

Prediction of Variability

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October 22, 2010

Outline

- Value of Forecasts
- Wind Power Forecasting
- Forecast Accuracy
- Improved Use of Forecasts

Value of Forecasts

- Balancing grids requires knowledge of demand and wind
- Reserve generation used when problems occur.
- Uncertainty in forecasts increases the need for spinning reserves.



Wind Power Forecasting

- Numerical Weather Prediction (NWP)
 - Physics based models
- Statistical models
 - Trend analysis to determine future states
- Hybrid approaches
 - Combination of NWP and Statistical methods

Wind Power Forecasting

Weather Service NWP Model



NWP Model for Specific Location



Model Output Statistical Correction



Wind Generation Forecast



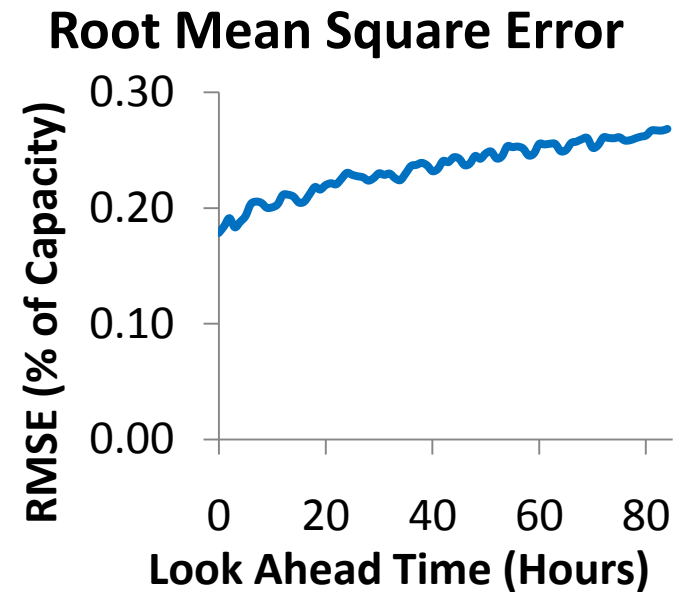
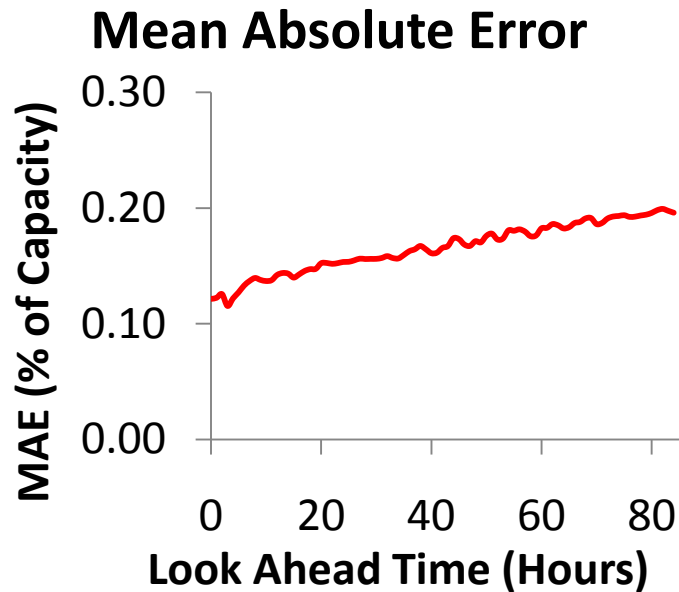
Forecast Accuracy

- Mean Absolute Error (MAE)
- Root Mean Square Error (RMSE)
- Standard Deviation of Errors (SDE)

