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TESTIMONY of

BARTHOLOMEW A. MCMANUS, STEVEN B. BARTON, JUERGEN M. BERMEJO, STEPHEN H. ENYEART, and RONALD E. MESSINGER

Witnesses for Bonneville Power Administration

SUBJECT: GENERATION RESERVE FORECAST

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SECTION 1: INTRODUCTION AND PURPOSE OF TESTIMONY

Q. Please state your names and qualifications.

A. My name is Bartholomew A. McManus, and my qualifications are contained in WP-10-Q-BPA-45.A. My name is Steven B. Barton, and my qualifications are contained in WP-10-Q-BPA-03.

A. My name is Juergen M. Bermejo, and my qualifications are contained in WP-10-Q-BPA-05.

A. My name is Stephen H. Enyeart, and my qualifications are contained in WP-10-Q-BPA-16.

A. My name is Ronald E. Messinger, and my qualifications are contained in WP-10-Q-BPA-46.

Q. What is the purpose of your testimony?

A. The purpose of our testimony is to sponsor the Generation Reserve Forecast in the Generation Inputs Study (Study), WP-10-E-BPA-08, section 2. Our testimony describes the forecast of the reserve necessary to provide within-hour balancing services during the rate period and the method for developing that forecast. In addition, we describe the key components of the analysis and assumptions underlying the forecast methodology, along with certain improvements to the methodology that we have identified since completing the forecast and updates that we expect to make for the Final Proposal. Finally, we describe the results of our analysis using 30-minute, 45-minute, and 60-minute

persistence scheduling models, which differ from the two-hour persistence model that we relied on to forecast the reserve requirement for the Initial Proposal.

Q. How is your testimony organized?

A. Section 1 is the introduction. Section 2 describes BPA's reserve requirements and the reasons why BPA must hold generation reserves to provide within-hour balancing services. Section 3 describes the background of the methodology that we use to forecast its reserve requirement. Section 4 summarizes our forecast methodology and key assumptions that we make in performing the analysis. Section 5 describes BPA's Wind Integration Team (WIT) and the work that the WIT has performed with respect to the forecast methodology since first completing our forecast.

SECTION 2: BPA'S RESERVE REQUIREMENTS

Q. Why must BPA maintain reserves to provide within-hour balancing service within its Balancing Authority?

A. BPA must maintain load-resource balance within its Balancing Authority Area (BAA) at all times. Load-resource balance means that the amount of energy being consumed inside the BPA BAA (load) plus the amount of energy that is being sold to other BAAs equals the amount of energy being produced by generation inside the BPA BAA. On a broad level, BPA must provide within-hour balancing in order not to burden the rest of the interconnection with changes to load or generation inside the BPA BAA boundaries.

More specifically, BPA must comply with multiple North American Electric Reliability Corporation (NERC) and Western Electricity Coordinating Council (WECC) reliability standards. The primary standards that relate to within-hour balancing services are BAL-001-0a, Real Power Balancing Control Performance, and BAL-005-0b, Automatic Generation Control (AGC). The purpose of BAL-001-0a is to maintain

Interconnection steady-state frequency within defined limits by balancing real power demand and supply in real time. The requirements in BAL-001-0a limit how far out of load-resource balance a BA can be before it violates the standard. BAL-005-0b establishes requirements for BA AGC necessary to deploy Regulating Reserve to maintain load-resource balance.

Q. What resources does BPA use to provide generation for the overall reserve requirement to maintain balance within the hour?

A. Power Services (PS) designates Federal Columbia River Power System (FCRPS) generating resources under AGC to provide the generation inputs necessary to maintain within-hour balance. BPA's AGC system adjusts plant generation based on the differences between scheduled and actual load and generation. The cumulative increases (*inc*) and decreases (*dec*) in generation required to maintain load-resource balance within the hour form the basis for the reserve requirement.

Q. What components make up the reserve requirement?

A. BPA separates its reserve requirement into regulating reserve, following, and imbalance components. The following reserve component is sometimes referred to as "load following" reserve. Our testimony and section 2 of the Study, WP-10-E-BPA-08, use "following" and "load following" interchangeably.

Q. Please describe these components and how they interrelate.

A. Regulating reserve is the amount of reserve needed to balance the changes in load or wind generation on a minute-by-minute basis. Following reserve is the amount of reserve needed to balance the changes in average load and average wind generation every 10 minutes over the course of an hour. The imbalance reserve component is the additional amount of following reserve caused by a difference between the actual hourly average load or wind generation and the hourly amount estimated (scheduled) for the

load or wind generation. We add these components together to determine the total reserve requirement.

