



B O N N E V I L L E P O W E R A D M I N I S T R A T I O N

# Large Wind Integration Challenges and Solutions for Operations/System Reliability

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Photo courtesy of PPM Energy

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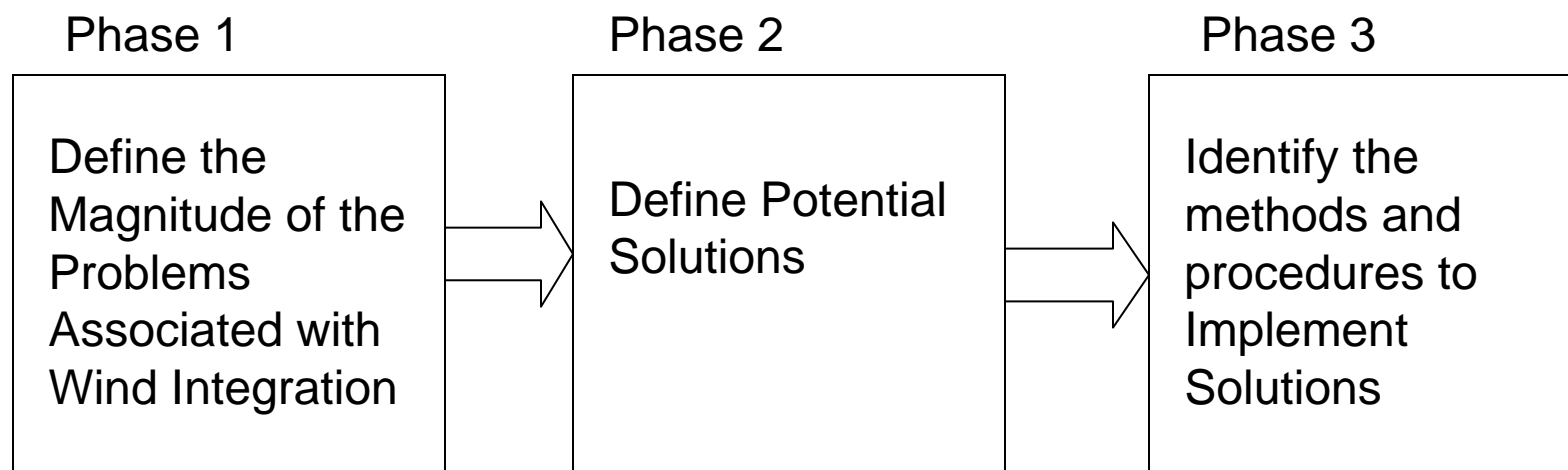


# Introduction

- Cross-Agency Wind Integration Team
- Study of wind integration through 2013
  - Scaling in planned projects
  - Forecasting issues
  - Reserve Capacity Needs
- Proposed Solutions



## Wind Integration Team – High Level Work Stream



# Reserves Forecasting Methodology

- Scaling of wind
- Estimating future wind forecasts
- Methodology for reserves forecasting
  - Base methodology
  - Time series of studies
  - Wind and Load contribution to total capacity requirement
- Results



