# PacifiCorp Response to Comments on the 2010 Wind Integration Study Methodology June 21, 2010

## Introduction

This document is PacifiCorp's response to participant comments on the 2010 Wind Integration Study methodology paper provided on April 16th and April 23rd and finalized on May 19, 2010. PacifiCorp appreciates these comments, and has implemented changes to the methodology based on participant recommendations.

PacifiCorp has responded to comments received from the following organizations:

- Renewable Northwest Project (RNP)
- Northwest Power and Conservation Council (NWPCC)
- National Renewable Energy Laboratory (NREL)
- Utah Association of Energy Users (UAE)
- Utah Clean Energy (UCE)
- Utah Division of Public Utilities (DPU)

## Renewable Northwest Project (RNP)

### RNP Comment 1:

As we pointed out on April 28, we continue to be concerned about the proposed methodology for developing unavailable ("missing") data. As stated, and outlined at the April 28 workshop, the proposed methodology remains unclear to some extent and appears likely to miss certain important aspects of the data that need to be replicated. We would like to stress that irrespective of the methodology ultimately used, it is vitally important to establish validation criteria that the developed data must pass. At a minimum, we feel the developed data should reasonably reflect observed (or derived from NREL data) correlations among the projects. The distributions of ten-minute to ten-minute and hour-to-hour generation changes should be reasonably close to those at observed projects of similar sizes (nameplate capacity).

### PacifiCorp Response to RNP 1:

The development of missing wind generation data continues. As the data is being produced, both PacifiCorp and The Brattle Group are running diagnostics on these data that report how the developed data compare to observed data, whether the latter is metered data from existing projects or mesoscale NREL data. Once finalized, the company will document in more detail the final methods used to create the missing data and the diagnostics used to test the data.

### RNP Comment 2:

It bears repeating that holding all "following" reserves in the model is problematic if the model cannot release them to be dispatched as necessary to meet changes in inter-hour wind/load variability. This is of concern because entering both following and regulation reserves into PaR will likely over estimate the cost of accommodating with wind variability.

### PacifiCorp Response to RNP 2:

For unit commitment, the production cost model sets aside sufficient capacity to meet load plus reserve requirements on an hourly basis. For dispatch, the committed resources are optimized on an hourly basis. Also see the response to NREL Comment 7.

### RNP Comment 3:

As we pointed out in the April 28 workshop, it will be extremely important to bear in mind how the integration costs are expected to be used. For example, it would be inappropriate to add wind integration costs that include costs of holding and dispatching reserves to an IRP PaR model run in which additional reserves are being held out and the wind is represented as an hourly pattern of wind generation.

### PacifiCorp Response to RNP 3:

The methodology developed for the wind integration study will produce an estimate of incremental reserve needs required to maintain system reliability consistent with historical performance. The cost associated with this incremental reserve demand is being isolated in the wind integration study by running two PaR simulations for each wind penetration scenario (PaR simulations 1 and 2 as identified in Table 4 of the project method white paper dated May 19, 2010. As the PaR model is used to evaluate stochastic risks for portfolios in the IRP, the model will either be configured with the incremental reserve demand or with an operating reserve wind integration cost adder, but not both.

### RNP Comment 4:

The potential for confusion around use of the terms "regulation" and "following" that RNP pointed out in our previous comments and in the April 28 workshop appears to exist in the PacifiCorp document itself. In the third paragraph on the first page, regulation is defined

(consistent with BPA and others) as variability "…managed within ten minute timeframes" (emphasis added). Conversely, on page 6 regulation is defined (for wind) as "variability among ten-minute intervals…" (emphasis added) This latter definition is consistent with the ensuing mathematical formulations later in that section. Again, we urge PacifiCorp to be as clear and consistent as possible.

### PacifiCorp Response to RNP 4:

In the latest project method white paper dated May 19, 2010, the reference to "within" on page 1 has been changed to "among" for consistency. Regulation is defined by the company as the difference between the forecast wind and load for each 10-miute interval compared to the 10-minute wind and load that actually materializes. While this may be different terminology than that used by BPA, it is consistent with the company's internal operations.

### RNP Comment 5:

PacifiCorp made clear in the April 28 workshop, its intent on establishing the "regulation" reserve requirements as four-times the standard deviation of ten-minute load-net-wind variability. At the same time, PacifiCorp proposes determining the "following" reserve requirements from specific percentile levels of the distribution for hourly variability. We would like to emphasize that it is more consistent and much clearer if the basis for determining "regulation" reserves is changed to be consistent with the probability-based "following" reserve methodology.

### PacifiCorp Response to RNP 5:

In the latest project white paper dated May 19, 2010, the reserve estimation methodology for regulation reserves has been updated. Rather than using the standard deviation as a metric for establishing regulating reserve need, we are implementing a percentile-based method.