Q. What is the basis for the regulating reserve?

A. The regulating reserve is based on the difference between the one-minute average load net wind and the 10-minute average load net wind at the same time. We calculate the 10-minute average every 10 minutes using the clock hours as the base. For example, the first 10-minute period is from the top of the hour to 10 minutes past, and the second is from 10 minutes past to 20 minutes past. The regulation requirement is the difference between each one-minute average compared to the 10-minute average.

Q. What do you mean by "load net wind?"

A. Load net wind actual is the total actual load minus total actual wind generation. Load net wind schedule is the total load forecast minus the total wind generation schedule. This is explained in more detail in section 4 below.

Q. What is the basis for the following reserve?

A. The following reserve is based on the difference between the 10-minute averages for the load net wind and the one-hour average for the load net wind ramped in over a 20-minute period. The one-hour average is based on the average amount of load net wind for each clock hour. This is ramped in by linear interpolation from clock minute 50 to clock minute 10 of the following hour. The difference every minute between the 10-minute average and one-hour average as ramped in is the following requirement.

Q. What is the basis for the imbalance reserve?

A. The imbalance reserve is based on the difference between the 10-minute averages for the load net wind and the ramped in load net wind schedule instead of the actual one-hour average of load net wind for that hour, less the following reserve. In other words, the

imbalance reserve is the incremental increase in the following reserve due to using estimated hourly averages (schedules) as opposed to actual hourly averages.

Q. How is the imbalance component different from Generation or Energy Imbalance?

A. The imbalance component refers to the within-hour 10-minute balancing requirement, whereas Generation or Energy Imbalance is based on the difference between the one-hour average actual generation or load and the generation or load estimated (scheduled) for the hour. In addition, Generation and Energy Imbalance are used to settle the energy difference between schedule and actual after the fact, while the imbalance component in the forecast is used to determine the amount of capacity reserve needed to meet the BAA reserve requirement.

SECTION 3: BACKGROUND OF RESERVE FORECAST METHODOLOGY

Q. What does your forecast of BPA's reserve requirement reflect?

A. Our forecast reflects an estimate of the amount of FCRPS generation that BPA would need to be available to *inc* or *dec* output during an hour (within-hour balancing) in order to keep the BPA BAA in load-resource balance. The reserve forecast identifies the amount of generation that PS must set aside to react to the changes in wind generation and load through each hour during the rate period.

Q. How does the forecast methodology in this Initial Proposal differ from the methodology used to develop the current wind integration within-hour balancing rate adopted in WI-09?

A. Our forecast methodology differs significantly from the methodology in the WI-09 rate case. During that case, BPA attempted to determine the balancing requirements without regard to schedule, because the wind integration rate did not include the capacity requirements for imbalance. As described previously, the capacity requirements for

imbalance include the reserve requirement associated with deviation between scheduled generation and actual generation during an hour. As a result, BPA developed rolling averages without regard to the clock hour to estimate the reserve requirement in WI-09. In addition, because BPA was not considering imbalance or schedules, and because all of BPA's balancing in-hour is performed by generation on the AGC system, the timeframe for the study consisted of rolling hourly averages, which were then compared with actual data every minute. The methodology in this case takes into account the clock hour as well as estimates and forecasts for each hour.

Another major difference between the methodology used in the WI-09 case and the current methodology is that the calculations for WI-09 did not take into account the time-sensitive varying pattern of wind versus load. BPA performed two calculations to estimate the reserve requirement for WI-09: 1) requirements for load; and 2) requirements for load net wind (total load minus total wind). The difference between these two was considered to be the amount of balancing required due to wind. The methodology used in this case calculates the load and wind contributions to the reserve requirements at all times.

Finally, the methodology used in WI-09 relied on only four months of historical data to determine the reserve requirement for FY 2009. The current methodology relies on 21 months of historical data as the basis to forecast the reserve requirement for FY 2010 and FY 2011.

Q. Does the forecast methodology account for the within-hour balancing requirements associated with generators other than wind?

A. No. Observations of actual operations indicated that generators other than wind are dispatchable and do not contribute to the overall reserve requirements calculated for wind and load. BPA staff will do additional analysis in the future to test this conclusion, but

these studies are not expected to be complete in time to incorporate results into this rate proceeding.

SECTION 4: KEY ASSUMPTIONS IN THE FORECAST METHODOLOGY

Q. Have you prepared a detailed description of the forecast methodology and the assumptions in your analysis?

A. Yes. Section 2 of the Study, WP-10-E-BPA-08, describes our methodology in detail. Sections 4.1 through 4.7 below summarize key components of the methodology and explain certain of BPA's assumptions.