## Reserves Forecasting Methodology Scaling in Planned Wind

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



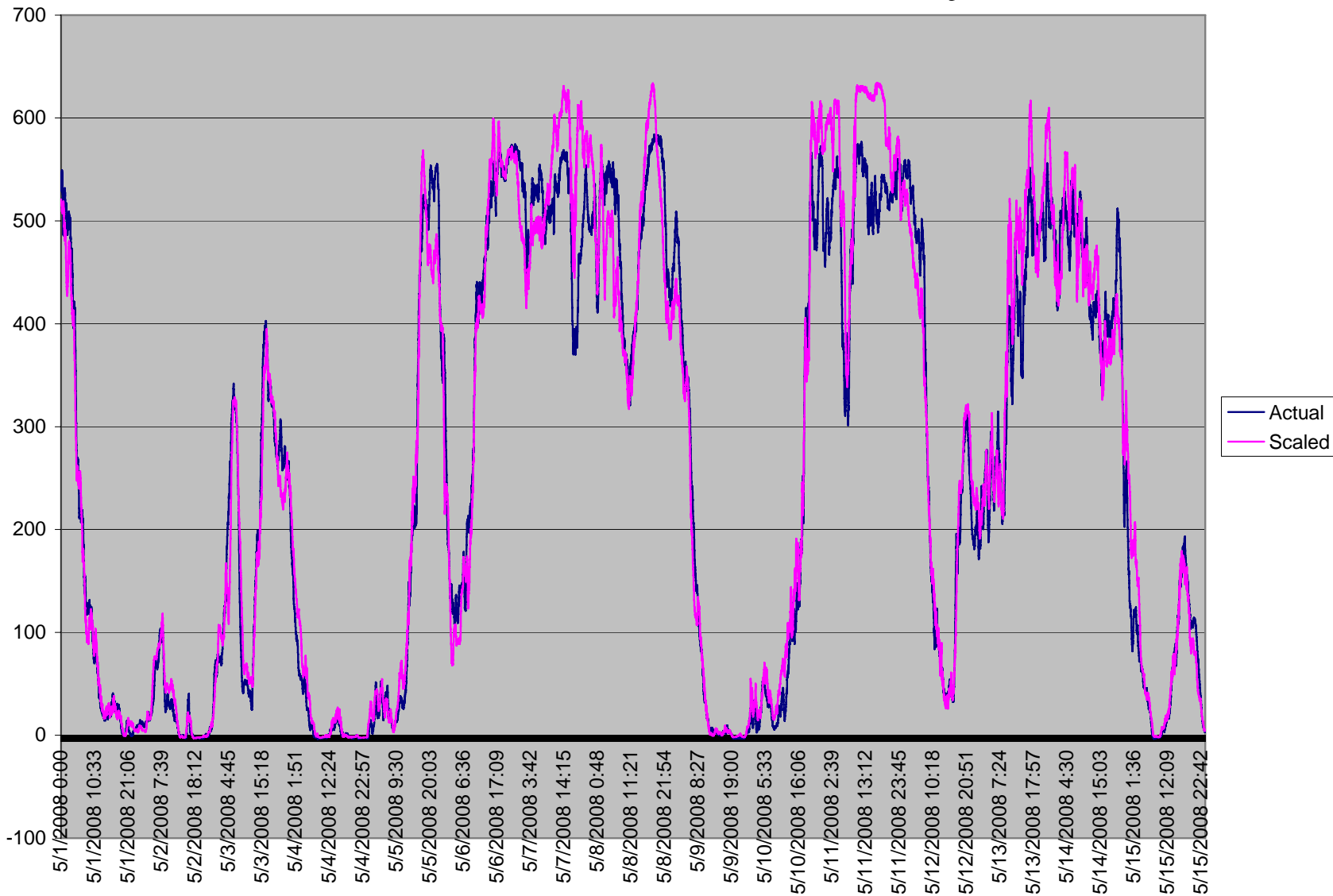
## Reserves Forecasting Methodology Scaling in Planned Wind

