January 2013

Seasonal power oversupply in 2012

The Bonneville Power Administration implemented the Oversupply Management Protocol in spring 2012 to manage a temporary oversupply of electricity. Under the policy, BPA curtailed generation when necessary to balance energy supply and demand to reduce the amount of total dissolved gas in the river.

The Columbia River runoff at The Dalles, Ore., from January to July 2012 was 129.4 million acre feet, significantly higher than the average of all water years since 1929, approximately 103 maf. That 2012 volume, however, was still lower than the 2011 volume of 142.7 maf. Periods of strong spring winds in 2012 also drove generation via

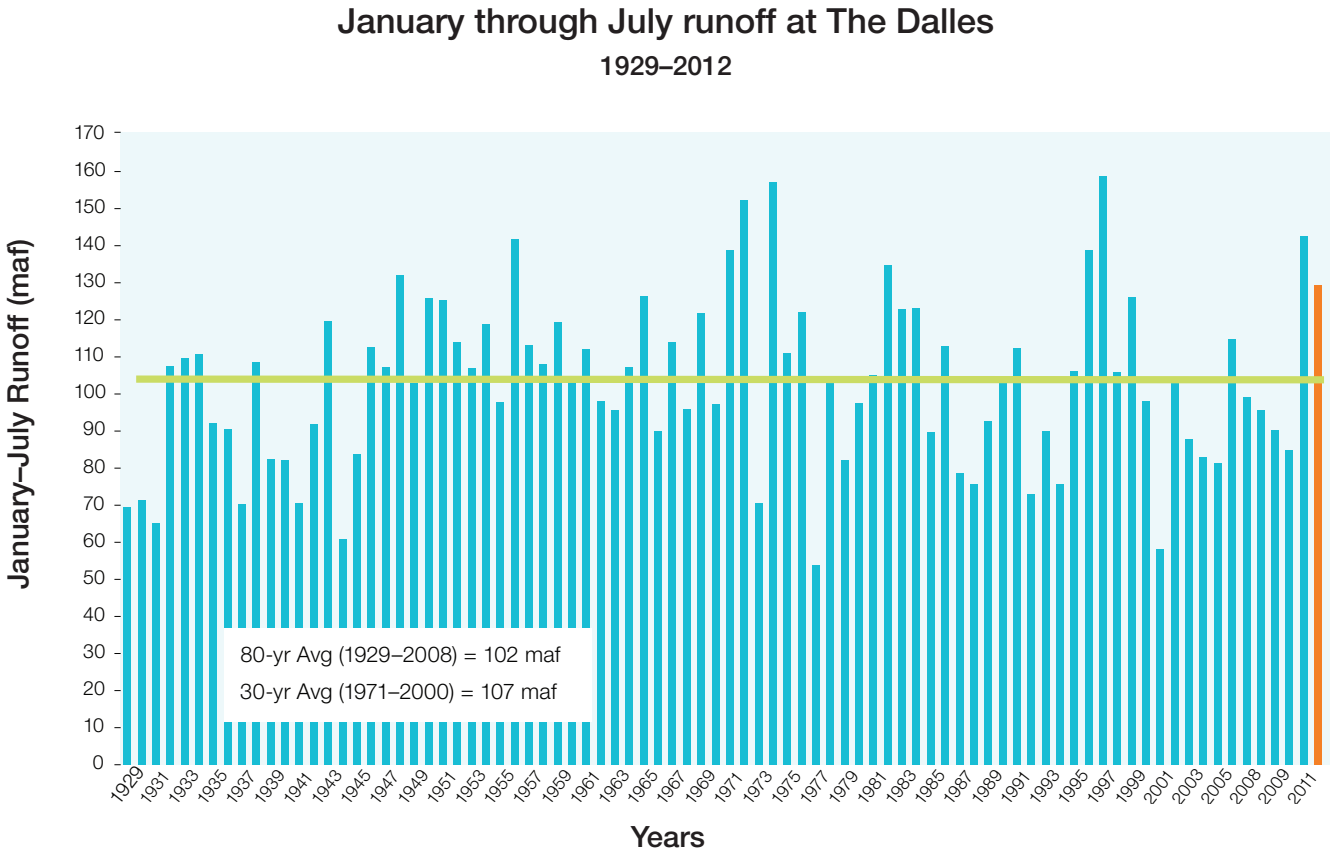
Spill operations

Pursuant to the Federal Columbia River Power System Biological Opinions (BiOps), the U.S. Army Corps of Engineers issues an annual Fish Operations Plan (FOP) in which it describes planned operations for fish passage at mainstem FCRPS dams during the fish migration season, April through August. These operations have undergone Endangered Species Act consultation, are implemented in accordance with the BiOps and are consistent with applicable state and tribal water quality standards adopted pursuant to the Clean Water Act, to the extent practicable.

