2010 BPA Rate Case

TR-10 Transmission & Ancillary Services Customer Workshop

September 10, 2008

Agenda

9:00-9:15	Opening
9:15-10:15	Background
10:15-Noon	Reserves Forecasting Methodology and Results
Noon-1:00	Lunch Break
1:00-1:30	Summary of Wind Forecasting Process
1:30-2:00	Approach to BPA 2010 Rate Case
2:00-3:00	Next Steps

Objective

- To provide background on generation inputs that support ancillary services and control area services that support the integration of wind and to roll-out the reserve forecast methodology and results for wind integration needs in the BPA Balancing Authority.
  - (**Today**) Transmission Services will discuss the reserves forecasting methodology and preliminary results.
  - (Later workshop) Power Services will discuss pricing of generation inputs needed to support ancillary service requirements.
  - (Later workshop) Transmission Services will discuss how rate design options for inclusion in initial proposal.

Power Services Scheduled Workshops

Generation Inputs Pricing Methodology

Date	Topic
▪ 23-Sep *afternoon*	Pricing Generation Inputs for Wind Integration: Within-Hour Balancing Service.
▪ 22-Oct *afternoon*	Pricing Generation Inputs for: ▪ Within-Hour Balancing Service ▪ Operating Reserves ▪ Regulating Reserves ▪ Synchronous Condensing ▪ Station Service ▪ Redispatch ▪ Federal Remedial Action Scheme (RAS) for Generation Dropping ▪ Segmentation of Corps of Engineers (COE) and Bureau of Reclamation (USBR) Network and Delivery Facilities.

- Following the Sep 23rd workshop, BPA Power Services will hold informal meetings open to all interested parties for discussions of generation inputs pricing.

Transmission Services Scheduled Workshops

- BPA Transmission Services has scheduled the following workshops:

Date	Topic
▪ 31-Jul	Kickoff for 2010 BPA Rate Case (transmission focus)
▪ 6-Aug	Continued Discussion on Workshop Issues and Priorities
▪ 10-Sep	Wind Integration: Within-hour Balancing
▪ 23-Sep	Segmentation, UIC, Failure to Comply Penalty Charge
▪ 8-Oct	Segmented Revenue Requirement, Risk Analysis, Cost Allocation
▪ 21-Oct	LGIA Credits, Load Forecast, Compliance and Risk Analysis
▪ 22-Oct	*NEW!* Wind Integration: Within-hour Balancing
▪ 5- Nov	Rate Design

- All workshops dates and topics are subject to change with notice. **More workshops may be scheduled**. Please regularly check BPA's "Agency Calendar" for workshop changes and updates at: http://www.bpa.gov/CORPORATE/PUBLIC_AFFAIRS/CALENDAR/

Background

Background

- Ancillary Services are needed with transmission service to maintain reliability within and among the Balancing Authorities affected by the transmission service. They support the transmission of electric power from resources to loads and ensure system reliability.
- Control Area Services meet the Reliability Obligations of a party with resources or loads in the BPA Balancing Authority.
- Reliability Obligations for resources or loads in the BPA Balancing Authority must be consistent with North American Electric Reliability Corporation (NERC), Western Electricity Coordinating Council (WECC), and Northwest Power Pool (NWPP) criteria.
- Operating Reserve – Spinning Reserve is needed to serve load immediately in the event of a system contingency. Spinning Reserve Service may be provided by units that are on-line and loaded at less than maximum output.
- Operating Reserve – Supplemental Reserve is needed to serve load in the event of a system contingency; however, it is not available immediately to serve load but rather within a short period of time. Supplemental Reserves may be provided by generating units that are on-line but unloaded, by quick-start or by interruptible load.

Background

- Regulation and Frequency Responsive Reserves is necessary to provide for the continuous balancing of resources (generation and interchange) with load and for maintaining scheduled Interconnection frequency at sixty cycles per second (60 Hz). RFR is accomplished by committing on-line generation who output is raised or lowered (predominantly through the use of automatic generation control equipment) to follow moment-by-moment changes in load. RFR due to load variations is charged to transmission customers serving load in the BPA BAA.

- Load Following Reserves describes the spinning and non-spinning capacity to meet the within-hour shifts of average energy due to variations in forecasted and un-forecasted load and generation. No standard exists for the load following time-frame, but BPA is following a typical 10-minute clock cycle. Load Following due to load variations is recovered through power rates to load served in the BPA BAA.

  - Both regulation and load following capacity provide for continuous balancing of resources (generation and interchange) with load within the hour.

Background

- Within-Hour Balancing Service(s) describes the regulation and load following reserves to follow the within-hour variations due to intermittent resources (i.e. Wind) in the BPA BAA to maintain the power system frequency and reliability.

- Energy Imbalance is an after-the-fact calculation of the difference between a customer's hourly scheduled load and hourly actual load. This energy component does not address any capacity cost of service.

- Generation Imbalance is an after-the-fact calculation of the difference between scheduled and actual energy delivered from generation resources inside the BPA BAA. This energy component does not address the capacity cost of service.
  - Rate Design covering both Energy and Generation Imbalance is intended to encourage accurate scheduling. Currently, wind resources and new generation resources undergoing testing before commercial operation are exempt from band three of generation imbalance.
  - Due to the lack of time and complexity of the reserves forecasting analysis, imbalance impacts were not addressed in the WI-09.

Background

Operating Challenges

- Wind power is the fastest growing resource in the Pacific Northwest and helps to reduce the nation's reliance on foreign oil.
- There are now 1,500 MW of wind power in BPA's Balancing Authority and more wind projects planned or under construction. This large scale integration of wind introduces operating challenges due to wind farm are location and the intermittent nature of the resource.
  - Meeting peak loads means utilities must maintain capacity reserves to stand ready to meet peak loads if wind generation suddenly dies down or is not available when power use is highest.
  - Maintaining load and resource balance is required to keep lights on. In real time, the system is rebalanced moment-to-moment by increasing or decreasing generation from other sources. The Transmission Operator make such with-in hour adjustments to keep the system in balance. These services are known as within-hour balancing services.
    - Capacity reserves and with-in hour balancing services combine as "Wind Integration Services" to help Transmission Operators keep the system and grid reliably managed.
  - The lack of geographic diversity in the BPA BA wind fleet (primarily located east of Columbia River Gorge) increases demand for wind integration services.

Background

Operating Challenges & Opportunities

- Roughly 75% of the 1,500 MW of wind power in BPA’s Balancing Authority is exported to other BA’s including PGE and PAC. About 250 MW is exported to California.
- Existing wind fleet imbalance amounts have already reached a level where capacity must be set aside in order to meet the competing needs of the hydro system.
- Today’s hydro system is less flexible to absorb large, fast changes in wind power output. Increasing amounts of wind have strained the hydro system’s ability to quickly respond and threatens the limit of federal capacity available to handle large swings in wind output.
- To this end, BPA released a Request for Information (RFI) on August 21, 2008 to solicit third-party interest in supplying Generation Inputs and/or Load Interruption Services. Alternative resources may allow BPA to:
  - Partially offset FCRPS obligations
  - Secure generation inputs at the lowest possible cost
  - Diversify the generation portfolio
- Responses to the RFI are due by September 26, 2008.

Reserves Forecasting Methodology and Results

Reserves Forecasting Methodology

This part of the presentation is divided into the following sections:

- Scaling of wind
- Load estimates
- Estimating future wind forecasts
- Methodology for reserves forecasting
  - Differences from WI-09 to now
  - Base methodology
  - Time series of studies
  - Wind and Load contribution to total capacity requirement
- Preliminary Results

Reserves Forecasting Methodology
Scaling of Wind (pp 3-4 and Appendix A)

- To calculate the balancing requirements for planned wind generation, BPA contracted with 3TIER, a Seattle-based wind forecasting company, to provide the prevalent wind patterns across the BPA BAA using data from the MesoScale model created by 3TIER.
- The analysis involved computing leads and lags for planned wind from existing wind that were multiplied by installed and planned capacity to derive estimated output of wind farms.
- For example, if a planned 100 MW wind farm (A) had a 20 minute lead before an existing 200 MW wind farm (B) and a 10 minute lag after an existing 50 MW wind farm (C) and both B and C were equally indicative of the output of A, A would have the following estimated generation for any minute:

$$A = (100/200)*(B^{+20minutes})*0.5 + (100/50)*(C^{-10minutes})*0.5$$

Reserves Forecasting Methodology

Scaling of Wind (pp 3-4 and Appendix A)

- The scaling of wind calculations were performed for all planned wind generation through CY 2012 and therefore include a few wind farms planned for FY 2013. The preliminary results form the basis for the wind portion of the calculations used to estimate the balancing needs required for increasing wind integration.