### RNP Comment 6:

Finally, we note that the proposed methodology for assessing the cost of day-ahead wind forecast error does not appear to be adjusted for other day-ahead forecasting errors. Just as the wind variability needs to be netted against load variability to determine reserve levels, so should wind forecast error be netted against load forecast error in determining additional day-ahead transaction costs. For example, if the day head load forecast is too high, but the wind forecast is too low there will be a lesser effect than examining the wind error in isolation.

### PacifiCorp Response to RNP 6:

The method being used to assess system balancing integration costs captures both day-ahead load and day-ahead wind generation forecast error. Unit commitment from the PaR will be established against the day-ahead forecast for both load and wind. Units will then be dispatched against actual load and wind generation using the unit commitment state of generation assets

established by the day-ahead forecast simulation. Day-ahead wind forecast error is not being measured in isolation of day-ahead load forecast error.

## Northwest Power and Conservation Council (NWPCC)

### NWPCC Comment 1:

I'm not certain from the paper but it appears that the proposed analysis uses an estimated standard deviation of load net of wind to calculate the size of deviation that need to be covered by operating reserves to be able to balance load net of wind with generating resources 97% of the time (assuming deviations are distributed normally?).

The BPA analysis simulated the load net of wind for every minute and determined what reserves would be necessary to cover the simulated deviations 95% of the time, both for regulation and load following as they define it. The simulation of every minute deviations would avoid the necessity to assume a distribution for the deviations, and would provide a more detailed picture of the resource capabilities necessary to cover various ramp-rates that are likely to be necessary (see NWPCC comments, bullet #5). Further, it would avoid the necessity for assuming a particular distribution for the deviations. It doesn't seem like a simulation approach would be significantly more difficult than what you seem to be describing.

If I have misinterpreted your methodology, my apologies, although if I have managed to misinterpret I may not be the only one and you might want to see if you can make the description clearer.

### PacifiCorp Response to NWPCC 1:

In the current project method white paper dated May 19, 2010, we describe our intention to use a 97th percentile of the data for both regulation and load following independent of their shape.

### NWPCC Comment 2:

The working definitions of regulation and load following in the third paragraph on page 1 seem to match the definitions used by BPA in their analysis, but the description of load following on page 6 (in Regulation and Load Following") seems to equate load following to the difference between each hour's average actual load net of wind and the average forecasted load net of wind, or the hourly imbalance. I agree with Ken Dragoon that it would be desirable to use standard definitions for regulation and load following; you may have compelling reasons to use other definitions, but the definitions need to be clear and consistent throughout your document.

### PacifiCorp Response to NWPCC 2:

Please refer to PacifiCorp Response to RNP 4.

## NWPCC Comment 3:

The introduction of the section Calculating Incremental Operating Reserve Requirements, especially the bottom of page 4 up to the subsection Regulation and Load Following on page 6, outlines how the Brattle Group proposes to create synthetic wind generation data for sites with incomplete and missing records. The description of statistical methods is not helpful. Creating synthetic wind data is a complex task, and there undoubtedly have been many different statistical approaches taken to problem. If it is important that the reader understand these details, specific examples and more explanation will be necessary. More important than the details of the method used to create the data, however, is that the resulting data appear reasonable. This leads to the next observation.

## PacifiCorp Response to NWPCC 3:

The development of missing wind generation data continues. As the data is being produced, both PacifiCorp and The Brattle Group are running diagnostics on these data that report how the developed data compare to observed data, whether the latter is metered data from existing projects or mesoscale NREL data. Once finalized, the company will document in more detail the final methods used to create the missing data and the diagnostics used to test the data.

## NWPCC Comment 4:

PacifiCorp should independently validate the Brattle Group's synthetic wind data. PacifiCorp can prepare simple comparisons of real and synthetic data for sites with incomplete data without significant effort. For example, PacifiCorp could plot histograms of wind generation levels and of changes in generation levels (ramp rates) from each source. Distinct plots, for each month or time of day, would also be informative. I would expect the plots from the synthetic data at a given site to resemble those from the actual data. I would expect data from sites in close physical proximity of each other to resemble each other. While not as complete as they could be, these tests might identify issues early on that would make the data unsuitable for PacifiCorp's specific purposes.

## PacifiCorp Response to NWPCC 4:

As noted in the response above, PacifiCorp is validating data produced by The Brattle Group.

## NWPCC Comment 5:

It is not clear that standard deviations of ten-minute average excursions from schedule will provide sufficient information to select least-cost resources to meet ancillary service requirements. For example, the illustration in NWPCC Figure 1 below shows two sequences of deviations having the same standard deviation over the hour. The implied decremental ramp-rate requirement (megawatts per minute) of the second plot, however, is six times that of the first

plot. A set of operating reserves that can respond quickly enough for the first plot may not be able to respond quickly enough for the second plot.

