

*Presented at UWIG Fall Technical Workshop*

*Sacramento, CA November 8, 2005*

# **PIRP System and CEC Research Project Results**

**John W. Zack**

**AWS Truewind LLC**

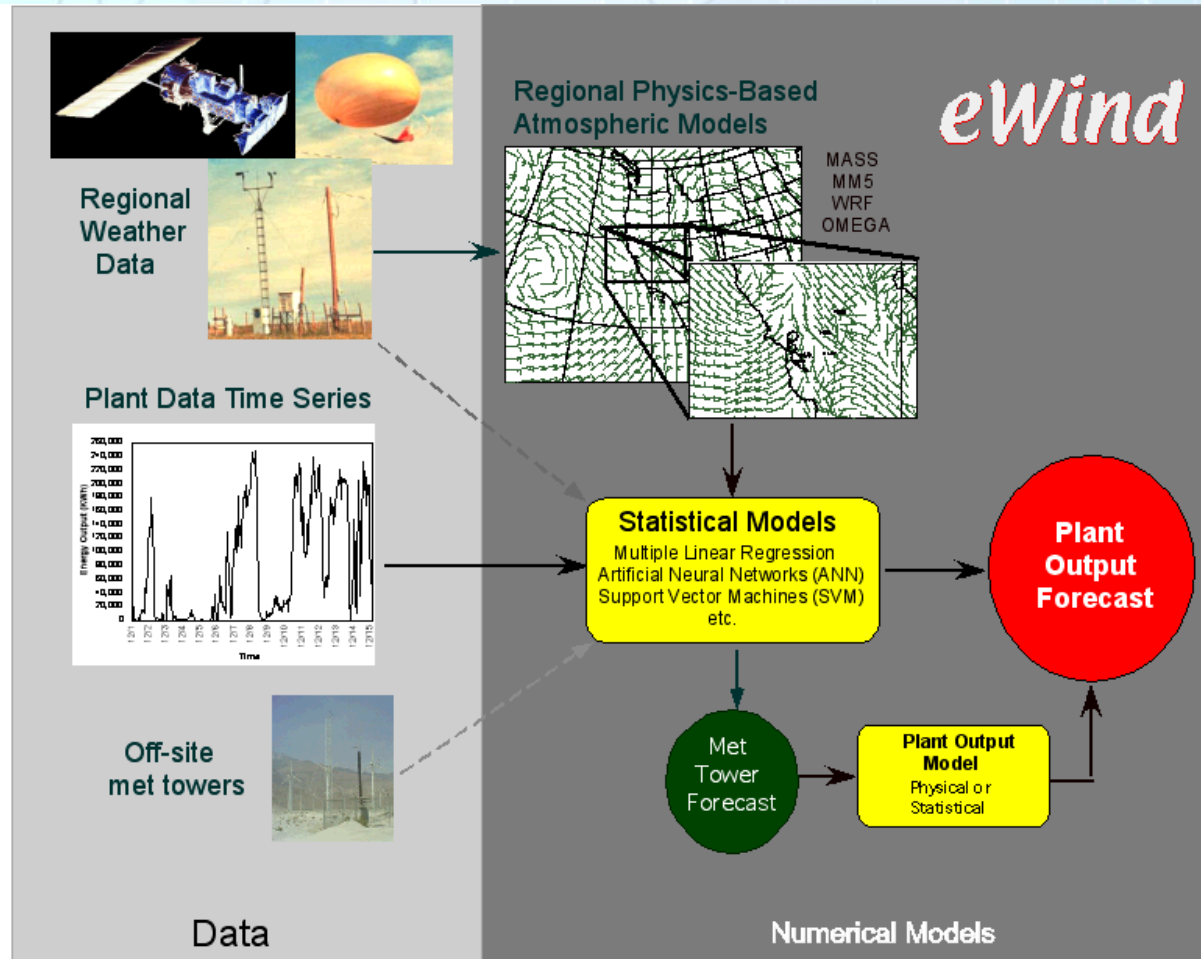
**Albany, New York**



# Outline

- Background: How Wind Forecasts are Made
- Overview and Status of CA ISO's PIRP
- CEC-EPRI Research Project Overview
- CEC-EPRI Research Project Results

