



November 2008

**W**ind power development in the Northwest is exceeding all expectations. Just last year, BPA and the Northwest Power and Conservation Council outlined steps to integrate up to 6,000 megawatts of wind in the region's power grid by the early 2020s. About 3,000 megawatts of that were expected to locate in the area BPA controls for reliability purposes.

The reality is much more, much sooner. As much as 6,000 MW of wind power is now seeking interconnection to the BPA system within the next five years. The 3,000 MW BPA was expecting to have on its grid in the early 2020s is now expected to be on-line by December 2009. Challenges we thought we would address over the next several years need to be resolved now.

The vast amounts of wind power lined up to interconnect to BPA's transmission grid are overwhelming the federal hydropower system's ability to provide sufficient integration services. Integration services maintain the constant balance of loads and resources to assure system reliability second-by-second, minute-by-minute and hour-by-hour. Variable wind power requires large amounts of balancing services.

## BPA strongly supports wind power

BPA supports wind and other new renewable resources. We have successfully interconnected 19 wind farms that cumulatively include more than 1,000 wind turbines to our transmission grid in the last few years and have built five new substations and six new tap lines to do so. Our strong support for wind is the reason why we want to get a handle on solving the integration services challenge as soon as possible.

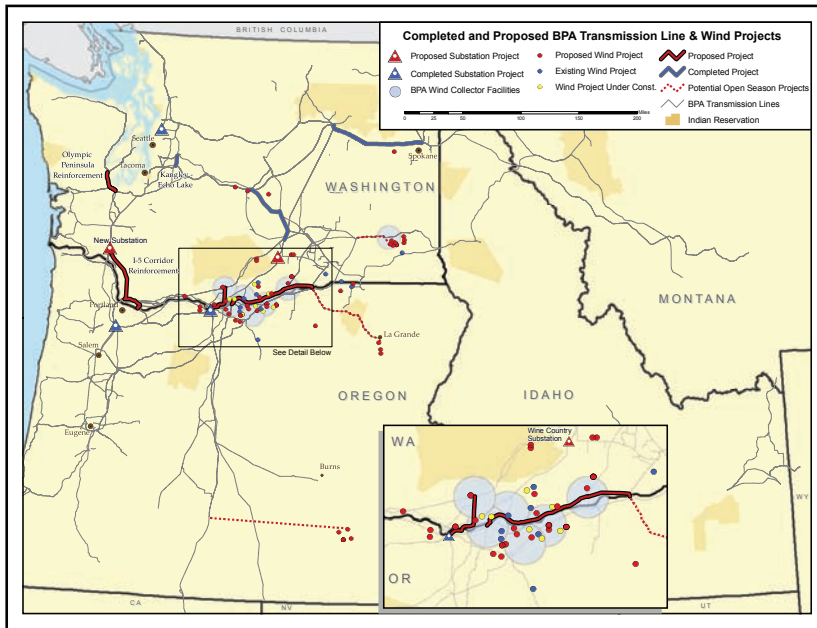
## We are entering uncharted territory

A large fraction of the wind power in the Northwest is locating in the heart of BPA's transmission grid. Wind power in BPA's balancing area has grown from 25 MW 10 years ago to more than 1,500 MW today. We expect this figure to double by the end of 2009.

At that point, wind generation will equal 30 percent of the peak load in BPA's balancing authority area. This will be one of the highest if not the highest proportion of wind power to load in any power system in the U.S. We are entering uncharted



## Wind farm locations



Map by Geospatial Services

Most of the wind power in the Northwest is clustering in the heart of BPA's grid.

territory. We now estimate that BPA may have as much as 4,330 MW of wind in its balancing authority by 2011.

Last spring, BPA launched a Network Open Season to facilitate grid expansion for many pending transmission service requests, most of which were submitted to obtain service for new power resources. Of the 6,410 MW of transmission service requests that responded to BPA's Network Open Season, 74 percent or 4,716 MW represent new wind farms.

BPA had already accounted for some of these projects in its forecast. Add the rest, and 6,000 MW of wind power could be served by the BPA grid as soon as 2013. This could mean BPA would have to constantly balance loads and generation for 6,000 MW of wind capacity in a balancing area where loads themselves today average 6,000 MW and peak at 10,500 MW.

## Integration services keep the system in balance

Electricity generation must match loads in a power system at all times or the lights go out. Today, BPA provides balancing services to back up wind from federal dams. But the hydro system's limits are being reached.