Section 4.1: Future Wind Projects

Q. Please explain how you evaluate projections for future wind projects.

A. BPA manages an interconnection "queue" that currently has pending requests for 90 wind projects representing approximately 14,000 MW to interconnect to BPA's transmission system, and most of these requests seek to interconnect by 2013. Prior to BPA offering an interconnection agreement and allowing the project to interconnect, each of these requests must go through a series of studies called for under the interconnection procedures in BPA's Open Access Transmission Tariff and environmental studies required under the National Environmental Policy Act (NEPA). Projects vary widely in terms of their siting process, the time it takes to complete the environmental studies, and the time required for BPA to construct the required interconnection and network facilities. BPA's primary purpose for maintaining an internal forecast of future wind generation projects is to anticipate future interconnection workload and address related commercial and operations issues. BPA maintains an internal forecast of which future projects are likely to connect to BPA's transmission system, when those projects would

connect, and the amount of plant capacity that would connect. BPA regularly updates and revises its forecast based on changes in the interconnection queue, updates in the projections, and information received from project developers. We have used this internal forecast as our forecast of future wind projects.

Q. What factors and information does BPA consider in developing its assumptions about the amount of wind projects that will come online in the future and the timing of the interconnection and energization of those projects?

A. BPA considers a variety of factors and information. One of the primary sources of information that BPA considers is information that developers provide in the interconnection process. Each request in the queue must go through a study process under BPA's interconnection procedures prior to BPA offering an interconnection agreement and permitting the facility to interconnect. Under this study process, BPA completes a series of studies regarding the interconnection, and BPA conducts meetings with the customer to review the study results at each phase. Those meetings include discussions with the customers regarding their project plan of service, including the schedule for the interconnection. The developer provides a proposed project schedule with the interconnection request. BPA typically assumes that the project will not interconnect earlier than the date in the proposed project schedule, but most often the date is determined as the plan of service is developed. During the meetings with BPA, customers provide information about issues such as their siting process and timing, project scheduling, financing commitments, and turbine orders. This information provides some general indicators of when the project is likely to interconnect. BPA updates the project schedules at each study phase based on information provided by the customer and BPA's schedule requirements. If a project has not obtained financing commitments or ordered wind turbines, BPA generally considers those projects as less

ready to interconnect in the near term, and BPA takes that readiness into account when estimating the timing of interconnection for particular projects.

The information provided in the interconnection process typically does not provide a complete picture of the circumstances surrounding a particular request. BPA, based on its experience, also evaluates the project schedules based on certain independent criteria. For example, as described previously, BPA must conduct environmental review under NEPA before deciding whether to interconnect a particular generator. NEPA review can take substantial time to complete, and BPA typically coordinates that review with the timing of the state/county environmental permitting process. As a result, the status of the environmental review process and interconnection customer permitting process for a request plays a significant role in BPA's assumptions regarding interconnection and energization schedules.

BPA also considers the specific interconnection and system facilities that will be required to interconnect a particular project. Larger, more complex interconnection facilities and network additions typically require more time to complete and are a factor for any particular project. As BPA and the customer establish a more well-defined plan of service in the interconnection process, BPA refines its assumptions about the timing of the interconnection based on the particular network additions and interconnection facilities required to interconnect the generator. Other projects in the queue, especially those with earlier request dates, also may impact what facilities are required and the schedule.

A customer may sign an engineering and procurement agreement to firm up the customer's intent and commitment to complete the interconnection process and bring a facility online within a defined schedule. An engineering and procurement agreement typically commits the customer to provide funds for BPA to begin work on the design of

the necessary interconnection facilities or acquisition of equipment with a long lead time. If a customer executes an engineering and procurement agreement, BPA often will incorporate the project into its construction program schedule, which provides more certainty as to the timing of a particular project.

The last major factor that BPA considers with respect to requests that are further along in the study process is the customer's commitment to fund the BPA facilities necessary for the interconnection and to sign an interconnection agreement. Once a customer agrees to fund the interconnection facilities and signs an interconnection agreement, BPA can establish a firm construction schedule and provide a more defined estimate of when the those facilities will be complete.

Q. You refer to "future" or "planned" projects in the testimony above and in section 2 of the Study, WP-10-E-BPA-08. Do these references indicate that these projects are in the advanced stages of planning?

A. No. As explained previously, the references to "future" or "planned" facilities reflect BPA's expectations with respect to the interconnection of certain facilities based on BPA's assessment of the circumstances and information at the time. That is one reason why Table 2.1 in the Study, WP-10-E-BPA-08, does not name the future projects. The projects listed may change as the information that BPA receives and the developers' plans change.

Q. When did you estimate which future projects would be online for purposes of the reserves forecast used in the Initial Proposal?

A. For purposes of the reserves forecast prepared for the Initial Proposal, we use BPA's July 15, 2008, estimate of which projects would interconnect and the timing of the interconnection.

Q. Do you expect to update your assessment of which projects will be online during the rate period for the Final Proposal based on the most recent information available at that time?