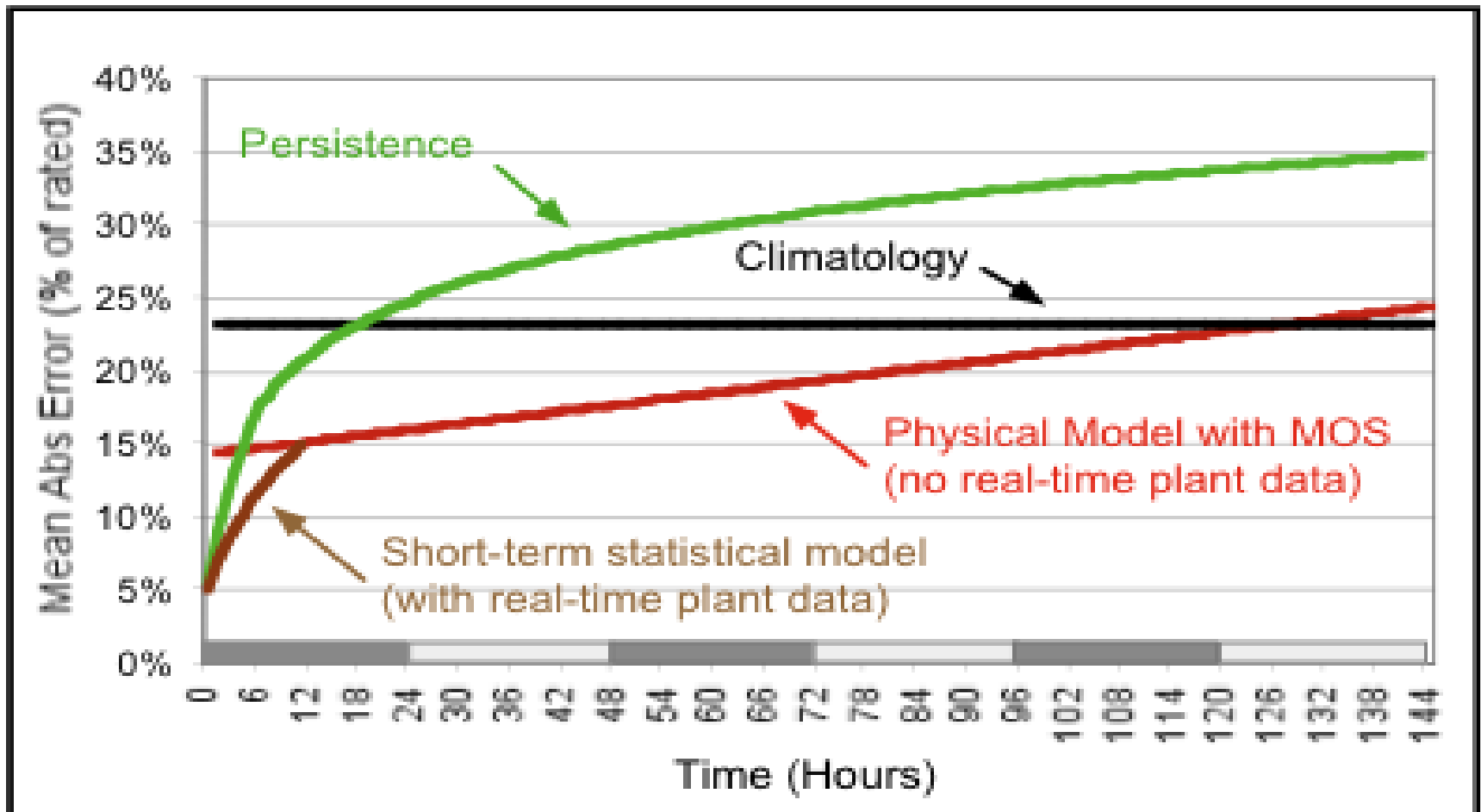
$$MAE = \frac{\sum_{i=1}^N |e_i|}{N} \quad RMSE = \sqrt{\frac{\sum_{i=1}^N e_i^2}{N}} \quad SDE = \sqrt{\frac{\sum_{i=1}^N (e_i - \bar{e})^2}{N}}$$