On Aug. 2, 2011, the United States District Court for the District of Oregon issued an order requiring that "spring and summer spill operations (be conducted) consistent with this Court's annual spill orders." The Court's annual spill orders are implemented through the annual FOPs. The 2012 FOP states that, during the spring freshet's high spill levels, "the Corps will attempt to minimize TDG on a system-wide basis," using the spill priority list reviewed by regional sovereigns with spill caps set for "122 percent, 125 percent, 127 percent, 130 percent, or 135 percent TDG as a means of minimizing TDG throughout the system."

In an April 10, 2012, letter to BPA, Will Stelle, regional administrator for the National Oceanic and Atmospheric Administration, noted that symptoms of fin gas bubble trauma (GBT), which is correlated with fish mortality, increase in salmon and steelhead as TDG levels rise. Studies indicate that, in water with TDG concentrations of 120 percent of saturation or less, GBT occurs in less than 1 percent of fish, but the incidence of GBT increases to more than 6.5 percent of fish as TDG concentrations exceed 130 percent. To address TDG levels over 120 percent, Stelle recommended the continued "use of the spill priority list in consultation with the Technical Management Team to minimize the impacts of high levels of TDG on salmon and steelhead."

For more information, go to *www.salmonrecovery.gov/Hydro/Operations/TDG.aspx.*



the fleet of wind projects interconnected to BPA's transmission system.

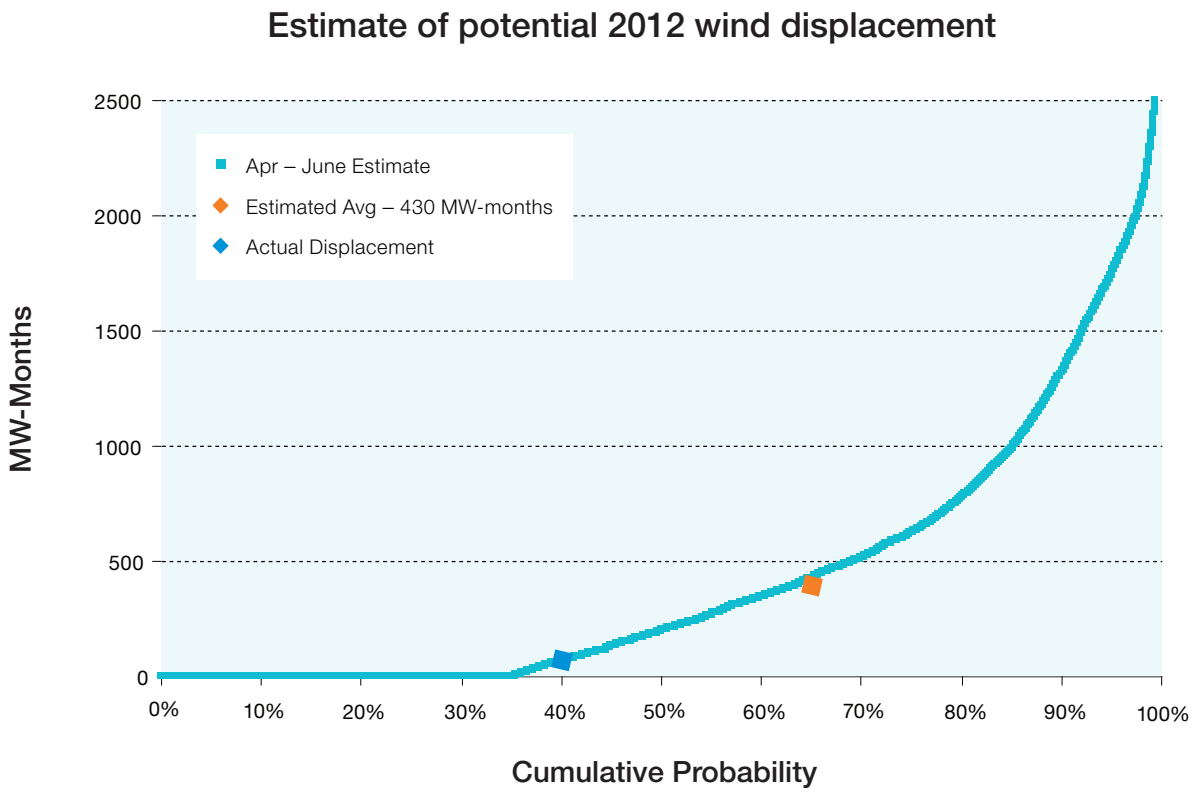
This combination of factors at times created a problem of too much power and not enough demand, particularly at night during light-load hours and on weekends. BPA implemented the Oversupply Management Protocol, displacing approximately 70 megawatt-months of non-hydro generation (49,744 MW-hours) with federal hydropower to maintain the reliability of the power system and reduce adverse conditions for protected fish and other aquatic life.