- The table below outlines the number of existing wind generation sites as well as the planned sites in future years.

Fiscal Year (FY) achieved	Installed Wind (MW)	Total Plants
2007	733	9
2008	1425	14
2009	2105	21
2010	3155	30
2011	4330	40
2012	5570	48
2013	6670	53

Reserves Forecasting Methodology

Load Estimates (pp 4-5)

- Load growth factors were determined from average estimated annual customer load growth corresponding to the yearly installed wind integration level.

- The load forecast was downloaded from historical storage. In order to change the stored system load forecast to an area load forecast, the total of the transfer customer schedules was subtracted from the system load forecast. The transfer customers are located in other BAAs and are therefore excluded from the area load.

- The following multipliers were applied to determine load estimates:
  FY09_Load FY 2008 * 1.010 Load Growth
  FY10_Load FY 2009 * 1.022 Load Growth
  FY11_Load FY 2010 * 1.020 Load Growth
  FY12_Load FY 2011 * 1.004 Load Growth
  FY13_Load FY2012 * 1.017 Load Growth

Reserves Forecasting Methodology

Load Estimates (pp 4-5)

The area load used in the load estimate calculations is slightly different than the area load posted on the BPA external Operations web site. The area load on the Operations page is simply the total generation in the BPA BAA minus the total of all interchanges (transfers to/from adjacent BAAs). Since the pump load is not part of the load forecast, it was subtracted from the area load prior to loading it into the load estimate calculations.

Reasons why pump load is not part of the load forecast:

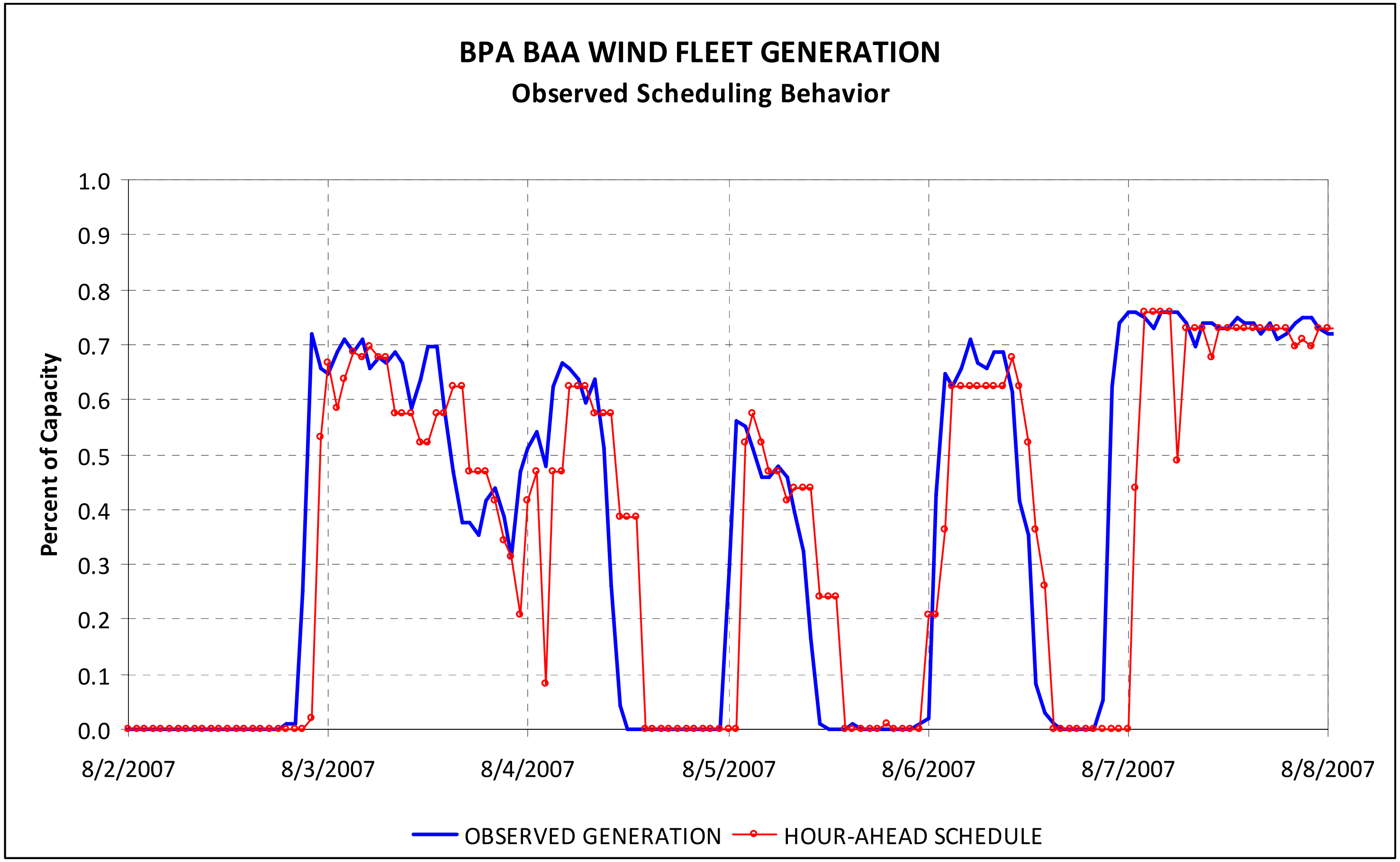
(1) Pump load is scheduled at precise times
(2) Weather variation does not affect it (same MW draw whether it is 30 degrees or 100 degrees)
(3) Pump load power is directly fed by Grand Coulee so does not affect the rest of the controlled hydro system.

Reserves Forecasting Methodology

Estimating Future Wind Forecasts (pp 5-7)

- Need to represent the uncertainty surrounding wind generation schedules to estimate the reserves required to provide imbalance service.
- Required to develop a model that replicates the forecast behavior and accuracy that has been observed in the BPA BAA.
- Wind generation schedules (e.g. hour-ahead forecast generation) exhibit consistent lag behind the observed generation. Highest correlation with observed schedules was a 2-hour lag.

Reserves Forecasting Methodology
Estimating Future Wind Forecasts (pp 5-7)



Reserves Forecasting Methodology
Estimating Future Wind Forecasts (pp 5-7)

- Predicted the wind project generation using the actual hour-average generation from two hours prior.

- Goal is to match accuracy statistics within +/-1% of project capacity.

Reserves Forecasting Methodology

Estimating Future Wind Forecasts (pp 5-7)

- Forecast accuracy is measured primarily by mean absolute error (MAE) and root-mean squared error (RMSE)

- MAE measures how close the forecast is to the observed outcome.

