BPA Wind Interconnection and Operational Experiences

Presented by Stephen Enyeart for the Idaho Wind Working Group Meeting
Sept. 15, 2011
Wind Progress in the US, NW

- Thirty-Three (33) States now have Renewable Portfolio Standards.
- ~1000 MW = Output of a Nuclear Power Plant
- USA: Installed capacity 42,400 MW by June 2011
- Germany, Denmark, Spain and China are leaders outside US, but USA is now world leader
- Texas, Mid-America (Iowa, Minnesota), NW (OR, WA), California most active regions
  - NW now has over 5000 MW (as of 9/2011)
- BPA interconnected 750 MW in 2011, expects over 1100 MW in 2012
  - BPA totals over 3890 MW connected to our grid
  - 805 MW was connected in 2010
  - (BPA does not own or build Wind Generation)
U. S. Wind Power Installed Capacity (provided by AWEA)

- Texas: Highest capacity through 2010
- California: Most capacity additions in Second Quarter 2011
- Ohio: Fastest growing in Second Quarter 2011

<table>
<thead>
<tr>
<th>State</th>
<th>Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>420.0</td>
</tr>
<tr>
<td>Oregon</td>
<td>201.3</td>
</tr>
<tr>
<td>Illinois</td>
<td>150.0</td>
</tr>
<tr>
<td>Utah</td>
<td>102.0</td>
</tr>
<tr>
<td>Ohio</td>
<td>56.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>State</th>
<th>Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ohio</td>
<td>517.2%</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>109.2%</td>
</tr>
<tr>
<td>Maryland</td>
<td>71.1%</td>
</tr>
<tr>
<td>Utah</td>
<td>45.7%</td>
</tr>
<tr>
<td>California</td>
<td>13.2%</td>
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</table>
U. S. Wind Power Installed Capacity (provided by AWEA)
John Day Dam 2200MW
2\textsuperscript{nd} Largest Dam on the Columbia
(Over 3000 MW of Wind now connected within 30 miles)
Go to http://www.bpa.gov/corporate/WindPower/ for BPA Wind Web page
Based on BPA’s wind interconnection queue and work done by E3

Wind Resources Thru 2020

- PNW and CA RPS targets would require ~10,000 MW of installed NW wind by 2020.
  - Nearly 6,000 MW currently operating or under construction.
  - BPA has offered ~ 9,300 MW of transmission service to wind projects.
Renewable Projects Connected to BPA Grid and Forecast

Progress of Wind Interconnection to BPA

Renewable Generation Interconnection Projects to BPA Grid (Oct 1 - Sept 30)
(Note: Graph presents MW interconnected and Forecast, some may not be in BPA BAA)
Hopkins Ridge 157MW Wind Farm – 2005
87 x 1.8MW Turbines
(Near Dayton WA)
Klondike 2007 Expansion Underway
What Klondike Phase 3 Today (2008)
(400 MW over 240 Turbines operating)
Portland GE (450 MW - 2010)
New Xmsn Projects Resulting from Network Open Season 2008

- McNary – John Day 500 kV line 2012
- Big Eddy – Knight 500 kV line 2013-14
- Lower Monumental – Central Ferry 500 kV line 2013-15
### Firm Transmission Service Commitments and PTSA Offers for Wind (as of September 2010)

<table>
<thead>
<tr>
<th>Source</th>
<th>MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signed long-term firm Tx contracts for wind</td>
<td>3,981 1</td>
</tr>
<tr>
<td>2008 NOS PTSA pending new facility construction</td>
<td>2,575 2</td>
</tr>
<tr>
<td><strong>Total Committed Service (LTF Tx and PTSA)</strong></td>
<td>6,556</td>
</tr>
<tr>
<td>Eligible TSRs Tendered a 2009 NOS PTSA</td>
<td>923 3</td>
</tr>
<tr>
<td>Eligible TSRs under review for 2010 NOS PTSA</td>
<td>2493 4</td>
</tr>
<tr>
<td><strong>TOTAL POTENTIAL WIND TX COMMITMENTS</strong></td>
<td>9,972</td>
</tr>
</tbody>
</table>

1. Based on aggregate TSRs for contracts in the 2010 ATC Base Case (2,892 MW) and offers from the 2008 NOS Restack (1,089 MW). Does not represent actual system usage.

2. Conditional Firm is being offered as a bridge product for 505 MW


4. NOS 2010 still in study review, no firm offers yet
Wind Generator Types

- **Type 1 - Induction Machine (Condon, 9-Canyon,):**
  - Governor controls Variable Pitch Blades.
  - Lower initial cost and maintenance, but less efficient, may cause Voltage problems.
- **Type 2 - Wound Rotor Controlled (Stateline, Hopkins Ridge, Biglow):**
  - Electronic Control to compensate for wind fluctuations.
  - More efficient, less voltage flicker.
  - Still requires voltage compensation (capacitors, DVAR device).
- **Type 3 - Double-Fed Wound Rotor Controller (Klondike, Big Horn, LJ1):**
  - Advanced Electronic design controls output and voltage.
  - More efficient, higher initial cost
  - Preferred for interconnection into Grid, local power systems
- **Type 4 – (Klondike 3, White Creek) variable speed Alternator (like your car) converts power to grid voltage using electronics.**
  - Similar performance to Type 3, most costly
BPA Interconnecting Wind Generation
BPA Interconnection of Wind Power