# How Wind Power Production Forecasts are Made



# A Forecasting Application:

## CA ISO's **Participating Intermittent Resource Program (PIRP)**

- **CONCEPT:** Wind generation resources agree to supply production and met data and schedule to CA ISO forecast in exchange for economic benefits
- **Participation Rules**
  - Fee of \$0.10/MWh of production
  - Maintain T1 communications link and DPG computer
  - Supply 10-min generation, availability and specified meteorological data
  - Schedule “next operating hour” to CA ISO generation forecast
- **Benefits**
  - Imbalances are settled on net monthly deviation, not 10-min deviations
- **Forecast Provider**
  - AWS Truewind selected in a competitive solicitation

# PIRP Forecast Requirements: Delivery

- **Next Hour**
  - Production (MW) for each of the next 7 hours
  - Delivered by 15 minutes after each hour
- **Next Day**
  - Production (MW) for each hour of next calendar day
  - Delivered by 5:30 AM Pacific Prevailing Time (PPT)
- **Extended Forecasts**
  - Production (MW) for each hour of days 2, 3 and 4 after delivery day
  - Delivered by 5:30 AM PPT on Thursdays, Fridays and on selected days before scheduling holidays

# PIRP Forecast Requirements: Performance

- Next Operating Hour
  - Definition: Hour starting 2 hr 45 min after forecast delivery
  - Penalty
    - Monthly MAE  $> 12\%$  of installed capacity
    - Monthly Bias  $> 0.6\%$  of monthly production
  - Bonus
    - Monthly MAE  $< 10\%$  of installed capacity
    - Monthly Bias  $< 0.1\%$  of monthly production
- Next Day
  - No performance criteria

# PIRP: Current Status

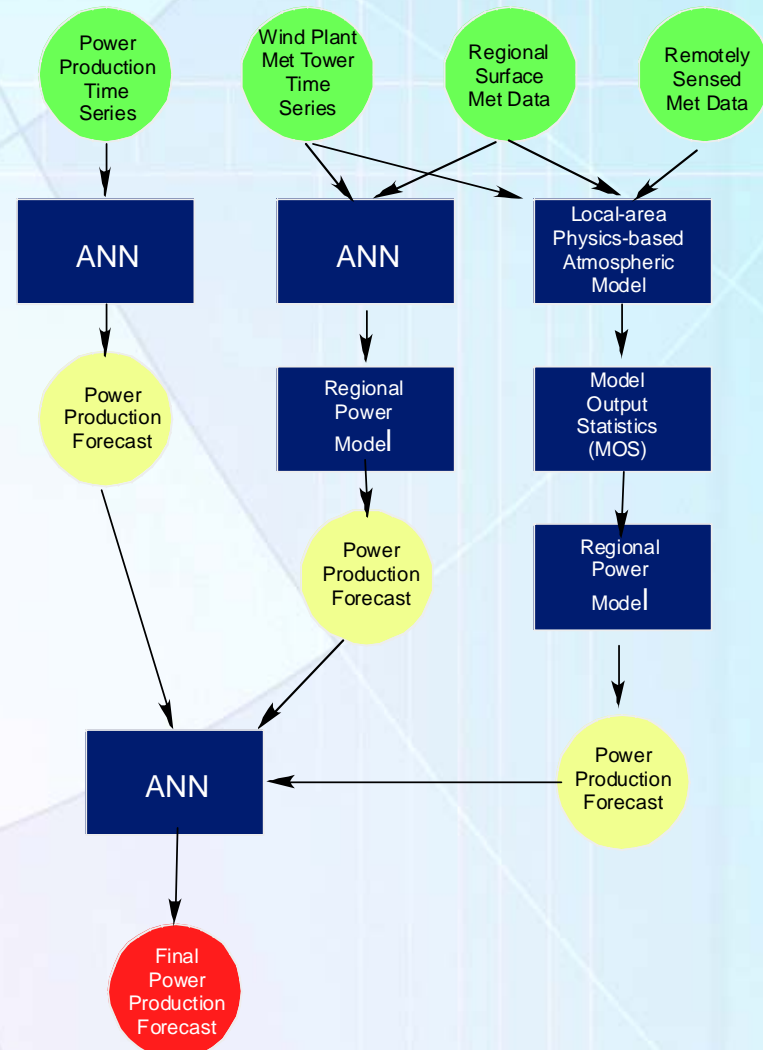
- Participants
  - 11 wind plants
  - 465.34 MW of installed capacity
- Performance
  - Next operating hour
    - MAE: 10-14% of installed capacity
    - Bias: 0.2% to 0.9% of monthly production
  - Next Day
    - MAE: 13% to 18% of installed capacity
- Issues
  - Large amount of missing plant data
  - Poor quality of availability information