- 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

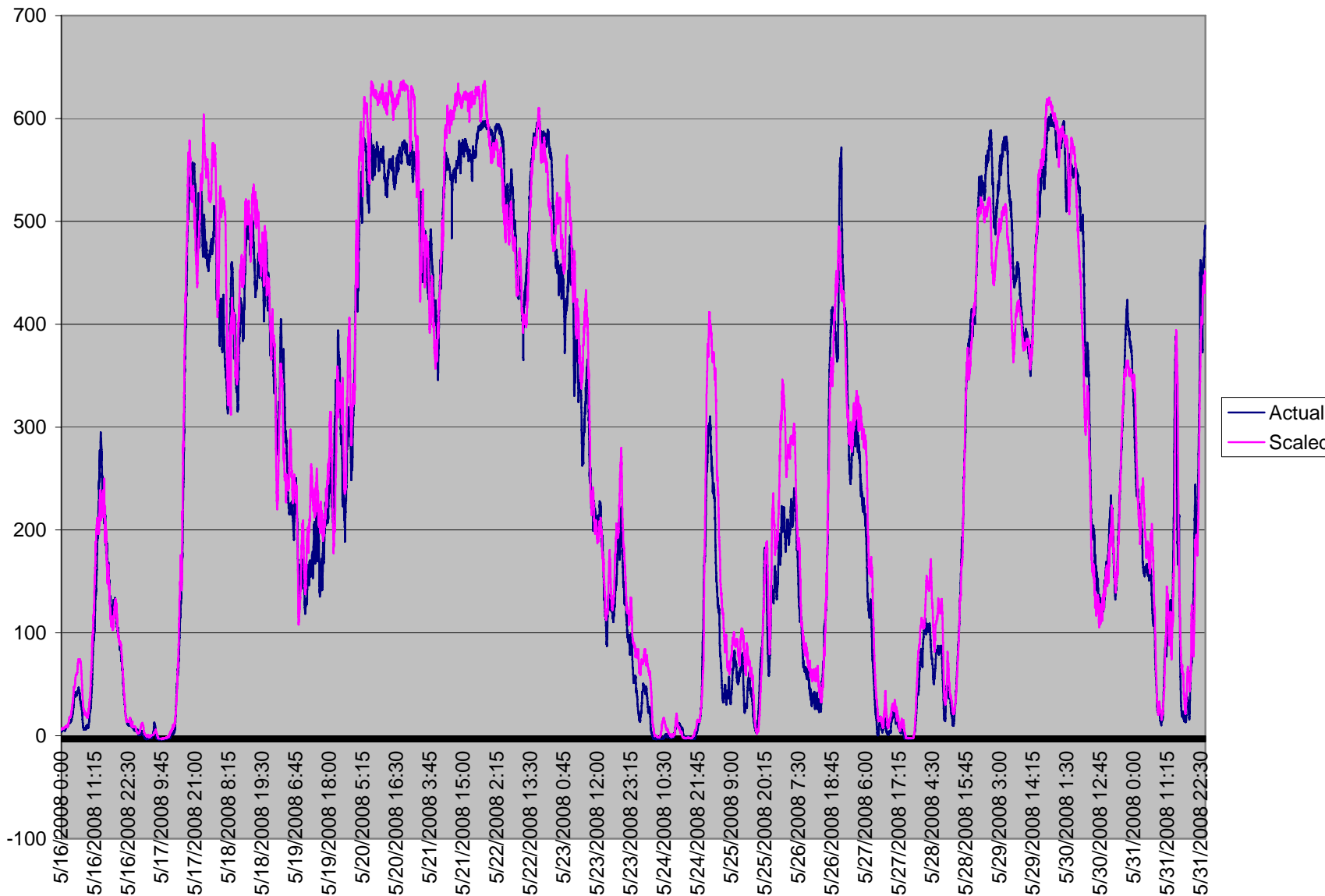


# Actual versus scaled values, May 1-15 2008



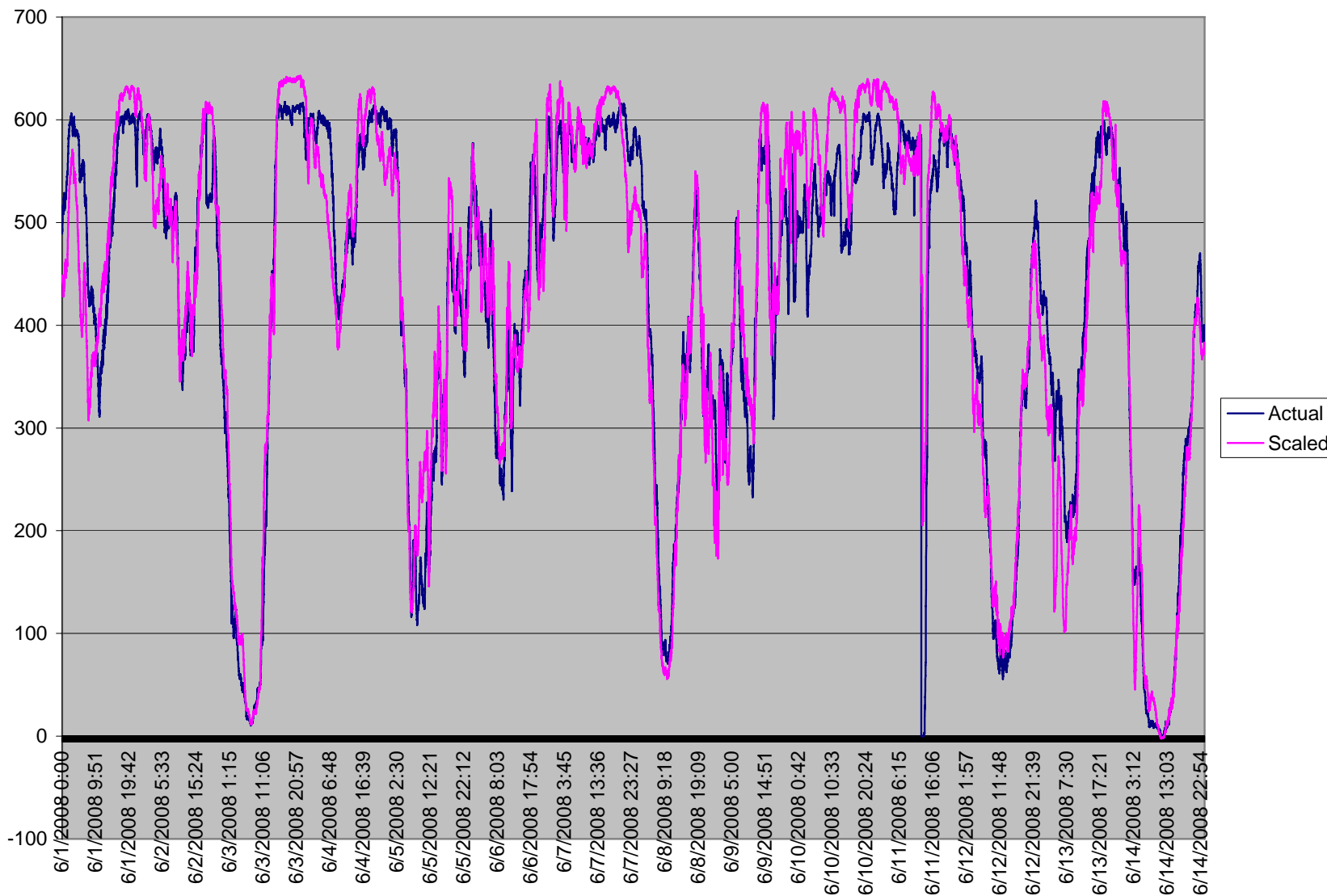


## Actual versus scaled values, May 16-31 2008



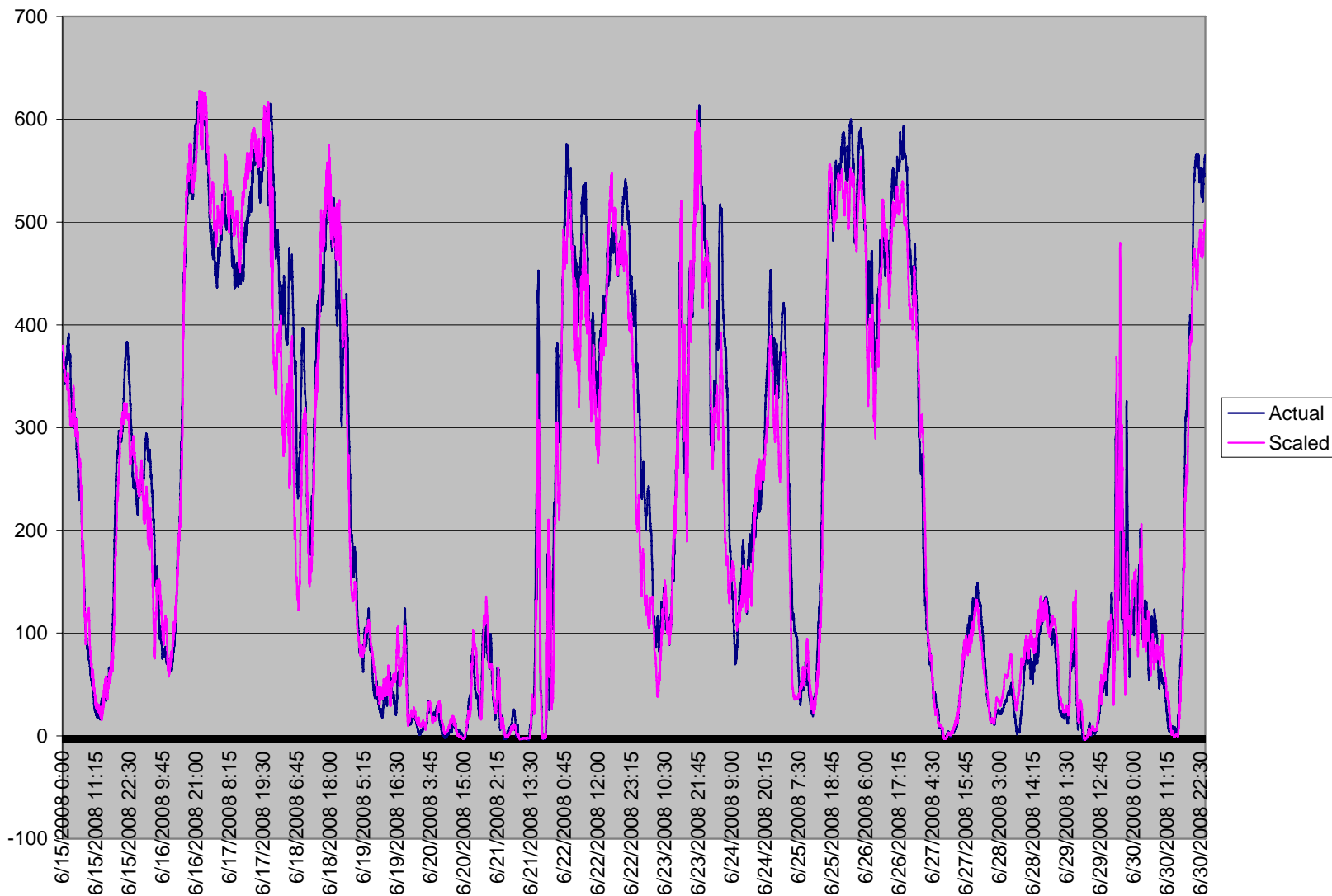


