Northwest Power and Conservation Council

April 26, 2012

To: Wind Integration Forum Steering Committee

From: Ken Dragoon, Council Staff

Subject: Oversupply Technical Oversight Committee Recommendations

The Council was asked to lead an effort to identify physical changes to the Northwest power system to address oversupply concerns at the June 6, 2011 Wind Integration Forum (WIF) Steering Committee meeting. Pursuant to that request, Council staff asked WIF Steering Committee members to appoint representatives to an Oversupply Technical Oversight Committee (OTOC). Members of the OTOC (listed below) met to develop a list of measures deserving more in-depth analysis. It was recognized from the beginning that technical solutions abound, yet ferreting out cost-effective solutions is a larger challenge.

The attached report out of the OTOC represents the collective efforts of the group to identify measures that the group felt deserved additional study in developing cost-effective market efficiency improvements targeting periods of low demand and high supply. While not every member of the OTOC may agree with every characterization in the document, all would agree that the document reasonably represents the work of the group. The report largely avoids endorsing specific measures and does not address some of the potentially thorny cost allocation and environmental issues that some of the measures raise. Its purpose is to raise awareness and recommend further study of measures that appear to have the greatest potential for improving the economically efficient operation of the power system during oversupply conditions.

It has been a pleasure working with the OTOC members and the others who contributed to the workgroups. The process has been positive, innovative, and energetic from the beginning and the report is an important contribution to the economic, reliable, and efficient operation of the Northwest power system. I would like to thank all the people who helped in this effort and to the Steering Committee members who appointed outstanding staff to participate in this effort.

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Recommendations of the Oversupply Technical Oversight Committee to the Wind Integration Forum Steering Committee

April 26, 2012

Background

An outcome of the June 6, 2011 Wind Integration Forum (WIF) Steering Committee meeting was a request to the Northwest Power and Conservation Council (Council) to develop recommendations for changes to the power system that could address periodic energy oversupply events. In response, Council staff organized the Oversupply Technical Oversight Committee (OTOC), with participants appointed by members of the WIF Steering Committee. On December 20, 2011 OTOC approved a set of recommendations to the WIF Steering Committee for additional study presented here.

Executive Summary

The Wind Integration Forum Oversupply Technical Oversight Committee began its work by holding a brainstorming session in which participants outlined conceivable means of reducing the frequency or severity of oversupply events—periods of time when the supply of energy is very high compared to regional demand. Work groups were organized under general categories to develop recommendations for improving the economic efficiency of the power system under oversupply conditions. The recommendations of the work groups were adopted by the OTOC and are presented here.

Although technical solutions to address oversupply abound, these are not always cost-effective. The Bonneville Power Administration (Bonneville) expects the average cost of displacing wind to be approximately $12 million per year[1]. Spreading that over the several thousand megawatts of potential oversupply in some hours implies that alternative infrastructure solutions must cost less than a few dollars per kilowatt per year -- orders of magnitude less than the capital cost of, say, a new pumped-storage energy project, and a daunting cost hurdle.

It should be noted that recommendations 6, 7 and 8 relate to reducing the level of reserves held by the power system. The need to hold high levels of reserves reduces hydro operators' ability to take advantage of daytime markets by reducing the maximum allowable daytime generation and flows. This forces more water through the system at night and raises the potential for saturating nighttime markets. Reducing reserve levels adds flexibility operators can use to manage through high flow events. The Market

[1] Bonneville press release: "BPA Proposes Resolution to Electricity Oversupply," February 7, 2012.

Assessment and Coordination Committee co-chaired by Bonneville and Pacific Power was established in March to coordinate related market-efficiency activities identified in these measures.

In producing its list of potential measures for further investigation, the OTOC members recognized that although many solutions can be imagined, financial resources are scarce and should be targeted to those most likely to address oversupply at lower cost than the cost of wind displacement. The full list contains eleven recommendations for follow up work, some of which are being pursued in existing forums. The list is organized by potential and feasibility, but not prioritized for action -- all the measures merit immediate attention to determine relative cost and feasibility. Questions of cost allocation and environmental effects were not addressed in this process.

Recommendations with High Potential and Feasibility

1. <u>Remove barriers to shifting load to light load hours.</u>

Oversupply occurs primarily as a result of market saturation that occurs more readily at night when demand is low. Many commercial and industrial loads can shift some of their daytime demand into light load hours but may face increased peak demand charges in doing so. Load shifting not only reduces oversupply events but also results in net energy savings by relying less on low efficiency peaking units operating during heavy load hours. The potential could reach into the thousands of megawatts and reduce regional cost of service by many tens of millions of dollars annually.