There was less oversupply in 2012 when BPA displaced about 70 MW-months of generation than in 2011 when BPA displaced about 135 MW-months of generation. Significant factors included the runoff volume and shape; demand for energy in California and BPA's purchase of intertie capacity to increase exports; and creative marketing strategies that allowed BPA to shift generation out of the light load hours (10 p.m. to 6 a.m.) into hours when there was greater demand for power.

MODEL ASSUMPTIONS COMPARED TO ACTUAL DATA

Before the oversupply season, BPA performed studies to assess the frequency and magnitude of wind in its balancing authority that would be displaced with federal hydropower from April through June 2012. These studies assumed a fixed amount of thermal generation, load and exports in the region. Hydro and wind generation were varied in weekly heavy load hour and light load hour blocks to create 31,500 outcomes.

In the graph on page 3, the results of the analysis are represented in terms of cumulative probability, or the probability of observing less than or equal



BPA's analysis suggested there was a 35 percent probability that no wind displacement would be needed in 2012. There was a 65 percent probability that wind displacement would not exceed 430 MW-months, the estimated expected value of wind displacement. Actual displacement in 2012 totaled about 70 MW-months, which was around the 40th percentile.

to a given value. The further you look to the right of the curve, the lower the probability of that event occurring. For example, at the 35th percentile, the MW-month value is zero, meaning there was a 35 percent probability there would be no wind displacement in 2012.

The expected value of estimated wind displacement was 430 MW-months, which fell at the 65th percentile of the distribution. The actual displacement in 2012 of 70 MW-months fell around the 40th percentile of the distribution. In other words, our model indicated there was a 40 percent probability that there would not be more than 70 MW-months of displacement.

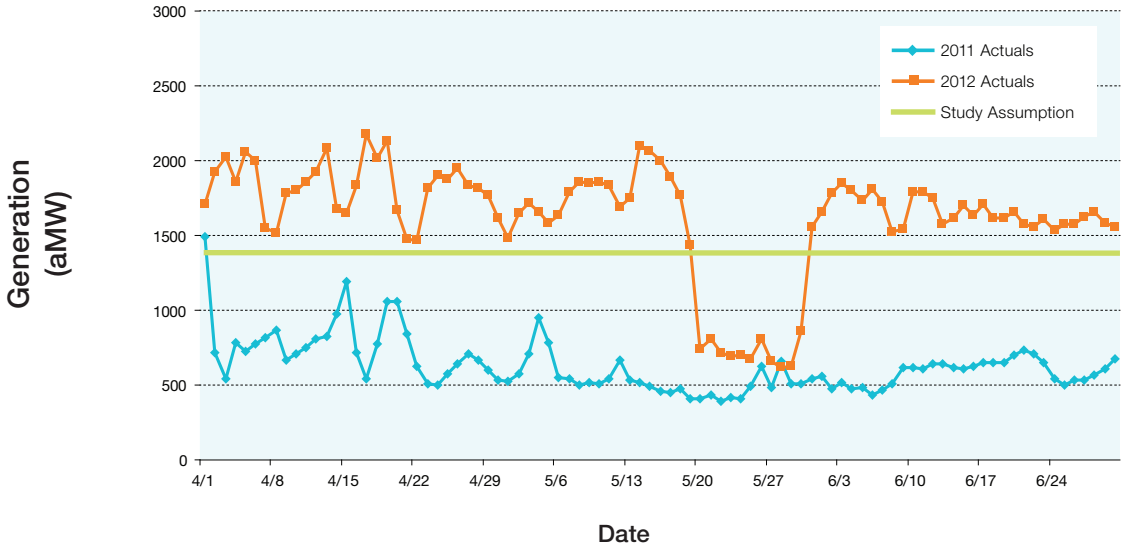
BPA ran the model again after the 2012 oversupply season using actual generation and export data, which differed from our fixed model assumptions. The result was about 46 MW-months of displacement, which is close to the actual total and validates the methodology. However, BPA believes it could refine the model by varying some of the assumptions, such as thermal generation, rather than using a fixed value. These refinements are discussed at the end of the paper.