## Actual versus scaled values, June 1-14, 2008





## Actual versus scaled values, June 15-30, 2008





## **Reserves Forecasting Methodology**

### Estimating Future Wind Forecasts

- 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**

- Eleven of 14 projects 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

## Base Methodology

- 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

- 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

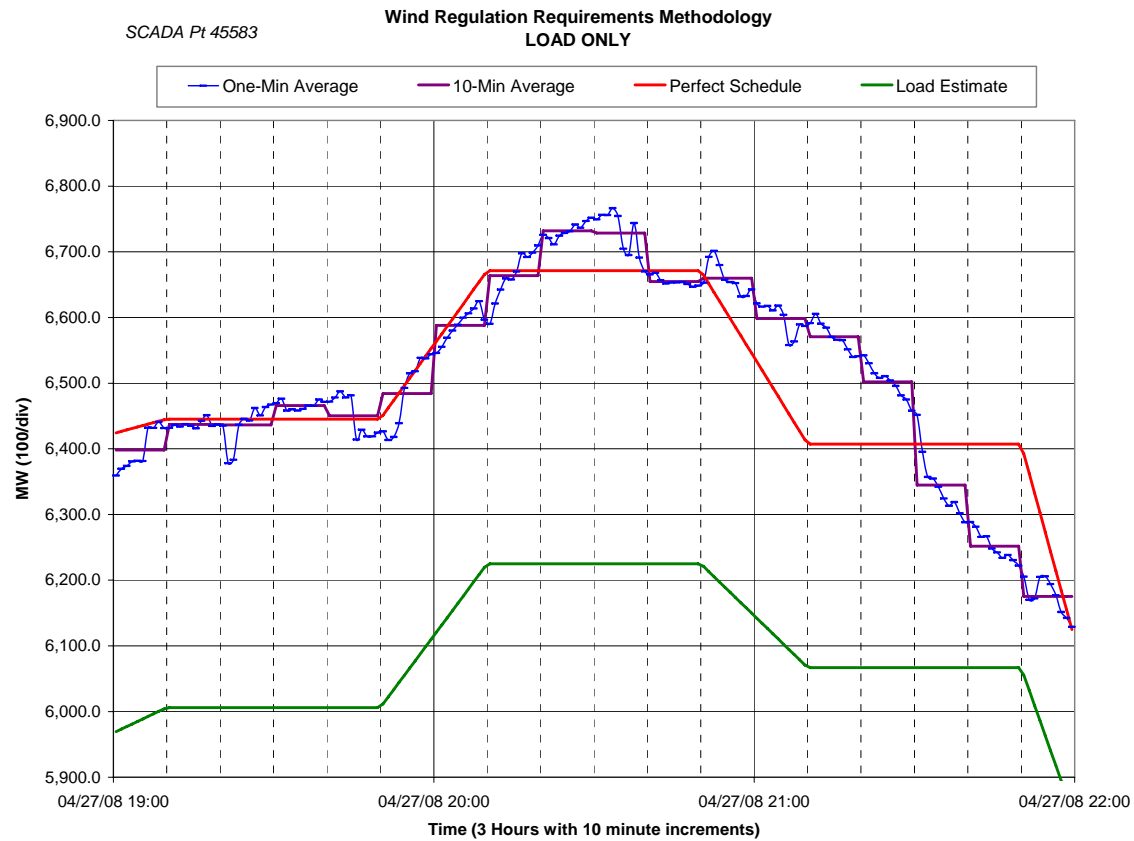
### Base Methodology

- 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 2009) BPA has used three standard deviations for capacity requirements, this equates to 99.7% of all values.