OTOC recommends surveying commercial and industrial loads and rate structures in the region to determine the extent of the potential and encourage rate structure changes that better reflect wholesale market values of power and energy.

2. <u>Improve power system coordination.</u>

Bonneville has done extensive work getting cooperation from Canada on Canadian reservoir operations to minimize oversupply and continues to pursue additional coordination to manage through oversupply events with the hydro system. Additional power system coordination may also be possible with respect to managing flood control rule curves, encouraging residential customers to delay usage into nighttime hours, improving streamflow forecasting technology, and spilling at projects off the mainstem or that are not on the spill priority list. Significant potential likely exists in these areas, but more needs to be done to quantify them. OTOC recommends identifying additional opportunities for optimizing system coordination.

3. <u>Construct resistive load banks.</u>

Resistive load banks are devices that dissipate electrical energy as heat without physically spilling water over spillways. Load banks are a relatively low cost ($20-40/kW) near-term interim adjunct to the longer term effort to realize efficiencies from load shifting.

Load banks would effectively expand the market for zero-market-price power by giving sellers another destination for low marginal cost power. Other resistive load opportunities may exist to leverage district heating system and domestic hot water loads, and infrastructure dedicated to former industrial load customers.

OTOC recommends that Bonneville study the feasibility and costs of constructing resistive load banks.

Recommendations with Moderate Potential and Feasibility

4. Efficient generation displacement.

Generating projects in the region that could have been economically displaced may not have been displaced during oversupply events over the last two years. Generation such as hydro, cogeneration, and even coal units could potentially be displaced under expanded or different, terms, conditions, and pricing incentives.

OTOC recommends that the region continue to investigate additional opportunities to broaden resource displacements of intra- and extra-regional resources to address oversupply conditions in an economically efficient manner.

5. Reduce total dissolved gas (TDG) levels.

Historically, oversupply was managed by diverting water from turbines over spillways. The imposition of dissolved gas caps has limited the amount of water that can be diverted in recent years. There are potential changes in spill patterns (e.g., which spillways are activated), spill priority, and physical changes in spillways that can increase the amount of water that can be spilled prior to reaching caps.

OTOC recommends requesting the Technical Management Team and the Action Agencies to continue to study cost-effective means of reducing dissolved gas levels.

6. Transmission system trading enhancements.

The region is evaluating more efficient trading among utilities and across balancing areas. Fledgling efforts include the Dynamic Scheduling System (DSS), Intra-hour Transaction Accelerator Program (I-TAP), and intra-hour scheduling enhancements.

OTOC recommends encouraging consideration of wider utility and generator participation in DSS and I-TAP and other technical enhancements to improve liquidity of markets and the ability to find and use available transmission. The newly formed Market Assessment and Coordination Committee is an appropriate venue for pursuing this recommendation.

7. Mini Energy Imbalance Market (EIM).

Oversupply can be addressed to a lesser extent by reducing the reserve requirements for variable generation and load that can be achieved by aggregating balancing services and needs across balancing areas. An EIM has been under consideration by regional transmission planning bodies as one way to accomplish the aggregation, but is complex and would take substantial time and investment to institute. As well, its efficacy is under study. By limiting participation in a "Mini EIM" to entities with access to the Mid-Columbia trading hub, the complexity is significantly reduced, and the Mini EIM can serve as a proving ground for the larger EIM effort.

OTOC recommends increasing efforts to define and evaluate a Mini EIM. The Market Assessment and Coordination Committee is an appropriate venue for pursuing this recommendation.

Recommendations for Longer-Term Efforts

8. Cross-balancing area exchanges.

Another potential for reducing the need for balancing reserves and relieving some of the oversupply burden includes more modest proposals for aggregating balancing services and requirements across balancing areas such as the Area Control Error Diversity Interchange (ADI) developed by some western utilities. The ADI can be expanded to more participants as well as to longer timeframe interchanges.

OTOC recommends pursuing ideas to expand cross-balancing area exchanges through the Market Assessment and Coordination Committee.

9. Aquifer recharge.

River flows could be somewhat reduced and electrical demand somewhat increased if existing water rights were used to remove water from the Columbia River to restore depleted aquifers. Bonneville has estimated 1,500-2,000 cubic feet per second might be removed, reducing hydro generation by 75-100 MW. Bonneville announced in early April that it would work with United Electric Co-op and the Southwest Irrigation District in Idaho to test a small-scale aquifer recharge demonstration project to determine if the technology can be expanded to address oversupply.