# A Path to Improved CA Forecasting: CEC-EPRI Forecasting Research Project

- Project Objectives
  - Design 0 to 3 hr 5-minute interval forecast system
  - Analyze and improve day-ahead forecasting performance
  - Explore options for improved plant-scale power curve models
  - Create a numerical simulation database for future research activities
- Project Participants
  - EPRI (project manager)
  - AWS Truewind, LLC
  - UC-Davis
  - Lawrence Livermore National Laboratory

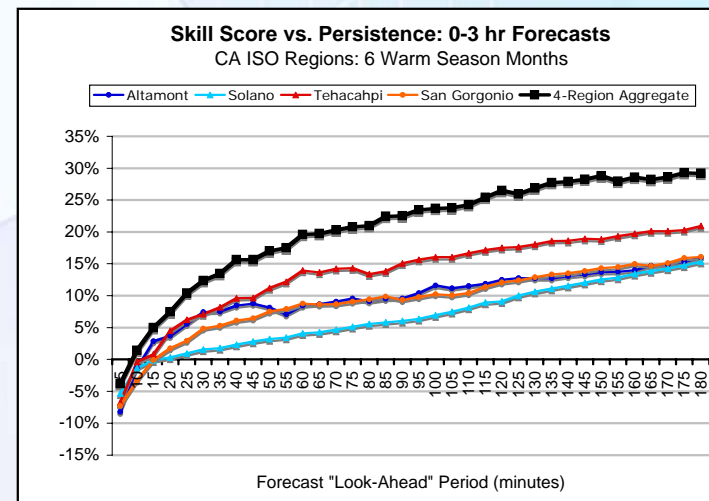
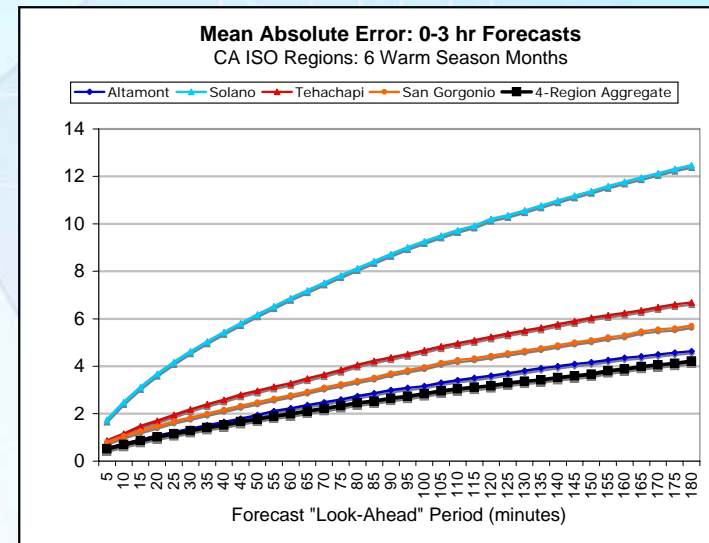
# 0-3 Hr Forecast System Design

- Two-stage ensemble scheme
- Stage 1: Three independent forecasts
  - (1) ANN with power production time series data
  - (2) ANN with met data time series and production model
  - (3) Local-area physics-based model with MOS and production model
- Stage 2: ANN-based compositing algorithm
- **Only Stage1-Method 1 tested in this project**