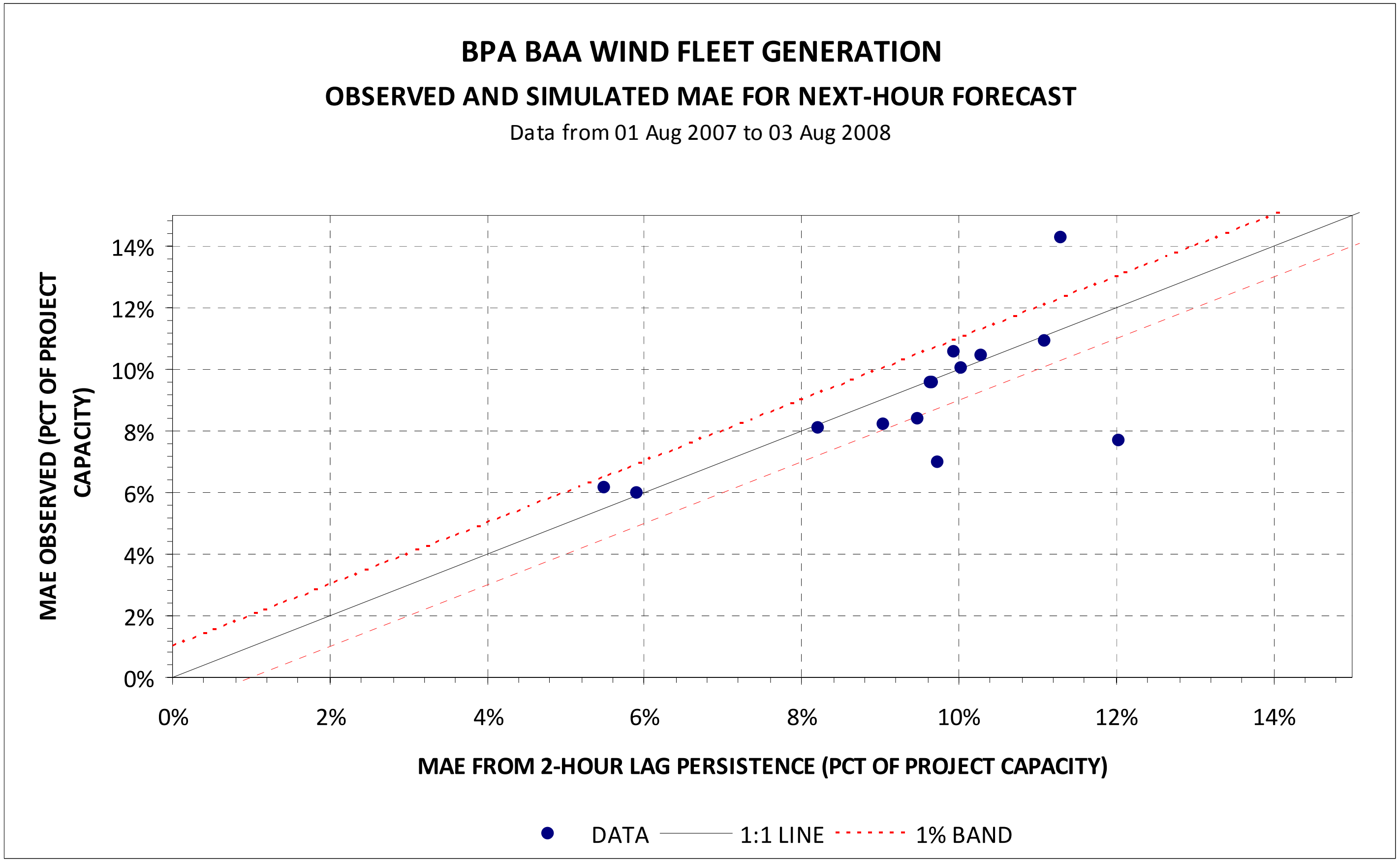
$$MAE = \frac{1}{n}\sum_{i=1}^{n}|e_i|$$

- RMSE also measures how close the forecast is to the observed outcome, but assigns a greater penalty to larger errors.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} e_i^2}{n}}$$

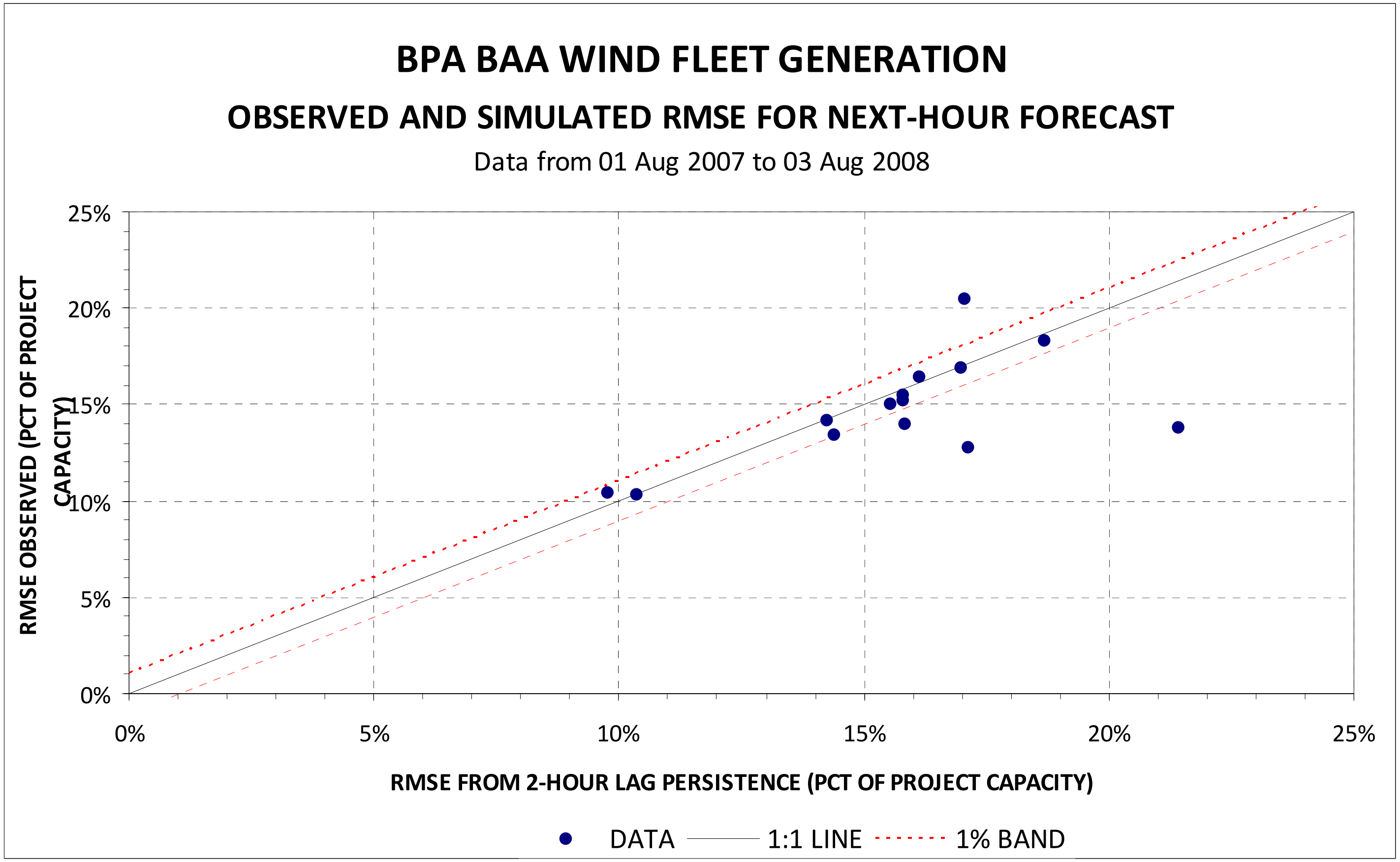
Reserves Forecasting Methodology

Estimating Future Wind Forecasts (pp 5-7)



Reserves Forecasting Methodology

Estimating Future Wind Forecasts (pp 5-7)



Reserves Forecasting Methodology

Estimating Future Wind Forecasts (pp 5-7)

- 11 of 14 project's accuracy statistics were met or improved by using a 2-hour lag persistence model.
- It is assumed that current forecast behavior and accuracy will continue until demonstrated otherwise.
- All new wind generation facilities where assumed to use a 2-hour lag persistence pattern to develop the imbalance profile.

Reserves Forecasting Methodology
Comparison from WI-09 (p 8)

This table to the right is a high level summary of the changes in the reserves forecasting methodology from WI-09.

The intent of this table is to facilitate discussion surrounding the evolution methodology, to invite customer comment, and to focus research efforts.

		WI-09	TR-10
1	Data Period	4 months	21 months
2	Data Pattern	varying pattern of wind and load **not** included.	varying pattern (by hour of day) of wind and load included.
3	Components of Reserve Requirement:		
4	Regulation	delta between one minute average and 60 minute rolling average	delta between one minute average and ten minute average
5	Load Following w/Perfect Schedule	delta between 60 minute rolling average, and 60 minute rolling average 60 minutes earlier	delta between clock 10 minute average and clock 60 minute ramped average
6	Load Following w/Estimated Schedule	N/A - did not consider estimated schedules	delta between clock 10 minute average and clock 60 minute ramped estimate
7	Allocation to Load and Wind	wind assigned delta between Load only and Load net Wind	incremental standard deviation used to allocate Load net Wind to seperate Load and Wind components
8	Exceedence Probability	99.5 percentile of absolute value	99.75 percentile of incremental and decremental values (99.5 percentile overall)
9	Averaging	Rolling	clock hour (includes estimates and forecasts)

Reserves Forecasting Methodology

Comparison from WI-09 (p 8)

- WI-09 did not use schedules or forecasts; new methodology has schedules and forecasts as a key component.
- WI-09 did not use any methodology to distinguish variations caused by wind versus load, it simply subtracted load contribution from total requirements and left the remainder as wind requirements. New methodology uses incremental standard deviation to calculate wind and load contributions
- WI-09 only had a four month data set due to software limitations, now using a 21-month data set. Will continue increasing this dataset as we go forward with WIT.