**NWPCC FIGURE 1**

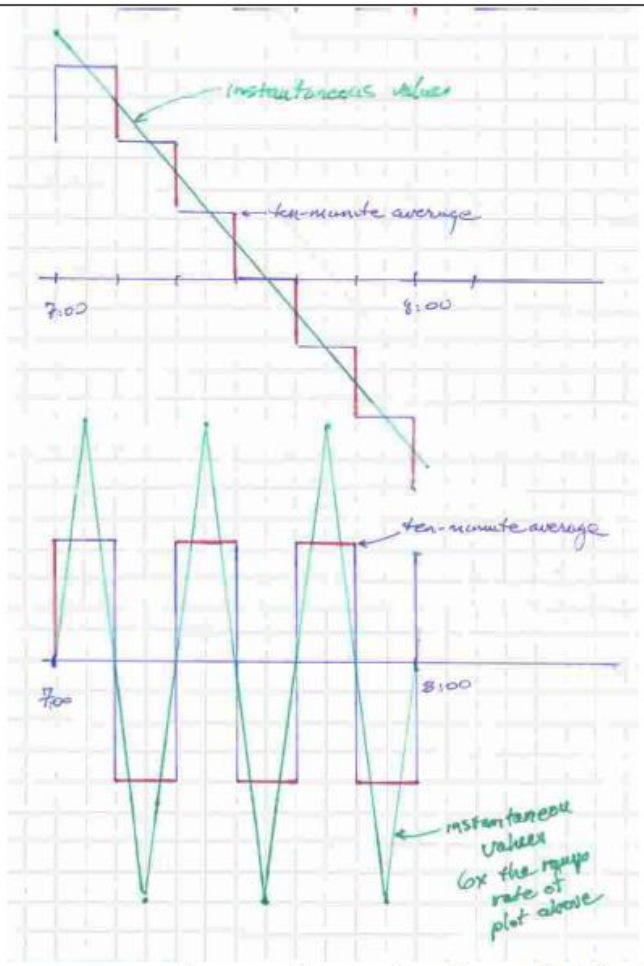


*Illustration of two sequences of averaged excursions from schedule. While the 10-minute averages have identical standard deviation and identical average over the hour, they represent instantaneous ramp rates that differ by a factor of six.*

PacifiCorp may want to consider data about the frequency of changes in generation levels or of load-net-wind requirements when evaluating its future ancillary service requirements. In the absence of any discrimination, the default action would be serve all requirements with the most flexible and expensive equipment.

## PacifiCorp Response to NWPCC 5:

In the most recent project method paper dated May 19, 2010, the reserve estimation methodology for regulation reserves has been updated. Rather than using the standard deviation as a metric for establishing regulating reserve need, we are implementing a percentile-based method.

Additionally, ramp rates have not been specifically considered in the intra-hour analyses. However, on the hourly level, the production cost model does take ramp rates of available generation into consideration when dispatching them to meet the hourly load (net wind). Future improvements can include a specific analysis of intra-hour ramp rate needs of the system, which may require additional flexible resources.

## NWPCC Comment 6:

Steps appear to be missing in the description of the chain of logic that takes the reader from standard deviations in wind and load to the economics of ancillary services. For example, will the costs for sub-hourly variation in load-net-wind be a function of the wind generation level, as they are in the referenced NREL paper?

## PacifiCorp Response to NWPCC 6:

In the latest project method white paper dated May 19, 2010 the procedures for calculating incremental reserve demand are detailed on pages (7-14). Load following reserve demand is based upon load and wind generation levels and integrated over a given month. These demand requirements will serve as inputs into the PaR production cost model for purposes of estimating the cost of meeting the added reserve demand. The PaR simulations required to ascribe costs are detailed on pages 15-18 of the project method white paper. Simulations 1 and 2 as identified in Table 4 will be used to establish the cost of operating reserve integration.

## NWPCC Comment 7:

The section analysis, pages 10 to 12, is confusing. It is missing a stated objective and links of the chain of logic. The NREL paper (pages 137 to 155) has a reasonably careful development of its calculations and approach. It appears that Figure 5 of the PacifiCorp white paper is intended to be analogous to Figure 5-10, page 147, of the NREL paper, expressing standard deviation, hence reserve requirement, hence CPS2 requirement as a function of load. I would guess that there is also an unstated assumption that this CPS2 requirement is proportional to cost, which might motivate the "averaging of volumetric position over the study period." Is this the intent? I am at a loss to understand this section, otherwise.

