Customer Workshop

Wind Integration Team (WIT)

June 9, 2008

Purpose Statement

The purpose of this presentation is to respond to customer requests made at the May 5, 2008 FY2010-2011 BPA Transmission Rate Case Workshop for Wind Integration regarding the relationship between the WIT and the FY2010-2011 Transmission Rate Case efforts.

Scope of WIT

The WI-09 Wind Integration Settlement requires BPA to charter a cross-agency WIT to determine how to cost-effectively interconnect wind in a way that maintains reliability and allows sound power and transmission operational planning. Over the next two to three years, the WIT will work with other BPA groups to develop a set of coordinated processes and procedures for:

1. Managing the requirements for generation inputs used by the BPA balancing authority to provide reserves.

2. Identifying new supply generation resources for generation inputs.

3. Reducing the demand on the existing capacity of the FCRPS to provide generation inputs.

4. Acquiring cost-effective capacity resources that meet BPA's firm power obligations and the generation input needs of the BPA Balancing Authority.

Scope of FY2010-2011 Transmission Rate Case

as it relates to Wind Integration

The Transmission and Ancillary Services Rate Case will establish rates for the **short term** FY2010-2011 period. In order to establish rates for Wind Integration, the following sequence of events will need to happen:

1. TS will determine the reserve requirement for the BPA Balancing Authority.

2. PS will assess how much of the reserve requirement can be with FCRPS and determine generation input costs through FY2010-2011 Power Rate Case.

3. TS will decide rate design. If third party supply is required, rate design will be flexible to accommodate; otherwise, conditions of third party supply requirements will be addressed separately through Business Practice.

Key Questions

1. What are the Balancing Authority's reserve requirements to integrate increased wind resources?
2. What capability does the power system have to integrate intermittent wind resources from a system operations perspective?
3. How does wind energy impact the system flexibility to supply load and undertake trade?
4. What are the associated costs of integrating wind energy?
5. What forecasting standards are needed to reduce the integration impacts of wind?
6. What wind generation dynamic performance criteria is needed to maintain system reliability?

Rate Case – High Level Work Stream

Phase 1 (Jun '08)

TS will determine the reserve requirement amount needed to maintain reliability standards.

Requirements

Phase 2 (Sep '08)

PS will determine how much of the reserve requirement can be met with FCRPS supply and at what cost.

Supply

Phase 3 (Nov '08)

TS will determine if third party supply is needed and develop appropriate rate design.

Rates

WIT – High Level Work Stream

Quantify issues

BPA to define the Magnitude of the Problems Associated with Wind Integration

Requirements

→

Potential Solutions

BPA to Address Potential Solutions

Solutions

→

Methods & Procedures

BPA to identify the methods and procedures to Implement Solutions

Implementation

Key Issues	RC	WIT
BPA BA Reserve Requirement	X	X
Predictability of Wind Generation		X
FCRPS Availability		X
Third Party Supply		X
Pricing FCRPS Generation Inputs	X	
Scheduling & Forecasting		X
Ramping		X
Wind Farm Dynamic Performance		X
Disturbance Ride Through		X
Voltage Stability Control		X

Legend:
RC= Rate Case
WIT = Wind Integration Team

Closing

- Take live tour of new BPA Rate Case website featuring one stop shopping of Rate Cases, WIT, wind data developments
- Open for questions and comments

Customer Workshop

Wind Integration Team (WIT) - Reserves Forecasting Methodology

June 9, 2008

Introduction

- Develop a Reserves Forecasting Methodology to accommodate higher levels of wind penetration and changing system operations within the BPA Balancing Authority.

- The Reserves Forecasting Methodology will ultimately serve as the basis for estimating the quantity of within-hour reserve needs for the Initial Proposal of the FY2010-2011 Transmission Rate Case.