A. Yes. Because BPA periodically updates its projections regarding the amount of wind generation that will come online in the future, we intend to update our assessment for the Final Proposal based on BPA's most current update.

Section 4.2: Scaling in Future Wind Facilities

Q. What is meant by scaling in future wind facilities?

A. Scaling in future wind facilities means estimating the output of future wind facilities based on the output of existing wind facilities. The term "scaling" in this case refers to applying a percentage to the existing wind facilities' output (with associated lead or lag, explained below) to estimate the future wind facilities' output.

Q. Why is scaling an important aspect of the Generation Reserve Forecast?

A. Scaling is a very important aspect of Generation Reserve Forecast because the generation variability of all wind projects, existing and future, as well as their associated schedules affect the amount of reserve required in BPA's BAA. Without the scaled-in future wind facilities in the Study, we risk forecasting less reserve than BPA would carry to meet the in-hour balancing requirements through the rate period.

Q. Please summarize your analysis with respect to scaling in the generation for future wind facilities.

A. We use a 21-month dataset (October 2006 through June 2008) with one-minute average actual wind generation data as a starting point. With that dataset, we forecast the wind generation output for the FY 2010-2011 rate period. We use the installed capacity of the wind projects that BPA estimated would be online during that period and calculate the

future output using the prevalent direction of weather pattern changes and time delays between existing and future projects within the BAA. Where possible, we use multiple existing projects to scale in the generation of a particular future project. In the end, we produce an estimate of the generation for the different amounts of installed wind capacity during the rate period.

Q. Why do you use wind generation data from the study period October 1, 2006, to July 1, 2008, as the basis for your analysis regarding the generation of future wind projects?

A. The data for the period October 1, 2006, to July 1, 2008, covers generation from all existing wind generators in BPA's BAA and was the most up-to-date data at the time BPA began its analysis. In order to cover all seasons, we need to use a minimum of 12 months of data. However, we do not want to limit the data to one year, so we use data back to October 1, 2006, in order to maximize the dataset. We used July 1, 2008, as the end date so the database could be finalized and studies could be run.

Q. What is the basis for your assumption that you can predict generation for future wind projects by using leading or lagging generation values from existing projects?

A. Weather data typically reflects a west to east wind pattern across the area from Hood River east along the Columbia River, which is where most of the future wind facilities are planned. In addition, 3TIER, a renewable energy forecasting and assessment company, provided data to BPA that showed the leads and lags between the locations of certain existing and future facilities in the BAA. This data reflected the west to east wind pattern as well, and the amount of time it takes for a weather pattern to move across the area was calculated from the 3TIER data. Based on all this information, we forecast the future project generation using the leads and lags from other projects.

Q. How was the 3TIER data used in your analysis?

A. 3TIER provided information regarding leads and lags between the locations of certain existing and future facilities in the BAA, and we adjust some of the leads and lags to reflect its experience with the actual wind facilities in the BAA. The existing wind facilities in the BPA BAA rarely ramp up or down at exactly the same time. For certain locations and facilities, however, the 3TIER data indicates minimal or no difference in the ramp-up or -down time as compared to other locations. We adjust the data in these circumstances to reflect our observations and experience. Specifically, if the most-prevalent lead or lag time for the common delays reflects minimal or no difference in the lead or lag, we adjust the data to reflect a 10- to 20-minute lead or lag. The amount of the lead or lag is determined by the distance between the facilities, i.e., the farther the distance, the longer the lead or lag. Ten minutes is the minimum used because we have not observed many facilities with less than a 10-minute lead or lag from another facility.

Q. Why did you attempt to use more than one existing project to scale in a future project in certain circumstances?

A. The diversity of the output of the existing wind facilities is an important factor when scaling in a future wind facility. By using more than one existing wind facility, we are able to ensure that some of the diversity in wind output was reflected in the future wind facilities. If using a single facility, the estimated output of the future facility has the same pattern as the existing facility, just moved forward or backward in time.

Q. How do you decide which existing projects to use to scale in a particular future project?

A. The lead and lag data shows which existing facilities' output would most likely have the highest correlation with the future facilities' output. Using this as a starting point, we then add facilities that are close to the future facility if we observe a correlation between those two geographical areas based on existing facilities' measured output.

Q. Please explain the adjustments that you made to the generation data to develop generation estimates for a particular future wind facility.

A. We time shift generation of the existing project and develop ratios of the existing project capacity to the future project capacity. Time shifting means that the output of an existing facility is moved forward in time if the weather pattern normally would reach the existing project before the future facility or backward in time if the weather pattern normally would reach the existing project after the future facility. The number of minutes the project output is shifted is based on the prevalent pattern seen in the area for existing facilities and the lead and lag data.

