Thank you for sharing your analysis of the potential overgeneration issues facing BPA in the near future. We appreciate the opportunity to learn your concerns and to review your work. We found the analysis you have performed is informative and provides a very good starting point for further deliberation. However we feel that the analysis was limited because it only addressed issues with the current mode of operations, and it may not provide a broad enough scope to encompass all issues and potential remedies of the evolving environment we are facing today and in the future. As the report stated in its conclusion that BPA expects wind generation to continue its expansion beyond 2012, so the potential for occasional seasonal overgeneration may well continue to escalate. We thus would encourage BPA to not limit the analysis and discussions to only the current operating practice, but to explore what new paradigm could offer to remedy the potential problems.

Comment [srk1]: The contents of this paper are from NREL

The comments marked srk which say ACCEPT indicate that BPA either accepted the comment/edit "as-is" or edited the paper to reflect the intent

Scheduling Practice Appears to be a Significant Contributor to the Problem

We would like to start our comments by discussing what we see as the two big-picture issues: scheduling and exporting. We have learned from previous work that approximately 80% of the wind power within BPA balancing authority is for export out of the BPA. From the analysis one of the biggest constraints appears to be hourly flat block delivery of wind to off-takers outside the BPA balancing authority. Under this situation the hourly schedules to the neighbors will play a big part in the overgeneration problem. We think the problem can be mitigated or perhaps solved by allowing export schedule to change within the hour. Using the first equation on page 5 as an example:

$$G_{Fh} + G_t + G_w + G_{Nh} + G_m = L + E$$

Let us suppose that this equation represents the hourly schedule. If there were no wind forecast errors or load forecast errors, then the equation is balanced both in the pre-schedule and in real time, assuming no overgeneration.

Now assume that G_w is 1500 MW (average schedule for the hour) but a storm front moves in during the hour. The wind ramps from 1000 MW to 2000 MW in the hour (example only – the maximum wind ramp within the hour for 2010 is just under 900 MW). BPA must compensate for this wind ramp to maintain the hourly schedule because E is fixed for the hour (for the example we assume that L is fixed also, but of course there is some load forecast error).

Because E is fixed, G_t or G_{Fh} must be reduced to maintain balance. If G_t is already at 0 then this can be a challenging situation and wind may need to be curtailed, and this presumably matches the case outlined in the draft report that BPA is concerned with (all thermals are already off; hydro or wind curtailment are the only remaining options).

If E is allowed to change within the hour, the problem may be mitigated or perhaps solved. In the limit, the wind for export could be put on a dynamic schedule; thus G_w and E would contain a common term (i.e., an increase in G_w of 200 MW would be scheduled as an increase in 160 MW -- 80% of 200 MW -- to E). This would likely be cheaper than paying wind plant for curtailment.

As an alternative to a dynamic schedule, a fast schedule change every 5-10 minutes, or even 15 minutes, would help. This is explored using 10-minute schedule changes in the report "Market Characteristics for Efficient Integration of Variable Generation in the Western Interconnection." (http://www.nrel.gov/docs/fy10osti/48192.pdf, page 32 ff). As discussed in the report, the faster scheduling provides a benefit to both BPA and the off-taker. Under an hourly schedule, the off-taker must swing the opposite direction of BPA to pick up a potentially large schedule change. With a faster schedule, multiple smaller adjustments are made within the hour, reducing the burden on the CAISO (or other off-taker) regulating units. Instead, generators in the dispatch stack can be used to follow much of the schedule change.

Alternative approaches that BPA could explore:

- The Joint Inititiatives Dynamic Scheduling System (DSS) . CAISO may be able to join this initiative so that BPA and CAISO could use a dynamic schedule to move wind.
- BPA and CAISO could explore other scheduling options outside of the DSS that range from a conventional dynamic schedule to a faster scheduling interval.