Methodology

WIT Methodology

- Data is set to one-minute averages
  - Continuous data stream to be fed into database
  - No constraints on amount of data used, not held to spreadsheet limitations
  - Multiple months per analysis rather than single month at a time
  - Data queries via Excel, so limitation still exists for some cases

Methodology

Data stored:

- Actual MW output of each wind site
- Basepoint (schedule) of each wind site
  - Hourly value
  - Ramped in over standard 20 minute ramp
- Area load
- Area load forecast
  - Hourly value
  - Ramped in over standard 20 minute ramp
    - Ramp in full amount with one case
    - Ramp in 1/3 of change in second case
- Other generation (Thermal, etc.) not directly controlled by BPA
  - Actual output
  - Scheduled output

Methodology

- For each minute calculate difference between actual load and load forecast.
- Subtract total wind from load, subtract total wind basepoint (schedule) from load forecast.
  - For each minute, calculate difference between actual load minus wind and load forecast minus wind basepoint.
- Create percentile distribution by hour of day for both sets of numbers.
  - This will bring time back into the method
  - Load ramps will not dominate full data set
- Start with 99.5% on the percentile distribution calculations for amount needed.
  - Use same amount as in previous studies
  - Can be modified as more data is obtained

Methodology

- Resultant numbers will be a combination of load following, regulation and generation imbalance.
  - Load following will be 10 minute change.
  - Regulation will be the deviations around the 10 minute averages.
- Rerun studies using ‘perfect’ forecasts as input.
  - Difference between this and the previous study should give us the generation imbalance.
- No absolute values in the studies.
  - Need to calculate total inc and dec needed.
  - Need the inc and dec by time of day, specifically on and off peak values.

Methodology

- Add the AGC signals to plants to the data being downloaded.
  - Calculate the amount of actual generator movement created due to load and wind.
    - Take the hour by hour data created in the previous set of studies, correlate this to plants on response.
    - Create methodology to insure that the plant movement calculated is due to wind/load rather than frequency excursions, etc. in the system.
    - Find accurate method of decomposition for ACE regulation and basepoint adjustment signals.
  - Once this has been tuned for future years, we have a baseline to use when adding improvements to the system.
    - ADI
    - Feedforward AGC, etc.

Methodology

- Scaling in planned wind
  - In beginning, use approximately the same methodology as used before.
  - When possible, use more than one existing plant to scale in new one, for example say plant D is 150 MW, plant A is 200 MW, plant B is 225 MW and plant C is 100 MW with the following time delays and multipliers.
    - 60% of plant A, 20 minutes earlier
    - 20% of plant B, 30 minutes later
    - 20% of plant C, 10 minutes earlier
    - Cont'd next slide

Methodology

Time	Plant A	Plant B	Plant C	Plant D
1:10	0	10	0	9.0
1:20	5	15	0	34.7
1:30	20	30	3	61.5
1:40	75	80	10	81.7
1:50	130	150	13	107.0
2:00	170	180	50	117.4
2:10	200	210	78	130.7
2:20	200	225	100	140.0
2:30	200	225	100	144.0
2:40	200	225	100	148.0
2:50	200	200	100	123.0
3:00	200	150	100	111.0
3:10	140	110	75	150.0

Balancing Requirement Assignment

- Another take on Balancing
- Goal is to calculate the total reserve requirement and allocate to E/GI and balancing by the sources driving the need
- Balancing need plus E/GI is essentially station control error (SCE)
- Total SCE consists of a within hour balancing component and E/GI component
- The within hour component is derived by assuming a perfect energy schedule over an hour
- Departures about the perfect hourly schedule are considered within hour balancing
- Departures about the actual schedule is SCE
- SCE less departures about the perfect schedule is energy/generation imbalance
- Total SCE = Total EI/GI + Balancing