When the amount of wind in BPA's balancing area was small, systems designed to handle swings in loads also accommodated variations in wind output without difficulty. Now, with so much wind

entering the system, swings in wind output are beginning to tax and overshadow the systems that were designed to handle only variations in loads. New solutions are needed.

## Wind power schedules are proving inaccurate

BPA is seeing frequent, large discrepancies between the generation that wind farms schedule for each hour and actual generation. This is known as generation imbalance. BPA is counterbalancing these discrepancies by increasing generation from federal dams when wind generation falls below schedules and decreasing federal hydropower output when wind output exceeds schedules.

Specifically, wind turbines in BPA's balancing area are tending to realize dramatic changes in the amounts of power they generate about two hours before those amounts change in their generation schedules. This results in large discrepancies

between scheduled and actual output, which in turn require large amounts of generation imbalance service, placing enormous strain on BPA's reserve capacity.

Several years ago, BPA exempted wind farms from certain generation imbalance penalties designed for traditional power sources, recognizing that wind operators cannot increase the output of their plants at will and can decrease at will only by feathering blades and spilling wind energy – the equivalent of spilling water at dams. Now we need to address the particular generation imbalance problems that are related to wind power. Wind generation imbalance is beginning to impose real consequences on system operation that could affect both system reliability and fish protection. For example:

- Twice this year, BPA's transmission grid has operated outside bounds set to maintain reliability because wind generators were operating so far from scheduled output that it took the system beyond Western Electricity Coordinating Council standards. Compliance with these standards is mandatory under federal law, and violations can lead to sanctions including financial penalties.

- This spring, wind turbines in BPA's balancing authority produced significantly more power than scheduled over several hours on one day, peaking at over 400 MW of excess generation. BPA had to reduce hydro generation to accommodate this unscheduled wind generation. Due to high flows, water was already spilling over dams above that needed for fish protection, so backing off hydro generation further meant increasing water spill, and nitrogen saturation in the water rose nearly to levels dangerous to fish.
- Last August, wind turbines in BPA's balancing area generated 730 MW more than scheduled in one hour and 680 MW over schedule in another. On Sept. 10, wind plants in BPA's balancing area generated 625 MW less than scheduled. Each of these deviations represents more than the average power use of a city the size of Portland.

## Needed services soar

The pace of wind power's growth is outstripping our ability to provide the needed services with the tools we have.

Wind compared to load (Selected utilities)			
Utility	Installed Wind	Peak Load	Proportion of Wind to Peak Load
Pacificorp East	858 MW	5,689 MW	15%
Pacificorp West	251 MW	3,555 MW	7%
PNM	204 MW	2,500 MW	8%
Northwestern Energy	146 MW	1,724 MW	8%
CAISO	2,800 MW	49,071 MW	6%
ERCOT	5,812 MW	62,400 MW	9%
BPA	1,530 MW	10,500 MW	15%
BPA FY 2010	3,100 MW	10,500 MW	<b>30%</b>

*BPA already has among the highest ratios of wind power to load of any U.S. balancing authority.*

For FY 2009, BPA projected a need for 203 megawatts of hydro capacity to provide regulation and following services for a weighted average of 2,343 MW of wind power. BPA established a wind integration rate to cover the costs of these services. But the FY 2009 wind integration rate does not address reserves needed for generation imbalance services, which is proving to be the biggest need. At customers' requests, we created a Wind Integration Team that is developing

### Wind integration services

Before each hour, power plant operators schedule the amount of power they plan to produce and transmit over the transmission system in the coming hour. If actual real-time output diverges from this hourly schedule, the transmission operator of that balancing area must rebalance the system moment-to-moment by increasing or decreasing generation from other sources. When these and other actions are taken to help wind power operate smoothly in the grid, they are known as wind integration services. The primary wind integration services include:

- **Regulation:** Correcting in real time for moment-to-moment deviations between generation and load. Corrections are made on a four-second response cycle by Automatic Generation Control.
- **Following:** Correcting in real time for differences between load and generation over longer time increments of five to 10 to 60 minutes between hourly scheduling adjustments. Includes load following and now generation following. Corrections are made by AGC or by dispatcher action.
- **Generation imbalance:** Correcting after the fact on a billing basis for discrepancies between the amount of power scheduled at the beginning of an hour to be produced by a specific resource during that hour and the amount actually produced. For FY 2010-2011, BPA intends to include the cost of maintaining necessary generation balancing reserves.

new methodologies and new techniques for providing wind integration services.

Because wind generation is significantly overshooting and undershooting scheduled output, providing the necessary generation imbalance and following services (not including regulation), would require setting aside and reserving significant incremental capacity and decremental capacity to meet the wind integration service needs. Given the estimated wind fleet of 4,330 MW in 2011, the amount of needed incremental capacity alone could exceed the capacity of Bonneville Dam.