## PacifiCorp Response to NWPCC 7:

The "Analysis" section in the project method white paper (starting on page 12 of the most recent document dated May 19, 2010), there is a subheading under the "Load Following" section (page 11 of the current white paper), and discusses the analysis of the load following error statistics developed in the previous section. Figure 5 of the project method white paper (page 13) is an illustrative sample of how load following requirements are estimated from an hour ahead forecast of load at the 97th percentile and the 94th percentile. The 97th percentile will be used for our analysis, as it ties to historical CPS2 performance levels. It should be noted that the same

approach will be used for wind, where the hour ahead wind forecast will be used to estimate load following requirements at the 97th percentile. It is not directly analogous to Figure 5-10 of the NREL Eastern Wind Integration Study, which shows the standard deviation on the y-axis as opposed to actual load. Figure 5 in our project method white paper is consistent with the approach used by Idaho Power, as documented in the addendum to their wind integration study dated October 2007 and available for download at the following hyper link: http://www.idahopower.com/pdfs/AboutUs/PlanningForFuture/wind/Addendum.pdf.

### NWPCC Comment 8:

Figure 5 of the PacifiCorp white paper appears to suggest that forecast error decreases above 8,210 megawatts, reaching a minimum around 10,440 megawatts. This is certainly contrary to the NREL assumption of negligible or increasing forecast error with size of load. I wonder if the variations in PacifiCorp's requirements in Figure 5 could instead be related to high ramp rates at moderate load levels. If this is the case, time of day or anticipated ramp rate might be better predictors for forecast error.

### PacifiCorp Response to NWPCC 8:

Figure 5 is simply a representation from a very small subset of data and was included in the project method white paper for illustrative purposes only. It is intended to show how the methodology will be implemented. The binning procedure will be developed for each month of the year. Because similar load and wind levels are likely to require the use of similar conventional generating resources to compensate for the forecast errors within each month, this method is equivalent to using time of day or anticipated ramp rate of the demand as the independent variable.

### NWPCC Comment 9:

NREL's use of the hourly production level for wind as the basis of wind regulation and wind forecast error is based on the physical situation for wind generation, as they explain on page 146. If PacifiCorp needs an estimate of load forecast error as a function of the state of the system – as input to its production cost model, for example – other explanatory variables are probably more appropriate.

### PacifiCorp Response to NWPCC 9:

The project method white paper describes procedures used to estimate retrospective hour ahead forecasts for both wind and load, which are intended to reasonably align with operational practice. It is not clear what other explanatory variables that are "probably more appropriate" should be used in lieu of this approach.

### NWPCC Comment 10:

As NREL points out, the assumption that it can use the day-ahead market price for 10-minute adjustments relies on the availability organized markets for this energy, and even then is a tenuous assumption (page 155). PacifiCorp may want to reconsider use of market energy prices as prices for these ancillary services.

### PacifiCorp Response to NWPCC 10:

The NREL Eastern Wind Integration and Transmission Study evaluates wind integration for the year 2024 assuming highly organized markets are in place and a high degree of balancing area aggregation in which the entire eastern interconnection has just seven balancing areas. The project method white paper does not rely upon using market energy prices for ancillary services, as this type of market does not exist today for the western interconnection. As such, PacifiCorp is using system costs to for purposes of estimating the cost of ancillary service needs by deploying the PaR production cost dispatch model.

### NWPCC Comment 11:

The final sections of the PacifiCorp white paper, Calculating Operating Reserve Wind Integration Costs and Calculating System Balancing Wind Integration Cost appear to be essentially sound. The accuracy of the results will turn on how the costs are represented and accrued in the PaR, however, which is unclear. One issue to consider, however, is that the order in which reserve costs and balancing costs are estimated can affect their relative size. That is, if reserve cost is estimated with forecasting error in both the base case and the change case, the results may differ from those without that error in both cases. I have no reason to believe that will be the case, but I would not be surprised if it is. I will simply note that PacifiCorp has chosen a particular path.

### PacifiCorp Response to NWPCC 11:

Day-ahead wind and load forecast errors ("System Balancing") are addressed separately from intra-day deviations (operating reserves) from expected values. The approach is designed to keep the measurement of these values independent and avoid issue of cumulating or compounding errors.

## National Renewable Energy Laboratory (NREL)

### NREL Comment 1:

**Calculating Load Following and Regulation**

The use of a rolling average to separate regulation and load following is one we and others have use. It is simple, robust, and appropriate. The exact equations are not provided, however, and it is not possible to tell if the method is being implemented correctly. Figure 2 appears to show an

incorrect time shift between the rolling average and the actual load. The rolling average should be centered on the actual data. That is, the rolling average should be an average of the 30 minutes before the interval and 30 minutes after the interval. The plot shows an average which is predominantly or completely before the interval. It is not possible to calculate the regulation burden unless the rolling average is balanced around the actual data.