The Analysis Scope Appears to be Limited and Would Benefit from More Detailed Analysis

It did not appear that the analysis looked at real transmission constraints. Were the export data used in the analysis (on page 9, one week in June 2010) really a good proxy for constraints facing the system? It is not clear to the readers whether this is a physical limit or an amount reached under certain conditions. The electricity demand of this country in 2010 was generally down from historic record. As the region continues to recover, demand and export will increase. How much more export can be made in 2012? The equation on page 5 demonstrates that export capability is the critical variable in determining the amount of overgeneration. The sensitivity analysis showed that 500 MW additional load or export, which represents a 7.4% increase in export during HLH, will result in 31% reduction in overgeneration during a much-above-average hydro year. How much more export capability is required for an average hydro year (or the most probable hydro year) to avoid overgeneration and forced generation displacement? Are there any conditions when dissolved gas limits are exceeded even with no wind?

Comment [srk2]: ACCEPT.

The analysis showed that wind profile and hydro generation profile had significant effect on overgeneration situation. The analysis used average monthly capacity factors (derived from 2002 to 2010 actual wind production data) to represent future wind power profiles. Can the report comment on how different are the actual month wind capacity factors to the average monthly capacity factors? The HLH/LLH method of analysis may be adequate for a first cut, but we think the results clearly show that finer resolution is required. Averages likely create an artificial transition below which there is no curtailment and above which there is a large amount of curtailment. Reality is likely more gradual. More importantly, hourly analysis would show whether there would be an ability to shift production that would be enough to resolve some of the curtailments. Ideally, time synchronized data should be used. At a minimum, analysis should be conducted that determines if there are correlations between wind, load, and hydro conditions (although we caution that actual correlations are typically non-linear and possess complex time-lag properties that are not captured by simplistic correlation coefficients).

Comment [srk3]: ACCEPT

Comment [srk4]: ACCEPT

We also suggest including demand response to the list of possible mitigation measures BPA could promote. For example there appear to be physical opportunities immediately available with Banks Lake pumped hydro storage facility. If there are currently no financial incentives for the owner/operator to provide response that should be changed with shared savings. There are likely other opportunities as well that could be implemented relatively quickly.

Other Detailed Comments

More specifically, we have these notes and comments of the report. Several of the comments are suggested to help BPA further explain what is already being done to mitigate overgeneration problems.

1. 1st sentence on the 3rd paragraph under introduction on page 1 states that *BPA intends to manage the Federal Columbia River Power System to store, sell, and spill as much surplus hydro energy as possible before requiring other resources in the region to reduce generation.* We think BPA also takes actions to reduce as much non-hydro generation as possible too and the report might want to include that as well.

Comment [srk5]: ACCEPT

2. Item 2 on page 3 states that *Flow augmentation requirements for Columbia and Snake River salmon and steelhead listed under the Endangered Species Act dramatically changed the way the reservoirs*

are managed, generally reducing storage space available to manage high spring flow events. Does the term "flow augmentation" include the dissolved gas limit? Should the limits on spilling in addition to the reduction in storage be also mentioned here?

3. Items 3 and 4 on page 3 seem to discuss the same thing. Item 4 states the impacts more clearly. The report might consider combining the two items.

4. On page 3 the paragraph immediately before the section title General Methodology, we suggest adding the following sentence before the last sentence "This report is not intended to directly address the question of who should be paid what but rather," and add the following to the end "As such, this report is intended to provide information for all parties in resolving the larger issue. Quantifying the magnitude of the physical and economic problem can also help determine if alternative mitigation methods are worth investigating further." This is to emphasize that the report is just intended to quantify the impact and to help move the discussion forward. The report is not trying to settle the larger issue.

5. On page 5, the paragraph immediately below Figure 2 states *In these conditions, we assume that all available thermal generation has been taken off line in exchange for hydroelectric power, leaving wind generation (GW) as the only remaining displaceable resource.* We think this comment may not be relevant to this report, since the report is just quantifying the MW and $ impacts. Has BPA thought through any unintended consequences that might occur when thermal generation is given replacement energy? If BPA provides free replacement energy for curtailed thermal generation the thermal generator gets a windfall in fuel savings. That could create a perverse incentive for the thermal plant to overschedule (selling at a loss) during times when it is pretty confident to get curtailed. The free BPA energy would turn the loss (when the thermal plant had to burn fuel) to a profit (when BPA supplies free replacement energy). This could worsen the overgeneration problem rather than improve it.