### More than hydro alone can handle

With the now-expected growth of wind in the BPA balancing authority area, there might not always be enough water or flexibility in the Columbia River system to provide enough integration services while also meeting power loads and non-power obligations. At times, federal power operations are highly constrained for flood control, fish mitigation, irrigation, navigation, tribal fisheries and recreation obligations. In addition, BPA power loads and Columbia River Treaty obligations have grown significantly over the past decade and are consuming ever increasing system capability. Further constraints on hydropower production could further diminish the hydropower system's ability to provide wind integration services.

We think we are currently able to provide integration services (including generation imbalance and following reserves) for approximately 3,500 MW of installed wind generation capacity, given current wind generation forecast and schedule accuracy and current scheduling practices.

Absent solutions, the imminent danger is that we would no longer be able to balance the system correctly and would either start failing to meet

Western Electricity Coordinating Council or North American Electric Reliability Corporation reliability standards or risk violating operating criteria for the federal dams.

## Potential solutions

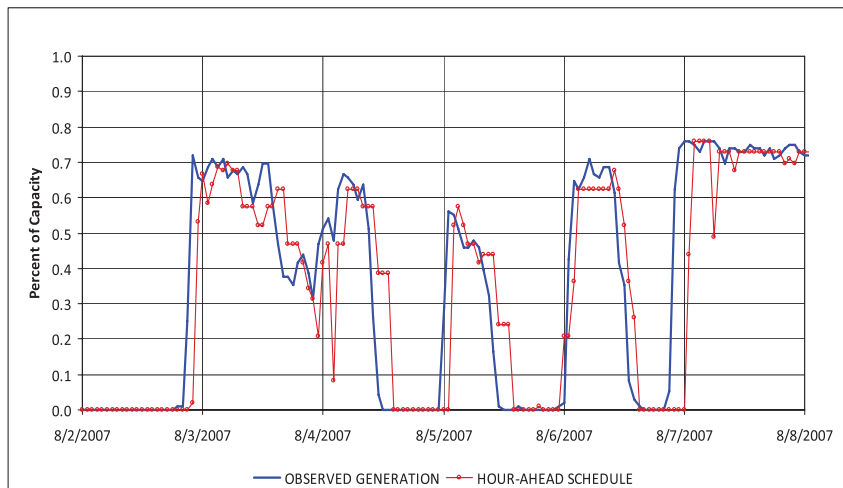
Fortunately, there is a long list of potential actions BPA can take to address the generation imbalance issue. BPA is already exploring a number of potential solutions to the generation imbalance problem and is now accelerating its discussions. Possibilities include:

**Seeking third-party services:** BPA received 18 responses to a Request for Information on third-party, within-hour wind integration services and their costs. The responses include a wide range of potential products, from limited capacity purchases to demand-side management to construction of new facilities. We will work through the Wind Integration Team to involve interested customers and members of the public in the next stages of this effort.

**Limiting wind output to schedule for reliability:** BPA already has called on wind project generators to limit generation to that scheduled when necessary to maintain transmission system reliability rather than exceeding their generation schedules. BPA plans to automate this system early next year.

**Improving wind generation schedule accuracy:** To diminish the need for generation imbalance service, BPA is working with wind owners and operators to improve the accuracy of generation schedules BPA receives.