## PacifiCorp Response to NREL 1:

The most current project method white paper dated May 19, 2010 describes a revised approach for calculating 10-minute interval load variability. The revised approach no longer relies upon a rolling 60 minute average for load. The approach uses the concept of an "intended schedule", which is described on page 8 of the white paper. The methodology for calculating 10-minute interval variability and unpredictability in wind generation is based upon a forecast using information available prior to the actual 10-minute interval. We have chosen to use the average of the 60-minute prior as the forecast for the next 10-minute interval. The company contemplated using a rolling average centered on the actual data for wind generation, but determined, in consultation with The Brattle Group, that a trailing average was more representative of information available to operations staff, which does not have the luxury of perfect foresight 30-minutes into the future.

## NREL Comment 2:

**Synthesizing Data for Future Wind Plants**

The NREL Western Wind System Integration Study (WWSIS) mesoscale wind data set is still the best method for analyzing the integration impacts of future wind facilities and we encourage PacifiCorp to use that data set with time-synchronized loads. The PacifiCorp proposed method of synthesizing data based on time-lagged data from existing wind plants would work if wind always blew from the same direction, at the same speed, and remained coherent over long distances. Since wind does none of these things previous studies have found that time lagged synthesized wind data is not very good. It is very important in any event to scale the wind data correctly. It is inappropriate to use data from a wind plant of one size to generate data for a wind plant of another size.

## PacifiCorp Response to NREL 2:

The company chose not to use exclusively the NREL mesoscale wind data for this analysis because we do not have coincident load data at the same 10-minute interval level of granularity over the same 2004 – 2006 timeframe. The development of missing wind generation data continues. As the data is being produced, both PacifiCorp and The Brattle Group are running diagnostics on these data that report how the developed data compare to observed data, whether the latter is metered data from existing projects or mesoscale NREL data. Once finalized, the company will document in more detail the final methods used to create the missing data and the diagnostics used to test the data.

## NREL Comment 3:

**Calculating Reserve Requirements**

Page 2 states that operating reserve requirements will be "calculated seasonally for application in the production cost model". Wind reserve requirements should be applied based on the wind output. There is no need to carry additional up reserves when the wind is at full output. Similarly there is no need to carry down reserves when the wind is at zero. Load has a similar characteristic. Down ramping reserves are not required during the morning ramp up and up ramping reserves are not required during the evening ramp down. Applying reserves seasonally will greatly overstate the reserve requirements and result in incorrect production cost calculations.

## PacifiCorp Response to NREL 3:

Load following reserve demand is based upon load levels and wind generation levels and calculated as a weighted average over a given time interval. For example, all the wind data occurring in each individual month (Septembers, for example) is analyzed discreetly for the reserves demand (load following up and down, regulation up and down) for each output level bin occurring within that month. This analysis is similarly performed by load level for each balancing area authority by the forecast load, in megawatts, similar to the Idaho Power paper referenced in the footnote of the draft. The trends you reference for the reserves demand for load are present in the Idaho power paper. In the original draft white paper, the integration period was identified as "seasonally" and in the current version, we intend to perform this integration on a monthly basis because we found the monthly level analysis provided reasonable trends and results.

## NREL Comment 4:

**Calculating Reserve Requirements #2**

Combining regulation and load following is inappropriate as well. Load following should be obtained first from the flexibility of the generators on economic dispatch and responsive load rather than from a regulating reserve.

## PacifiCorp Response to NREL 4:

Also see the response to NREL Comment 7.

## NREL Comment 5:

**Calculating Reserve Requirements #3**

It is also necessary to include the reserves in the unit commitment time frame but release them in the operating time frame so that they are free to respond to the net-load variability and

uncertainty. This is different from how contingency reserves and regulation need to be modeled. It is not completely clear from the write-up if this will be done.

## PacifiCorp Response to NREL 5:

See the response provided to NREL Comment 7.

## NREL Comment 6:

**Displaced Generation can Provide Reserves**

Because wind displaces other generation, there are times that the displaced generation can provide reserves. If there is enough capacity without wind to supply load, then there is enough capacity to serve load after wind is added to the generation mix, and there is some displaced conventional generation capacity. Therefore, one must be careful to not simply add additional reserves with wind. Wind will increase the ramping requirements on the system, and therefore a different type of capacity may be needed. It is not clear from the PacifiCorp document whether this has been taken into account.

## PacifiCorp Response to NREL 6:

It is true that if there is enough capacity to serve load without wind, and wind is added to the system, then there is enough capacity to serve load after wind is added to the generation mix. It is also true that wind increases ramping requirements on the system. The study is designed to first estimate how ramping requirements are affected (by calculating the incremental demand for regulation and load following reserves) and then estimating the cost to hold these reserves (by using the PaR production cost model). The approach does not simply add "reserves", but adds demand for specific reserve services (regulation and load following). While it is true that ramping needs within the hour have not yet been evaluated, the hour to hour ramping need should be accounted for by the production cost simulations. Reoptimization of the system resources at each point of calculation will prevent the phenomenon of simply "adding additional reserves with the wind".