REGIONAL THERMAL GENERATION

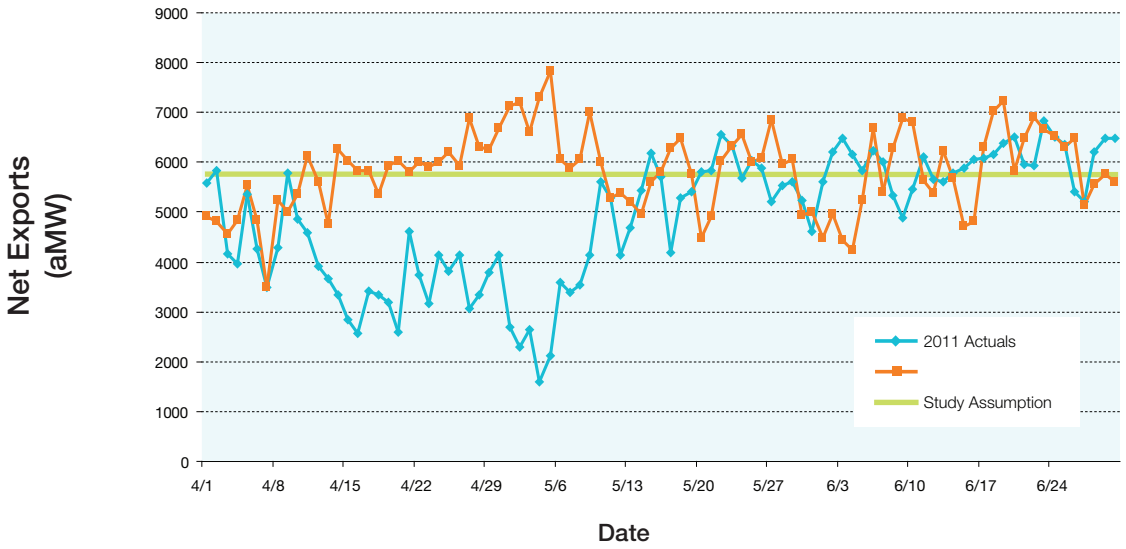
Actual thermal generation in the region in 2012 was greater than assumed in the analysis.

In light load hours from mid-May through June 2012, about 600 to 2,100 MW of thermal generators in the region operated. Thermal generation was greater in 2012 than in 2011, largely due to the 1,100 MW Columbia Generating Station, the region's only nuclear plant, being on line. However, Energy Northwest, the CGS

Regional thermal generation in light load hours



Regional exports in light load hours



operator, did reduce generation to minimum reliability levels when BPA faced oversupply (see page 9 for more information). The nuclear plant was down during the 2011 oversupply season for a scheduled refueling outage.

As in 2011, before each oversupply event, BPA offered federal hydropower into the Northwest wholesale market that resulted in zero revenue to the agency. This arrangement is generally of interest to thermal owners who then save the cost of fuel. To encourage thermal displacement, BPA sold more than 1,000,000 MW-hours of energy that resulted in zero revenue in FY 2012.

REGIONAL EXPORTS

There were significantly more exports in late April and early May from the Northwest to California,

Idaho, Nevada, Wyoming and Utah than assumed in the analysis. Drivers for this additional demand were below average hydro conditions in northern California and an extended outage at the San Onofre nuclear power plant in southern California. The nuclear plant's two units, with a combined capacity of 2,200 MW, were down the entire oversupply season. Coupled with its below average hydro conditions, California relied more heavily on Northwest generation than in 2011.

REGIONAL LOADS

An assessment of actual regional loads is not yet available, but we do know that temperatures were 3.2 degrees below average from April through June in the BPA load centers. It's likely that the actual loads were higher than assumed in the study, especially at night, given the cooler temperatures.

REGIONAL WIND FLEET

The capacity of the wind fleet in the region was about 200 MW less than assumed in the study. While the amount of wind in BPA's balancing authority was very close to study assumptions, the amount of regional wind outside of BPA's balancing authority was lower than assumed.

The analysis used 30 different wind shapes with varying capacity factors (the average generation of the wind fleet compared to its capacity). The actual capacity factor for April, May and June fell within the ranges assumed in the study.

The actual capacity factor of 29 percent in April was at the very low end of the assumed range. The lower capacity factor combined with an actual fleet size that was smaller than assumed in the study resulted in nearly 600 average MW less wind generation than the mean indicated in the study. May and June actual capacity factors, 34 and 39 percent respectively, were slightly higher than the assumed means of 33 and 38 percent. The combined effect of the higher than assumed capacity factors and the lower than assumed wind fleet size resulted in actual wind generation that was close to the average assumed in the study for May and June.