OTOC recommends Bonneville continue working toward assessing opportunities for aquifer recharge within the limits of existing water rights.

10. Electric vehicle charging coordination.

Major automobile manufacturers are expanding rechargeable electric vehicle options for sale in 2012 and 2013. The immediate effect on the electric system is expected to be fairly small, but coordinating the development of charging strategies with the manufacturers is prudent to make use of this burgeoning opportunity.

OTOC recommends utilities engage with automobile manufacturers to ensure interface capability with recharging devices.

11. John W. Keys III Pump-Generating plant improvements.

Bonneville is investigating improvements to the 600 MW John W. Keys III pump generator station at Grand Coulee Dam to enhance the reliability and flexibility of the plant for storing energy during oversupply conditions. Proposed plant improvements could potentially increase the dependable pumping load.

OTOC recommends Bonneville continue its analysis of project improvements.

Conclusion

Cost-effective adjustments can be made to improve economic efficiency of power system operations during oversupply events. The measures identified in this document merit additional study as a productive next step toward that end.

Detailed Recommendations

1. Remove barriers to shifting load to light load hours.

   Oversupply conditions occur when demand for electricity is saturated and most dispatchable resources have been displaced by low-variable-cost generation such as hydro and wind. This occurs more readily during traditionally light load hours (nights, weekends, and holidays). One approach for addressing oversupply would be to bolster demand at night.

   Ongoing demonstration projects are showing that electric water heater loads can largely be shifted into light-load hours. However, commercial and industrial end uses such as municipal water pumping, pulping mills, irrigation, computer server centers, refrigeration warehouses, and air conditioning also appear to have significant ability to shift demand from heavy-load hours into light-load hours. Anecdotally, a number of end-use customers report that they would preferentially take power at night to take advantage of lower nighttime rates if not for the peak demand charges.

   Utilities levy peak demand charges on the maximum (usually one-hour) demand taken over some period-- sometimes the billing month, but over the past 12 months in at least some cases. As a result, at least some commercial and industrial load customers receive a rate disincentive for shaping significant amounts of their energy requirements into the light load hours as it can create a new peak demand level. As a consequence, end users with flexibility tend to smooth out their demand over all hours.

Conversely, some utilities levy demand charges on peak consumption occurring only during historically heavy load hours. Limiting the peak demand charge in that way encourages flexible loads to shape demand to the nighttime hours to reduce their cost of service. One way to address oversupply might be to restructure demand charges region-wide to apply only to peak demand occurring in heavy load hours. Not only would this potentially address much of the oversupply issue, it would also lower the overall cost of service to Northwest utilities because serving nighttime load when wholesale market prices are low is generally less expensive. Another benefit is reduced fuel consumption by relying more heavily on the higher-efficiency marginal generating units available at night.

Bonneville's current rate structure has gone far to provide its wholesale customers price signals that encourage shifting daytime demand into light load hours. Bonneville's new rate structure sets the stage for its full requirements customers to reflect the recent changes in their rate structures to send the new price signals to retail, commercial, and industrial customers. Other utilities can largely be expected to receive appropriate price signals directly from exposure to wholesale electric markets.

In many cases implementation costs are expected to be minimal -- one municipal water bureau manager said that the bureau used to pump at night until the local utility changed how it levied the demand charge. Many utility rate structures either provide insufficient incentive for light-load-hour shaping or actively penalize customers who do so. Shifting 10 percent of the region's demand into light-load hours would not only relieve oversupply events, but potentially reduce the overall cost of service by more than $100 million each year[2].

Due to limited time and staffing resources, OTOC was unable to collect more than anecdotal information about utility rate structures and end-use potential. OTOC recommends that a task force be established to comprehensively survey end users' interest and ability to shift load, and survey utility rate structures to verify the feasibility and desirability of adjusting rate structures to provide appropriate price signals for raising light-load-hour demand.

2. Improve power system coordination.

Bonneville has done a good job of coordinating hydro operations with Canada during oversupply events. Canadian reservoir operations can help reduce flows in the United

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[2] Based on shifting 10 percent of 20,000 MW of regional load over 5,000 heavy load hours per year and a $5/MWh basis between heavy and light load hour prices (10% X 20,000 MW X 5,000 h/yr X $5/MWh), the value of the shifted energy is $50 million per year. A capacity value might be estimated at $5/kW-month, for an additional value of $120 million per year (10% X 20,000 MW X 12 month/yr X $5/kW-month X 1,000 kW/MW).

States during oversupply events. However, additional coordination extending beyond the hydro system in some cases may also be possible.