The ratio used to calculate the estimated output of the future facility is the proposed installed capacity of the future facility over the installed capacity of the existing facility. When more than one existing facility is used to calculate the estimated output of a future facility, the existing facilities are normally weighted equally. In some cases, however, an existing facility is much closer geographically than the other facility used in the scaling, so it is given more weight when calculating the estimated output of the future facility.

Section 4.3: Load Assumptions

Q. Please summarize how you derived the actual BAA load and BAA load forecasts that it used in its analysis.

A. Similar to the generation data, we use a 21-month dataset (October 2006 through June 2008) with one-minute average actual load data as a starting point. With that dataset, we forecast the load through the FY 2010-2011 rate period using load growth projections. We use hourly archived data for the load forecasts and adjust that data using load growth factors for the forecasts for future years.

Q. Why is it necessary to take load estimates and forecasts into account in forecasting BPA's reserve requirements?

A. Load variations affect the within-hour balance similar to the impact of variation in wind generation. To accurately calculate the amount of reserve needed, the methodology needs to account for all factors that contribute to the reserve requirement at the same time. Because load and wind generation are the primary variables in the amount of power consumed in the BPA BAA, both load and wind data must be used as inputs to the methodology.

Q. Why was it necessary for you to develop 21-month datasets for load amounts in future years?

A. Our methodology requires load datasets for particular periods that correspond to the amount of wind generation that we forecast for those periods. To estimate the amount of load in future years, the estimated load growth should be applied for the timeframes corresponding to a certain amount of wind generation forecast for the same time period.

Section 4.4: Future Wind Schedule Accuracy

Q. Please summarize your analysis and assumptions with respect to the accuracy of future wind schedules.

A. We assessed forecast accuracy using the overall mean absolute error (MAE) and root-mean squared error (RMSE) statistics that measure how close a forecast is to the observed outcome. We deem replicating these statistics within one percent of the plant capacity sufficiently representative of the forecast. Historical scheduling and generation data from 14 wind projects in BPA's BAA from August 1, 2007, to August 1, 2008, demonstrate that the schedules consistently lagged actual generation values, so we focus on simple persistence models for our assumptions about the future scheduling accuracy.

We found that a two-hour lag model replicated the accuracy statistics to within acceptable levels for 11 of the 14 projects and modeled all the future wind projects using a two-hour lag.

Q. Why does the reserve forecast methodology require you to make assumptions about the accuracy of wind generation scheduling in the future?

A. A key component of the forecast methodology is the accuracy of wind generation scheduling, because the methodology considers the capacity requirements associated with the imbalance component (e.g., actual generation relative to scheduled generation). To accurately determine the reserve requirement for the future wind fleet, it is necessary to develop generation schedules for those facilities that have yet to be built. To use the most accurate estimate possible, we assume that scheduling accuracy for future wind facilities would be the same as we see for existing wind facilities.

Q. Why do you use the 12 months of scheduling and generation data for the period from August 1, 2007, to August 1, 2008?

A. The data for that period represent the most recent data that BPA had available from all of the wind facilities operating within the BAA when we performed our analysis. We want to use at least a full year's worth of data to avoid reflecting any bias in the data for any particular season. Certain of the facilities came on line after August 1, 2007, however, so BPA has less than 12 months of data for those facilities.

Q. Why do you focus on using a persistence model to estimate future wind schedules?

A. We compared the hour-ahead wind generator schedules and actual generation levels for the hour, and the data demonstrates that the hour-ahead schedules consistently lag the actual generation in the BAA. *See* Study, WP-10-E-BPA-08, Table 2.2.

Persistence models use historical actual values to predict future performance, which is consistent with our observations of the lags between actual generation and

schedules. Our analysis relies on actual generation values in a previous hour to predict the generation values in a future hour.

Q. Why do you use the MAE and RMSE statistics to assess the accuracy of forecasts?

A. The overall MAE and RMSE statistics are industry standard metrics used to describe the accuracy of a forecast. MAE is the average of the absolute value of the error over the sample size. RMSE assigns a more significant penalty to larger errors by squaring the forecast error on a given time step. These statistics often are expressed in terms of percentage of a facility's capacity in order to allow comparison between facilities of different sizes.

Q. Why is it acceptable to replicate the MAE and RMSE within one percent of plant capacity?

A. We considered certain alternatives to define an acceptable replication of the forecast but want a measure that was simple and would be sufficiently narrow. Exact replication is not possible, so it is appropriate to have a band around an exact match that allows for a small amount of error but is not so broad that it overstates meeting the match criterion. The one percent band is close to the limit of rounding error, and we consider it to be very restrictive.