# Reserves Forecasting Methodology

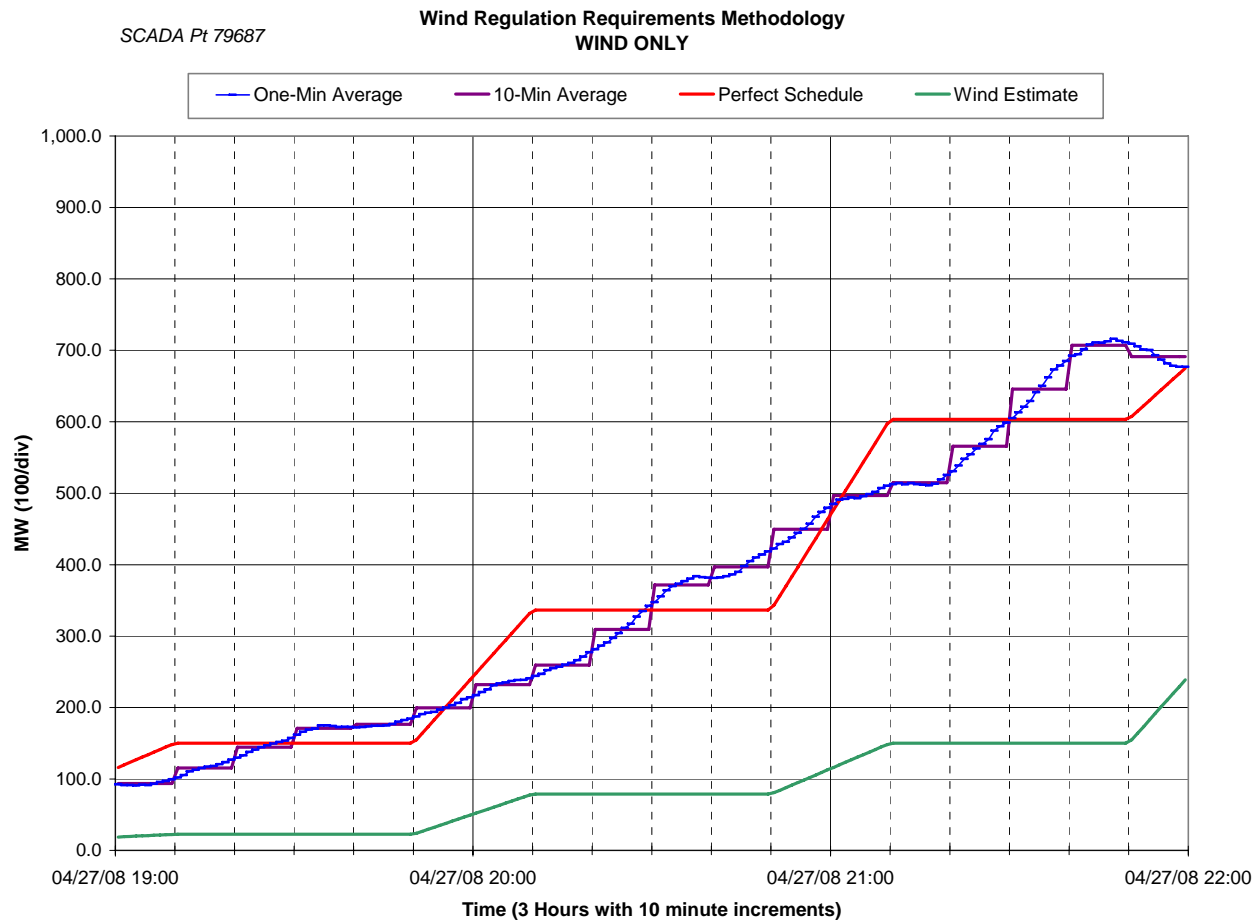
## Graphical depiction of base methodology





