Valuing Wind Forecasts

Phillip de Mello
University of California, Davis

Wind Energy Forum
April 5, 2011
Overview

• Background
• Forecasts
• Motivation
• Methodology
• Results
• Conclusions
Wind Integration Concerns

- **Intermittent**
  - Not available on demand

- **Variable**
  - While generating production is unstable
  - Limited dispatchability

- **Uncertain**
  - Difficult to predict quantity and timing of wind generation

*Five Minute Wind Generation*
Managing Wind Integration

- **Flexibility** – Increase the power system’s ability to adjust
- **Diversity** – aggregate wind generation (and load) to reduce the intermittency and variability
- **Forecast** – predict the wind generation
Forecast Timeframes

• **Day ahead forecast**
  - Long term forecast up to 48 hrs
  - Developed with mesoscale atmospheric models
  - Average hourly energy forecast

• **Hour ahead forecast**
  - Covers 0-8 hours
  - Uses combination of statistical and atmospheric models
  - Average hourly energy forecast

• **Real time forecasts**
  - Short term covers 0-2 hours
  - Developed primarily with persistence techniques
  - Uses real time telemetry
  - Power production forecast
Using Forecasts

• Day ahead forecast
  – Unit commitment and scheduling

• Hour ahead forecast
  – Short term unit commitment, and scheduling
  – Revises day ahead predictions

• Real time forecast
  – Used for dispatch
Evaluating Forecasts

• Forecast Error measured as percentage capacity

\[ \varepsilon = \frac{\text{Forecast} - \text{Actual}}{\text{Capacity}} \]

- Each forecast error is limited to ±100%

• Average over time using Mean Absolute Error or Root Mean Square

\[ MAE = \frac{\sum |\varepsilon|}{n} \]
\[ RMS = \sqrt{\frac{\sum \varepsilon^2}{n}} \]
Forecast Accuracy

- California Independent System Operator Forecast Study 2009
- Accuracy changes by season, hour of day, production level, etc.
- Error under 15% RMSE for day ahead forecasts
- Error under 10% RMSE for hour ahead forecasts
Improving Forecasts

• Forecast error reduction:
  – Improvements in atmospheric models
  – Better sensing and telemetry
  – Offsite data

• Specialized forecasts
  – Forecasts for ramps, events
  – Forecast variability

• Improve use of forecasts
  – Better integration with system operations
Current Value Assessment

- Forecast value estimated in many studies
- Annual operating cost benefits
- Forecasts have substantial value
  - $1-5 billion/year in savings for state of the art
  - Additional $500 million in savings for perfect forecast

Motivation

• Forecasts are uncertain, errors will have an effect on the system
• Very large benefits of forecasts already estimated
  – Additional benefits of forecasts are still large
• Are current forecasts providing their maximum benefit
• How can we target improvements to forecast that most benefit the system
Goals

• Create a methodology to assess forecast value
  – Comprehensive to include all relevant processes
  – Isolate key attributes of forecasts
  – Flexibility to test many different conditions

• Test different forecasts in each process
  – Perfect, no forecasts, state of the art, etc.

• Measure the benefits of the different forecasts

• Identify the areas for improvement
Measuring Forecast Benefits

• Model the major power system processes
  – Day ahead, hour ahead, and real time markets
  – Full California system model
  – Wide variety of system conditions

• Model Wind forecasts
  – Simulate forecasts similar to current forecasts
  – Adjust simulated forecast parameters individually

• Simulate power system
  – Vary forecast parameters to isolate variables
  – Measure changes to system with different forecasts
Simulation Tree

Realistic Wind Generation and Load Scenario

Day Ahead Simulation Forecast A

Hour Ahead Simulation Forecast A

Real Time Simulation

Day Ahead Simulation Forecast B

Hour Ahead Simulation Forecast B

Hour Ahead Simulation Forecast A

Real Time Simulation

Hour Ahead Simulation Forecast B

Real Time Simulation
Case Study

- Spring day
- Peak load 39GW
- Wind capacity 7.5GW
- Wind capacity factor 28.5%
- Peak wind 3.9GW
- Minimum wind 415MW
- 3 Forecast cases
  - Perfect, No forecast, Full forecast

Acknowledgement: CAISO for support of research
Day Ahead

- Simulates the Day ahead market process
- Full unit commitment process
- 24 hours co-optimized in 1 hour time-steps
- Uses a wind forecast
Hour Ahead

- Simulates the hour ahead market process
- Uses unit commitment and schedules from day ahead
- 6 hours co-optimized in 15 minute time step
- Locks commitment of long start units
- Uses hour ahead wind forecast
- Adjusts commitment of short and medium start units
Real Time

- Uses the day ahead schedules
- Locks commitments from day ahead and real time
- Five minute time step
- Adjusts the schedules
- Uses the actual wind profile
- Dispatches generation to meet load
Value

- Forecast value is a combination of the three runs
- Unit commitment costs
- Energy costs
  - Two settlement market system
  - Real time is balancing market
- Ancillary service cost
- Other factors
  - Transmission congestion
  - Minimum generation costs
Results

- Significant variation in energy costs
- Over forecasting depresses prices
  - Reduces generator revenue
- Under forecasting increases prices
  - Increases system costs
- Combine with hour ahead
Conclusions

• Forecasts add significant value to power systems operations
• Current forecasts add the majority of possibly benefit
• Studying forecasts can help:
  – Improve forecasts
  – Improve the use of forecasts
  – Gain further benefits
Questions?