With perfect foresight of streamflows, both reservoir operations and power marketing functions could better manage through oversupply events. For example, reservoir levels are reduced for flood control in anticipation of the spring freshet, and must ensure a large margin of safety due to volume and timing uncertainty. Reducing the uncertainty would allow closer tailoring of flood control to the runoff, reducing the level of uncontrolled flows.

To the extent large flows can be foreseen, advance sales of power can be made, potentially at higher prices than would be available in the more immediate cash markets. Pre-marketing the power does more than just shift the oversupply issue to the purchasing entity, it allows the entire power system to adjust to the expectation of higher generation levels and potentially take down additional generation that might otherwise operate.

Improvements in flood control operations and streamflow forecasting could provide additional ability to manage through oversupply events. Coordination can also be extended to the public, encouraging energy consumption at night during extreme spring conditions (e.g., washing clothes and dishes).

There is potential for reduction of spill and TDG issues through coordination across the Columbia Basin and with hydro and thermal generation in adjacent areas. With very little planning beforehand and quick action in 2011 Bonneville, the Army Corps of Engineers, Bureau of Reclamation and the Mid-Columbia utilities were able to avoid 10,000 MWh of environmental redispatch that would have been added to the total of 97,000 MWh that did occur. There was potential for greater reductions but the entities working on this were short on time in 2011. Additional reductions may be possible in the future through better forward planning. Some key observations and lessons learned from the 2011 experience were:

- There is a need to establish the proper incentives for the different entities to participate in this effort.
- The biggest driver for success is when the participants can demonstrate that they are as good or better off as a result of participating in the effort. This goes beyond what is "good for the region."
- It is important to map out needed actions many hours ahead.
- For the future, an inventory of generating resources displacement has been developed showing potential displacement beyond resources displaced in 2011 (perhaps on the order of 100 megawatts).
- Off-mainstem participation was not fully explored, and there should be more opportunities here.
- Additional Canadian participation could contribute more, and it is important to continue discussions with Canada.

- There is significant potential with regard to thermal displacement that still needs to be examined.

OTOC recommends Bonneville continue its discussions regarding Canadian reservoir operations. The OTOC also recommends establishing a separate task force to examine flood control operations, request recommendations for forecasting instrumentation and methodology improvements from the Columbia River Forecasting Group, and reassess the current spill priority list giving consideration to spilling at hydro projects that may be off the mainstem or not on the spill priority list.

3. Resistive load banks.

Resistive load banks are commercially available devices at megawatt-scale designed to absorb electric power and transform it into waste heat. The devices are relatively simple and have capital costs orders of magnitude lower than storage devices. They offer the energy equivalent of hydro spill without increasing dissolved gas levels. The Northwest hydro system has long diverted water from turbines over dam spillways for multiple reasons. In recent years, dissolved gas caps have limited hydro operators' discretion to shed the available hydro energy over spillways. Resistive load banks provide a means of electrically spilling hydro energy without the incremental dissolved gas.

In contrast with storage or generation technology, the capital cost of resistive load banks ($20-40/kW) is low enough to provide a competitive alternative to displacing wind projects. Resistive load banks could provide a reliable interim solution until power system coordination and load shifting recommendations can be implemented. Load banks would effectively extend the market for near-zero price power, reducing the frequency and severity of negative-market-price events.

Bonneville owns and operates a similar-type device known as the Chief Joseph Dynamic Brake. That facility was constructed to absorb very short term regional surpluses of energy due to the sudden loss of the Pacific Northwest-Southwest Intertie during high export conditions, providing dynamic stability to the transmission system. It was designed to absorb some 1,200 MW but only for periods up to two seconds. Commercially available load banks are typically much smaller, but are often designed to operate continuously.

Variations on this theme of diverting electric power into resistive load devices include accessing electric boilers in district heating systems, residential and commercial electric water heaters, and potentially repurposing infrastructure for defunct industrial loads such as shuttered aluminum smelters.

OTOC recommends Bonneville undertake a feasibility/cost study of implementing resistive loads to absorb power at levels from one to several thousand megawatts.

4. Efficient generation displacement.

In the spring of 2011, Bonneville declared Environmental Redispatch events in which wind generators were required to limit generation (to zero at times) when wholesale market prices fell below zero and federal hydro projects with unloaded turbines were at TDG limits. Most other Northwest generation had already been displaced by low-priced wholesale market purchases. However, not all generators had reduced their output to zero in response to low market prices. There may be several hundred megawatts of additional displacement potential in the region. However, similar to many wind projects, most of the remaining generation would incur costs to reduce output.