NONFEDERAL HYDRO GENERATION

The analysis assumed varying levels of nonfederal hydro generation consistent with the Hydrologic Simulator Model (HYDSIM), a widely used computer model of federal and nonfederal hydro projects in the Columbia River Basin.

After-the-fact generation data from a subset of nonfederal hydro projects indicates that the level of nonfederal hydro generation was lower by several hundred average megawatts in May and June than what would have been expected given the runoff volume. While it is likely that these projects spilled more than assumed in the HYDSIM study, specific project data is not readily available, and BPA can not determine the cause or implications for future years.

Wind fleet size

ASSUMED VERSUS ACTUAL (MW)

Location	Study assumption	April actual	May actual	June actual
BPA	4,416	4,267	4,369	4,459
Non BPA	2,460	2,258	2,258	2,258
Total	6,876	6,525	6,627	6,717

Wind capacity factors

ASSUMED VERSUS ACTUAL (%)

Capacity Factor	April 2012	May 2012	June 2012
Study Assumption	36 (29–45)	33 (23–43)	38 (25–48)
Actual	29	34	39

DIFFERENCES BETWEEN 2011 AND 2012

There are many variables in oversupply, and it is possible for each year to bring a unique set of circumstances. Below is a summary of the significant differences between the 2011 and 2012 oversupply seasons, including new actions BPA took to minimize displacement.

ACQUIRED MORE NON-SPINNING RESERVES

Generators are required to set aside contingency reserves in case of a unit outage within the Northwest Power Pool or some other event. Balancing authorities must also provide balancing reserves, the ability to increase (INC) or decrease (DEC) hydro generation to maintain a constant balance of generation and load. Some reserves have to be "spinning," or ready to respond instantaneously. A portion of the reserves can be "non-spinning," or able to respond within 10 minutes.

BPA's oversupply analysis assumed reserve obligations would be carried entirely on mainstem FCRPS projects. But in 2012, BPA was able to find sources of non-spinning reserves that were not available in 2011. This reduced the amount of reserves the agency had to hold, which increased FCRPS generation in heavy load hours and reduced spill in light load hours.

IRRIGATION PUMPING. BPA was able to acquire some non-spinning reserves in 2012 by maximizing the flexibility at Banks Lake, an irrigation resource that uses water pumped from the reservoir behind Grand Coulee Dam. There are two kinds of pumping units at Banks Lake: one that can provide non-spinning DEC reserves and one that can provide non-spinning INC reserves. The first, which can only pump water into the lake, consumes energy and helps maximize hydropower generation. Because BPA can disconnect the load at any time and decrease generation, it is a source of non-spinning DEC reserves. The second kind of units are pump generators. These units can not only pump water into the lake, they can also generate power by reversing the flow, moving water from the lake into the Grand Coulee reservoir. During oversupply periods, these pump generators were kept in standby mode so that they could increase generation quickly, which allowed BPA to use these units as a source of non-spinning INC reserves.

The ability to use the pumps for non-spinning reserves depends on several factors. In 2011, numerous pump unit outages limited the pumping load and therefore limited the potential for carrying DEC reserves to 200 MW for most of the spring. In 2012, the ability to carry reserves was also limited to about 200 MW due to elevation requirements for flood control at Grand Coulee Dam. As is normal during high runoff periods, the level of Lake Roosevelt, behind Grand Coulee Dam, must remain at low elevations to create space to catch runoff and prevent flooding down-stream. Due to limitations on the units, only certain pumps are able to operate when the reservoir is at low elevations. With the required low flood control elevations this year, the available pumping units were reduced, limiting the potential for carrying non-spinning reserves.

A NEW ENERGY PRODUCT: CAPACITY-RECALLABLE ENERGY. BPA also acquired a new source of non-spinning reserves in 2012, which enabled the agency to use nearly all of its allowable generating capacity that otherwise would have been used to carry non-spinning reserves. BPA's Trading Floor began selling a new product called Capacity-Recallable Energy (C-RE). C-RE is an energy product that BPA has the rights to interrupt during a contingency event. This product is sold at a discount and generates minimal revenue, but it is a source of non-spinning reserves because it allows BPA to interrupt the load and back off the generation when necessary.

To sell C-RE, Transmission Services set up systems so that the energy deliveries could be interrupted automatically in case of a contingency. BPA's Trading Floor offered up to 150 MW of C-RE for 16 hours a day (during heavy load hours) and sold more than 134,000 MW-hours between April and July.

Capacity-Recallable Energy deliveries

April through July 2012

Delivery Month	Net MWh	Average MW
01-Apr-12	16,815	23
01-May-12	55,840	75
01-Jun-12	5	0
01-Jul-12	61,725	83
Total	134,385	181

As with irrigation pumping, this product allows BPA to hold less spinning reserves and generate more hydropower in heavy load hours, which has the effect of lessening spill during light load hours. This helps control dissolved gas without asking a thermal or renewable energy source to reduce its output.

