Integrating Renewable Resources into the Electric Grid

BPA Transmission and Operational Planning
October 28, 2010

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Director, Strategy Integration
Bonneville Power Administration
<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BPA established</td>
<td>1937</td>
</tr>
<tr>
<td>Service area size (square miles)</td>
<td>300,000</td>
</tr>
<tr>
<td>Pacific Northwest population</td>
<td>11,300,885</td>
</tr>
<tr>
<td>Transmission line (circuit miles)</td>
<td>15,397</td>
</tr>
<tr>
<td>BPA-owned substations</td>
<td>284</td>
</tr>
<tr>
<td>Employees (staff years)</td>
<td>3,000</td>
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</table>
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's 300,000 square mile service area includes Oregon, Washington, Idaho, western Montana and small parts of Wyoming, Nevada, Utah, California and eastern Montana

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

$3.5 billion in annual revenues

Headquarters in Portland, OR
Federal Columbia River Power System

- The US Army Corps of Engineers and the Bureau of Reclamation operate the federal dams for multiple public purposes
  - Flood Control, irrigation, power production, navigation, recreation, fish protection (Endangered Species Act, Clean Water Act)
  - Some purposes (such as system reliability, flood control and fish protection) take precedence over resource integration
  - Balancing all these purposes can be challenging when there is insufficient operational flexibility at the dams to manage uncertainty in water supply or demand for power

- BPA’s Role
  - BPA is one of 18 Balancing Area Authorities operating in the Northwest Power Pool area
  - Markets the power produced from the federal dams within the constraints and requirements for other river purposes
  - Primary high-voltage transmission provider in the Columbia River Basin
    - BPA integrates new power sources into the transmission grid that request such service
    - Significant growth in wind power in the past few years that is far in advance of regional power demand
Federal Columbia River Transmission System

- BPA owns and operates 75% of the Pacific Northwest’s high voltage electrical transmission system.
- The system enables a peak loading of about 30,000 megawatts and generates more than $700 million a year in revenues from transmission services.
- BPA’s Transmission Services operates under an Open Access Transmission Tariff based on FERC’s pro forma tariff as a non-jurisdictional entity.
- BPA has 245 “currently active” transmission customers.
ColumbiaGrid Planning and Expansion Functional Agreement (PEFA)

- As a PEFA Participant, BPA works with ColumbiaGrid on sub-regional and WECC-wide transmission planning related issues

ColumbiaGrid PEFA Process Overview
- Produces annual independent system assessment
- Coordinates planning work and, when needed, resolve issue
- Recommends cost allocation if parties cannot agree
- Develops a biennial transmission expansion plan
- Uses independent ColumbiaGrid Board to approve plan and resolve disputes
- Includes mechanisms to assure implementation of reliability-related projects

ColumbiaGrid planning answers these questions for reliability-related projects:
- What should be built?
- Who should build it?
- Who should pay for it?
Open Season

- BPA has successfully conducted Network Open Season (NOS) in 2008, 2009 and 2010 is underway
  - NOS enables BPA to cluster transmission requests and study the aggregate impacts of those requests, facility requirements, and estimated costs of facilities necessary to accept service
  - Customers that decline the precedent service agreement have their application for service withdrawn from the transmission request queue, but may resubmit at any time

- BPA is scoping Intertie Open Season (IOS) in consultation with PAC, PGE, CAISO, PG&E, TANC, SMUD, WAPA, LADWP, SCE, PPC, and NRU
  - The objective of the initial February 2010 scoping report was to provide an assessment of interest in proceeding with efforts to increase Southern Intertie transfer capacity between the Northwest and California. The report also identifies several areas that should be further developed to establish a framework for an Intertie Open Season.

- ColumbiaGrid is facilitating an Open Season Scoping Process through which regional transmission providers, transmission customers and interested persons are examining alternative transmission service business practices.
  - Primary goal is to address in a comprehensive manner a service request that might span more than one transmission owner’s system. Other goals are to investigate cost allocation issues and to coordinate the construction of needed new transmission across multiple systems.
  - Should the process be implemented, ColumbiaGrid process and BPA IOS is intended to work together.
Changing Paradigm