Some resources remained in operation because they were able to make more money from relatively higher prices in the daytime market than was lost by operating during the negative market price conditions through the night. For other operating resources such as coal-fired generators, startup costs may have precluded economic displacement. In addition, some hydro projects not hitting dissolved gas limits may have had the ability to spill additional energy at low or even zero cost, had they been active in the wholesale markets. Cogeneration facilities may have, or may be able to acquire, the ability to shut down nighttime generation, albeit at some potential cost. Finally, the cost incurred by wind project owners and purchasers is not uniform, with some projects subject to production tax credits and others not.

In addition to opportunities for additional, cost-effective displacement within the Northwest, further displacement of resources outside the Northwest may exist as well. Bonneville's displacement of wind energy in the spring of 2011 occurred at times when the export capability of the transmission interties was not fully exploited. Figure 1 below shows the Pacific Northwest - Pacific Southwest intertie loading for June 2011, highlighting the midnight to 4:00 AM period when market prices typically dipped to negative values. Significant export capability was clearly available through most of the hours. Transmission capability was potentially left unused for a variety of reasons, including for example, oversupply issues in California and Bonneville's policy of not selling at negative prices. Export capability existed for much of this time on the northern intertie to Canada as well.

Zero and slightly negative market price opportunities may exist that were not made available to the market, perhaps because negative market price events are so few and far between (although perhaps increasingly less so) that owners of generation such as smaller off-mainstem hydro projects are not used to participating in the wholesale markets.

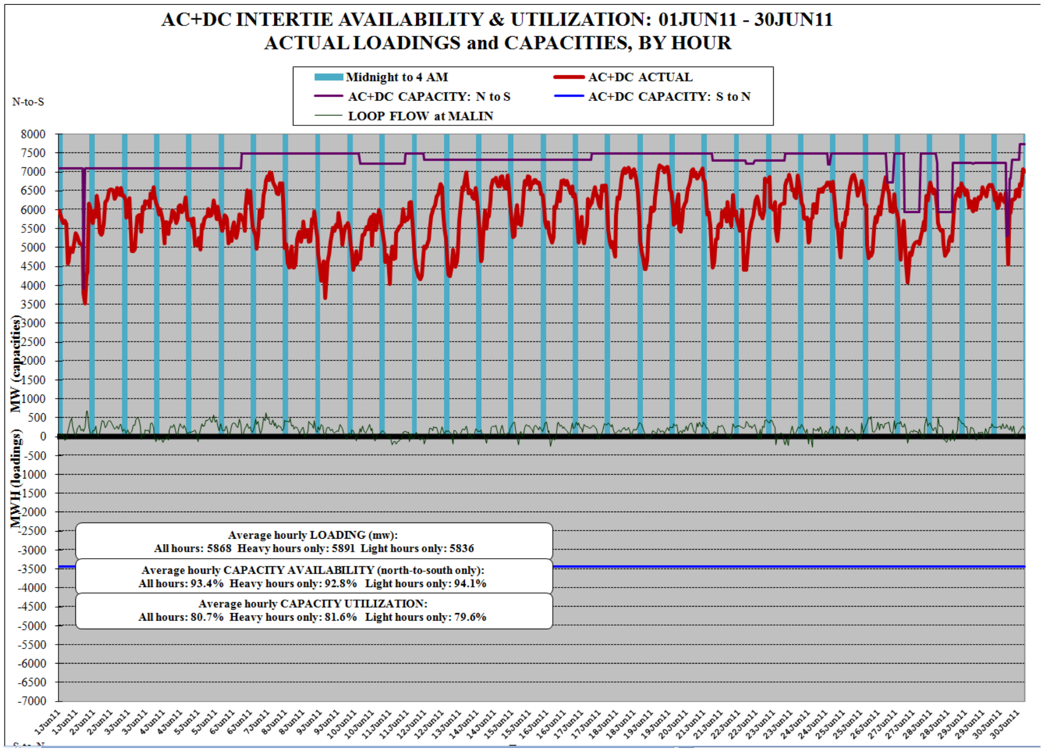

Figure 1 Pacific Northwest - Pacific Southwest Intertie Capacity and Loading for June 2011

Although these additional opportunities to displace generation would be expected to come at some cost, in some cases the costs may be significantly less than the cost to displace wind generation. The OTOC recognizes that improvements could be made in ensuring the least-cost displacement of generation beyond those that are typically active in wholesale markets. Some of the improvements involve widening participation in wholesale markets to include generators who do not typically trade, or who may not be aware of trading opportunities. Further work needs to be done to identify the potential for wider displacement of resources.