Q. How did you decide that using a two-hour persistence model produced acceptable results?

A. We evaluated the correlation coefficient between the actual schedules and the actual generation at different lag times. The correlation coefficient is a measure of the linear relationship between the two variables. A greater value indicates a stronger linear relationship. We found that the correlation coefficient was greatest at the two-hour lag time for 12 of the 14 projects. We evaluated alternatives to the two-hour persistence model, but the results were inferior to those using that model for various reasons. Using

a one-hour persistence model was more accurate (e.g., better MAE and RMSE) than 13 of the 14 projects, but we have not observed that level of scheduling accuracy from existing wind projects. Using a three-hour lag persistence model was less accurate than all 14 projects and not representative of observed schedules over the analysis period. In other words, we have observed scheduling accuracy that is better than a three-hour persistence model.

Section 4.5: Forecasting the Total Reserve Requirement Using the Wind and Load Datasets

Q. Please summarize your methods for forecasting the incs and decs associated with each reserve component.

A. With the wind generation and load data described previously, we create load net wind actual and load net wind schedule datasets for the forecast. The load net wind actual dataset is the total actual load minus the total actual wind generation. The load net wind schedule dataset is the total load forecast minus the total wind schedule ramped in over 20 minutes. We calculate the load net wind numbers for every one-minute clock period in the study.

We use the load net wind numbers to create the 10-minute averages, one-hour averages, and total schedules that it used to forecast the overall reserve requirements for the BAA. To calculate the regulating reserve component, we determine the difference between the one-minute average of load net wind actual and the 10-minute average of the load net wind actual for each minute of the 21-month study period. To calculate the following reserve component, we determine the difference between the 10-minute average of load net wind actual and the ramped-in one-hour average of the load net wind actual for each minute of the study period. To calculate the imbalance component, we

determine the difference between the 10-minute average of load net wind actual and the ramped-in load net wind schedule for each minute of the study period.

We calculate these values for each hour of the study period, resulting in 24 datasets representing each hour of the day throughout the study period for each reserve component. For example, all data that we downloaded or created for regulating reserve for hour 1:00 to 2:00 for each day of the study period is combined into one regulating reserve dataset for hour 1:00 to 2:00. For the dataset for each hour of the day, we remove the highest 0.25 percent of the numbers from the *inc* side and remove the lowest (largest negative) 0.25 percent of the numbers from the *dec* side. The resulting numbers contain 99.5 percent for each of the regulation, load following, and imbalance forecast by hour of day for the FY 2010-2011 rate period. We use the maximum of the remaining numbers in each dataset as the total *inc* and *dec* needed for each respective hour of day and reserve component. The maximum of the 24 hours of the day is taken as the requirement for each reserve component. The net imbalance requirement is then computed by subtracting the load following requirement. This entire process is repeated for increasing levels of forecasted installed wind to determine the reserve requirement for each month throughout the rate period.

Q. Please explain what you mean by the "load net wind actual dataset is the total actual load minus the total actual wind generation" and the "load net wind schedule dataset is the total load forecast minus the total wind schedule."

A. To create the load net wind actual dataset, we subtract the total actual wind generation from the total actual load. To create the load net wind schedule dataset, we subtract the total wind schedule from the total load forecast. These are used to calculate the net BAA reserve requirements, because these calculations result in the net power consumption in

the BPA BAA by load and wind (actual) versus the scheduled amount of power consumption in the BPA BAA (schedule).

Q. Why do you discard the highest 0.25 percent of the numbers from the inc side and the lowest 0.25 percent from the dec side?

A. Historically, BPA has used 99.7 percent as the standard for determining the regulating reserve requirement. This means that BPA has historically discarded 0.15 percent of the extreme events from the *inc* side and 0.15 percent of the extreme events from the *dec* side. Upon review of BPA's compliance with NERC and WECC Standards, BPA decided that it could allow 0.2 percent more variation on the system without holding the corresponding reserve and BPA would remain in compliance with the standards. Therefore, BPA now requires that it hold reserve for 99.5 percent of the changes in load net wind estimated to occur in the BPA BAA.

Q. Why is the forecast for the imbalance component based on a comparison of the difference between the 10-minute average of load net wind actual and the load net wind schedule?

A. The imbalance component is a load following type of component, in that the amount of reserve held is based on the difference between the 10-minute average of load net wind actual and the load net wind schedule. The difference between the load net wind actual and the load net wind schedule reflects the actual amount of FCRPS resources that are deployed due to the load net wind scheduling error.

Q. Why do you use the maximum values out of the hour of day data as the basis for the total reserve requirement?

A. The maximum values out of the hour of day data are used after the 0.25 percent of the *inc* and 0.25 percent of the *dec* extreme events are removed, leaving 99.5 percent of the load net wind reserve. Using the maximum value is consistent with the reserve study methodology in that we calculate the reserve requirement using only a subset of the full

amount required, in this case 99.5 percent of the total. In addition, BPA must set aside enough resources to meet almost all of the extreme contingencies on its system, so, for purposes of forecasting the amount of reserves required, it is reasonable to use the maximum hour out of the day after removing the most extreme events.