## Generation imbalance



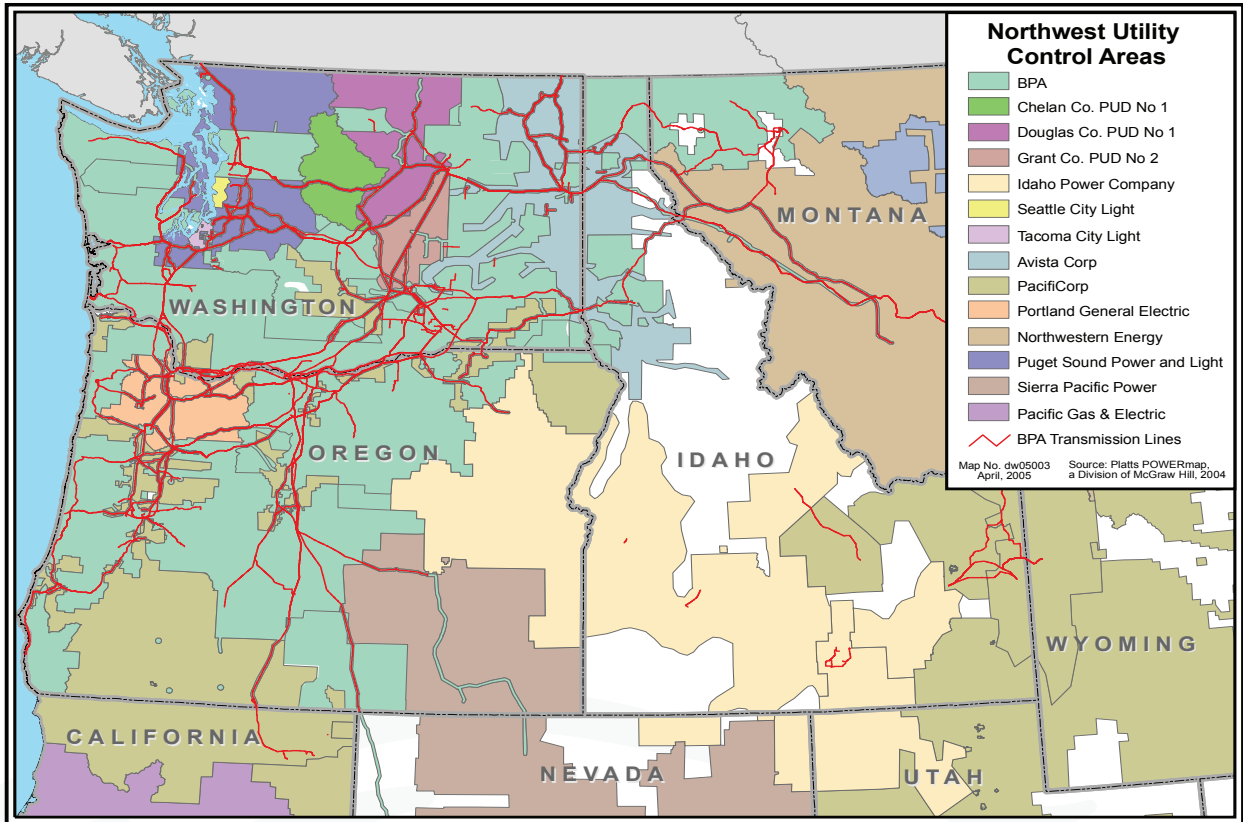
*Large changes in wind generation (blue) tend to appear about two hours before they're scheduled (red), requiring BPA to make equally large shifts in hydro generation in real time.*

**Improving wind forecasts:** BPA is sponsoring research to improve short-term forecasting of extreme wind fluctuations in the Northwest and will collaborate with the region through the Northwest Wind Integration Forum to develop a more accurate day-ahead, hour-ahead and near real-time wind energy forecasting system.

**Refining reserve requirements:** BPA is working with the wind consultant 3Tier to analyze how much planned wind in the BPA system will actually generate at any time to refine calculations of the amount of reserves BPA must hold ready. This study will help us determine subsequent rates for wind integration services.

**Improving Automatic Generation Control:** BPA is studying whether its Automatic Generation Control system can be improved to anticipate changes in both loads and wind generation, instead of just loads. This should reduce the amount of stand-by generation needed and reduce wear and tear on hydro turbines.

## BPA's balancing authority area



BPA is the balancing authority responsible for maintaining a constant balance between the power load and power generation in the area **shown in teal**. (A balancing authority is also known as a control area.) Most of the wind power on line and planned for the Pacific Northwest is clustered in BPA's balancing authority at the eastern end of the Columbia River Gorge. However, three-fourths of the wind power in BPA's balancing authority area serves loads in other utilities' balancing authorities.

### Dynamically scheduling wind across interties to Canada and California:

BPA does not now have the technical capability to dynamically schedule large amounts of wind power from its balancing authority to those of balancing authorities in Canada and California due to transmission constraints, but is exploring ways to increase this ability.

### Inventing new transmission scheduling practices and procedures:

BPA is working with the California Independent System Operator and other balancing authorities to create a sub-hourly scheduling procedure that would allow the wind project owners to move the imbalance portion

of their integration service requirements to another balancing authority. We also are looking at how we could implement a generation schedule that is changed every 10 minutes or in other increments shorter than one hour.

### Shifting the pattern of wind development:

Through coordinated planning among utilities and generation developers, we might be able to achieve a more diverse geographic pattern of wind farms in the Northwest with a more disparate pattern of wind generation. This could reduce the volume of generation imbalance service required.