IMPLEMENTED SPILL EXCHANGES

A spill exchange is an agreement between BPA and another hydropower generator that is able to spill water without operational concerns. BPA sends that generator energy to replace what would have been generated by the water that is spilled. This exchange helps manage spill at Grand Coulee and Chief Joseph dams when when total dissolved gas levels may be approaching the state water quality standards by moving the spill to nonfederal dams that still have room to spill before reaching state water quality standards.

Through the Mid-Columbia Spill Exchange Agreement, BPA and nonfederal hydro generators implemented more than 66,000 MW-hours of spill exchanges in April 2012, compared to 13,200 MW-hours from May to mid-June in 2011. The impact of spill exchanges on wind curtailments is difficult to estimate, since some of the exchanges were implemented proactively to reduce the need for spill days later.

After April 2012, spill exchanges were no longer useful, as additional spill at mid-Columbia projects would have led to total dissolved gas levels above state water quality standards.

FLOOD CONTROL DRAFT OF GRAND COULEE ENDED EARLY

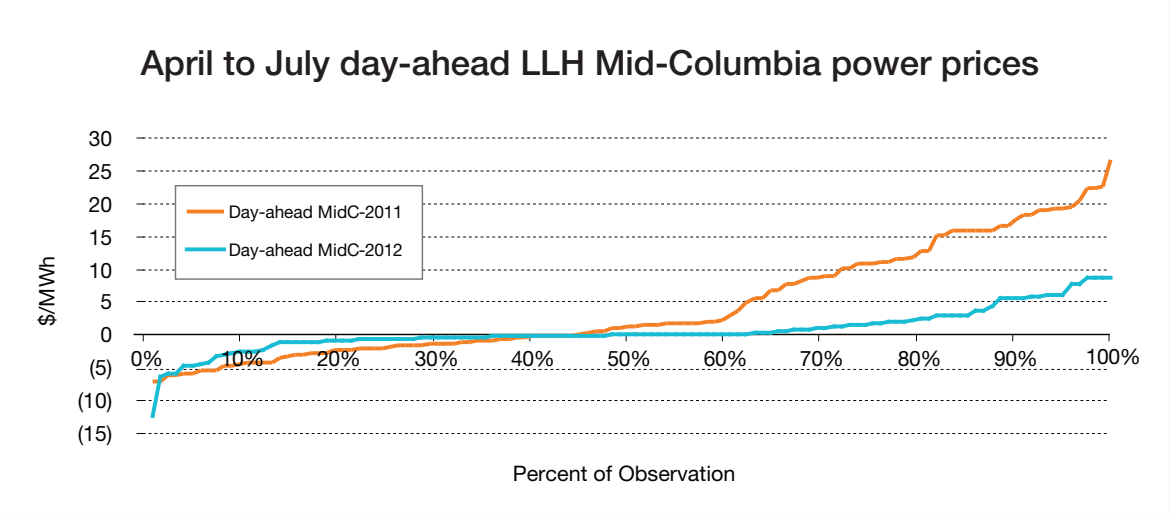
During flood control season, based on water-supply forecasts, the Corps of Engineers determines the amount of water to be released for flood risk management from Grand Coulee Dam, a federal project that is operated and maintained by the Bureau of Reclamation. The release of water from the reservoir behind Grand Coulee Dam creates storage space to manage the freshet and high flows. The Corps is responsible for declaring the end of the flood control draft, triggering refill of the reservoir. The Corps makes this determination when unregulated flows measured at The Dalles Dam reach the Initial Control Flow, an estimate of the flow that could be sustained while refilling reservoirs and managing flood risk through the spring.