Section 4.6: Allocation of the Total Reserve Requirement

Q. Please describe you method of allocating the total reserve requirement between wind and load.

A. Using the maximum numbers out of the 99.5 percent of the total *inc* and *dec* values described above, we determine the contribution of wind and load to the regulating reserve, following reserve, and imbalance reserve components each hour of day using incremental standard deviation (ISD). The ISD measures how much the load and wind contribute to the total load net wind reserve requirement, based on the sensitivity of the total reserve to variation in the individual components.

To calculate the wind and load components for the FY 2010-2011 rate period, we use the maximum wind and load components that resulted from the allocation using the ISD and determined the percentages to apply to the total load net wind requirement. The total load net wind requirement did not necessarily occur during the same hour of day as the maximum wind or load component. In order to ensure that we take into account the full variation and therefore reserve requirements caused by load and wind, we use the maximum number from load and wind irrespective of the hour of day in which those occurred. We calculate the wind percentage as the wind requirement divided by the load requirement plus wind requirement. The load percentage is calculated as the load requirement divided by the load requirement plus wind requirement. We then multiply

these individual percentages for wind and load by the total reserve requirement to determine the specific allocation to wind and load.

Q. Why do you propose to use ISD to allocate the total reserve requirement to wind and load as opposed to other allocation methods?

A. We propose ISD because the calculation is a portfolio-based approach that allocates the reserve need based on how load and wind each contribute to the total reserve need while taking into account any netting benefits that may exist between load's regulation signal and wind's regulation signal; load's following signal and wind's following signal; and load's imbalance signal and wind's imbalance signal. The result is an allocation of the 99.75 percent and 0.25 percent load net wind reserve requirements, where the sum of the individual load and wind reserve requirements linearly sum to the load-net-wind reserve requirement. Because the BAA is effectively a portfolio of megawatts, we use a calculation rooted in financial portfolio analysis. The result is a method identifying the relative drivers behind the BAA's need for reserves.

Q. Please explain your basis for using the maximum wind component and maximum load component that you mention above.

A. We use the maximum components for wind and load as described above to attempt to depict most accurately the use of reserve in the BPA BAA by the respective component (wind or load). Because the wind maximum usage and load maximum usage does not occur on the same hour of the day, we propose to fairly distribute the total reserve requirement by using the maximum requirement for wind and maximum requirement for load when calculating the percentage of the total requirement assigned to each.

Section 4.7: Results

Q. What are the results of your forecast of BPA's reserve requirement for the rate period?

A. Our forecast for the Initial Proposal is based on using the two-hour persistence scheduling model described in section 4.4, and assuming 2,655 MW of installed wind capacity in the BAA as of October 2009, increasing to 4,530 MW in September 2011. Based on these assumptions, the total (load net wind) reserve *inc* requirement ranges from 1,446 MW in October 2009 to 2,011 MW in September 2011. This results in a rate period weighted average of 1,777 MW. The total *dec* reserve requirement is -1,882 MW in October 2009 and -2,613 MW in September 2011. This results in a rate period weighted average of -2,340 MW. Study, WP-10-E-BPA-08, Table 2.11.

The wind reserve *inc* requirement increases from 683 MW in October 2009 to 1,312 MW in September 2011. This results in a rate period weighted average of 1,042 MW. The wind *dec* reserve requirement goes from -979 MW in October 2009 to -1,785 MW in September 2011. This results in a rate period weighted average of -1,480 MW. Study, WP-10-E-BPA-08, Table 2.12.

The load reserve *inc* requirement goes from 764 MW in October 2009 to 699 MW in September 2011. This results in a rate period weighted average of 735 MW. The load *dec* reserve requirement goes from -902 MW in October 2009 to -828 MW in September 2011. This results in a rate period weighted average of -860 MW. Study, WP-10-E-BPA-08, Table 2.13.

SECTION 5: WIND INTEGRATION TEAM WORK SINCE COMPLETING THE RESERVES FORECAST

Q. Please describe BPA's WIT and its work on the reserves forecast.

A. BPA formed the cross-agency WIT in 2008, following the WI-09 case. One of the WIT's primary goals is to address issues that are created by the integration of large amounts of

wind generation in the BPA BAA. The WIT developed the reserve methodology proposed in this Initial Proposal.

Q. Please describe the additional work done by the WIT since completing the reserve forecast methodology.

A. The WIT has not changed the reserve forecast methodology since completing the forecast used for the Initial Proposal, but it has continued to consider and identify ways to improve the methodology. In some cases, the WIT has begun working on modifications to some inputs to the reserve forecast methodology that eventually may be incorporated into the Final Proposal.