Reserves Forecasting Methodology

Base Methodology (pp 8-9, Appendix C)

- Data requirements
  - Actual area load
  - Area load forecast
  - Total actual wind generation
- Data created
  - Load net wind actual (actual area load minus total actual wind generation)
  - Load net wind schedule (area load forecast minus total wind generation forecast)
  - Perfect schedules (average load, wind and load net wind for each hour)
  - Total wind generation estimated forecasts (schedules)

Reserves Forecasting Methodology

Base Methodology (pp 8-9, Appendix C)

- Three components of total reserve requirement
  - Regulation
  - Load following with perfect schedules (LFPS)
  - Load following with submitted/estimated schedules and/or load forecast (LFES)
    - Difference between LFES and LFPS is imbalance
- Regulation is difference between actual and 10 minute average
- LFPS is difference between 10 minute average and perfect schedule
- LFES is difference between 10 minute average and submitted/estimated schedules and/or load forecast.

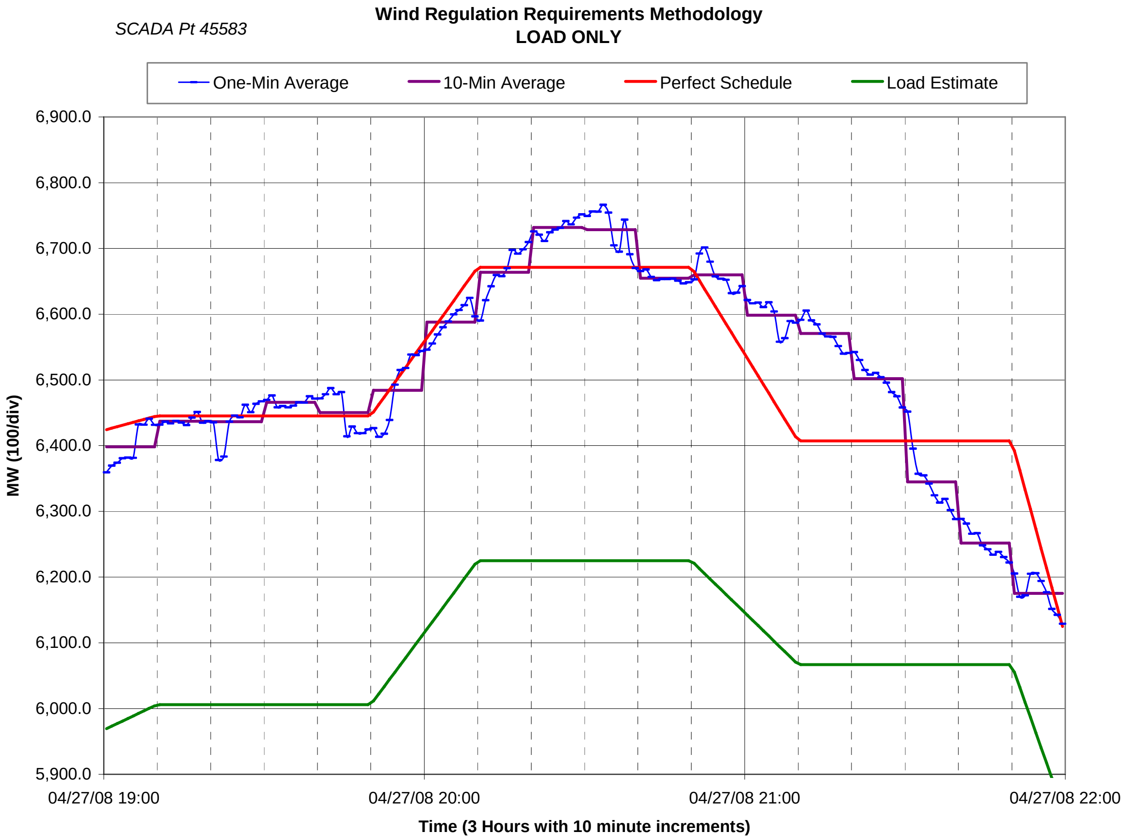
Reserves Forecasting Methodology

Base Methodology (pp 8-9, Appendix C)

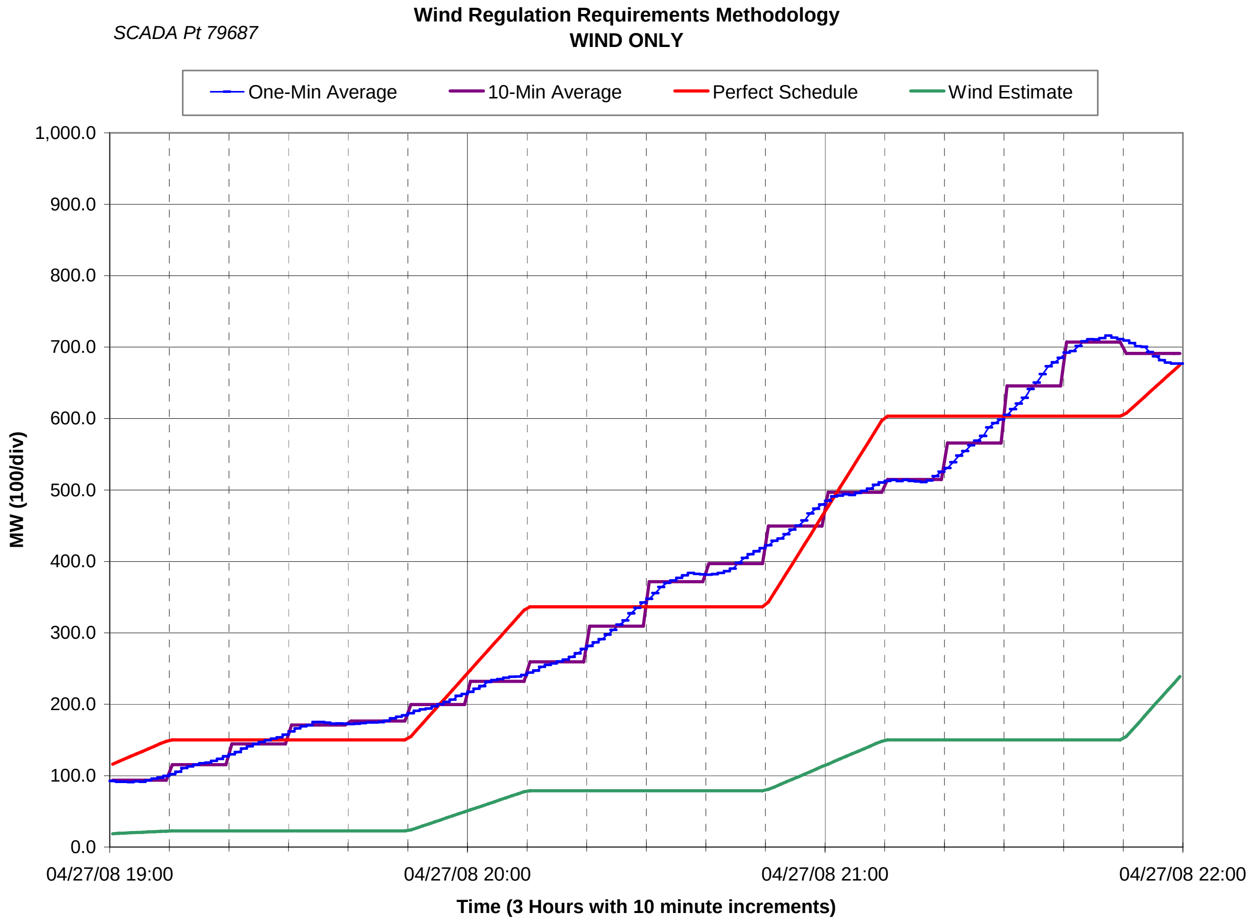
- For each component, inc and dec requirement calculated.
- Removed 0.25% of extremes from each case, leaving 99.5% of all values. This is used to calculate capacity requirements for BPA.
  - Historically (pre-WI-09) BPA has used three standard deviations for capacity requirements, this equates to 99.7% of all values.