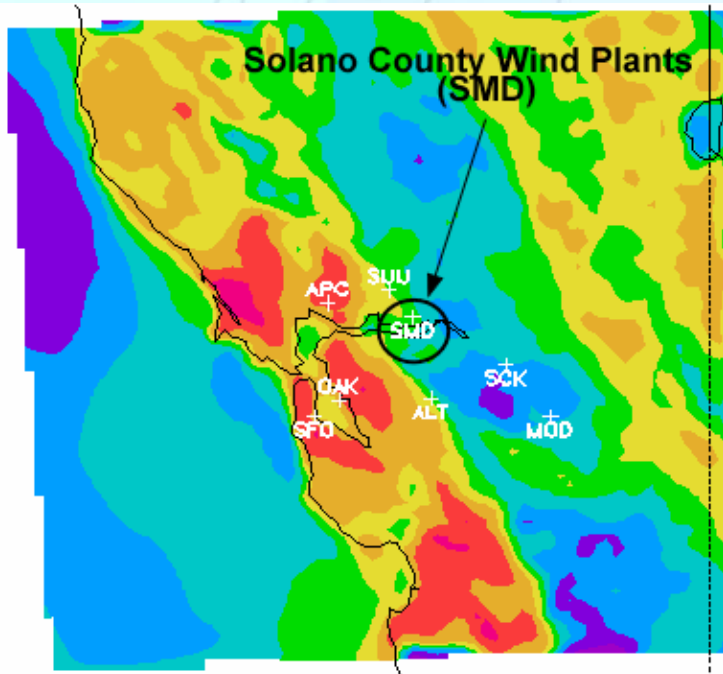
# Initial 0-3 Hr System Testing

- CA ISO regional wind power production data from calendar year 2004
- Only autoregressive component (method #1) of the forecast system was tested
- MAE ranged from about 0.5% of capacity for 5 minutes ahead to about 4% to 6% for 3 hours ahead
- Considerable skill vs. persistence demonstrated for the warm season; less for the cold season



# Development of Method #2

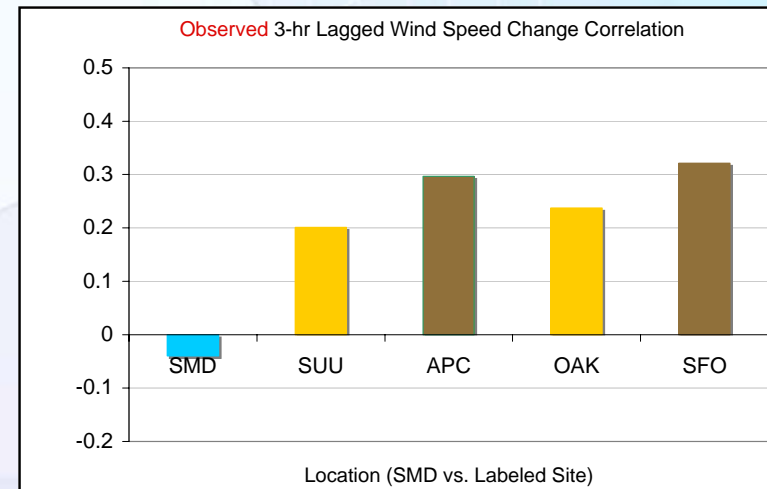
## Spatial Forecast Relationships



Numerical simulations with 5 km Grid  
June 2005

- Use numerical simulations to find predictive relationships with other locations for each forecast site; verify with obs data where possible
- Example: 3-hr lagged wind speed change correlations for the SMD site for June 2005 (below and left)