- Typical Interconnections
  - Direct connection to Wind Collector substation, providing tap, relay, control and communications (69 or 115kV only). (6 each)
  - New 230 or 115 kV substation looping in BPA lines and line from wind site, collector substation work. (6 each)
  - New 500/230 kV substation with 1300 MVA transformer, 1250 MW of wind generation (Hub Facility). (4 each so far)

- BPA interconnection challenges have been:
  - 20,000 MW in GI study queue: Whose real? When?
  - Transmission service: 9700 MW of transmission service subscribed: Is it all real? When? Will there be defaults?
  - Impact on future customer costs of all of this new construction.
  - Timing – wind plants can ‘build’ in 6 months, 18 months from funding; BPA has 2 year work plan and a huge work load already.
Small Project Interconnection
(Condon Wind Site - Oregon 2001)
Typical Small Wind Interconnection Diagram
Typical Small Collector Substation
BPA Operational Issues

- biggest Problem is balancing the wind variability with other generation resources
BPA Operational Issues

- BPA concern is managing wind generation
  - Wind is an energy resource, must have firm resources to rely on for capacity needs.
  - Wind Plants are remotely controlled, unlike traditional generation, communications is an issue.
  - Schedules seldom match actual generation – we have to adjust other generation to maintain load-generation imbalance.
  - Rapid increase in wind generation – growing pains
    - The wind fleet is now paying $46M a year for BPA to manage the short term variability of wind (within hour).
    - For the NW region this will continue to be one of the biggest issues, and across the nation too.
TOTAL WIND GENERATION IN THE BPA BALANCING AUTHORITY AREA (Control Area)
JAN-08, at 5-min Intervals

MAX 5-MIN RAPMS: +201 MW, -200 MW
MAX 30-MIN RAPMS: +398 MW, -314 MW
MAX 60-MIN RAPMS: +580 MW, -423 MW
MAX FOR MONTH: 1217 MW (Jan30)

Source: 5-min data via SCADA/PI for Pt. 79687

<= Actual
Schedules are Much improved, but.... Steep ramps will become an issue
Operational Improvements

- Wind Plant operators have become much better at forecasting and adjusting wind schedules – reducing reserves.
- The per MW charge for wind imbalance service has actually reduced for the coming rate period.
- Collaboration with other NW utilities can improve (reduce) imbalancing costs (80% of wind energy generated in BPA is exported to other NW and CA utilities).
- BPA has implemented several initiatives to improve grid operation:
  - Inter-Hour schedules (30 Min) to reduce the hourly errors.
  - Better forecasting tools including adding 12 new Met Towers in the region (data available to all wind plants).
  - DSO216 protocol to shift tail events to the wind fleet
  - Customer supplied balancing reserves and DTC to allow wind projects to contract for balancing from other generation resources
Future Enhancements

- Increase use of gas plants and other generation resources in the NW
  - The FCRPS is limited. BPA will need to rely on other resources to accommodate more wind.
- New pilot program, “Committed Inter-Hour”, shifts imbalances to load receiving entity via 30 minute schedule adjustment of wind schedules.
- BPA Banks Lake will add some storage capability.
- Many storage technologies are now being pursued that may help in the future.
- Demand response adds another option to reduce the impact of wind’s variability.
- Balancing resource markets are being considered.
- The WECC is considering EIM – an Energy Imbalance Market to allow generators across the system to provide balancing services.
An EIM would provide access to a broader range of balancing resources to BAs and market participants than they have under current scheduling practices.
DSO 216 Control (iCRS)
Example of Limiting Wind Output (Feathering) for Reserves Depleted Event
Environmental Redispatch 2011

- BPA developed and implemented the Environmental Redispatch (ER) process to limit spills when total dissolved gas (TDG) exceeds limits.
  - BPA must put more water through turbines to avoid increasing spill and dissolved gas levels in the river.
  - BPA arranges to ‘buy’ the output of non-hydro generation by offering zero cost power from the FCRPS
  - And temporarily limits the output of all other non-hydro generation in order to maintain TDG levels.

- Environmental Redispatch
  - BPA issued draft ROD Feb 2011 and final ROD on May 13, 2011.
  - BPA offered free energy in the market prior to ER
  - ER implemented as last resort.
  - ER was used to control TDG levels May 18 – July 10
  - Mostly during light load hours and more infrequently during July (range of 4 – 7 hrs per night).
Environmental Redispatch 2012

What’s next (A note from management):

- Develop an equitable and durable protocol for managing the operational and cost allocation issues associated with over supply conditions for Spring 2012.
- Collaborate with the Wind Integration Steering Commission (WISC) to review and implement longer-term solutions (beyond FY 12) for over-supply conditions.
- Support Council efforts to define the supply curve of potential long-term physical solutions to the regional over-supply issue.
Closing

- Wind is Energy Resource not Demand Resource
  - Will need traditional power plants for increasing demand
  - But is helping NW meet energy needs.
- Private Corps and Utilities are installing 3-4000MW’s of Wind in NW next 3-4 years ($7 - $8 Billion capital cost including 2011).
  - This will add much Tax revenue to the local rural economies
- Wind Projects have had rapid expansion since 2007:
  - Locating first in areas with excess transmission interconnection capability (no new long lines required)
  - BPA has offered over 9,000 MW in new transmission service for wind generation enabled in part by BPA build of 3 new major lines.
  - The OR/WA/CA RPS’s one driver of the demand
  - Federal PTC extended thru 2012 is another driver.
- Community Wind Projects are picking up.
Questions ?