6. 1st sentence on page 8 states *Low water years were not included among the scenarios because they generally do not lead to overgeneration conditions and analysis of such years would not help not inform the issue.* We suggest that it may be a good idea to say (or repeat) something about the probability of the bad hydro years below which there will be no overgeneration to avoid the perception that the study is only looking for the absolute worst case and then considering assessing costs or imposing continuous restrictions based on an unlikely event.

7. On page 8, the condition listed in item 4 under Hydro Generation of *1988 conditions, with a water year volume much below average* seems to contradict the above statement that *Low water years were not included….*

Comment [srk6]: ACCEPT

8. Items 1 and 2 under Wind Generation on page 9: It may not be clear to the reader why 50th and 83rd percentiles of monthly capacity factors are used for HLH/LLH wind generation. We suggest that some explanation be added to clarify that the 50th and 83rd percentiles are to represent an average and a good wind case (year). Also the wind capacity numbers in these two items are confusing. Does it mean that the wind fleet was 3,400MW in 2010 and is expected to be 4,362 in April and May of 2012? And it will grow another 310 MW by June? Additional description should help reader here.

Comment [srk7]: ACCEPT

Comment [srk8]: ACCEPT

9. 2nd sentence under section title Other Parameters on page 9 states *Data was selected to represent conservative conditions in which thermal generation is significantly reduced and power exports are increased.* We suggest some clarification here to indicate which way BPA is being conservative. Is BPA biasing in favor of reliability or understating the problem? We suggest this statement: Data was selected to represent conservative conditions and understate the curtailment needs: in which thermal generation is significantly reduced and power exports are increased.

Comment [srk9]: ACCEPT

10. 2nd full paragraph on page 10, we suggest adding "Thermal generators also save the fuel cost when substituting hydro generation to supply their customers." after the 2nd sentence and adding "It might be appropriate to compensate generators for their individual losses, as is often done for out of merit operations in other regions." after the 3rd sentence (which begins with *However,…*).

11. The last paragraph on page 10, we suggest adding "Thermal generators may also require prices well below their fuel costs to compensate for the high cost of cycling their units off and back on." after the 2nd sentence, and adding "It is not yet clear if prices will ever approach these new floor levels. However," before the last sentence of the paragraph. On the subject of potential cost escalation, we are wondering if BPA should also estimate integration cost reductions if other mitigating measures are taken.

12. The table of MW-month wind displacement on page 11 is not immediately clear because it may be difficult for readers to get a feel of the scope of the problem, especially spanning over 3 months. We think it would be useful to convert it to a % curtailment as shown below (please check our calculations).

Wind Generation

	1997	**1998**	**1970**	**1988**
P50	1731 (40%)	1063 (25%)	284 (7%)	0
P83	2454 (45%)	1114 (20%)	138 (3%)	0

13. The last sentence of the last paragraph on page 11states *Even though the 83rd percentile wind scenario had higher average wind generation, the shape of the 50th percentile wind more closely matches the shape of the 1970 hydro generation.* It clearly shows the sensitivity to the actual times of hydro, load, and wind. It supports the idea that actual time-synchronized data and hourly analysis should be used rather than average values.

14. 2nd paragraph on page 14 states *The fact that the region may periodically face an oversupply of inexpensive, carbon-free energy also presents an opportunity. The availability of such energy may incentivize creative responses to access the surplus. In addition, economic recovery could increase spring loads and potential expansion of interties around the region could allow export of larger amounts of surplus energy, reducing oversupply situations.* It is a good summary but too brief. We would suggest a separate section discussing possible mitigation measures. It should also include what BPA is doing to facilitate any mitigation measures. We want to repeat our belief that the most obvious, and probably the easiest solution to implement is sub-hourly scheduling. It is likely to greatly reduce the curtailment problem.

We are looking forward to continuing collaboration with you on this issue.

Michael Milligan (NREL)
Brian Parsons (NREL)
Yih-huei Wan (NREL)
Brendan Kirby (consultant to NREL)

February 2, 2011