Balancing Requirement Assignment

- Calculate E/GI and Balancing time series for Load, Thermal, Small Hydro, and Wind (for example)
- From these time series, calculate the standard deviations (s), correlation matrix (R), aggregate standard deviation (sp), incremental (sinc) and marginal standard deviations (smarg)
  - $sp = [\mathbf{sRs}^T]^{1/2}$ Note: s is a row vector.
  - $\mathbf{s}inc = \mathbf{Rs}^T / sp$
  - $smarg_x = sinc_x * s_x$; for each variable x.
- These calculations allow for the straight sum of the component balancing requirements such that the sum of the components equal the total balancing requirement at any given probability

Balancing Requirement Assignment

- For example; given the following standard deviation values (s):

	E/GI Load	E/GI Thermal	E/GI Sm Hydro	E/GI Wind	Bal Load	Bal Thermal	Bal Sm Hydro	Bal Wind
s	8.08	35.98	12.90	45.42	59.96	32.64	7.46	12.18

- Correlation matrix (R):

	E/GI Load	E/GI Thermal	E/GI Sm Hydro	E/GI Wind	Bal Load	Bal Thermal	Bal Sm Hydro	Bal Wind
Load	1.000	-0.023	0.010	-0.023	0.000	0.000	0.000	0.000
Thermal	-0.023	1.000	-0.017	0.081	0.000	0.000	0.000	0.000
Sm Hydro	0.010	-0.017	1.000	-0.058	0.000	0.000	0.000	0.000
Wind	-0.023	0.081	-0.058	1.000	0.000	0.000	0.000	0.000
Load	0.000	0.000	0.000	0.000	1.000	-0.087	0.014	-0.036
Thermal	0.000	0.000	0.000	0.000	-0.087	1.000	-0.024	0.016
Sm Hydro	0.000	0.000	0.000	0.000	0.014	-0.024	1.000	-0.010
Wind	0.000	0.000	0.000	0.000	-0.036	0.016	-0.010	1.000

- Calculate the aggregate standard deviation (sp = sp = $[sRsT]^{1/2}$)

sp 90.70

Balancing Requirement Assignment

- Calculating the incremental and marginal standard deviations:

	E/GI Load	E/GI Thermal	E/GI Sm Hydro	E/GI Wind	Bal Load	Bal Thermal	Bal Sm Hydro	Bal Wind
sinc	0.070	0.433	0.108	0.523	0.626	0.303	0.082	0.115
smarg	0.56	15.58	1.39	23.74	37.54	9.87	0.61	1.40

  - Notice that smarg sums to the aggregate standard deviation value (90.70).

- Now, from the empirical distribution of total E/GI and balancing, a total requirement at p9975 and p0025 are calculated. In this case the values are 367.91 and 271.72.

- Given the sp of 90.70 and the above reserve requirements, it is seen that the requirements are at 4.06 and -2.99 standard deviations.

Balancing Requirement Assignment

- Applying the standard deviation values of 4.06 and -2.99 to the marginal standard deviations, the component contribution of each variable to the total reserve requirement is calculated:

	E/GI Load	E/GI Thermal	E/GI Sm Hydro	E/GI Wind	Bal Load	Bal Thermal	Bal Sm Hydro	Bal Wind	Total
p9975	2.3	63.2	5.6	96.3	152.3	40.1	2.5	5.7	367.9
p0025	-1.7	-46.7	-4.2	-71.1	-112.5	-29.6	-1.8	-4.2	-271.7

- These values can be further aggregated into EI/GI and balancing:

E/GI	p9975	167.4
E/GI	p0025	-123.6
Bal	p9975	200.5
Bal	p0025	-148.1
Tot	p9975	367.9
Tot	p0025	-271.7

Balancing Requirement Assignment

- Note that this is calculation was made using a limited data set and is not necessarily representative of values that would be produced from a comprehensive analysis
- The data were not filtered for contingency reserve deployments
- Further refinement of the analysis will allocate by hour of day
- These calculations are put forth as a test of concept only

Methodology

- Calculated and stored existing wind and load one minute averages from 10/1/2006 to 5/1/2008.
- Derived wind and load “perfect” schedules from hourly averages and a full 20-minute ramp for the same time period.
- Calculated the one-minute deltas for each of:
  - Load minus Load schedule
  - Wind minus Wind schedule
  - (Load minus Wind) minus (Load schedule minus Wind schedule).
- Determined a “total” reserve requirement as the maximum “inc” delta and maximum “dec” delta for each 10 minute clock period for each of the three calculations (see charts).
- Determined the “following” component as the average “inc” delta and average “dec” delta for each 10 minute clock period.
- Determined the “regulation” component as the delta between the total reserve requirement and the following component.