## NREL Comment 7:

**Combining Regulation and Load Following**

Page 6 states that regulation and load following will be combined into a single reserve capacity requirement. This is not appropriate. Regulation is a reserve requirement that should be carried throughout the production cost modeling time frames (though it should be adjusted based on the wind power output). Load following should be obtained from the economic movement of the energy supply generators. The load following capacity requirement should be checked each hour and the commitment adjusted only if the energy supply generators do not have sufficient ramping capacity that hour. In the production simulation, the regulating reserve will never be explicitly used because the time resolution of the model is insufficient. However, the load following

reserve can be used. This mimics actual system operation. If a given level of reserve is maintained in the load following time frame, and then the wind drops off unexpectedly, the model should be able to use the load following reserve when needed. Combining regulation and load following reserve would not allow for this.

## PacifiCorp Response to NREL 7:

As noted above in response to a similar comment from RNP, committed resources for meeting load and reserve requirements are optimized on an hourly basis. The resource stack used to meet demand is thus re-ordered to minimize costs. Given that the supply stack changes from one hour to the next, load following reserves held as either spin or non-spin are essentially "released" for economic use. The scenario mentioned in your second to last sentence is intra-hour, and would draw on the resources set aside in the reserves were intra-hour values to be calculated.

## NREL Comment 8:

**Combining Regulation and Load Following #2**

To calculate the regulation variability burden itself the rolling average should be centered on the actual data. That is, the rolling average should be an average of the 30 minutes before the interval and 30 minutes after the interval. The 20 minute rolling average discussed on page 142 of the EWITS final report, which was used to separate the minute-to-minute variability is centered on the operating interval.

EWITS used a 60 minute rolling average before the operating interval to calculate the wind forecast error, not the variability. Wind forecast error needs to be netted with load forecast error to determine the overall uncertainty that the system must compensate for. Though it would be advantageous to wind to use a persistence forecast, it would be inappropriate to use the same method for load due to the availability of more accurate forecasting techniques. Load forecasts, though not perfect, are typically better than persistence. Both day-ahead and hour-ahead load forecast error needs to be included, however and we are glad to see that PacifiCorp appears to be including the load forecast error terms.

## PacifiCorp Response to NREL 8:

The most current project method white paper dated May 19, 2010 describes a revised approach for calculating 10-minute interval load variability. The revised approach no longer relies upon a rolling 60 minute average for load. The approach uses the concept of an "intended schedule", which is described on page 8 of the white paper. The methodology for calculating 10-minute interval variability in wind generation is based upon a rolling prior 60-minute average. The company contemplated using a rolling average centered on the actual data for wind generation, but determined, in consultation with The Brattle Group, that a trailing average was more representative of information available to operations staff, which does not have the luxury of perfect foresight 30-minutes into the future.

### NREL Comment 9:

**Technical Review Committee**

We continue to encourage PacifiCorp to make use of a full strong and independent technical review committee (TRC) under a UWIG charter. If time does not permit the use of a TRC for this study then some type of public forum should be used to obtain feedback. In any case, PacifiCorp should use a TRC for the next study.

### PacifiCorp Response to NREL 9:

There is an opportunity for substantial review and stakeholder feedback through PacifiCorp's public process established for this study. Moreover, PacifiCorp has retained The Brattle Group to participate as a technical advisor, and committed to consultation sessions with NREL staff. Given the study schedule, a technical review committee could not be accommodated. Should time and costs allow it, PacifiCorp will consider the use of a technical review committee for future wind integration studies.

## Utah Association of Energy Users (UAE)

### UAE Comment 1:

In its comments submitted on March 12, 2010, UAE raised questions concerning how incremental operating reserves (associated with regulation and load following) will be valued for ratemaking purposes and specifically questioned how reserves required for load following "down" incur an opportunity cost, as these reserves are not withheld from economic activity.

It is UAE's understanding that the proposed analysis of wind integration operating reserve costs addresses this concern by using a production cost model in which the cost of incremental reserves is calculated based on the differences in production cost simulation runs. UAE infers that the absence of opportunity cost for reserves used for load-following down will be reflected in the results of the production cost runs, as will potential increased operating costs incurred with load following down due to potential sub-optimal operating configurations.

To the extent that UAE's inference is not correct, then UAE reiterates its objection to a methodology that calculates an "amount" of incremental reserves (inclusive of reserves for load following down) which is then exported to rate proceedings and valued separately in the rate proceedings.

### PacifiCorp Response to UAE 1:

The methodology developed for this wind integration study no longer relies upon a market based opportunity cost for establishing integration costs. As suggested, costs for incremental regulation and load following reserve demand will be estimated using the PaR production cost

model, and consequently, will be tied to system costs. That said, the company maintains that there is an opportunity cost associated with regulation down service as evidenced by Ancillary Service markets that include a regulation down product. Such opportunity costs reflect non-economic operation of resources needed to provide the regulation down service (e.g., ramping up out-of-the-money resources). To the extent that resources are run sub-optimally to follow load and wind, these costs will be present in the production cost simulations.