Forecast Accuracy

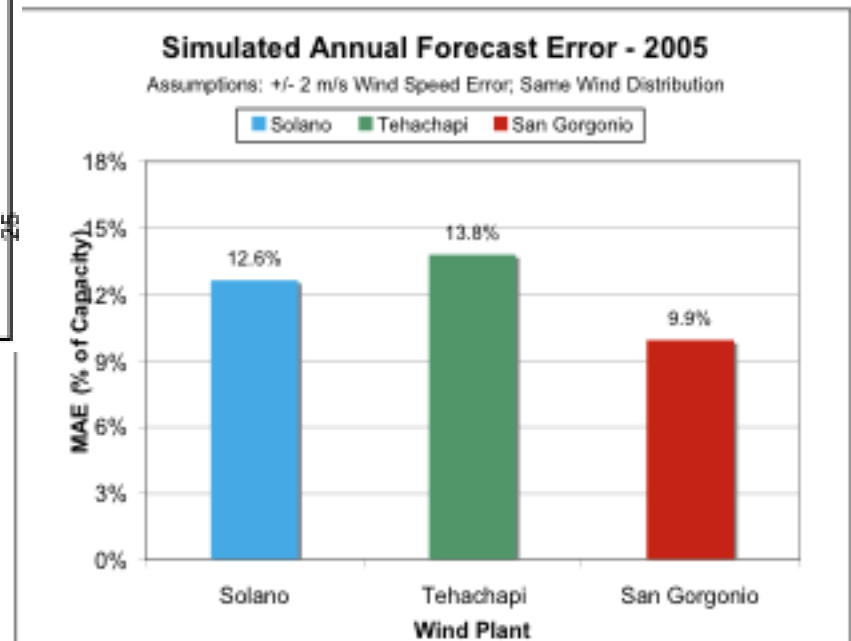
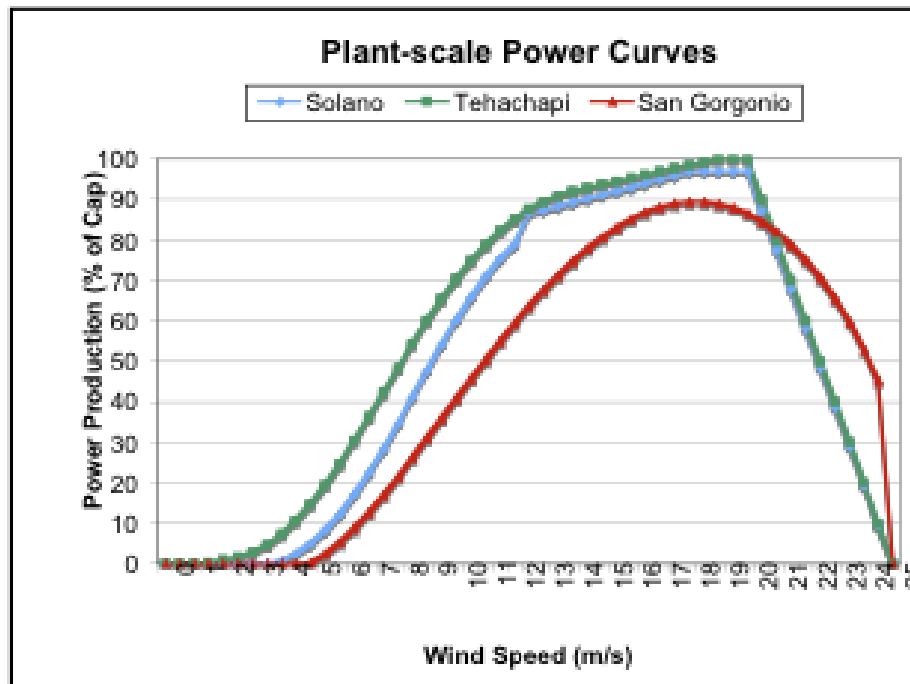
Single wind farm in 2008