# Reserves Forecasting Methodology

## Graphical depiction of base methodology

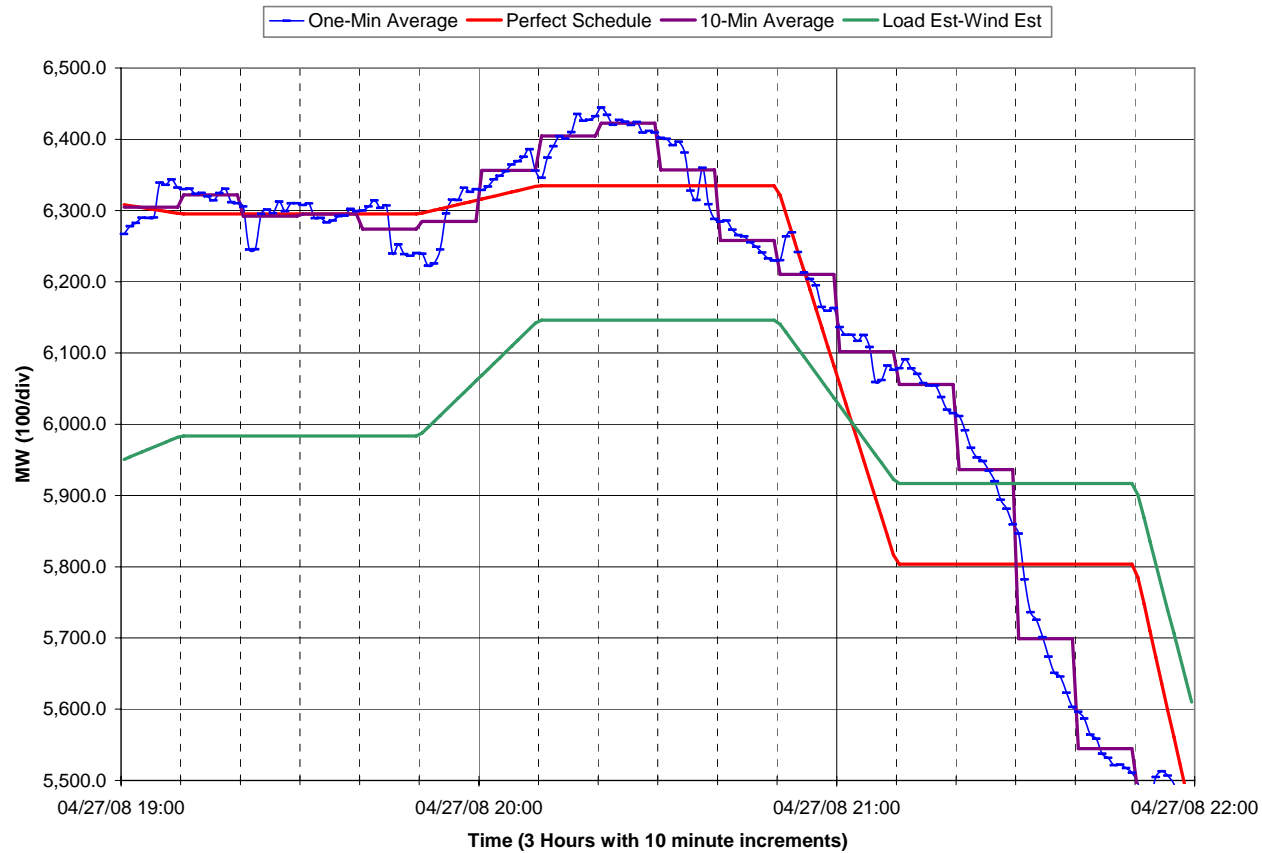




# Reserves Forecasting Methodology

## Graphical depiction of base methodology

Wind Regulation Requirements Methodology  
LOAD plus NEGATIVE WIND





## Reserves Forecasting Preliminary Results

### Load Net Wind Requirements

FY	Wind(MW)	Regulation		Following (PS)		Following (ES)		Following (D)	
		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

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

Wind Requirements, based on proportional max values

FY	Wind(MW)	Regulation		Following (PS)		Following (ES)		Following (D)	
		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

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

Load Requirements, based on proportional max values

FY	Wind(MW)	Regulation		Following (PS)		Following (ES)		Following (D)	
		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