### UAE Comment 2:

In its comments submitted on March 12, 2010, UAE requested that the Company consider and address the following issues and concerns:

- The accommodation of increased wind output above forecasted levels can occur through a decrease in balancing purchases as well as an increase in balancing sales.
- The accommodation of decreased wind output below forecasted levels can occur through a decrease in balancing sales as well as an increase in balancing purchases.

It is UAE's understanding that the proposed methodology will incorporate the options identified above when they are the most economical dispatch option. It is also UAE's understanding that the proposed analysis will use market prices for balancing purchases and sales without incorporating transaction cost differentials between buy/sell prices.

### PacifiCorp Response to UAE 2:

The method contemplated in this study addresses balancing with PacifiCorp's generation assets and market interaction under an unbiased economic framework. The market prices used in the study for balancing purchases and sales do not incorporate bid/ask spread transaction costs.

## Utah Clean Energy (UCE)

### UCE Comment 1:

While Utah Clean Energy understands that analysis of the net cost and benefits associated with wind integration is outside the scope of this current study, we strongly recommend that PacifiCorp include analysis of the net costs and benefits of wind integration in future analysis. UCE urges PacifiCorp to establish a methodology for future dockets that facilitates more complete cost/benefit analysis. Several studies concerning the integration of renewable energy sources have utilized methods that meaningfully analyze both the costs and benefits of wind integration, including the recent Intermittency Analysis Project in California, the Eastern Wind Integration and Transmission Study, and the Western Wind and Solar Integration Study. In particular, the Intermittency Analysis Project utilized an integration study that allowed it to quantify the effects of integrating wind, not only with regard to added costs but with regard to

broader system performance and operation issues. See e.g. Intermittency Analysis Project: Final Report at 19-21, available at http://www.energy.ca.gov/2007publications/CEC-500-2007-081/CEC-500-2007-081.PDF. PacifiCorp, their ratepayers, and interested stakeholders would all benefit from more complete understanding of the costs and benefits of integrating wind power.

### PacifiCorp Response to UCE 1:

For the current wind integration study, PacifiCorp is focusing its attention on addressing the key methodological issues raised by stakeholders in various state 2008 IRP acknowledgment proceedings, and has a regulatory commitment to complete the study by August 2, 2010. Broadening the study scope will be considered for the next version of the study, and can be a topic for discussion in future public input meetings.

### UCE Comment 2:

In lieu of a formal technical committee, Utah Clean Energy strongly recommends an informal process of special topic conference calls to address some of the technical issues and questions that have been brought up in a number of stakeholder comments. Ongoing, if informal, input of interested parties with topical expertise would facilitate a beneficial exchange of ideas and a better final work product. For example, PacifiCorp could request timely review of working drafts from an ad hoc committee of experts or host conference calls to brainstorm methodologies. We encourage PacifiCorp to utilize such participation. PacifiCorp, their ratepayers, and the public would be well served by incorporating an informal review process that includes input from the aforementioned experts on wind energy integration.

### PacifiCorp Response to UCE 2:

There is an opportunity for substantial review and stakeholder feedback through PacifiCorp's public process established for this study. Moreover, PacifiCorp has retained The Brattle Group to participate as a technical advisor, and committed to consultation sessions with NREL staff. Given the study schedule, a technical review committee could not be accommodated. Should time and costs allow it, PacifiCorp will consider the use of a technical review committee for future wind integration studies.

### UCE Comment 3:

UCE agrees with many of the concerns and questions that have been articulated by NREL, RNP and others. We believe that the informal technical committee described above would be useful in resolving these issues, including the following:

- Non-standard terminology and nomenclature
- Concerns with combining 'regulation' and 'load following' into a single reserve

- Concerns regarding the potential for 'double counting' Operating Reserves due to a disregard for the availability of conventional generation displaced by wind generation
- Concerns regarding the calculation of reserve requirements relating to the reserves needed when wind is at full capacity, reserves needed when the system is ramping up, and reserves needed when the system is ramping down.
- Wind data concerns

### PacifiCorp Response to UCE 3:

Please refer to responses to comments submitted by NREL, RNP, and others that address these topics.

## Utah Division of Public Utilities (DPU)

### DPU Comment 1:

As a general concern, the Division has repeatedly requested that data tables be provided in Excel rather in Adobe. In the Company's project paper, again on pp. 8, 9, and 11 for Figures 2, 3, 4, and 5, the exact equations and data tables are not provided; therefore, the Division cannot determine if the method is even being implemented correctly. We request that all data be provided in its original format and if possible provide work papers used in the study. Additionally, several key formulas in the project paper appear to be incorrect. The Division requests that these be corrected and a new version of the Project Paper be made available.