Reserves Forecasting Methodology

Graphical Depiction of Base Methodology (Appendix C)

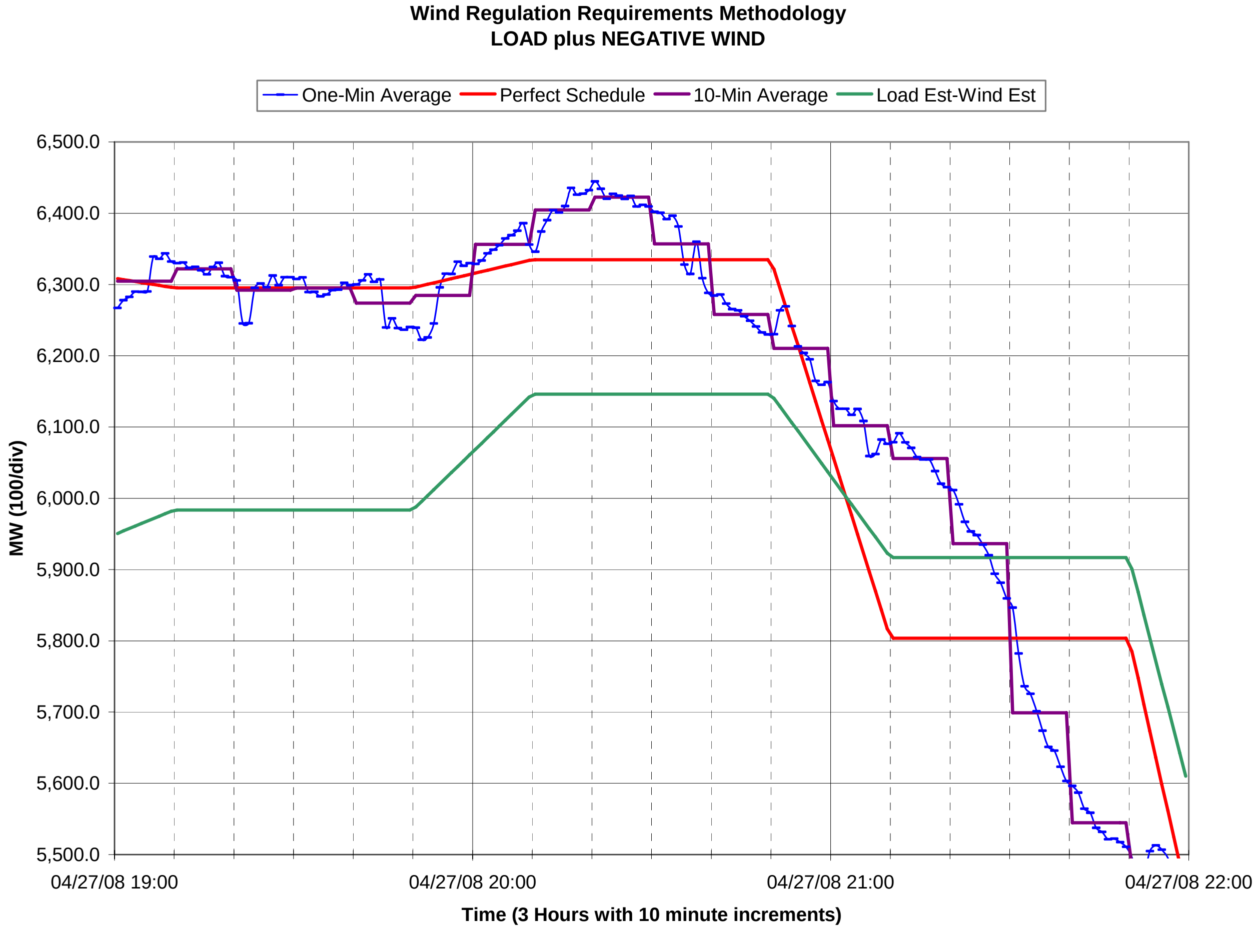


Reserves Forecasting Methodology
Graphical Depiction of Base Methodology (Appendix C)



Reserves Forecasting Methodology

Graphical Depiction of Base Methodology (Appendix C)



Reserves Forecasting Methodology

Wind/Load Contribution to Total Requirement (P9, Appendix B)

- Need to ensure fair calculation for wind and load contribution to total requirement.
  - Sum of wind contribution + load contribution must equal total requirement.
- Using incremental standard deviation
  - Example, for a 1 MW increase in wind regulation standard deviation, this will show the increase in the load net wind standard deviation.
  - Likewise for load.
  - For any MW increase or decrease in regulation for load or wind, the total regulation increase can be determined using the appropriate incremental standard deviation.

Reserves Forecasting Methodology

Wind/Load Contribution to Total Requirement (P9, Appendix B)

- The equations used for load and wind are:
  - Load allocation = (Load net Wind percentile) * [(Load St Dev) ^ 2 + Cov(Load, Wind)] / (Load net Wind St Dev) ^ 2
  - Wind allocation = (Load net Wind percentile) * [(Wind St Dev) ^ 2 + Cov(Load, Wind)] / (Load net Wind St Dev) ^ 2

Reserves Forecasting Methodology

Time Series of Studies (p 10)

- The timeline used in the studies is hour-of-day for the full dataset including twenty-one months:
  - 24 values for each of the capacity requirements.
  - 0.25% upper and lower values discarded for each hour.
  - Total requirement calculated based on max value for 24 hour series.

Reserves Forecasting Preliminary Results
(pp 10-13, Appendix D)

- Although requirements are evaluated for the projected wind fleet through 2013, no assumptions are made as to whether BPA BA will or will not be able to meet these requirements with available resources.
- Hour-of-day values are shown in detail in Appendix D.

Reserves Forecasting Preliminary Results
(pp 10-13, Appendix D)

Load Net Wind Requirements

		Regulation		Following (PS)		Following (ES)		Following (D)	
FY	**Wind(MW)**	**Inc**	**Dec**	**Inc**	**Dec**	**Inc**	**Dec**	**Inc**	**Dec**
08	**1425**	124.3	-140.4	313.4	-366.6	928.2	-1,143.3	614.8	-776.7
09	**2105**	126.8	-143.1	334.8	-381.5	1,130.0	-1,426.5	795.2	-1,044.9
10	**3155**	134.4	-151.1	380.1	-409.6	1,483.6	-2,013.5	1,103.5	-1,603.9
11	**4330**	143.8	-158.4	419.2	-448.3	1,794.9	-2,370.5	1,375.7	-1,922.2
12	**5570**	148.9	-162.8	465.7	-486.3	2,237.2	-2,884.8	1,771.5	-2,398.5
13	**6670**	149.8	-166.9	470.2	-479.7	2,157.1	-2,772.5	1,686.9	-2,292.7

PS – based on a perfect schedule (hourly average ramped in over 20 minutes)

ES – based on an estimated schedule (2 hour persistence for wind; scaled historical estimates for load)

D – the delta, i.e. the increase in following due to imbalance (ES – PS)

Reserves Forecasting Preliminary Results
(pp 10-13, Appendix D)

Wind Requirements, based on proportional max values

		Regulation		Following (PS)		Following (ES)		Following (D)	
FY	Wind(MW)	Inc	Dec	Inc	Dec	Inc	Dec	Inc	Dec
08	1425	10.0	-10.2	56.1	-58.0	276.7	-301.7	211.4	-238.3
09	2105	13.8	-14.5	83.3	-90.1	508.4	-620.3	415.7	-526.3
10	3155	27.3	-27.5	139.5	-146.1	834.6	-1258.1	694.7	-1126.4
11	4330	40.3	-40.2	178.5	-186.7	1187.7	-1651.7	1014.4	-1485.5
12	5570	51.0	-53.8	225.9	-228.4	1671.4	-2223.2	1466.8	-2023.3
13	6670	53.1	-54.1	224.1	-224.0	1571.7	-2100.5	1362.6	-1908.2

PS – based on a perfect schedule (hourly average ramped in over 20 minutes)

ES – based on an estimated schedule (2 hour persistence for wind; scaled historical estimates for load)

D – the delta, i.e. the increase in following due to imbalance (ES – PS)

Reserves Forecasting Preliminary Results

(pp 10-13, Appendix D)