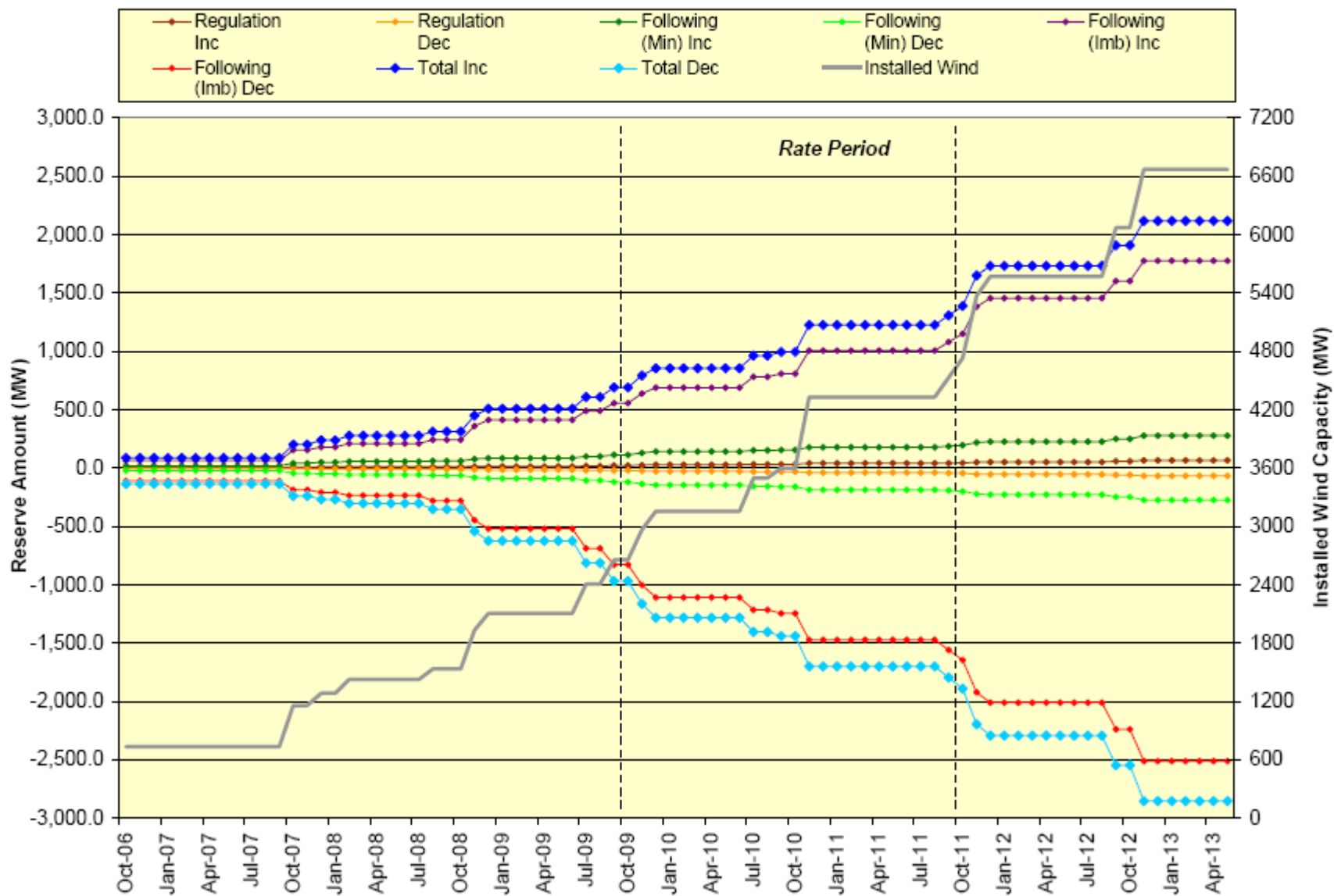
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## 2010 Rate Case Wind Reserve Requirement (using statistical allocation method)





## Solving the Reserve Issues

- Three primary efforts regionally
  - Improve Forecasting
  - Modify scheduling requirements
  - Self-supply, 3<sup>rd</sup> party supply or external supply of reserve
- Internal efforts
  - ADI
  - Modify Automatic Generation Control Algorithm to a look-ahead system

## Solving the issues – Forecasting improvements

- Creating a benchmark of 30 minute persistence
- Table shows amount of savings

Wind Reserves Requirement (MW) - Statistical Allocation							30-min persistence	
Wind Level (MW)	Regulation Inc	Regulation Dec	Following (Min) Inc	Following (Min) Dec	Following (lmb) Inc	Following (lmb) Dec	Following (lmb) Inc	Following (lmb) Dec
1425	10.4	-10.5	64.4	-64.1	322.3	-302.2	138.3	-137.7
2105	14.4	-15.0	100.3	-105.3	579.4	-648.2	246.4	-272.0
3155	30.3	-29.7	183.3	-187.2	913.2	-1,284.7	435.4	-472.0
4330	47.0	-45.1	233.1	-245.0	1,244.8	-1,689.9	609.0	-697.5
5570	62.0	-64.2	307.4	-298.0	1,684.2	-2,225.2	735.5	-871.3



## Solving the issues – Scheduling Changes

- Currently have hourly schedules
- Capability of Dynamic Schedules, severe limitations in WECC
- 10 minute schedule changes would solve ~80% of the issues BPA is anticipating



## Solving the issues – Other Suppliers

- Self-supply of reserve for large wind operators would offload half of the requirements
- 3<sup>rd</sup> party supply has potential to offload more
- Request for information recently published

## Solving the Issues – Internal Measures

- ACE Diversity Interchange
  - Enables multiple Balancing Authorities to share diversity in an Interconnection
  - Minimal impact to other Balancing Authorities
- Feed Forward AGC
  - Looks ahead to what is coming for control rather than correcting error
  - Lots of short-term forecasting needed for this effort, both wind and load.



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# Questions?

