

# Wind Forecasting for Renewable Integration Tools



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**Ron Tarkowski** – Applications Developer



- IPC Wind Generation
- Wind Forecasting Project
  - Forecast Displays
  - Model Implementation
  - Forecast Analysis
  - Tools
  - Challenges

# Idaho Power

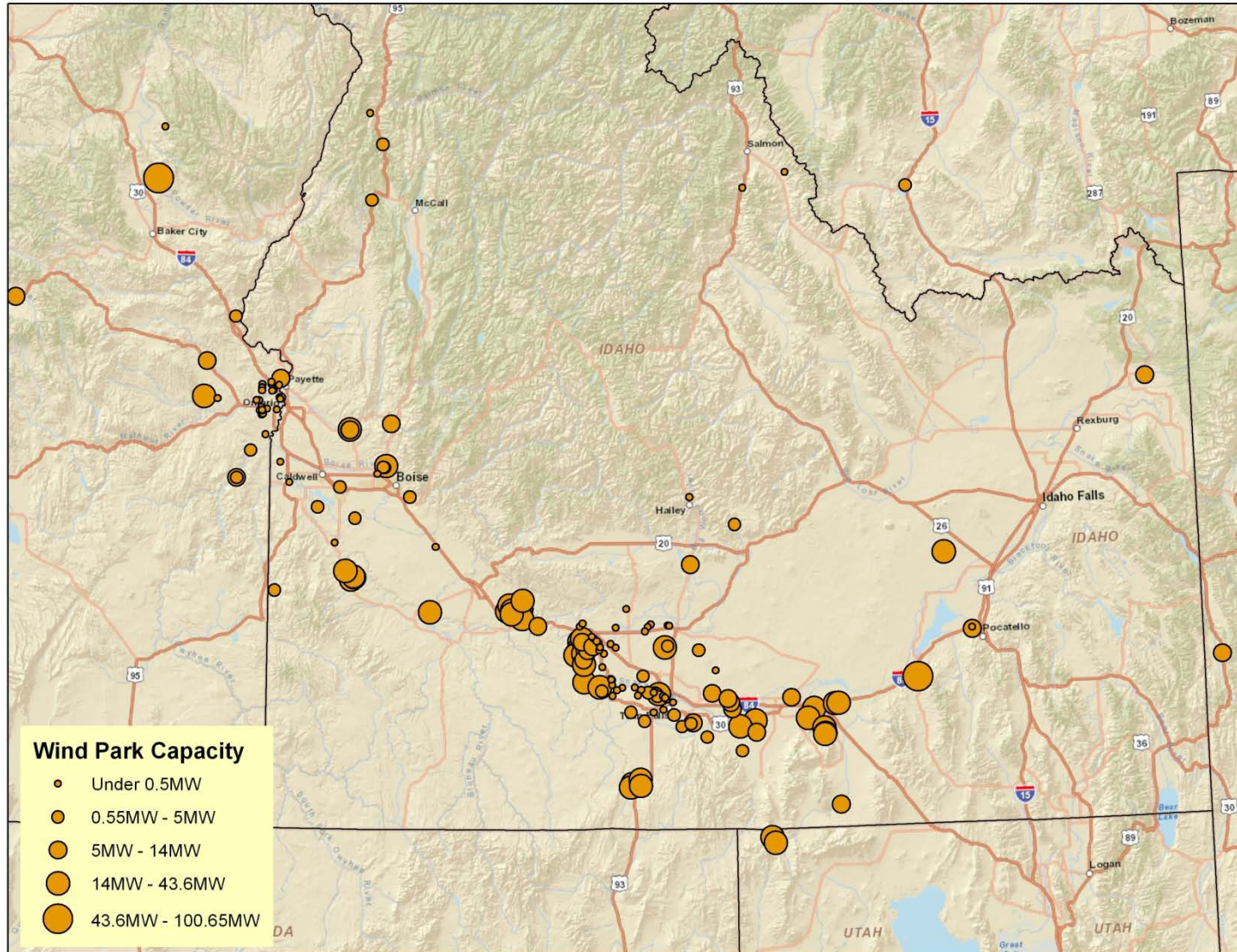
An Investor Owned, Regulated Electric Utility

- Service Area
  - Southern Idaho
  - Eastern Oregon
  - 24,000 sq. mi
- Population
  - 1 Million
- Total Sales
  - 15,500,000 MW / year
- Employees
  - 2,000
- Fully Integrated Utility
  - Generate Power
  - Interstate Transmission
  - Distribute to Customers
- Regulated by
  - FERC
    - USFS
    - IDEQ
    - ODEQ
    - NOAA ...
  - Idaho PUC
  - Oregon PUC