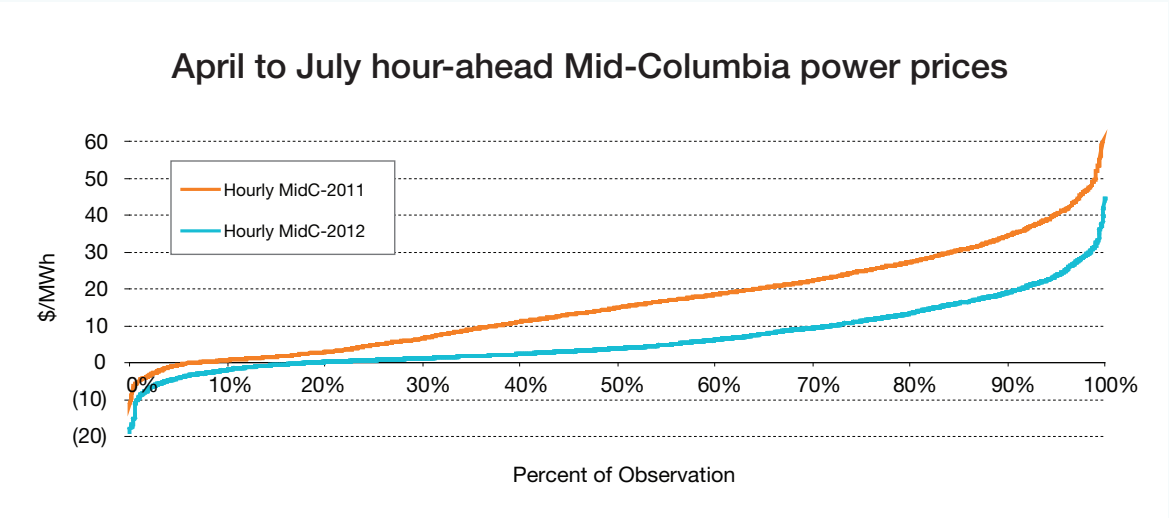
It is unusual to end the flood control draft before April 30. Therefore that is the date assumed in the HYDSIM rate case studies that were used in the oversupply analysis. But, in 2012, the reservoir draft ended on April 25. Relative to the April 30 flood control draft target, this enabled nearly 17 feet of additional reservoir storage at Grand Coulee in late April. Had flood control operations continued through April 30, the result would have been more oversupply in those five days.

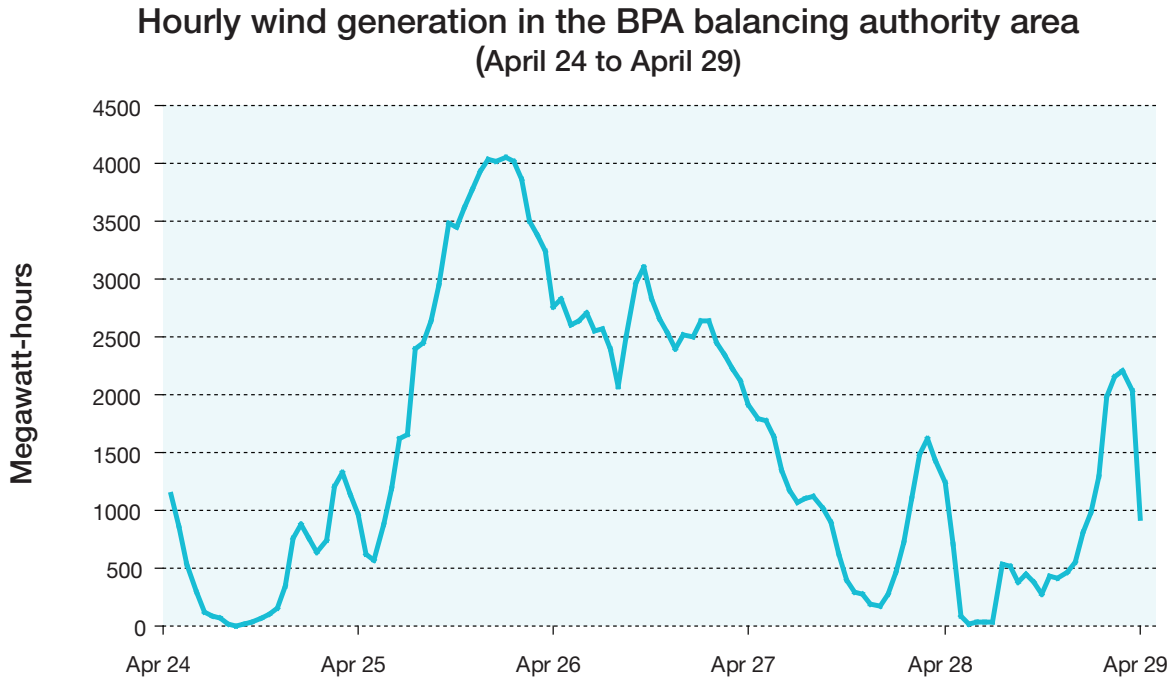
It is difficult to assess how much additional wind would have been displaced in late April, but there were periods of high winds during that time. For example, hourly wind generation on April 25, shown in the graph on page 9, exceeded 4,000 MW. BPA was on the verge of implementing the Oversupply Management Protocol when the Corps ended the flood control draft at Grand Coulee, enabling more water to be stored in the reservoir.