OTOC recommends:

i) Developing supply curves for generation displacement opportunities that characterize the diversity of displacement costs among projects.

ii) Surveying the flexibility of Northwest thermal units, with special emphasis on fuel supply constraints and gas storage capability.

iii) Surveying the ability of cogeneration plants to cycle generation and coordinate maintenance schedules.

iv) Encouraging Bonneville to consider agreements with wind schedulers that have the ability to spill their own hydro in lieu of displacing their wind generation.

v) Investigating the interest in and feasibility of establishing a regional bulletin board for posting hydro spill capability.

vi) Establishing an export/import task force to examine the contractual relationships involved in the region's imports and identify additional export markets using available transmission capability.

5. Reduce dissolved gas levels.

A number of measures were identified that could have the effect of reducing gas levels at dams that would allow additional spill without violating TDG caps. Such measures include adjusting spill patterns (how spill is divided across the various spillways at individual dams), spill priority (how spill is allocated among dams), spilling at off-mainstem projects, and structural improvements to spillways.

The Corps of Engineers developed a list of potential changes to current operations or structures that could reduce total dissolved gas levels for a given level of spill. However, at least some of the identified changes would need review for biological effects on fish and approval by the relevant entities.

OTOC recommends requesting the Technical Management Team and the Action Agencies to continue to find cost-effective means of reducing dissolved gas levels through changes in system operations and begin the appropriate environmental review.

6. Transmission system trading enhancements.

Northwest power system operators historically have traded in bilateral markets with hour-long operating periods. Inefficiencies in such markets have been recognized, and some regions have opted to address them through Independent System Operator (ISO) organizations hosting automated market trading. Northwest utilities are developing several efforts designed to increase the efficient trading of power in the Northwest. Among these are the Dynamic Scheduling System (DSS), Intra-hour transaction Accelerator Program (I-TAP), and half-hour scheduling periods.

These efforts may result in reducing reserve levels currently held by various balancing areas, freeing up system flexibility that can reduce the frequency and severity of oversupply events. Additional measures that could help would be agreements to forgive return of losses to Bonneville over longer time periods during oversupply events[3], fostering a liquid market for unused transmission rights (e.g., releasing unneeded transmission reliability margins), and discounted nonfirm transmission. Another possibility is expanding the transmission system.

[3] In 2011, Bonneville did forgive transmission loss return during the Environmental Redispatch events, but at least some entities report not taking the offer for economic reasons. Extending the period of forgiveness for more hours (e.g., 24-hour periods) around oversupply events would make the offer more attractive.

OTOC recommends:

i) Endorsing the efforts of the Joint Initiative[4] group to continue investigating mechanisms to increase energy and transmission market efficiency and liquidity such as the DSS, and I-TAP efforts.

ii) That Bonneville consider reviewing its policies with respect to transmission loss return and continue analyses of cost-effective transmission expansion opportunities.

iii) The Joint Initiative and regional planning entities continue to develop plans and studies of increasing the liquidity of markets for firm and nonfirm transmission rights.

iv) The Northwest Power Pool study the feasibility of releasing transmission reliability margins for sale in day-ahead markets.

v) Request transmission providers study the feasibility of allowing tags to be submitted up to 15 minutes prior to the scheduling period (hour or half hour).

The newly formed Market Assessment and Coordination Committee is an appropriate venue for coordinating work under these recommendations.

7. <u>Mini Energy Imbalance Market (EIM) Pilot.</u>

Another proposal that goes part way down the EIM path would be to establish a smaller-footprint EIM for participants with access (for example) to the Mid-Columbia trading hub. Although much more limited in scope, a voluntary mini-EIM centered around a trading hub would have a much simpler task by avoiding potential transmission congestion issues and calculations. It would also have the advantage of testing the concept prior to full-scale implementation to give participants a better understanding of participating in such markets.

OTOC recommends encouraging Mid-Columbia market participants to begin analyzing the feasibility and cost effectiveness of a hub-based energy imbalance market. The Market Assessment and Coordination Committee is an appropriate venue for coordinating this recommendation with other market efficiency recommendations as well.

8. <u>Cross balancing area diversity exchanges.</u>

Similar to proposals for establishing an Energy Imbalance Market (EIM), it is recognized that the region could reduce its overall reserve requirements by netting the need for balancing reserves, and sharing balancing resources, across balancing areas. More modest arrangements than the EIM can be envisioned, such as the ACE Diversity Interchange (ADI) project.

[4] The Joint Initiative is a collaboration among the ColumbiaGrid, Northern Tier Transmission Group, and WestConnect regional transmission planning bodies.