Load Requirements, based on proportional max values

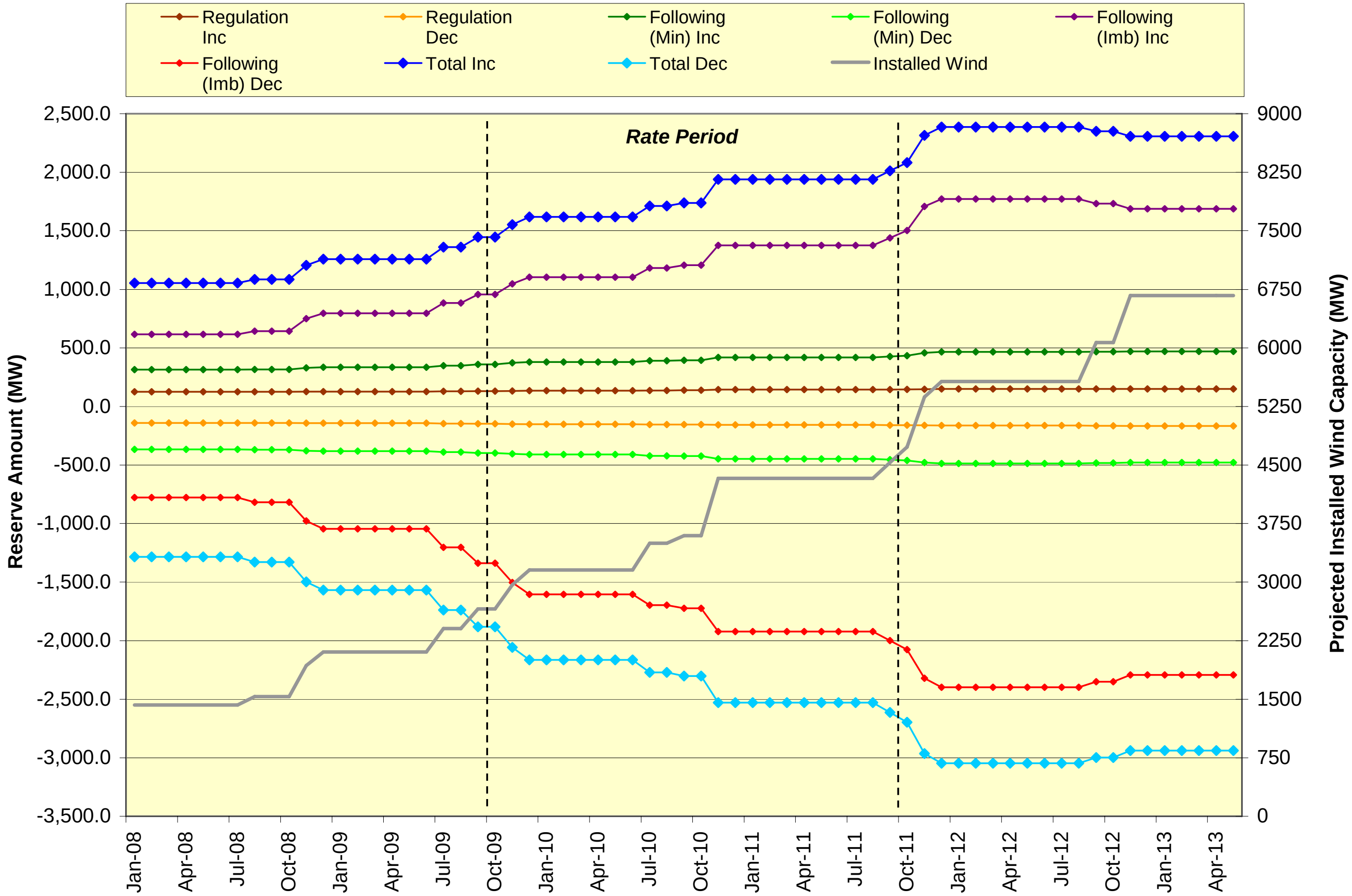
		Regulation		Following (PS)		Following (ES)		Following (D)	
FY	**Wind(MW)**	**Inc**	**Dec**	**Inc**	**Dec**	**Inc**	**Dec**	**Inc**	**Dec**
08	**1425**	114.3	-130.2	257.3	-308.6	651.5	-841.6	403.4	-538.4
09	**2105**	113.0	-128.6	251.5	-291.4	621.6	-806.2	379.5	-518.6
10	**3155**	107.1	-123.6	240.6	-263.5	649.0	-755.4	408.8	-477.5
11	**4330**	103.5	-118.2	240.7	-261.6	607.2	-718.8	361.3	-436.7
12	**5570**	97.9	-109.0	239.8	-257.9	565.8	-661.6	304.7	-375.2
13	**6670**	96.7	-112.8	246.1	-255.7	585.4	-672.0	324.3	-384.5

PS – based on a perfect schedule (hourly average ramped in over 20 minutes)

ES – based on an estimated schedule (2 hour persistence for wind; scaled historical estimates for load)

D – the delta, i.e. the increase in following due to imbalance (ES – PS)

Reserves Forecasting Preliminary Results
(pp 10-13, Appendix D)



Reserves Forecasting Preliminary Results
(pp 10-13, Appendix D)

- Appendix D shows the breakout by hour-of-day for each fiscal year.
- The load following for load declines through the years as more wind is integrated.
  - Marked decline for load following with estimates
  - Due to large amounts of wind being integrated with the associated variance. Causes the load imbalance and load following to actually decline

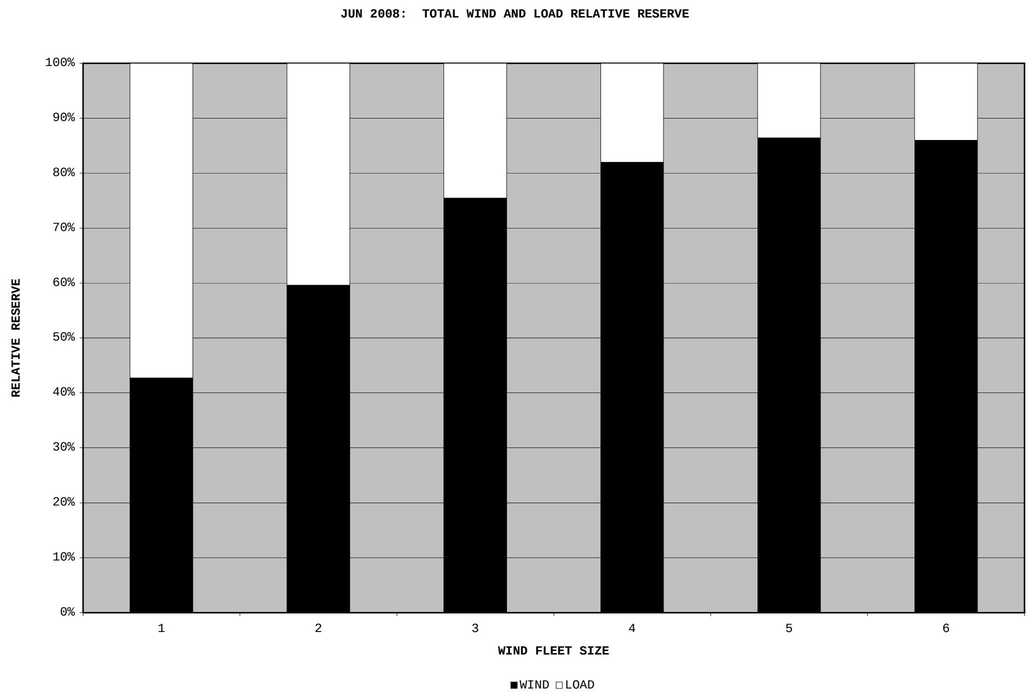
Reserves Forecasting Preliminary Results
(pp 10-13, Appendix D)

- The load following (perfect schedules) and regulation numbers are much lower than were calculated for WI-09.
  - Since we used no schedules or forecasts for WI-09, some imbalance crept into the numbers.
  - We used hourly deviations rather than sub-hourly deviations in WI-09 which resulted in larger numbers
  - This methodology gives more accurate numbers in greater detail than was obtained with the methodology for WI-09.

- The total load following requirement is much higher using current methodology versus WI-09 methodology
  - Calculating load following versus forecast load or estimated wind forecasts, in WI-09 did not include forecasts.