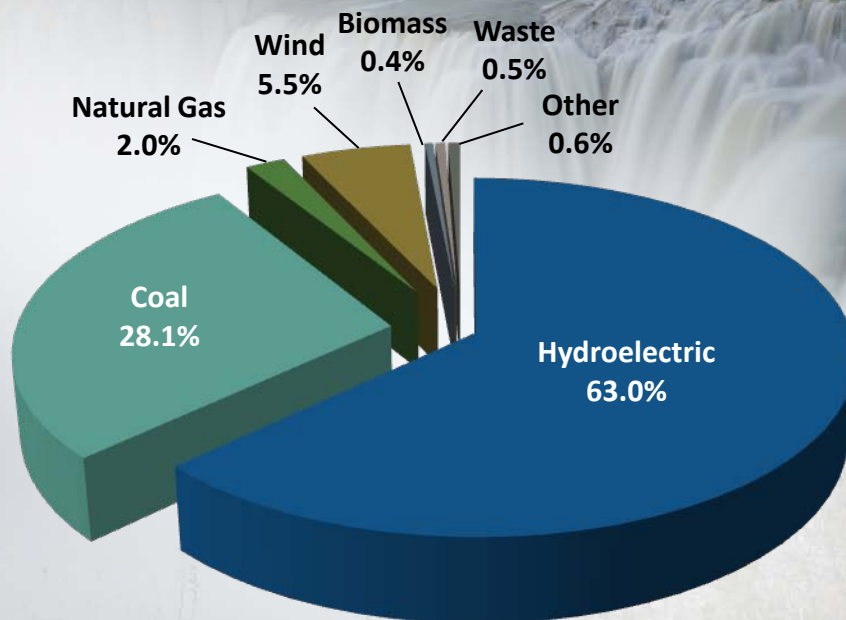


# Wind Generation Map

## Existing and Proposed Sites



# 2011 Fuel Mix





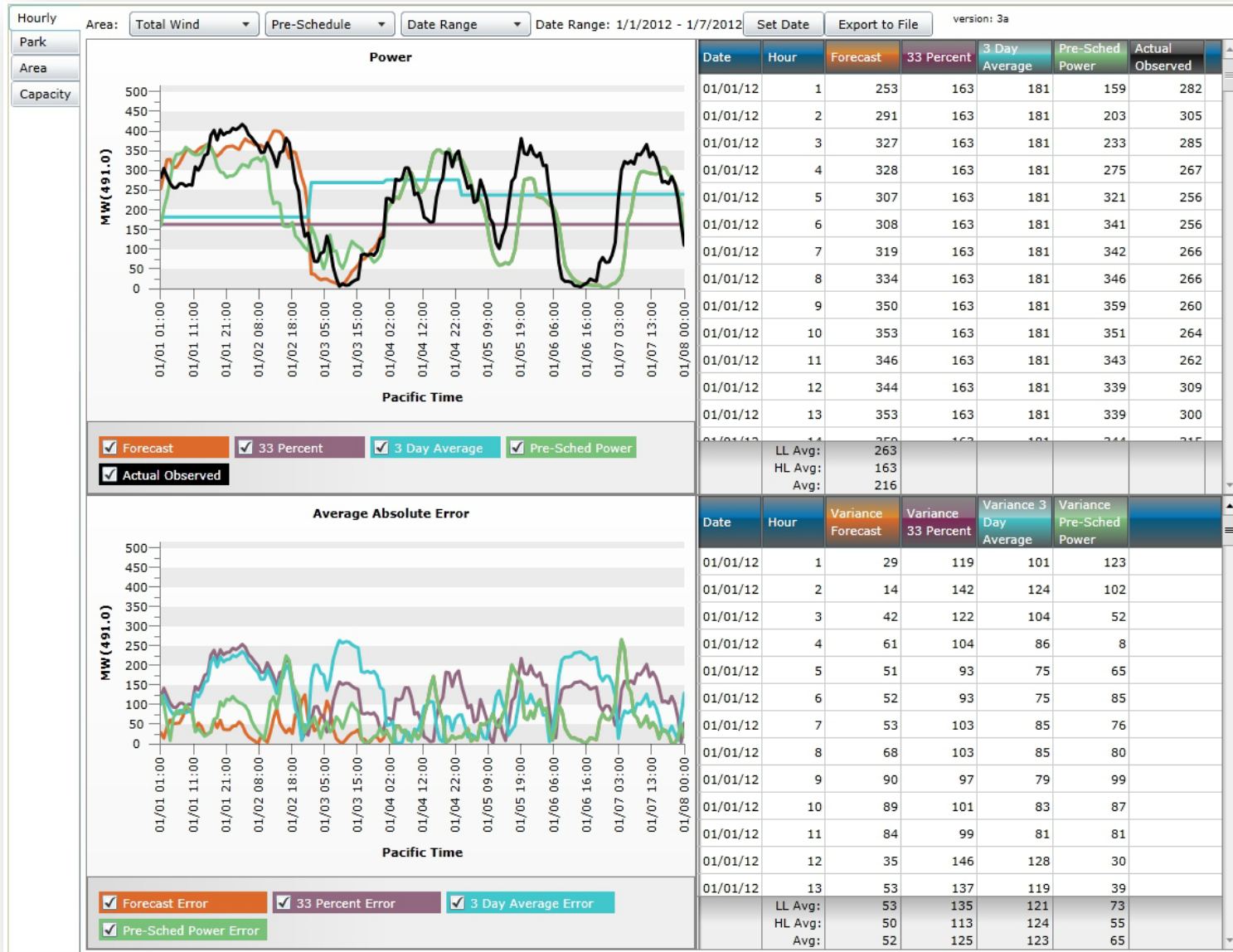
# Wind Generation Capacity 2004-2013



# Project Overview

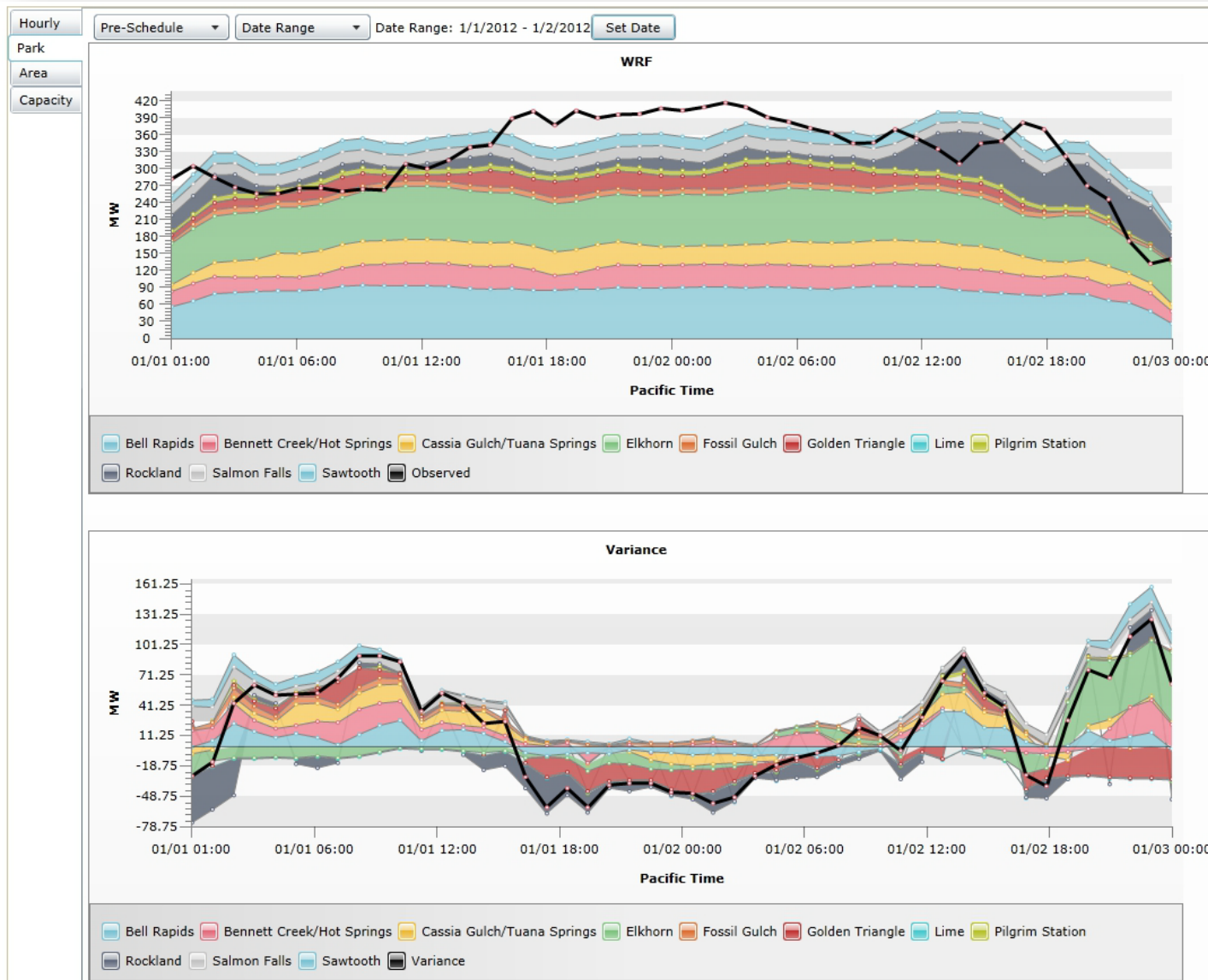
- Develop an Internal Wind MW Forecast Tool
- Enhance the Load Forecast
- Develop Situational Awareness Display
  
- Outputs
  - Day Ahead Forecast
  - Hourly / Real Time Forecast
  - Rolling 30/60 minute Forecast
  
- End Users
  - Power Supply Operations Transaction Specialists
  - Generation & Transmission Dispatchers