Q. What improvements to the methodology has the WIT identified that could be incorporated prior to the Final Proposal?

A. The numbers used for the load forecast assumptions in the methodology are simply the raw numbers generated by the system load forecasting tool. These amounts are not the same numbers that the Hydro Duty Schedulers use when setting up the system for the next hour. After the WIT completed its analysis for the forecast in September, it discovered that it could use a mathematical model to better reflect the Hydro Duty Schedulers' assumptions and thought processes when they modify the load forecast in order to set up the system for the next hour. The WIT did not discover these corrections in time to include them in the reserves forecast in the Initial Proposal; however, we expect to complete the modifications necessary to account for this model prior to the Final Proposal and to provide updated numbers to reflect the changed assumptions.

Q. How will these changes affect the reserve forecast?

A. The imbalance component of the reserve requirements will decrease, due to the decrease in the imbalance requirement on load. The load imbalance requirement will decrease, because the load forecast numbers will be more accurate than the raw numbers from the

system load forecasting tool. This change will also likely cause a slight increase in the wind imbalance component, because the wind component will be a larger percentage of the total variance.

Q. Has the WIT examined alternatives to the use of two-hour persistence scheduling assumptions for the reserve forecast?

A. Yes. The WIT developed forecasts of the reserve requirement using three different persistence scheduling models: 30-minute persistence, 45-minute persistence, and 60-minute persistence.

Q. How did the WIT incorporate the 30-minute, 45-minute, and 60-minute scheduling assumptions into the methodology?

A. For the 30-minute persistence model, the WIT used the average output of the wind facilities from the minute between XX:29 to XX:30 to estimate the scheduled generation for the next hour. For example, the WIT used the average output from 9:29 to 9:30 as the scheduled wind generation for 10:00 to 11:00.

The WIT applied the same approach for the 45-minute and 60-minute persistence models, but using one-minute averages from 45 and 60 minutes prior to the hour for estimating the schedule. In other words, based on the example above, the WIT used the average output from 9:14 to 9:15 as the basis for the scheduled wind generation from 10:00 to 11:00 under the 45-minute persistence model. Likewise, the WIT used the average output from 8:59 to 9:00 as the basis for the scheduled wind generation from 10:00 to 11:00 under the 60-minute persistence model.

Q. What were the results of using the alternative scheduling assumptions in the forecast methodology?

A. The alternative models would have a substantial effect on the reserve requirement forecast. The alternative scheduling models did not change the regulating reserve or

following reserve components (following with perfect schedules), because deviations from the scheduled generation going into the hour do not affect those two components. For the imbalance component (following with estimates), however, using the alternative scheduling models would reduce the forecast reserve requirement.

Tables 2.11 through 2.13 in the Study, WP-10-E-BPA-08, include the results of the WIT's analysis of all of these alternatives. For example, using the 30-minute persistence model, the total *inc* capacities are 1,120 MW with 2,655 MW of installed wind capacity in October 2009 and 1,426 MW with 4,530 MW of installed capacity in September 2011. This results in a rate period weighted average of 1,303 MW. The total *dec* capacities are -1,385 MW in October 2009 and -1,790 MW in September 2011, which results in a rate period weighted average of -1,615 MW. Study, WP-10-E-BPA-08, Table 2.11.

The wind *inc* capacities are 340 MW in October 2009 and 678 MW in September 2011, and the wind *dec* capacities range from -428 MW to -834 MW in the same period. This results in rate period weighted averages of 541 MW *inc* and -668 MW *dec*. Study, WP-10-E-BPA-08, Table 2.12. The load *inc* capacities are 780 MW in October 2009 and 749 MW in September 2011, while the load *dec* capacities are -957 MW and -956 MW in the same period. This results in rate period weighted averages of 762 MW *inc* and -947 MW *dec*. Study, WP-10-E-BPA-08, Table 2.13.

Q. Does the analysis regarding the impact of using 30-, 45-, or 60-minute persistence forecasts change the results of the forecast used in the Initial Proposal?

A. No. We use a two-hour persistence model in our analysis for the Initial Proposal, because that reflects the forecast accuracy that we have observed in the BAA based on data available. The reserve forecast, with the two-hour persistence model, is the forecast that we use for establishing rates in the Initial Proposal.

Since completing the reserve forecast, the WIT has continued to collect the data that is necessary to assess scheduling accuracy, but has not completed the analysis of the more-recent data to determine whether scheduling accuracy has changed. In addition, given that we propose the two-hour persistence scheduling model based on analysis of just 12 months of scheduling and generation data, we would prefer more than a few more months of additional data to validate any change in assumptions. The policy considerations associated with changing the persistence scheduling assumption are discussed in the testimony of Mainzer *et al*., WP-10-E-BPA-22.

Q. Does this conclude your testimony?

A. Yes.