Comparison of NWS and Statistical Methods Accuracy

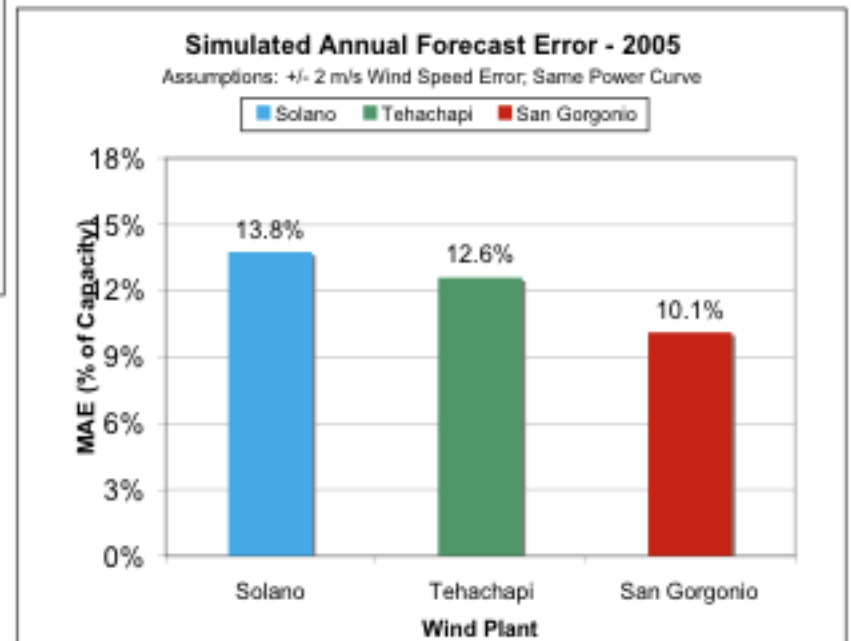
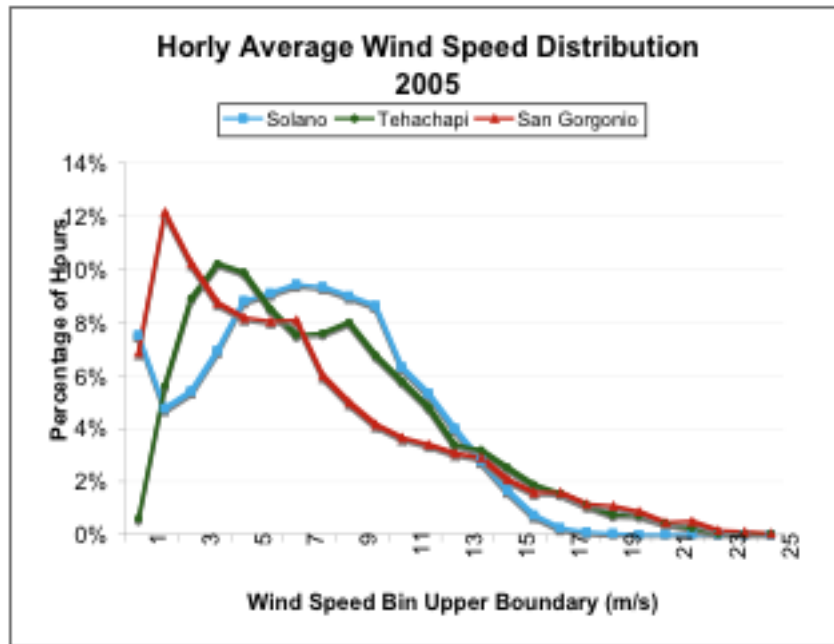