- Strong movement from conventional to variable energy resources
- In today’s environment, planning is a combination of art and science
  - Balance reliability, economic, environmental, renewable integration, & the other public purpose objectives to optimize transmission and resources to meet the needs of the region
  - How can transmission & resources be optimized to best meet the needs?
- Increased coordination and collaboration required among various sub-regional organization (i.e., ColumbiaGrid, NTTG, WestConnect, CAISO) and WECC TEPPC efforts.
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 Gen First Exceeded 1/2 of Current Nameplate Capacity</th>
<th>Cumulative Nameplate Capacity MW</th>
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<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>Condon</td>
<td>50</td>
<td>6/18/2002</td>
<td>180</td>
</tr>
<tr>
<td>Klondike II</td>
<td>76</td>
<td>6/28/2005</td>
<td>265</td>
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<tr>
<td>Hopkins Ridge</td>
<td>157</td>
<td>11/25/2005</td>
<td>422</td>
</tr>
<tr>
<td>Leaning Juniper</td>
<td>100</td>
<td>8/10/2006</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>
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<tr>
<td>Nine Canyon @ 52%</td>
<td>24</td>
<td>5/10/2008</td>
<td>1421</td>
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<tr>
<td>Klondike 3a</td>
<td>75</td>
<td>6/6/2008</td>
<td>1496</td>
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<tr>
<td>Arlington</td>
<td>103</td>
<td>12/7/2008</td>
<td>1590</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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<td>Wheatfield</td>
<td>97</td>
<td>3/22/2009</td>
<td>1968</td>
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<tr>
<td>Tuolumne</td>
<td>137</td>
<td>5/1/2009</td>
<td>2105</td>
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<tr>
<td>Biglow Canyon Phase 2</td>
<td>149</td>
<td>8/6/2009</td>
<td>2254</td>
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<tr>
<td>Windy Flats Dooley (phase 1)</td>
<td>20</td>
<td>9/21/2009</td>
<td>2284</td>
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<td>Windy Flats Dooley (phase 2)</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>
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<tr>
<td>Coastal Energy</td>
<td>6</td>
<td>6/30/2010</td>
<td>2836</td>
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<td>Biglow Canyon Phase 2 (add'l)</td>
<td>14</td>
<td>8/11/2010</td>
<td>2850</td>
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<tr>
<td>Biglow Canyon Phase 3</td>
<td>161</td>
<td>8/11/2010</td>
<td>3011</td>
</tr>
</tbody>
</table>

**Graphical Representation:**

- **Cumulative Nameplate Capacity MW:**
  - Vansycle: 25 MW
  - Stateline: 115 MW
  - Klondike I: 139 MW
  - Condon: 180 MW
  - Klondike II: 265 MW
  - Hopkins Ridge: 422 MW
  - Leaning Juniper: 522 MW
  - Big Horn: 722 MW
  - White Creek: 922 MW
  - Klondike III: 1148 MW
  - Biglow Canyon: 1274 MW
  - Nine Canyon @ 28%: 1301 MW
  - Goodnoe Hills: 1397 MW
  - Nine Canyon @ 52%: 1421 MW
  - Klondike 3a: 1496 MW
  - Arlington: 1590 MW
  - Willow Creek: 1671 MW
  - Pebble Springs: 1771 MW
  - Hay Canyon: 1871 MW
  - Wheatfield: 1968 MW
  - Tuolumne: 2105 MW
  - Biglow Canyon Phase 2: 2254 MW
  - Windy Flats Dooley (phase 1): 2284 MW
  - Windy Flats Dooley (phase 2): 2517 MW
  - Harvest: 2617 MW
  - Combine Hills: 2680 MW
  - Star Point: 2780 MW
  - Linden Farm: 2830 MW
  - Coastal Energy: 2836 MW
  - Biglow Canyon Phase 2 (add'l): 2850 MW
  - Biglow Canyon Phase 3: 3011 MW

**Date Range:**
- 1/1/1998 to 12/31/2011
- **Cumulative Nameplate Capacity MW:** 0 to 3011 MW

**Graphical Elements:**
- **Axis:**
  - X-axis: Dates from 1/1/1998 to 12/31/2011
  - Y-axis: Cumulative Nameplate Capacity in MW

**Legend:**
- **Legend Entries:**
  - Vansycle
  - Stateline
  - Klondike I
  - Condon
  - Klondike II
  - Hopkins Ridge
  - Leaning Juniper
  - Big Horn
  - White Creek
  - Klondike III
  - Biglow Canyon
  - Nine Canyon @ 28%
  - Goodnoe Hills
  - Nine Canyon @ 52%
  - Klondike 3a
  - Arlington
  - Willow Creek
  - Pebble Springs
  - Hay Canyon
  - Wheatfield
  - Tuolumne
  - Biglow Canyon Phase 2
  - Windy Flats Dooley (phase 1)
  - Windy Flats Dooley (phase 2)
  - Harvest
  - Combine Hills
  - Star Point
  - Linden Farm
  - Coastal Energy
  - Biglow Canyon Phase 2 (add'l)
  - Biglow Canyon Phase 3