Prevalence of negative prices

The prevalence of negative prices highlights the importance of actions to reduce the need for spill during light load hours. Prices were negative more often in 2012 than in 2011. Day-ahead light load hour prices in the Northwest were negative nearly 60 percent of the time from April through July 2012 compared to 40 percent of the time during the same months in 2011. Hour-ahead prices in the Northwest were negative 20 percent of the time in 2012 compared to 8 percent of the time in 2011. California prices measured at the California-Oregon border showed similar results.







REDUCED REGIONAL NUCLEAR GENERATION

Energy Northwest, the operator of Columbia Generating Station, agreed to reduce the plant output to 85 percent of capacity — a level that was selected for reliability reasons — when requested by BPA. There was also an opportunity to perform transformer maintenance and shut down the plant completely for 10 days. Had this shutdown not occurred, there would have been a greater chance of additional wind displacement during this time.

ACQUIRED ADDITIONAL NON-TREATY STORAGE

BPA and BC Hydro routinely coordinate non-Treaty storage. This is storage space in the Canadian portion of the Columbia River Basin in excess of storage operated according to the Columbia River Treaty.

HYDSIM rate case studies assumed no non-Treaty storage in spring 2012. However, an extremely wet spring in Canada allowed for a significant amount of water — 2.8 million acre feet — to be stored in Canada. That is roughly equivalent to 35 feet of storage behind Grand Coulee Dam. BPA and Canada shared the water equally and agreed to release it in the summer and early fall. This storage moved about 2,000 MW-months of regional hydro generation out of the spring.

In 2012, BPA and BC Hydro signed a new long-term agreement to use additional reservoir flow-shaping capability on the upper Columbia River in Canada. The term of the agreement will extend to September 2024. This agreement will benefit juvenile salmon and steelhead when water conditions from heavy spring runoff are high. It allows more flexibility to reduce flows from British Columbia to reduce flows and spill at federal dams.

PURCHASED THIRD PARTY INTERTIE TRANSMISSION

In 2011, intertie transmission to California was limited. But in 2012, BPA was able to purchase additional intertie capacity. In July and August 2012, BPA purchased and used an additional 7,596 MW-hours of intertie transmission capacity, increasing its ability to export power.

EFFECT OF COST CURVE DISPLACEMENT VERSUS PRO RATA

Under the Oversupply Management Protocol, BPA compensates the affected generators for lost revenue, including renewable energy credits and production tax credits. Based on costs submitted by the generators, which are subject to verification by an independent evaluator, BPA paid wind generators $2.7 million for spring 2012. Had the wind curtailments been pro rata rather than on a least-cost basis, the total costs to the agency would have been about 10 percent higher, or $2.9 million.

RECOMMENDATIONS TO IMPROVE ESTIMATES

Based on what the agency learned this year, the following refinements could improve BPA's model for estimating future displacement.

1) Assume that BPA acquires additional sources of non-spinning reserves.

2) Revisit HYDSIM assumptions on nonfederal hydro generation and use of non-Treaty storage

3) Modify the model to vary the amount of regional thermal generation, load and exports, rather than assuming a constant value.

4) Extend the analysis past June since oversupply conditions occurred during July in both 2011 and 2012.

The effect of these changes may result in lowering the estimated displacement curve and the expected value. But, as we have seen in past displacement estimates (refer to the graph on page 3), the displacement in the top 10 percent of the curve will likely increase sharply. That would indicate a potential for substantial displacement, although the probability would be low.

In addition, the submitted displacement costs for 2012 were significantly higher than BPA had expected based on discussions with wind generators in 2011. So, even if there is less displacement, the total cost could be higher than previously thought.

WHAT'S NEXT

BPA intends to re-file Attachment P — the Oversupply Management Protocol section of its Open Access Transmission Tariff — with FERC so the agency can implement the protocol in spring 2013 if necessary. The current protocol expires on March 30, 2013. Before re-filing, BPA will take public comment on several proposed changes to the tariff.

BPA is also continuing to develop a cost allocation methodology through the OS-14 rate case. Information is available at *www.bpa.gov/Finance/RateCases/Pages/default.aspx*.

BPA expects to refine its oversupply model and run the displacement estimate for 2013 by spring. Also, BPA continues its work with the Northwest Power and Conservation Council to find additional long-term solutions to oversupply challenges. This effort, called the Oversupply Technical Oversight Committee (OTOC), involves representatives from the Public Power Council, investor-owned utilities, the Northwest Power and Conservation Council, the Corps, Canada, the Oregon Department of Energy, the Washington Utilities and Transportation Commission, and the wind community.

For more information, go to *www.bpa.gov/goto/oversupply*.