# Day Ahead Forecast

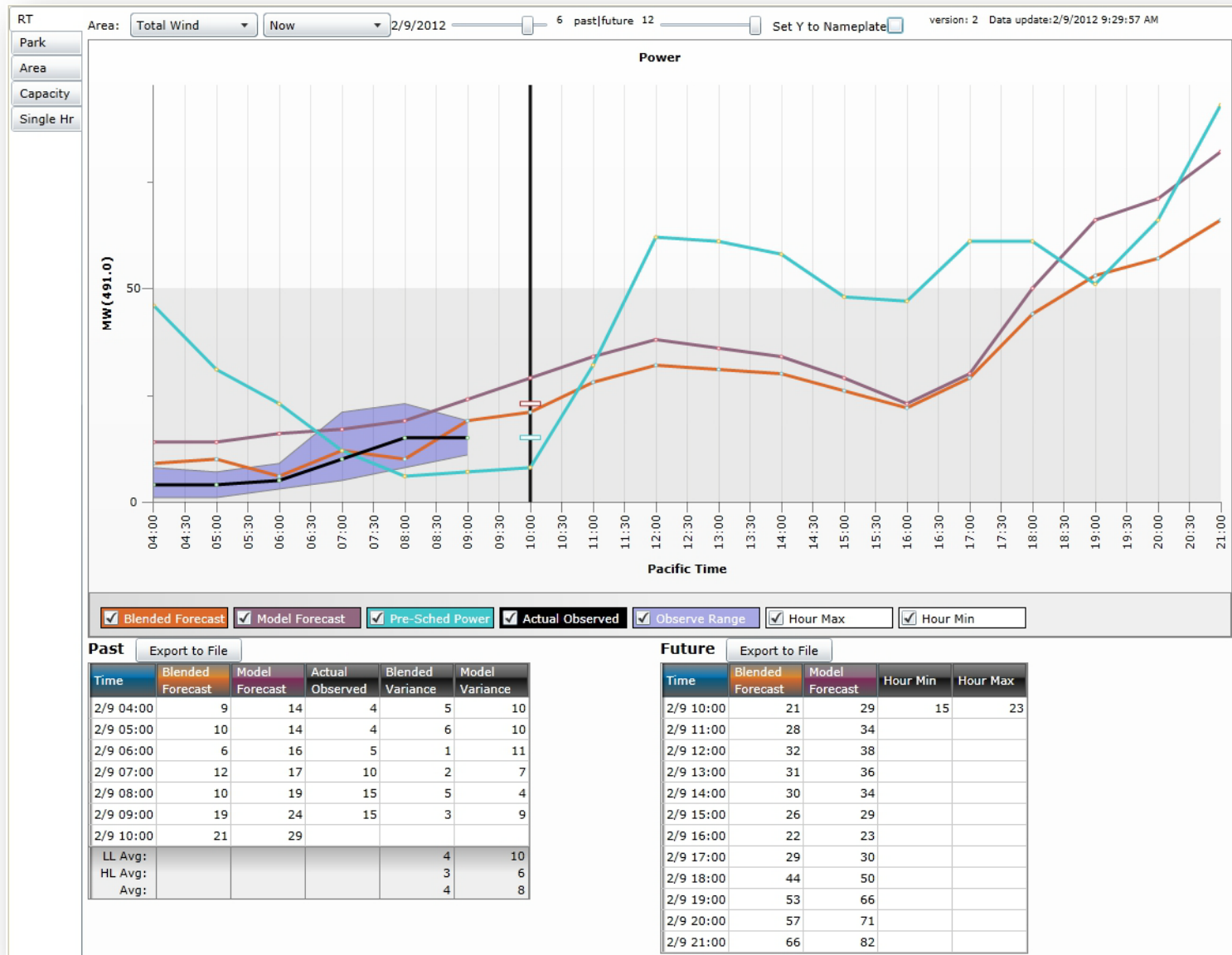




# Day Ahead Forecast

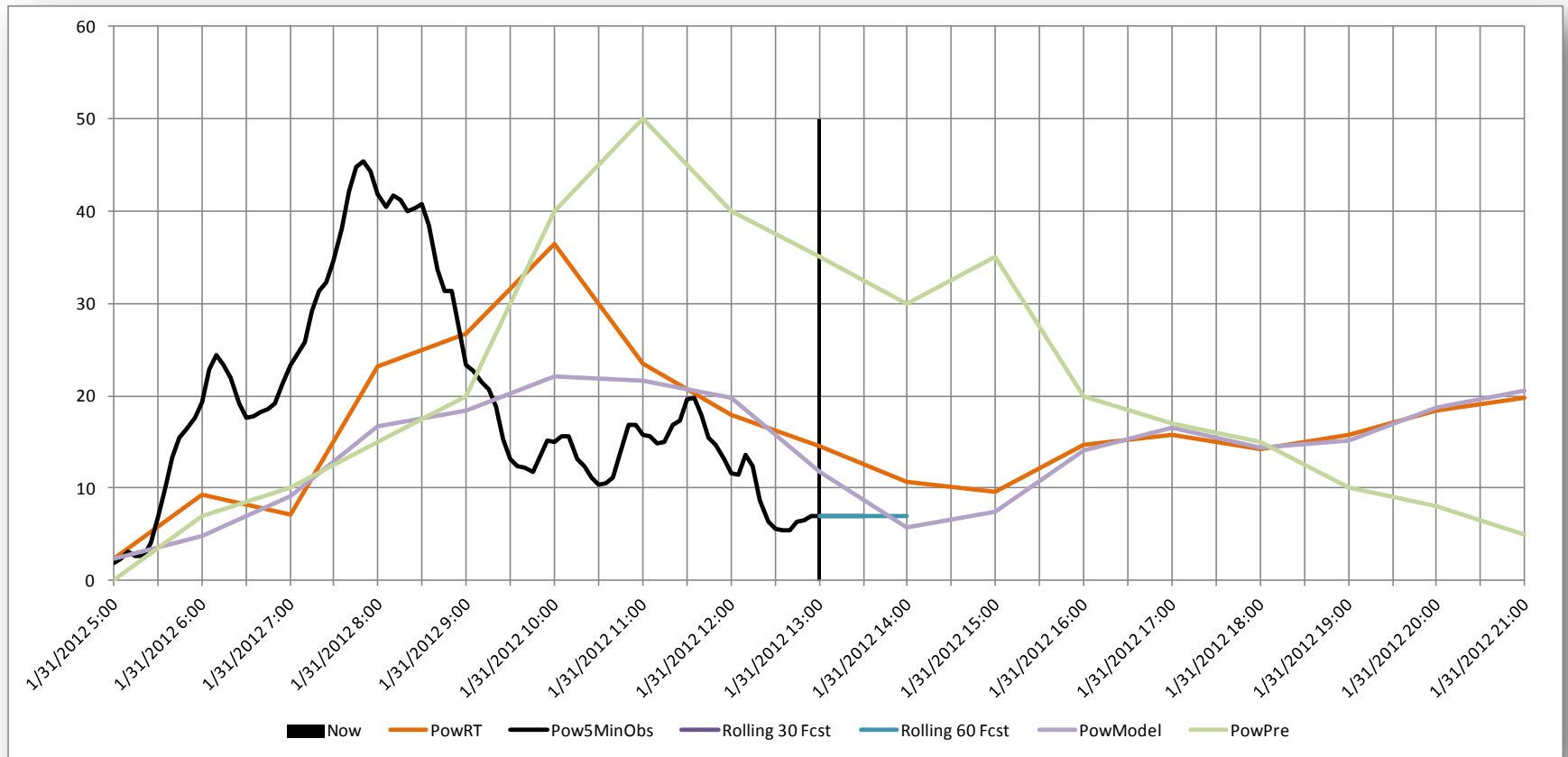


# Hourly / Real Time Forecast



# Rolling 30/60 Minute Forecast

## Proposed Display



# Day Ahead Forecast Accuracy

4/1/2011 – 2/8/2012	Wind Forecast	33 % Rule	3 Day Avg	Actual Pre Schedule
Avg Abs Error (MW / hr)	<b>51.5</b>	82.9	83.3	67.1
(% Nameplate)	<b>12.1%</b>	20.1%	20.2%	18%
Number of Errors > 20% Nameplate (~75 MW)	<b>1463</b>	3705	3249	*
(% Total Hours)	<b>19.6%</b>	49.7%	43.5%	45%
Number of Errors > 35% Nameplate (~130 MW)	<b>423</b>	655	1285	*
(% Total Hours)	<b>5.7%</b>	8.8%	17.2%	18%
Number of Errors > 50% Nameplate (~ 185 MW)	<b>110</b>	145	252	*
(% Total Hours)	<b>1.5%</b>	1.9%	3.4%	6%

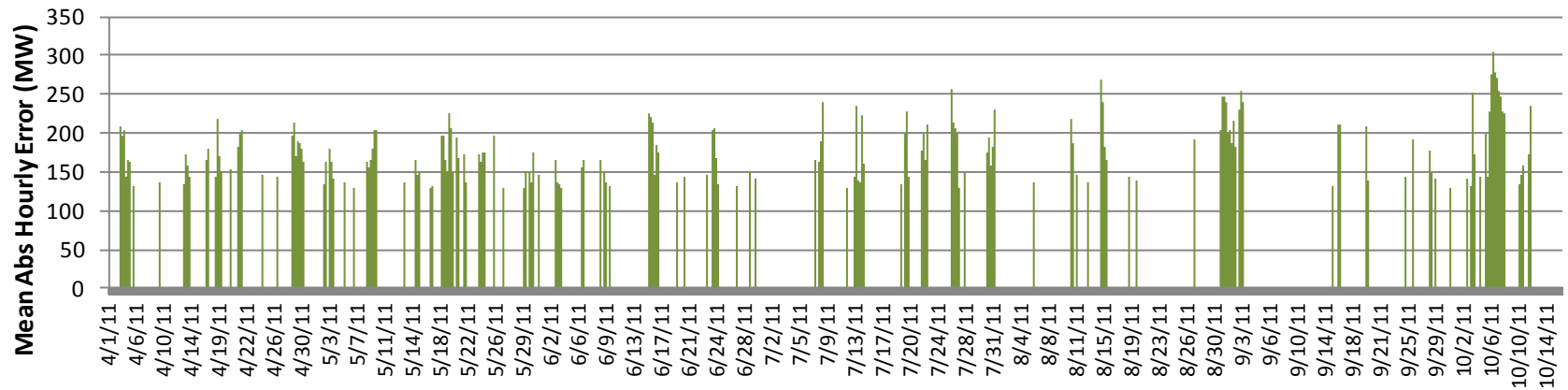
\* Counts not comparable due to variable time frame.