The ADI project was implemented in 2007 and its participants now include Arizona Public Service, Bonneville, British Columbia Hydro and Power Authority, Glacier Wind (NaturEner Power Watch), Idaho Power Company, NorthWestern Energy, Puget Sound Energy, and the Salt River Project.

Although ADI is a good example of the kind of arrangement envisioned, it is relegated to relatively short (less than one-minute) variability. Reductions in regional reserve requirements might be achieved by longer-timescale diversity sharing, on the order of five or ten minutes. This would free up additional resources that could be helpful in managing through oversupply events.

OTOC recommends that the Market Assessment and Coordination Committee is an appropriate venue for pursuing this recommendation.

9. Aquifer Recharge.

Some ability appears to exist under existing water rights to pump water out of the Columbia River system that could be used to recharge underground aquifers that have become depleted over time. Bonneville has done initial work identifying available water rights, and rough estimates place the potential at 1,500-2,000 cubic feet per second; this would reduce hydro system generation by about 75-100 MW. There would also be some additional pumping demand placed on the system, and associated transportation and pumping costs that would need to be identified and reasonably allocated to interested parties. Bonneville announced in early April that it would work with United Electric Co-op and the Southwest Irrigation District in Idaho to test a small-scale aquifer recharge demonstration project to determine if the technology used in this project can be expanded to address oversupply.

OTOC recommends Bonneville, along with states and interested stakeholders, continue to investigate the prospects for aquifer recharge and any significant implementation impediments.

10. Electric vehicle charging coordination.

Many major automobile manufacturers are expected to expand offerings of rechargeable electric vehicles for sale in 2012 and 2013. Controlling charge timing and rates could offer utilities a source of balancing reserves and storage capability beyond supply-side resources. While it is clear that the size of this market will remain relatively small over the next few years, it is important for the power industry to become involved with manufacturers in developing the needed understanding and relationships across industries to foster the most efficient development of the new flexibility electric vehicle charging represents.

OTOC recommends that regional utilities working through their states or national trade organizations coordinate efforts to work with automobile manufacturers to develop needed protocols and relationships for using electric vehicle energy storage to provide ancillary services.

11. John W. Keys III Pump-Generating Plant improvements.

Keys Pumping Station is the region's only hydro pumped storage facility, capable not only of pumping water from Grand Coulee Dam's Lake Roosevelt up to Banks Lake, the reservoir of the Columbia Basin Project, but also of reversing the pump turbines and generating power by allowing water to flow from Banks Lake back into Lake Roosevelt. Improvements to the aging facility would make it more reliable and available to provide an incremental means of storing water during oversupply events. The project pumps represent a total load of about 600 MW, and the generators a little more than 300 MW. Bonneville currently is reviewing the cost-effectiveness of proposed improvements.

OTOC recommends Bonneville continue its analysis of improvements to the Keys Pumping Station.

Other Ideas Considered

A number of measures were considered that did not make it onto the priority list of recommendations. In at least some cases, members felt the proposed ideas had merit, but simply were too uncertain, too costly, or too limited to be identified as meriting significant resource allocation at this time. Here is a brief summary of those measures:

Conventional and advanced storage technologies

Many technologies have been proposed for storing energy. Few have found commercial success at scales relevant to the Northwest outside of hydroelectric storage reservoirs, natural gas storage and production fields, natural gas pipelines, and coal piles. Both battery storage and flywheel storage are being implemented in niche markets such as isolated systems, or where ancillary service markets place a premium on providing regulation services (storage on the order of minutes). A utility-scale (110 MW) compressed air energy storage (CAES) facility on Alabama Electric Cooperative's system became operational in 1991; a second CAES plant is in Germany. Another is planned for California. Bonneville and Pacific Northwest National Laboratory are sponsoring a study of potential geologic formations suitable for CAES in the Northwest.

The basic economics of energy storage devices rely on purchasing low-cost energy (e.g., at night) to put into storage, and releasing the energy during higher-price (e.g., daytime) periods. The day/night difference in electricity prices is crucial to the economics of such systems, because both capital costs and energy losses (20-30 percent) are significant. This is particularly challenging in the Northwest where light- and heavy-load price differences have averaged well under $10/MWh over the last two years. Differences of several times that amount may be necessary for these technologies to be cost effective absent other value provided (e.g., ancillary services, or dual duty such as in electric vehicles).

Given that other opportunities exist at relatively low cost, this measure was considered to fall short of warranting additional study with the exception of the work Bonneville has undertaken to study upgrades at the Banks Lake Keys Pumping Station recommended separately. With multiple purposes and needs (irrigation pumping) it may be that this facility upgrade is economic to pursue.