Wind Farm Characteristics Affect Forecast Accuracy



Figures Courtesy of Dr. John Zack

Wind Speed Distributions Affect Forecast Accuracy



Figures Courtesy of Dr. John Zack

Aggregating Forecasts Can Reduce Errors

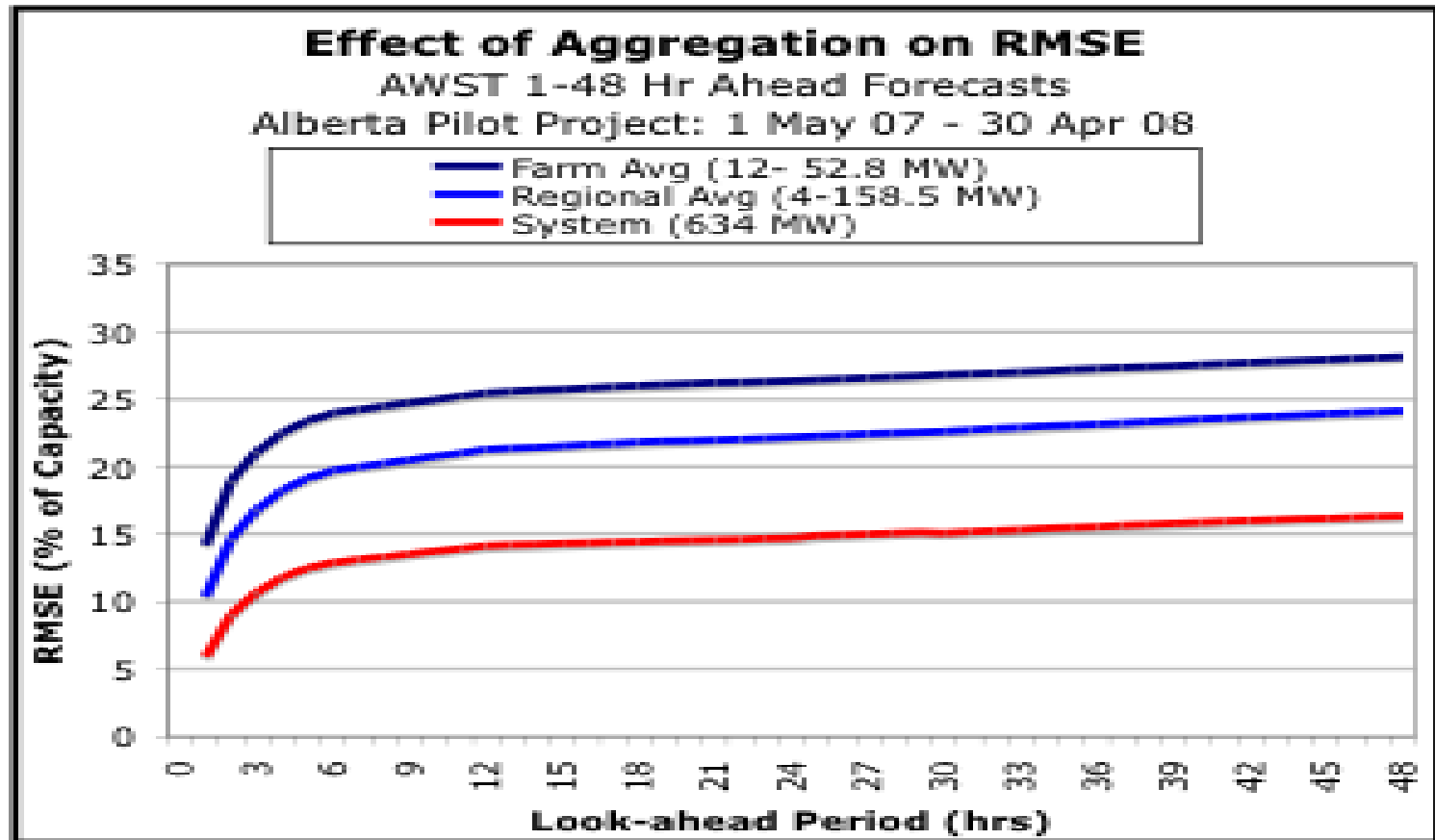


Figure Courtesy of Dr. John Zack

ISO/RTO Use of Wind Forecasts

- As wind capacity increases, forecasts play a larger role in daily operations.
- Wholesale markets – Wind forecasts affect unit commitment and economic dispatch
- Reserve requirements – Forecast uncertainty affects reserve requirements

Improved Use of Forecasts

- Extreme forecast errors are more important than average error statistics over a long period
- Periods with highly variable wind speeds produce the largest forecast errors
- More work is needed in the efficient use of wind forecasts
 - Forecast error analysis to determine appropriate confidence intervals in various weather conditions
 - Benefit cost analysis of improving forecast accuracy