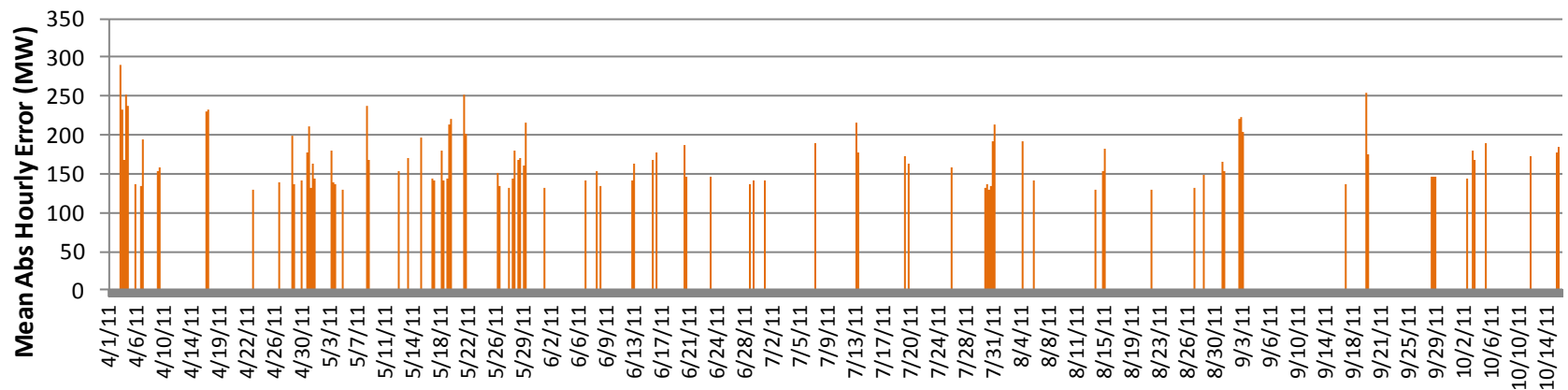
# Day Ahead Forecast Accuracy

Events with hourly error greater than 35% of Nameplate

## Orig Fcst (655 Events)



## New Fcst (239 Events)



# Hourly / Real Time Forecast Accuracy

4/1/2011 – 2/8/2012

	Wind Forecast
Avg Abs Error (MW / hr)	<b>23.1</b>
(% Nameplate)	<b>5.7%</b>
Number of Errors > 20% Nameplate (~75 MW)	<b>221</b>
(% Total Hours)	<b>2.9%</b>
Number of Errors > 35% Nameplate (~130 MW)	<b>34</b>
(% Total Hours)	<b>0.5%</b>
Number of Errors > 50% Nameplate (~ 185 MW)	<b>19</b>
(% Total Hours)	<b>0.3%</b>

45 to 105 minute outlook.

# Primary Weather Models

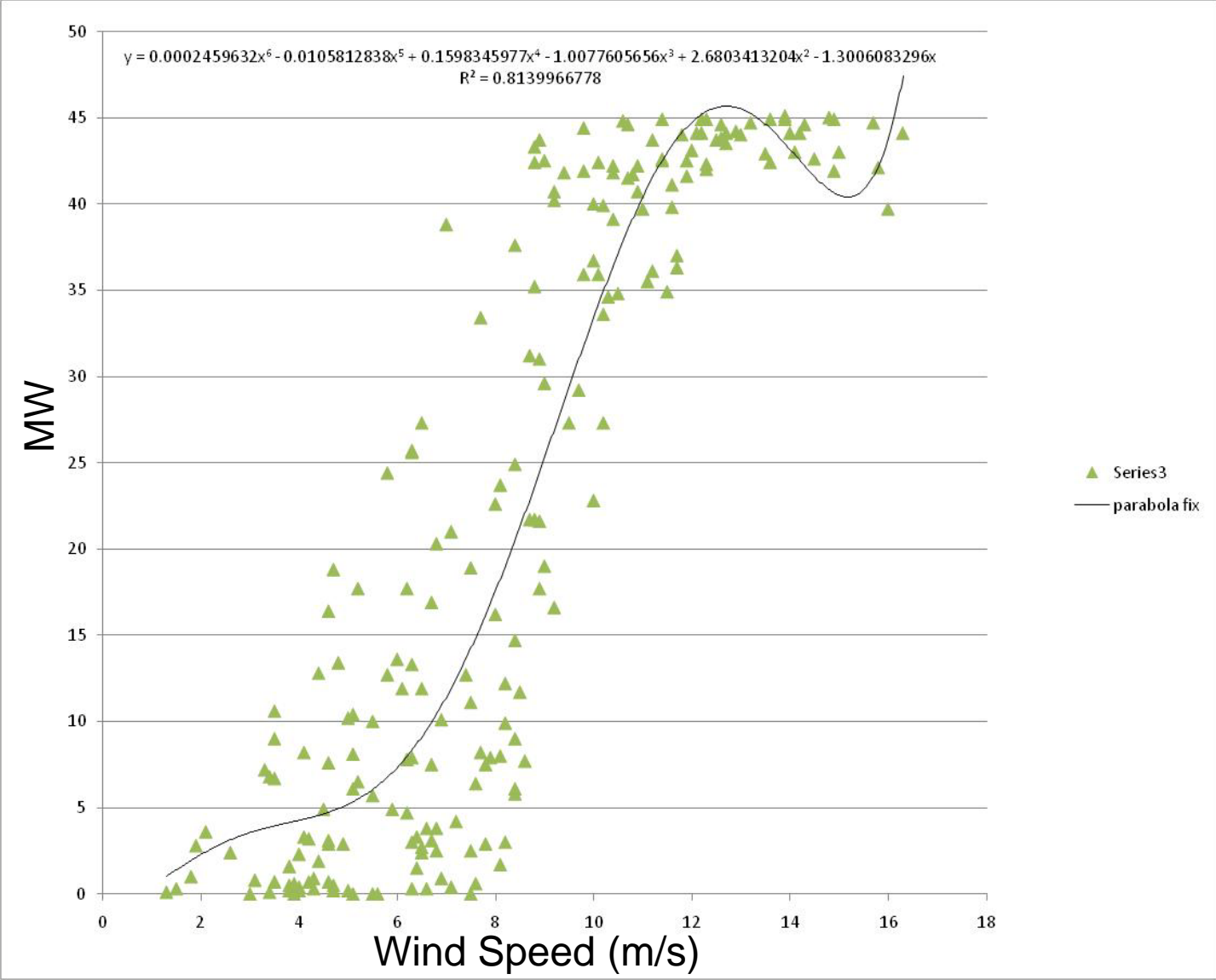
- University of Arizona provides Weather Research and Forecasting (WRF) Data
  - Trained to intermountain west dry climates.
  - Beowolf Cluster “Super Computer” 352 processors
  - NAM - 1.8km and 5.4km Hourly Forecast out 72 hrs.
    - 4 daily model run
  - GFS - 1.8km and 5.4km Hourly Forecast out 180 hrs.
    - 1 daily model run (to cover weekend load balancing)

# Power Model

- Power Curve Development
  - Derived from correlation between weather model wind speeds vs. observed power data
  - Skipped comparison of model wind speeds to observed wind speeds
  - Did not use turbine manufacturer's power curves
  - Regression analysis (10m & 80m speeds, Hr 1 & Hr2, Models)
- Theories tried
  - Different regression coefficients for Day/Night
  - Averaging 10m & 80m winds
  - Different coefficients depending on wind direction
    - Wind Rose Chart
  - Averaging forecasts for multiple geographic points
- Forecast Sets (Areas) Determined by:
  - Grid connection points & metered power availability
  - Geographic locations