### **Assigning receiving entity responsibility:**

About three-fourths of the wind capacity in BPA's balancing authority area serves loads in other balancing authorities such as Portland General Electric or PacifiCorp. About 250 MW serves loads in California. One idea to explore is whether and how the utility receiving wind power might take responsibility for providing wind integration services for that power.

**Working with other utilities:** BPA is exploring several ways that pooling its capabilities with other utilities might reduce costs for all. For example, BPA has signed up for a pilot project with the Northern Tier Transmission Group to explore pooling Area Control Error divergence from load-resource balance with other Western utilities. Looking at control errors across a larger portion of the Western Interconnection should allow participating utilities to net out differences when one is a little high and another a little low.

### **Exploring other wind output controls:**

Eventually, BPA could establish ramp controls to limit the need for balancing resources. BPA is exploring techniques used by European nations that allow power schedulers to control wind turbines in real time to avoid very large changes of wind generation in very short periods of time (such as large wind ramps or "tail events").

### **Natural gas or other generation:**

Most U.S. power systems rely on coal and natural gas-fired plants and typically use natural gas-fired combustion turbines to counterbalance variations in wind output. In fact, many view wind power as a way to offset natural gas. Capacity could be purchased from natural gas resources to support wind integration. Or, natural gas might be used to provide wind integration services across multiple balancing authority areas.



### **Flywheels, pumped storage, demand-side management, etc.:**

Another source of wind integration services could be technologies that can absorb excess wind generation and/or release energy on demand when the wind falls. These technologies have great potential but are not likely to be available in the near term. BPA has a research and development effort under way to evaluate this potential for the future.

## **Resolution is a high priority**

Resolution of the wind integration services issue is of immediate concern to BPA customers, wind power owners, Northwest states, renewable resource interest groups and to FERC. BPA is working on the issue with all these groups in several forums. The issue is evolving fast.

**FERC Order 890:** Last year, the Federal Energy Regulatory Commission issued Order 890, establishing a new pro forma Open Access Transmission Tariff. Schedule 9 of this revised OATT requires transmission providers to provide generation imbalance even if the resource serves load in another balancing area. Schedule 9 would obligate BPA to provide generation imbalance to new generators interconnected to its system "to the extent it is physically feasible to do so from its

resources or from resources available to it.” There is little guidance on the meaning of this clause. BPA voluntarily complies with FERC orders and filed its Order 890 tariff with FERC on Oct. 3, 2008. Because Schedule 9 could bind BPA to provide generation imbalance service that BPA is not sure it could provide, BPA did not include Schedule 9 in its Order 890 tariff filing, and will respond separately to Schedule 9.

BPA has committed to give FERC a work plan by Jan. 3, 2009, outlining the public process BPA will use to resolve this issue. BPA is now working with its customers and constituents in several venues to explore potential solutions and outline this process.

### Large Generator Interconnection

**Agreements:** BPA signs a Large Generator Interconnection Agreement with each new generator coming on line in its balancing authority. LGIAs include generation imbalance as a service BPA provides. BPA is considering whether it must clarify LGIA terms. BPA is talking with wind project developers about language options for their LGIAs and/or means to improve the accuracy of wind

generation scheduling that could enable new wind projects to move forward on schedule while protecting the reliability of the transmission system and the interests of other BPA customers. Once viable solutions have been worked out, BPA would expect to clarify LGIA contract terms accordingly.

BPA is also conferring with other Northwest transmission owners in the NTTG/WestConnect/ColumbiaGrid Joint Initiative on whether and how balancing authorities that receive wind power from BPA could provide generation imbalance service for that power.

**Wind Integration Team:** Following the 2009 transmission rate settlement, BPA established a Wind Integration Team as the focal point for its technical efforts to resolve wind integration issues. Contact WIT manager Eric King at (503) 230-5236.

**2010-2011 Rate Case:** BPA is currently holding a series of preliminary workshops on issues for its 2010-2011 power rates and transmission tariff, with initial rate proposals for both scheduled for January 2009. Wind integration issues have been a major ongoing subject of these workshops. The rate case Web site is: [www.bpa.gov/corporate/ratecase/2008/2010\\_BPA\\_Rate\\_Case/](http://www.bpa.gov/corporate/ratecase/2008/2010_BPA_Rate_Case/).

## Conclusion

Wind power is a success as a power resource for the Pacific Northwest. The generation imbalance issue is one of the growing pains that can be expected with any new resource with significantly different technical attributes. By working with its utility customers, wind developers, regulators and interested citizens, we are confident we can find practical, equitable and viable ways to meet the technical requirements of the wind resource and increase its role in an economic, reliable and environmentally sound Northwest power system.