Methodology

- Calculated (assigned) the Following and Regulation components of the combined reserves (Load minus Wind) by the proportional components calculated for Load and Wind separately.
- Calculated the 99.5 percentile of each component for the month (10 minute periods for a month is ~ 4,320 values per month or 20 to 22 eliminated for 99.5 percentile).
- Calculated for each month of the time frame identified (see resulting table).

Q & A

Open for customer questions and comments

Customer Workshop

Wind Integration Team (WIT) - Wind Pilot Project

June 9, 2008

Feed-Forward AGC Project Update

- 3-Tier effort underway to develop forecasting model (more on next slide).
- 5 minute x 12 within-hour wind forecasts required for FF-AGC input.
- BPA will be executing contract this summer to revise AGC software to:
  - Reinstate Feed Forward algorithm and load model module.
  - Add wind forecast module (will require testing and validation).
  - Provide mechanism to initiate Wind Ramp Limits control.
  - Provide mid-hour baseline generation adjustment to lower Balancing requirements and costs. (Input to GDAC system for Federal Hydro)
- FF-AGC is expected to lower costs for Wind Balancing service, but online target is within the FY2010-11 rate period. (Transmission rate design will need to be flexible)

Wind AGC Pilot Project

The R&D project proposal with 3-Tier has been modified to study only 1 wind farm (was 4 wind farms). The R&D effort will:

1. Obtain 2 years data (MW, MVAr, wind speed and direction) from pilot wind farm wind farm (under way 3-Tier has data).
2. 3-Tier developing a model forecast system (due this FY) using 1st year data and then validate using 2nd year data.
3. Next step: Need to connect wind farm for actual data to 3-Tier:
    a. Schedule target is 9/1/2008.
    b. Wind farm needs to provide aggregated data (see next slide).
4. BPA anticipates late FY 2009 to expand Pilot project to a multi-wind farm forecasting system.
5. Pilot project includes periodic review with wind farm operators as the project progresses.
6. BPA will begin Feed Forward AGC system software upgrade this summer.

Wind Farm Data Requirements

- Each wind farm will combine data into strings* in the wind farm (4 - 7 WTG's per string), to reduce data computing requirement and limit data transfer requirements.
- Required Data:
  - MW output and Wind speed average values for each 30 seconds.
  - Wind direction and units online in string, snapshot every 30 seconds.
  - Provide data every 30 seconds to 3-Tier using Internet FTP format (SSH secure).
- 3-Tier to provide forecast schedules for each wind farm to BPA 12 x 5 minutes. (need confidentiality agreement with WF's)
- Only aggregated data will be available to other Operators.

* String is defined as WTG's in same geographical location within wind farm

Wind Ramps – Ramp Limits

- Wind Ramps are ***large unscheduled*** changes in the output of a wind farm that impact Regulation reserves (increase the required amount of regulating reserves).
- BPA BA has 1,425 MW wind generation connected now, expects to be ~2200 MW by 12/08.
- BPA has experienced several large wind ramps, some that neared Regulation reserve limits.
- BPA will move forward with some form of Ramp limit controls this year - via Phone-up from BPA Dispatch. (Need discussion on implementation)
- BPA has SCADA at wind farms. Near term goal will be to implement signal to WF via SCADA – probably Fall 2009.
- Fully automated option using AGC controller output to wind farm control/ramp limiter is target future preferred option.

Q & A

Open for customer questions and comments.