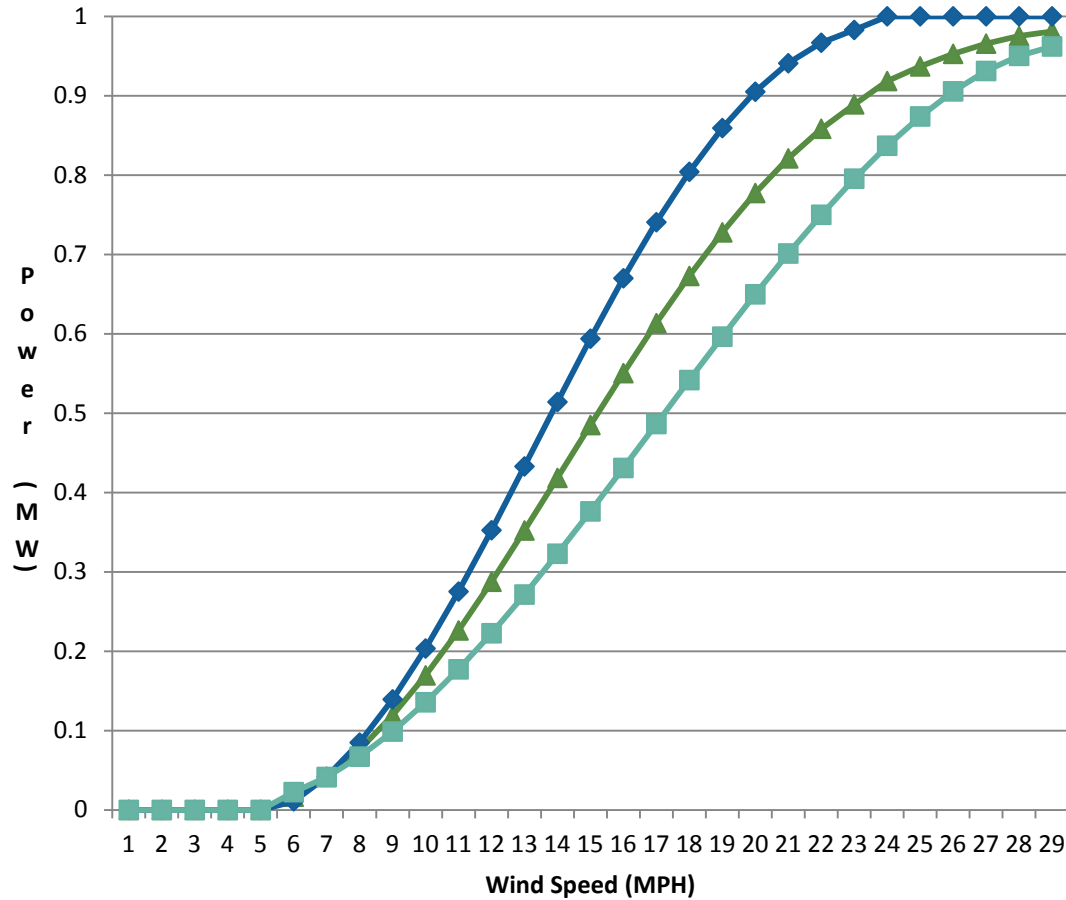


# Power vs. Model Wind Speed



# Sample Power Curves

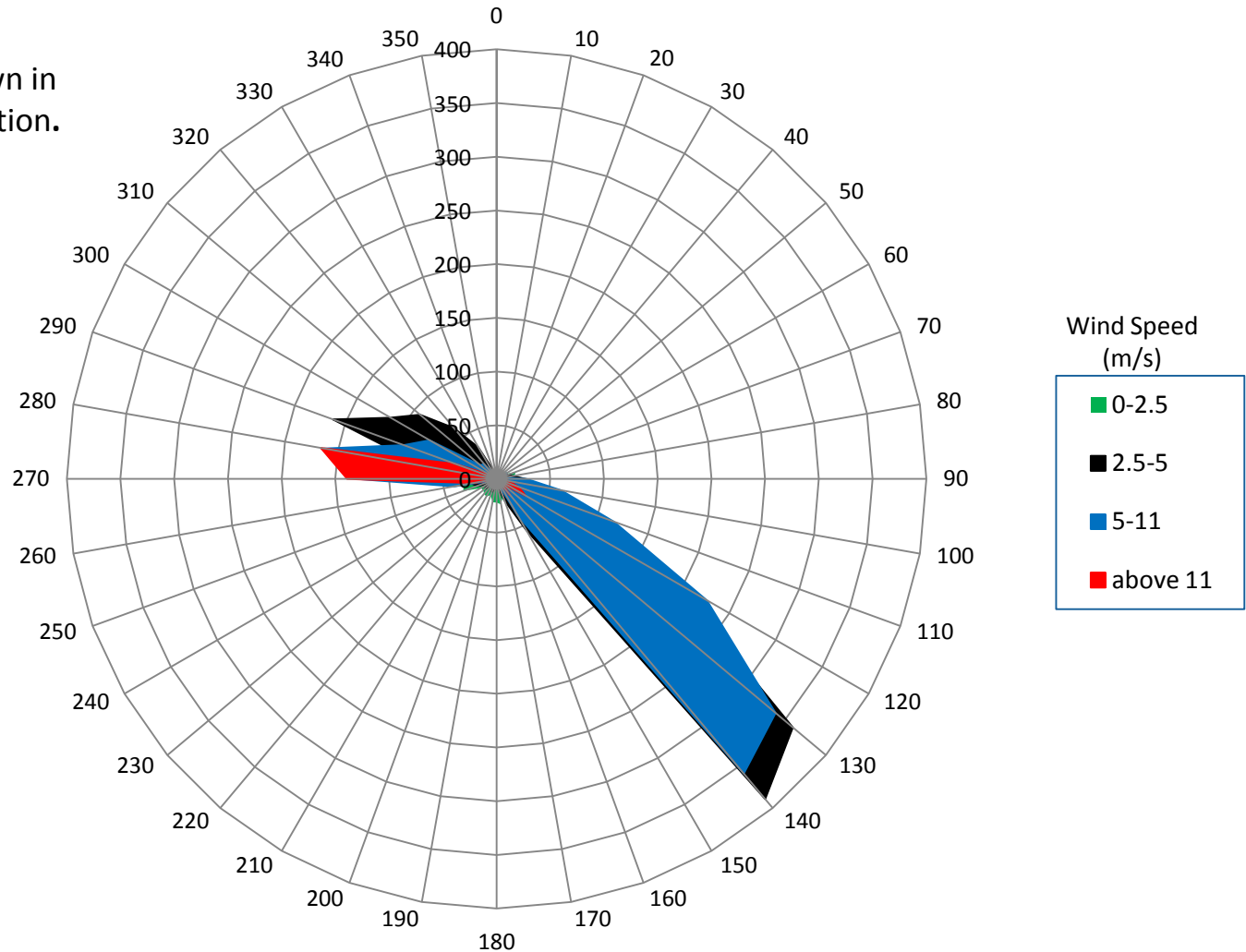
## Unit Power Curves



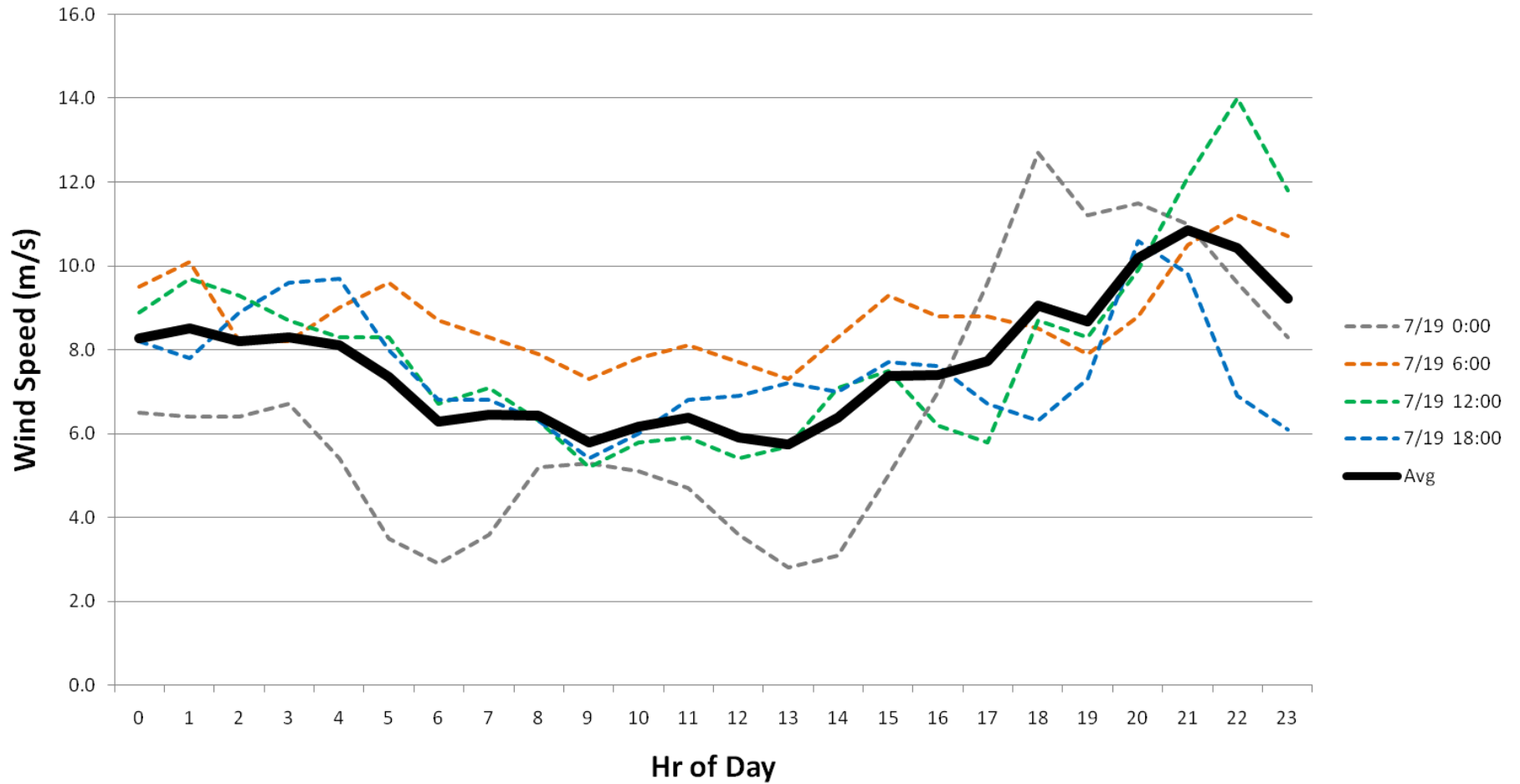
▲ Fossil Unit Power Curve ◆ Cassia Unit Power Curve ■ Elkhorn Unit Power Curve

# Elkhorn Wind (Jan – Aug 2011)

Note: Winds are shown in the "blowing to" direction.



# Weather Model Timing

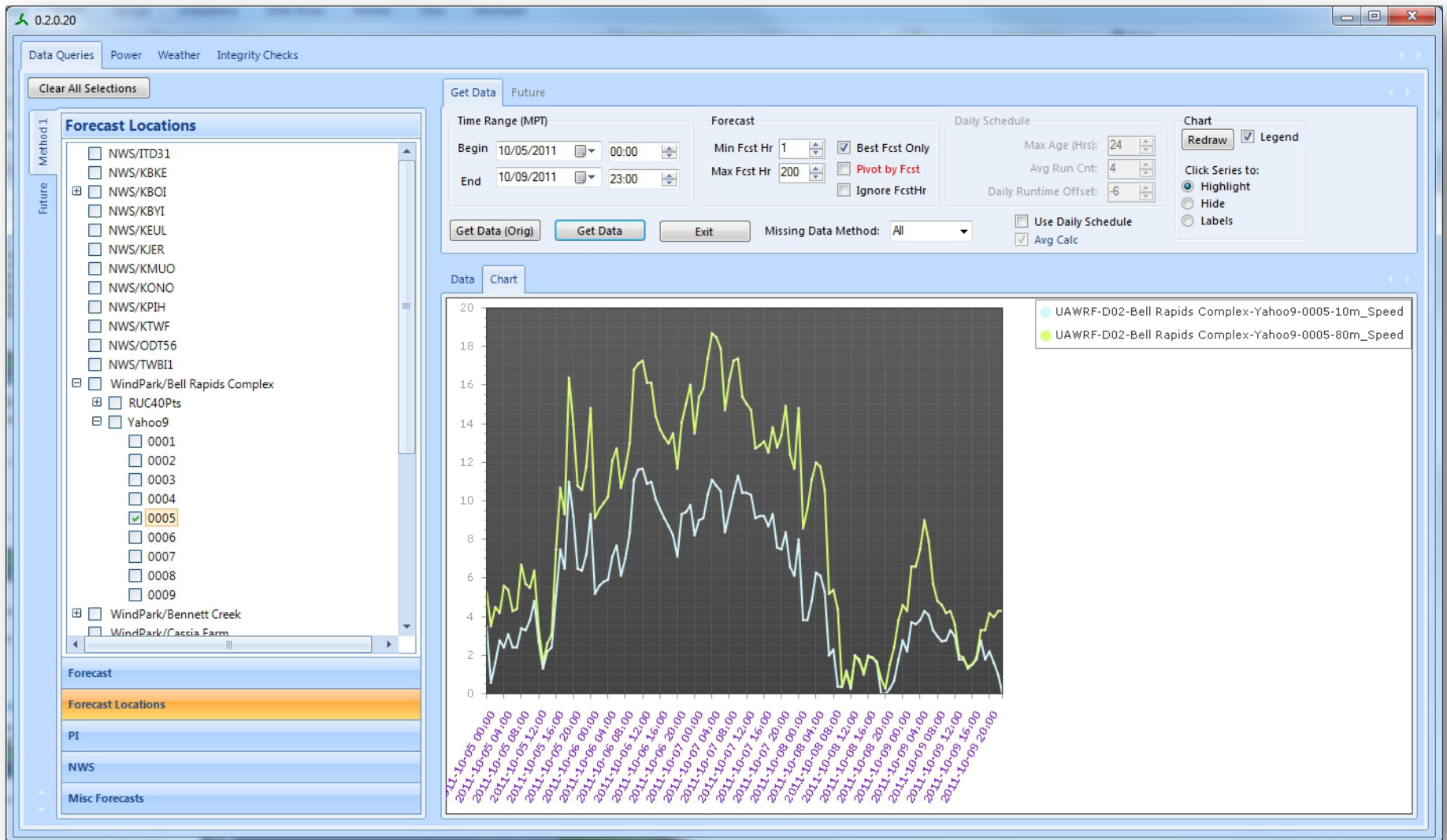




# Analysis Data Sources

- WRF NAM – Every 6 hrs
- WRF GFS – Every 24 hrs
- RUC40 – Every hr, 1-6 hr forecast, 40km resolution
- NWS Surface Stations
- SCADA data from wind parks (Speed, Direction, Power)
- Met data from IWP & Rockland wind parks
- Historical Met data from wind park owners
- Wind park owner supplied maps, geo coordinates
- Contracts & FAA filings
- Satellite photos