Reserves Forecasting Preliminary Results
(pp 10-13, Appendix D)

Sample graph of monthly analysis for 2008 through 2013, see ‘Graphical Analysis by Month’



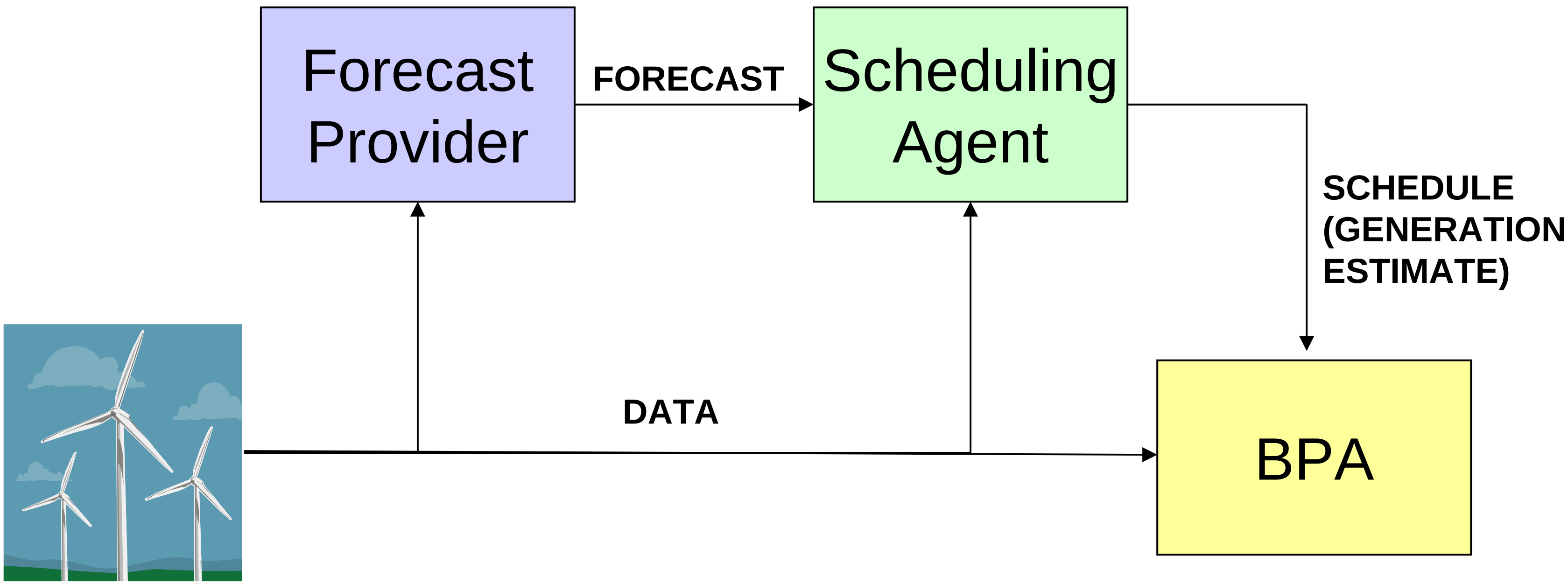
Reserves Forecasting Next Steps for WIT

- Expand analysis
  - Add hydro that is not part of AGC regulation
  - Add thermal generation

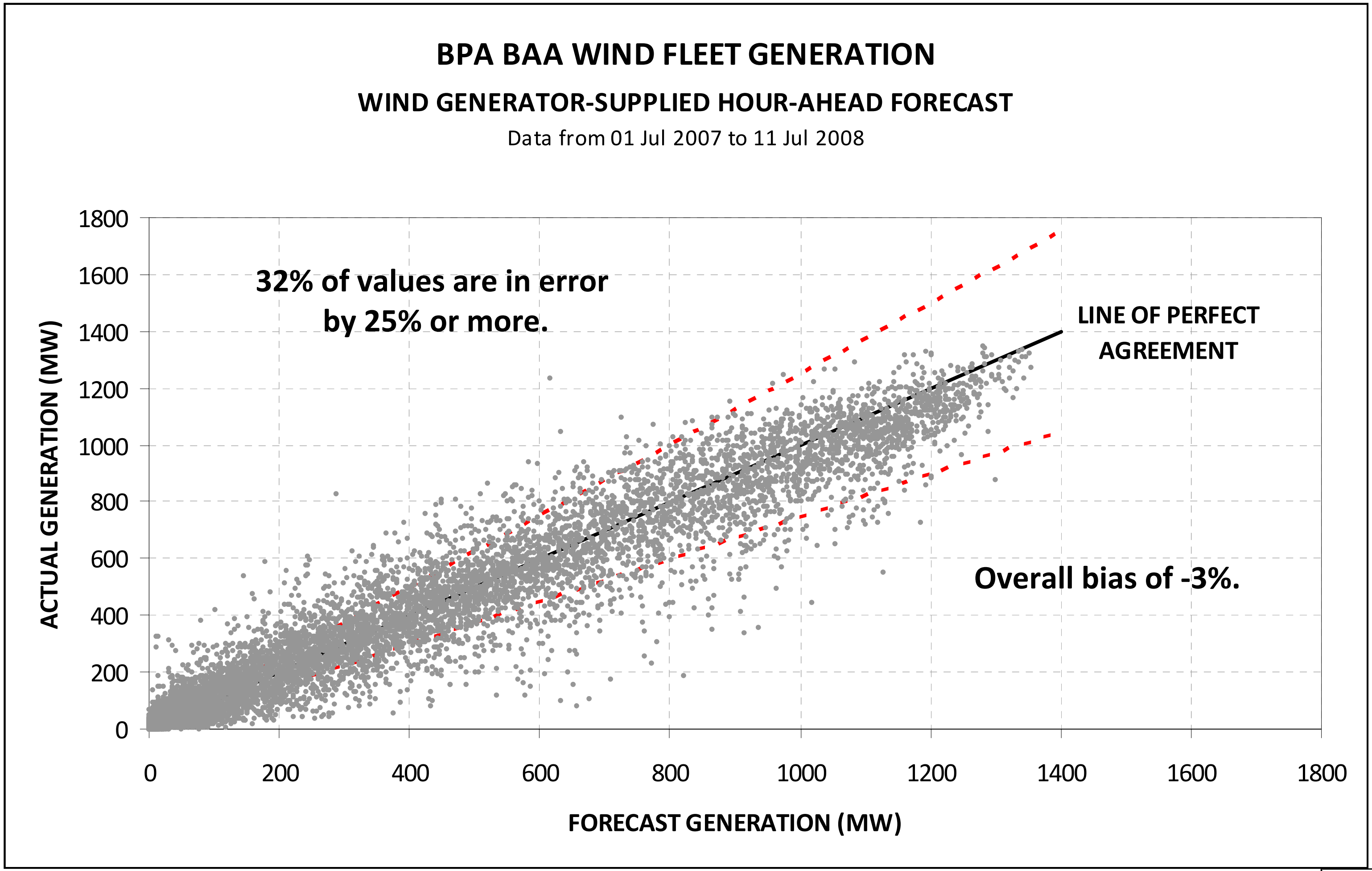
Summary of Wind Forecasting Process

BPA Wind Forecasting Process

- Below is a high level overview of the current wind forecast scheduling process from the BPA perspective.



BPA Wind Forecasting Process



BPA Wind Forecasting Process

- BPA only receives the generation estimate from the Scheduling Agent, without any knowledge of how that relates to the forecast.
- Federal dispatchable hydro resources are positioned hourly to serve the residual federal load (i.e. total load obligation minus scheduled non-dispatchable federal generation).
- Federal dispatchable hydro resources then move to offset any deviation from scheduled wind generation, keeping the schedule whole for the hour.
- In order to make schedules whole for wind serving load outside the BA, federal generation also provides the imbalance needed.
- Better forecasts will improve the accuracy of wind generation scheduling that may reduce the need for wind integration services.

BPA Wind Forecasting Process

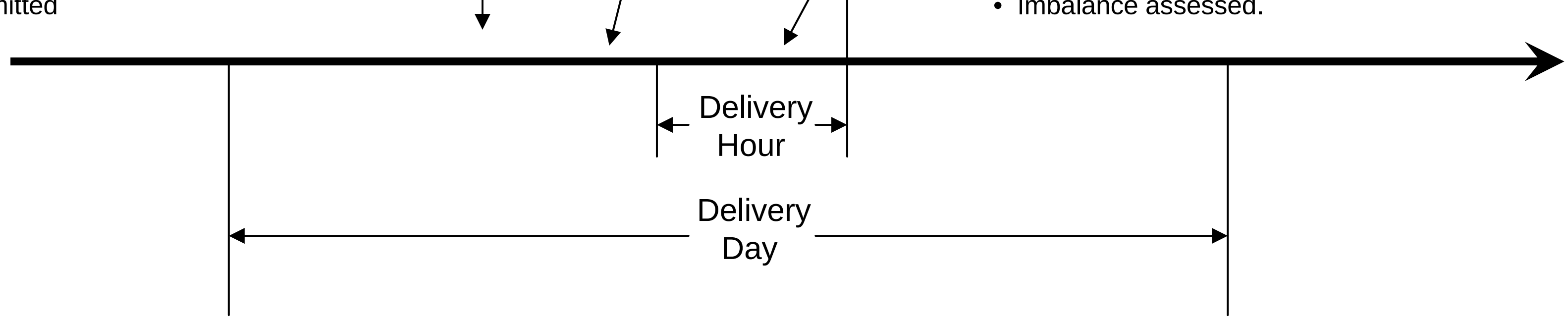
Within-hour
- Actual wind generation enters BA
- Hourly schedules are met
- Difference between actual wind production and schedule is met by balancing resources (regulation and following services).