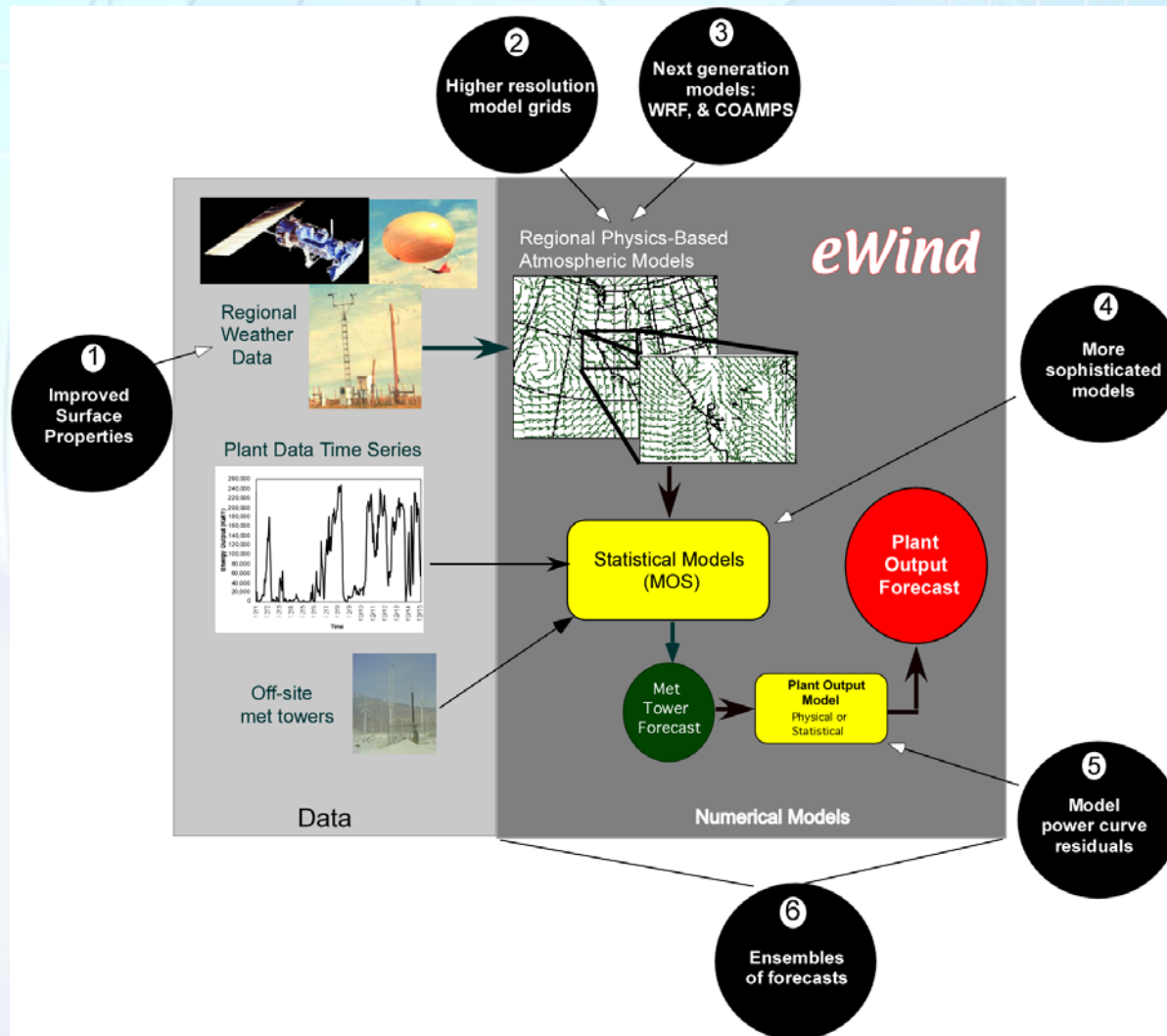
### Anemometer Data - June 2005



# CEC-EPRI Project: Day-Ahead Forecasting Research

- Screened new or modified forecast methods
  - Tested a variety of forecast system improvement concepts
  - Used subset of forecasts for 2 plants from previous project
- Evaluated forecast performance over 1 year
  - 1 to 48 hour forecast (assume no real-time plant data)
  - Power production and wind speed forecasts
  - July 2004 - June 2005
  - 5 participating wind plants
    - 2 from previous project; 3 new participants
  - 12 forecast methods (basis for an ensemble-mean forecast)
    - 3 physics-based models
    - 4 MOS techniques