### PacifiCorp Response to DPU 1:

As outlined in the meeting report prepared for the IRP public input meeting held April 28, 2010, PacifiCorp will provide data and analysis through a discovery procedure. Formulas have been updated in the most current version of the project white paper dated May 19, 2010.

### DPU Comment 2:

The Division agrees with the Company's project method to use as much real, observed, and concurrent data as possible. The Division is also pleased that the Company has retained The Brattle Group to obtain missing wind data, derive the statistical parameters, and simulate the wind data. However, the Division strongly opposes the derivation method for obtaining wind data for which there is no historical data available. The Division believes that the Company should use anemometer data collected from each site prior to construction and this, with the application of the appropriate power curve and correction from gross to net output, would be more representative of the actual wind data then performing sequential testing through econometric models to develop the data.

## PacifiCorp Response to DPU 2:

The development of missing wind generation data continues. As the data is being produced, both PacifiCorp and The Brattle Group are running diagnostics on these data that report how the developed data compare to observed data, whether the latter is metered data from existing projects or mesoscale NREL data. Once finalized, the company will document in more detail the final methods used to create the missing data and the diagnostics used to test the data.

PacifiCorp is aware of the substantial errors to be expected converting single or multiple point meteorological data to wind production data at a large scale wind farm. The method PacifiCorp is employing is being reviewed for comparability of reserves demand and other germane characteristics by the Brattle Group as well as internally. PacifiCorp is unsure what method the Division has employed to determine whether PacifiCorp's method is less representative than using meteorological data and modeling the myriad of errors to be expected when converting such data into large scale wind generation production.

## DPU Comment 3:

However, if the Company continues with this methodology, or there are sites which anemometer data are unavailable, the Company should address a key statistical issue. Starting on about page four, the Company describes its method of populating missing data for its wind plants. The procedure essentially repeatedly estimates a regression model until the parameter estimates of the model converge. This approach or proposed methodology is analogous to the multiple comparisons problem in, among other applications, hypothesis testing or construction of confidence intervals. In general, using the same data to perform multiple or sequential tests is not a good idea because of the effect such procedures have on the overall confidence levels for the final estimates. In short, confidence intervals or significance levels can be very different from what would be expected given a certain experimental design. The Company's paper explaining its proposed methodology to populate the missing wind data makes no mention of this problem and a potential solution. Before moving ahead with the Company's proposed methodology for populating the missing wind data, the Company needs to provide an explanation or proposal on how this problem will be addressed.

## PacifiCorp Response to DPU 3:

PacifiCorp agrees additional explanatory data would be helpful in characterizing the missing wind generation data, and is employing the NREL mesoscale data developed for the NREL Western Wind and Solar Integration Study toward this end.

## DPU Comment 4:

In the Project Paper, especially on page 5, the Company should provide an example or scenario using the Expectation Maximization algorithm described in the paper in order for parties to fully

understand the approach. Also, the Expectation Maximization algorithm needs to be defined more clearly. Additionally, the project paper lacks specificity in several key areas that make it difficult for parties to decipher the intent or method the Company will follow in its final study. Therefore, echoing a request that was made at the April 28th meeting, the Division recommends that the Company prepare a detailed numerical example of its proposed methodology with formulas and results intact. Since the methodology proposes using the Company's IRP models, which are not easily presented in summary fashion and take considerable time to run, these steps of the numerical example could be discussed with hypothetical results.

### PacifiCorp Response to DPU 4:

PacifiCorp's method remains under development with the Brattle Group; however, expectation maximization has not been employed to date. An expectation maximization procedure would be employed if deemed necessary to produce reasonable wind data demonstrating similar operating reserves demand in review. The final method will be published in detail.

### DPU Comment 5:

The Division concurs with comments filed by the Renewable Northwest Project on April 23, 2010, regarding the calculation of wind reserve requirements. Rather than calculating and applying reserves seasonally, wind reserve requirements should be applied based on the wind output.

### PacifiCorp Response to DPU 5:

PacifiCorp's method does account for the wind output at each discreet time wind reserve requirements are estimated, and this calculation is done for each month.

### DPU Comment 6:

The Company needs to provide more information on the culled bins referenced on pages 10-11. Also, the Company needs to provide the graph of bin analyses in Excel format in order for parties to conduct sensitivity analyses of the example.

### PacifiCorp Response to DPU 6:

The sample figures provided in the project white paper are for illustrative purposes and are provided for the sole purpose of communicating the overall approach. The data used to develop these illustrative figures represent a small subset of the data that will be used to implement the methodology. As such, it is not clear what value might be gained by conducting sensitivity analyses on the illustrative sample data. Nevertheless, PacifiCorp can provide data and analysis through the normal discovery procedure.