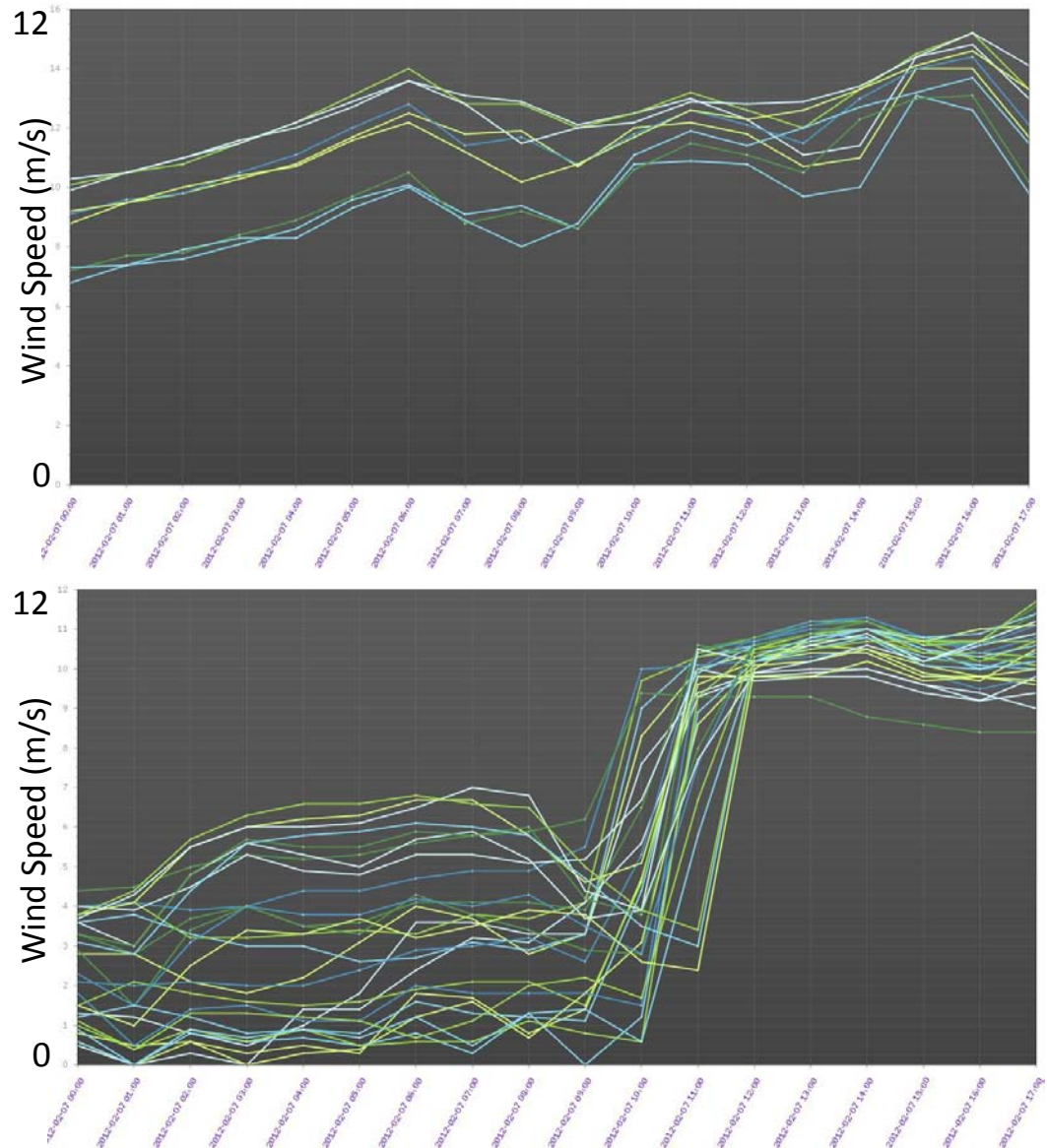
# Analysis - Windalyzer



# Analysis – Windalyzer

## Visualizing Data

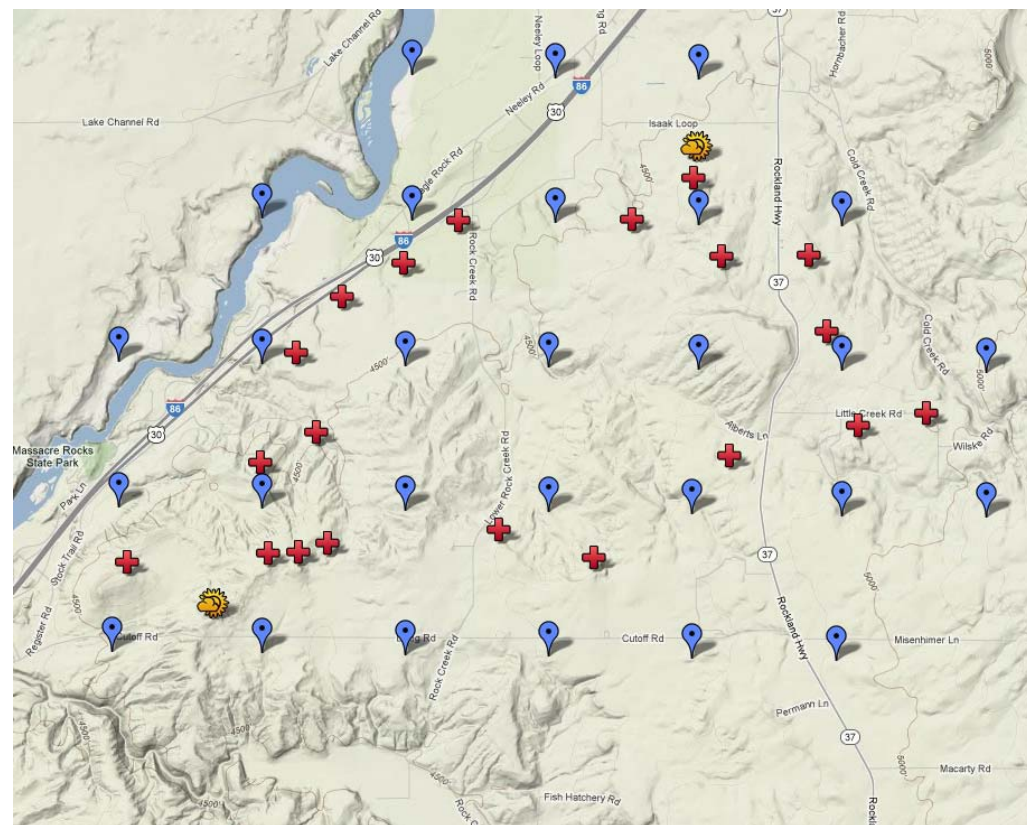
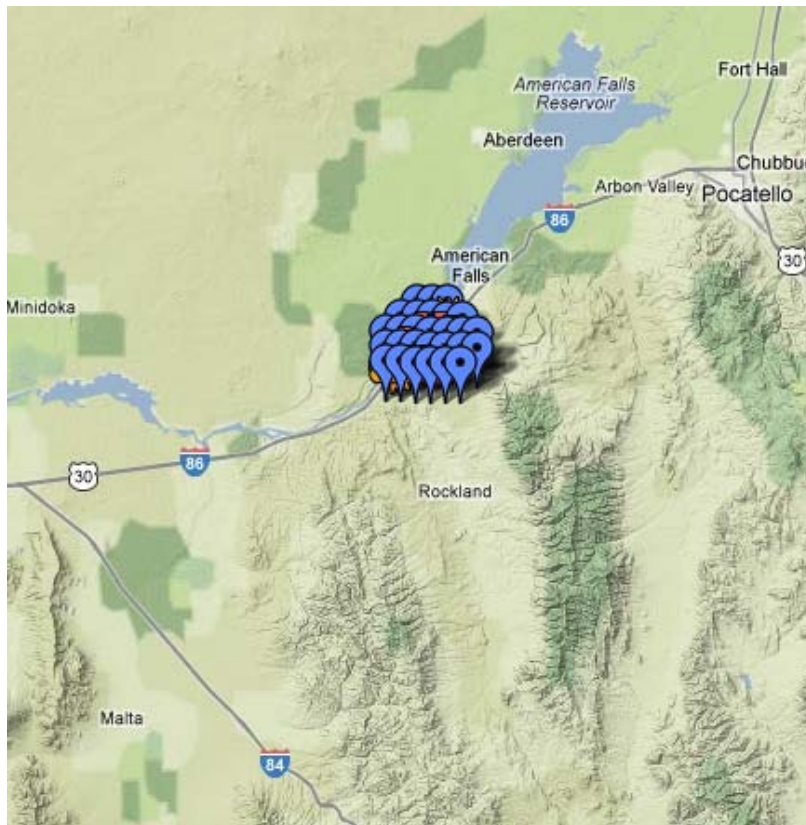
- 80m wind speeds across 2 different wind parks.
- Each line represents speed at 1 geographic point in park.
- Pts are spaced 1.8km apart.
- Graph 1 – Bell Rapids
  - Fairly consistent speeds across 9 geographic pts.
- Graph 2 – Rockland
  - Wind speeds vary from 0 to 7 m/s across the park.
  - Ramp occurs 2 hrs earlier at some points (Worst seen is 6 hrs)