**Graphical Notes:**
- **Legend:**
  - MW: Megawatts
- **Data Points:**
  - Each plant is represented by a data point at the date when actual generation first exceeded 50% of nameplate capacity.
- **Cumulative Capacity:**
  - The cumulative nameplate capacity is plotted along the y-axis, starting from 0 MW to 3011 MW.

**Graphical Analysis:**
- The graph illustrates the sequential increases in wind generation capacity within the BPA Balancing Authority Area.
- It highlights the growth of wind power from 1998 to 2011, showing significant increases in cumulative nameplate capacity.
- Key dates and plants are marked to show the progression of wind power growth over time.

**Conclusion:**
- Wind power has significantly increased in the BPA Balancing Authority Area, with cumulative nameplate capacities reaching up to 3011 MW by 2011.
- This growth is attributed to the installation of various wind farms, each reaching 50% of nameplate capacity at specific dates as shown on the graph.
Wind Generation Capacity Connected to BPA’s Transmission System is Growing

Renewable Generation Forecast (MW) for Interconnection Projects to BPA Grid (Oct 1 - Sept 30)
(Note: Graph represents MW forecasted for interconnection and commercial operation date, some may not be in BPA BAA)

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 / GI Study Requests 23,511 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.
I. PLAN & BUILD TRANSMISSION

Three New Proposed Transmission Lines To Integrate 1,800 MW of New Wind
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>
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</table>
Wind Generation Experiences Significant Ramps

BPA Balancing Authority Load & Total Wind, Hydro, and Thermal Generation, Last 7 days

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=3011 MW
BPA Technical Operations (TOT-OpInfo@bpa.gov)
The timing of the runoff is a huge factor in FCRPS operations

1 Average daily flows of the 18 highest April-August volume years (top 25%), 1929-99.
2 May Mid-Month forecast for April-August volume from the NW River Forecast Center; plotting April observed and distributing remainder of forecast equally by month based on percent of average flows.
II. MAINTAIN RELIABILITY

New Operating Protocols to Ensure Reliability

- Established new reliability protocols (DSO216)
- Establish amount of reserves we will hold, then require wind generators to:
  - adjust their schedules down to actual output if they substantially under-generate relative to schedule
  - reduce output if they substantially over-generate relative to their schedule
II. MAINTAIN RELIABILITY

Situational Awareness

- Installed 14 wind measurement sites
- Developed a wind forecasting system
- Adding a BPA “Wind Desk” to support dispatchers in the efficient use of wind, hydro and other generation

Accurate Forecasts and Situational Awareness are Key
II. MAINTAIN RELIABILITY

*Intra-hour Scheduling*

- Historic transmission scheduling protocols was for hourly schedules
- Created *intra-hourly* transmission scheduling protocols to allow power schedule changes to better match within-hour variations in wind generation
Inaccuracy in Wind Generation Forecasts Increase the Need for Other Generation Resources to Maintain Reliability

Legend
Total Schedule without Intra-Hour
Total Schedule With Intra-Hour
Total Generation

1. Hour Ending 11 scheduling window closes
2. Hour Ending 11 intra-hour scheduling window closes
3. Hour Ending 11 intra-hour schedule
II. MAINTAIN RELIABILITY

Customer Supplied Generation Imbalance

- Enable customers to self-supply their within hour balancing requirements from their own and/or contracted dispatchable resources for one or more wind plants.

- Participants supply their own Generation Imbalance.

- BPA continues to supply load following and regulation.
II. MAINTAIN RELIABILITY

*Become More Dynamic*

- Study and Increase **Dynamic Transfer Capability**
  - Allows wind generators physically located on BPA’s system to be remotely balanced by other utilities using electronic signals
Near and Long-term Solutions

- Transmission Additions
- Continued Scheduling, Operating, and Forecasting Improvements
- Development of Within-hour Energy Markets
- Improved Cross-Balancing Area Coordination
- Storage
  - Pumped Storage, Batteries, Compressed Air, Flywheels
  - Plug-in Electric Vehicles and Demand-side storage
- Load management