Increasing transmission intertie capacity

Raising transmission intertie capacity would potentially increase access to markets outside the Northwest. Although this would undoubtedly be helpful at times, in general the cost of increasing transmission capacity is fairly high compared to the potential benefit. As Figure 1 suggests, transmission congestion was not a limiting factor during the oversupply events in the spring of 2011. Cost effective transmission upgrades should be pursued, but the added value of relieving oversupply would likely represent a very small fraction of the cost of such upgrades.

Passing water through unloaded turbines

OTOC members discussed placing mechanical brakes on hydro turbines, or other changes to enable water to pass through turbines without producing energy or raising dissolved gas levels. The group felt the capital investment in making such large-scale changes to hydro units would be significantly more costly than other options.

Passing water through locks.

OTOC members considered operating the navigation locks on Lower Columbia and Snake River Dams to pass water around the dams without going through the turbines or over spillways. The Corps of Engineers opposed studying the matter further suggesting it would be expensive, ineffective, and potentially dangerous. OTOC members did not support studying the proposal further.

Lowering John Day Reservoir

OTOC members considered reducing generation at the John Day project by lowering the reservoir elevation to minimum operating pool. Lower reservoir pool elevation would reduce generation at the project by a few percent and increase irrigation pumping loads and may have other in-river benefits to temperature and stream velocity. Idea was rejected as too costly due to needed changes to irrigation intakes and pumps.

Encourage public demand

This proposal grew out of an idea to celebrate an abundance of energy similar to harvest or salmon festivals. The central theme would be to make use of the available surfeit of energy in a festive and appreciative environment. Governors could make announcements like, "This is an occasion when a very high proportion of the region's electricity is coming from renewable and carbon-free sources. From midnight to 5:00 am lights can be left on in celebration, at no cost." However, it was difficult for the group to develop many credible ideas-- perhaps an electricity bill holiday where electricity rates are reduced or eliminated for a short time would stir creativity. Such a celebration would need to be accompanied by a substantial publicity campaign, and carefully designed so that the proposed energy uses would not institute, or re-institute, wasteful use of energy in the longer run.

Hydrogen production and storage

Electrolysis uses electricity to split water into hydrogen and oxygen. Commercial facilities are in the range of 50-60 percent efficient in turning electric energy into hydrogen -- converting hydrogen back to electricity with fuel cells or high-efficiency gas turbines is on the order of 50-percent efficient as well, for a round-trip efficiency of about 25% (electricity-hydrogen-electricity). The capital costs, on the order of $500-$1,000/kW are added to that, but offsetting value exists in the oxygen byproduct. Because of the relatively high capital costs and relatively infrequent periods of very low market prices, electrolysis did not appear to be a high priority at this time.

Special industrial production incentives

The workgroup considered establishing rates dynamically to make low-cost electric power available for industrial purposes on an ad-hoc basis when market conditions force wholesale prices to very low levels. Although Bonneville suggested it has the needed flexibility on its part to make special rates available for demonstrably incremental demand, the sense of the group was that relatively few end uses could take advantage of such relatively infrequent and unpredictable conditions. There may be commercial opportunities along these lines that Bonneville can and should follow up on. For example, an aluminum smelter may have unloaded capacity that it could load if given a special rate for two months in a high-water year. Given that these opportunities are specific to individual loads and subject to negotiations, it is more appropriate that follow-up be pursued separately from the WIF process.

Relaxing TDG limits

Limits on TDG are set by the states of Oregon and Washington. The two states differ in allowable levels. OTOC members considered examining changing the Washington requirement to be consistent with Oregon's less-stringent standard. A Bonneville study[5] suggested slight reductions in oversupply ensuing from adopting the Oregon standard. Generally members felt that the institutional and biological hurdles made this a less-desirable option to pursue at this time.

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[5] http://www.bpa.gov/corporate/AgencyTopics/ColumbiaRiverHighWaterMgmnt/TDG_Analysis_APR_2011.pdf

Conclusion

Technical solutions to oversupply are readily available, but the cost of implementing them varies widely. These eleven recommendations suggest much can be done to relieve oversupply conditions even under the relatively severe cost constraints presented. Implementation of most of these ideas entails some cost, though the focus of the group was on solutions that would be less costly than displacing wind generation. Especially encouraging is the possibility that a significant amount of load could be shifted into the night, both relieving oversupply to some extent and reducing the cost of service region wide. The OTOC makes itself available to organize task forces or other undertakings as the WIF Steering Committee may direct, and appreciates the opportunity to be involved in this effort.

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