# Forecast System Modifications



# Day-Ahead Forecast Results

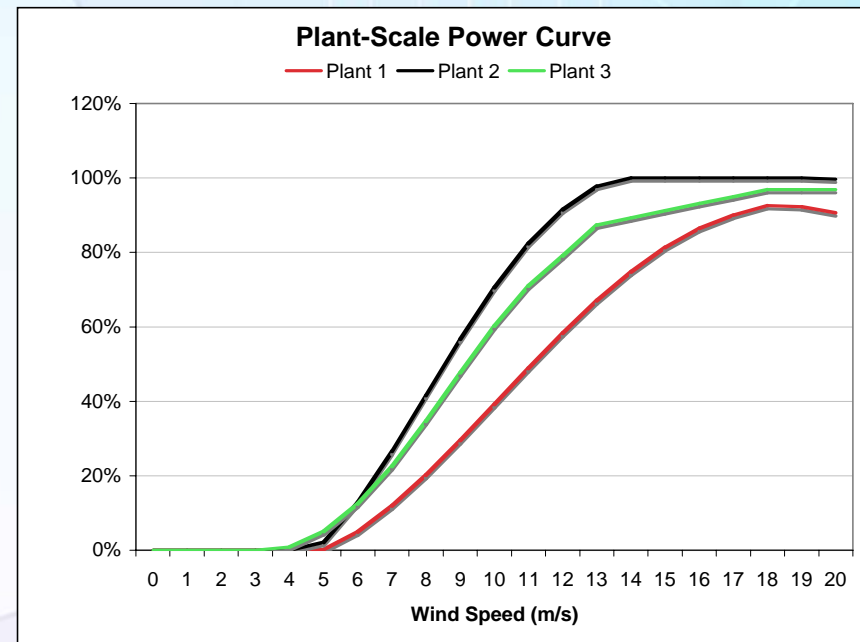
“Best method” performance statistics (July 2004-June 2005)

Site	Power Production Forecast MAE			Wind Speed Forecast MAE		
	MAE % of Capacity	MAE % of Prod	Skill vs Persistence	MAE m/s	MAE % of Speed	Skill vs Persistence
Mountain View	13.0%	36.6%	40.5%	2.65	27.5%	40.1%
Oak Creek	15.0%	57.1%	33.2%	2.03	40.6%	32.8%
PowerWorks	11.9%	58.5%	26.5%	2.52	34.4%	28.2%
SMUD	16.0%	60.8%	37.1%	1.98	35.9%	31.3%
High Winds	16.8%	50.7%	28.6%	2.16	31.9%	27.1%
<b>Overall</b>	<b>14.5%</b>	<b>52.7%</b>	<b>33.2%</b>	<b>2.27</b>	<b>34.1%</b>	<b>31.9%</b>

- Ensemble-mean forecast yields 3% to 5% lower MAE
- Substantial improvement at both plants from earlier project
  - Mountain View: MAE: 13.0% vs. previous 16.6%
  - PowerWorks: MAE: 11.9% vs. previous 14.1%
- Significant variation in performance among the plants. Why?

# What factors are responsible for the variations in the performance?

- Distribution of forecast hours along the plant-scale power curve
- Magnitude of wind speed errors as a function of wind speed
- Shape of the plant-scale power curve
- Amount of scatter in the actual production around the plant scale power curve



# Summary

- **PIRP currently in operation for over a year**
  - 11 wind plants; 465.34 MW of capacity participating
  - Forecast performance near requested levels
- **CEC-EPRI research project recently completed**
  - 0-3 hr forecast system designed & partially tested
  - Several new or modified day-ahead forecast methods evaluated
  - One-year day-ahead forecast test conducted for 5 wind plants in CA
  - Performance results indicate improvement over previous CEC project
  - Extensive analysis of day-ahead forecast errors performed
- **Results of CEC-EPRI project will be implemented into the PIRP forecast system**