</td>
<td>Variable Dispatch Charge = $ 3 million</td>
</tr>
<tr>
<td>based on HLH heat Rate</td>
<td>Total yearly cost $27 million</td>
</tr>
</tbody>
</table>

*Assume that dec is use 25% of LLH on average*

<table>
<thead>
<tr>
<th>Capacity Reservation Charge = $ 2 million</th>
<th>Total cost of 100 MWs of Inc and Dec Balancing Reserves from a Natural Gas fired generator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above Market Dispatch cost = $ 1 million</td>
<td>Total = $28 million per year</td>
</tr>
<tr>
<td>Variable Dispatch Charge = $ 2 million</td>
<td></td>
</tr>
<tr>
<td>Pay to BPA = $- 4 million</td>
<td></td>
</tr>
<tr>
<td>Total yearly cost = $ 1 million</td>
<td></td>
</tr>
</tbody>
</table>