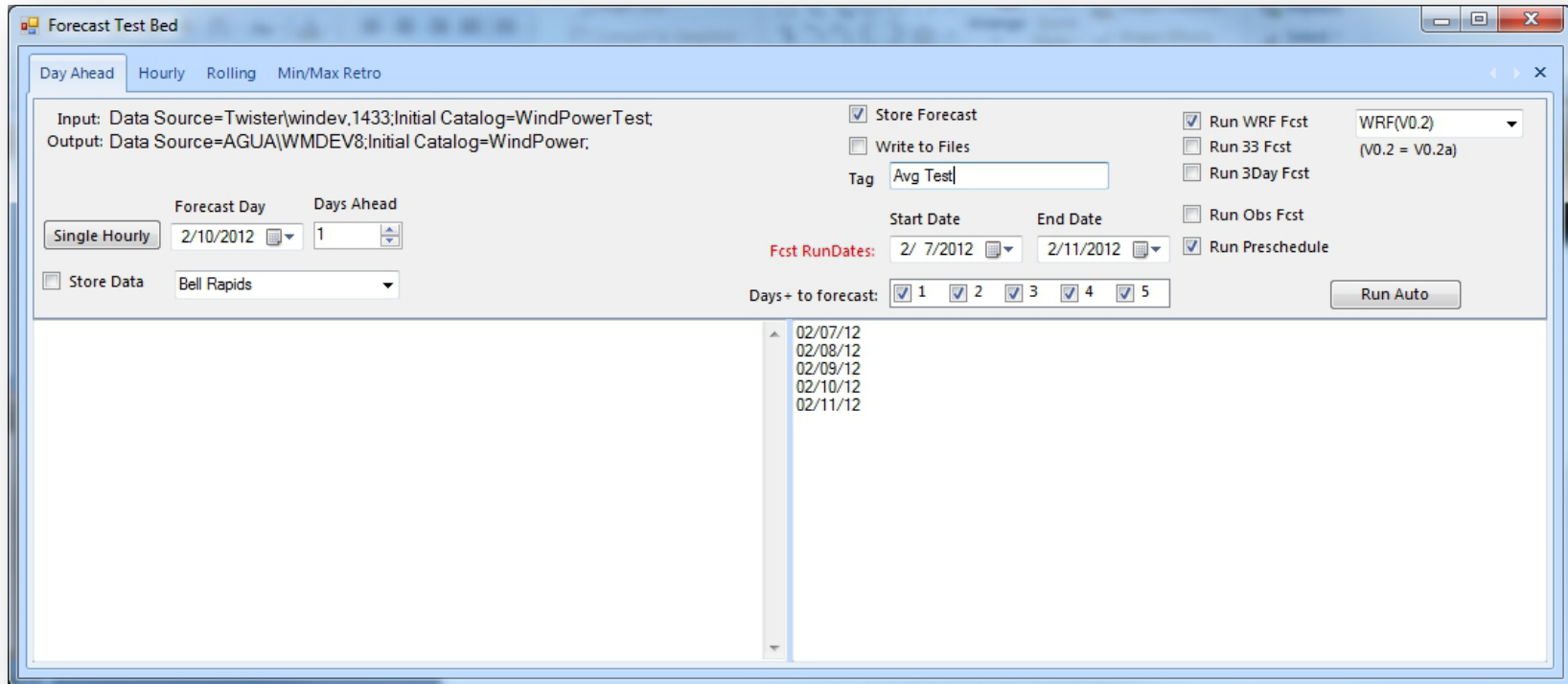
# Rockland Terrain Map

- 79 MW Capacity (44 Turbines)
- Wind Park Size - 6 x 3 miles



# Analysis – Retro Fcst Test Bed

- Simple application to execute test theories.
- Applies new algorithms to historical data.
- Allows quick evaluation of accuracy.
- Not a polished, releasable application.



# Tools

- Excel – Regression calculations, visualization, prototyping, validation, statistics, configuration
- Minitab – Statistics, visualization
- Visual Studio – SW development
- SQL Server 2008 R2 – DB, mapping, ETL
- Google & Bing maps – mapping, terrain info
- Degrib (Meteorological Development Laboratory)
  - Model Data Decoder



# Challenges

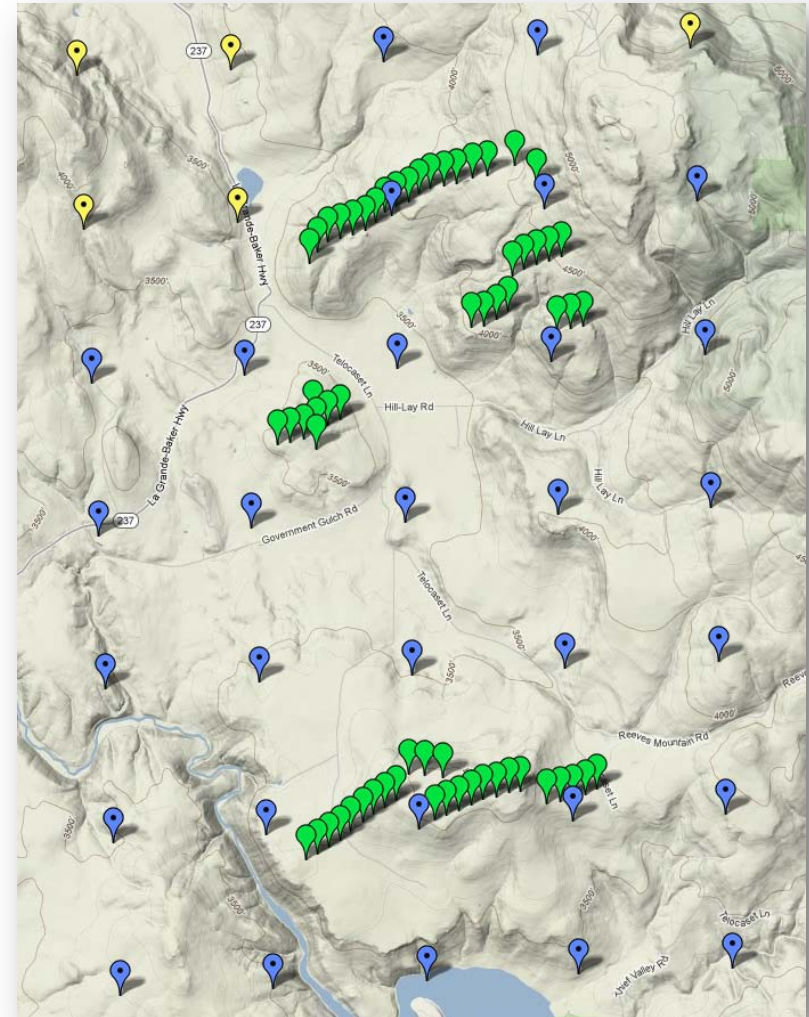
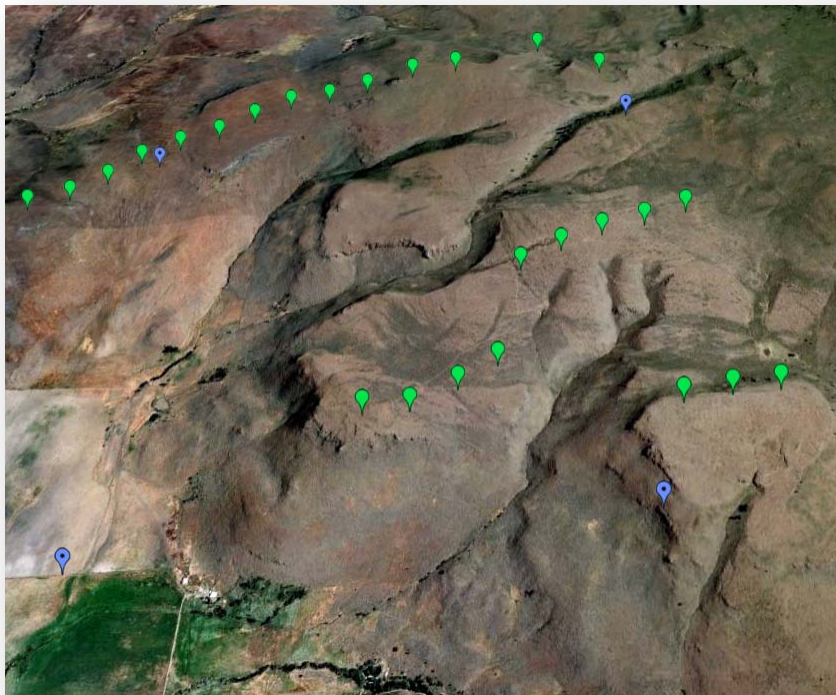
- Lack of observed weather data at surface and hub height
- Lack of observed power data except at interconnections
- Terrain
- Model timing
- Data volume



# Challenge – Elkhorn Terrain

Turbine elevations vary by 1000+ ft.  
4 mi distance from top to bottom.

Green – Turbine locations  
Blue & Yellow – Weather model pts.



# Keys

- Meteorology, Statistics, Data & System, Output Displays
- Many incremental improvements (Pt selection, wind directions, high pass filters, pt averaging, day/night, model averaging, etc)
- Agile development
- Ability to implement new theories quickly
- Repetitive retro-forecasting

# Questions?