Hour-ahead Timeframe
- Hourly schedules may be submitted for next hour through balance of day.

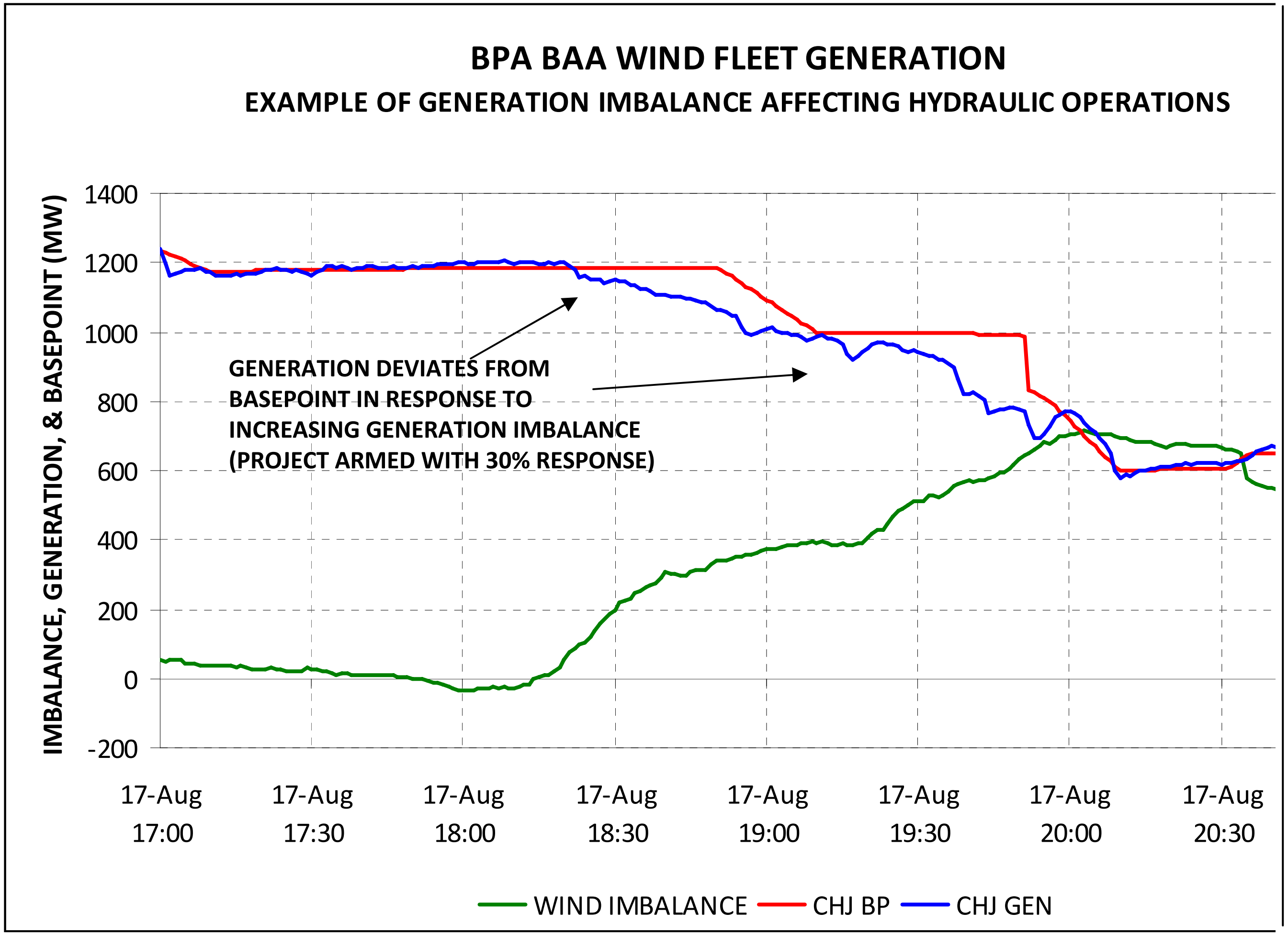
After-the-Fact
- Difference between scheduled and actual generation computed.
- Imbalance assessed.

Preschedule Timeframe
- Hourly, day(s) ahead schedules submitted

Schedules Due:
20 min prior to hour



BPA Wind Forecasting Process

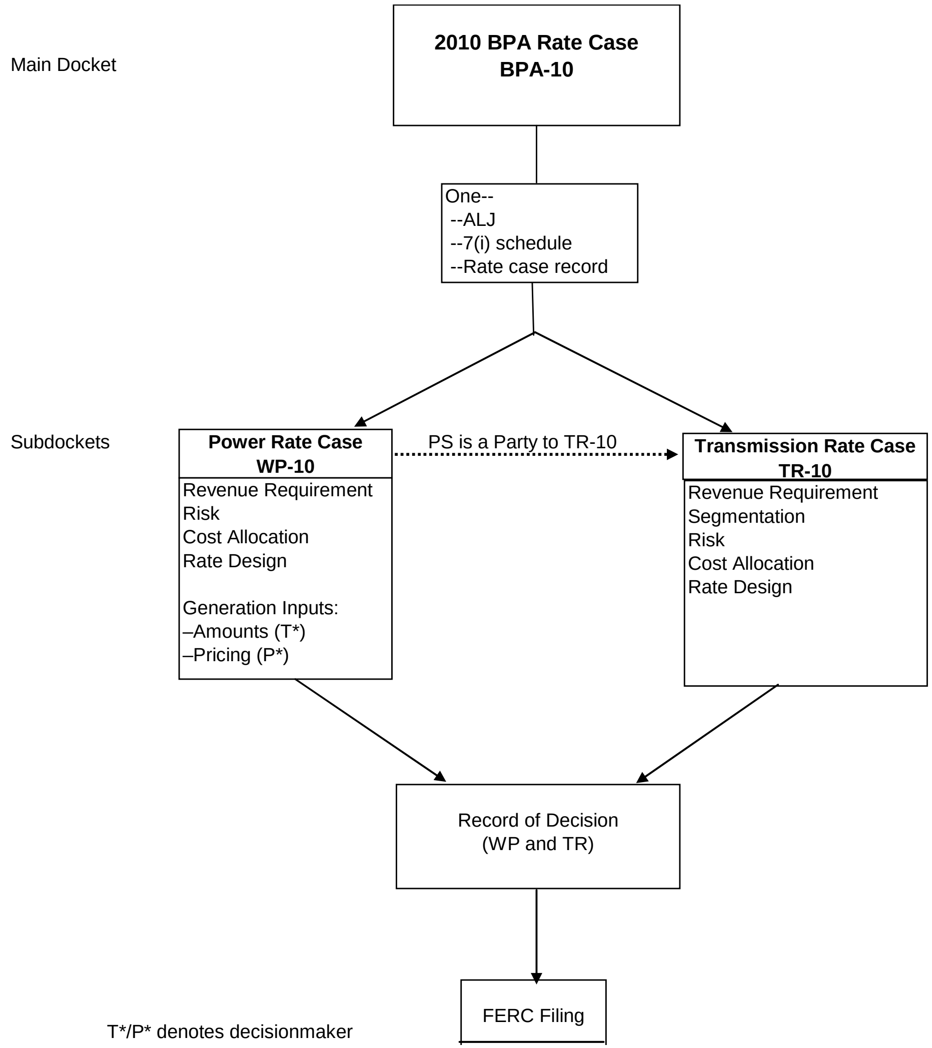


Approach to 2010 BPA Rate Case

Approach to 2010 BPA Rate Case

- This will be the first year since 1996 that the Power Services and Transmission Services rate cases will be held simultaneously. The primary drivers behind our approach to the rate case include:
  (1) to streamline the process, and
  (2) to address generation inputs issues in both rate cases.
- One overall rate case (BPA-10) with two sub-dockets (WP-10 and TR-10). The TR-10 docket will include the transmission revenue requirement (including risk and segmentation), cost allocation, and transmission rate design. All other issues will be decided in the WP-10 docket, including all generation inputs issues. Power Services will be a party in the TR-10 docket.
- This proposal will allow for one FRN, one rate case schedule, one record, and one ROD. It will limit the amount of the overall process while maintaining the separation between power and transmission rate making.

Approach to 2010 BPA Rate Case



T*/P* denotes decisionmaker

Next Steps

Next Steps

- The Customer Issues List is available for reference at: http://www.bpa.gov/corporate/ratecase/2008/2010_BPA_Rate_Case/working-docs.cf

- Open for customer comment or suggestions**.**