

Forecast Uncertainty and Trading Decision-making

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Polaris 
Systems Optimization

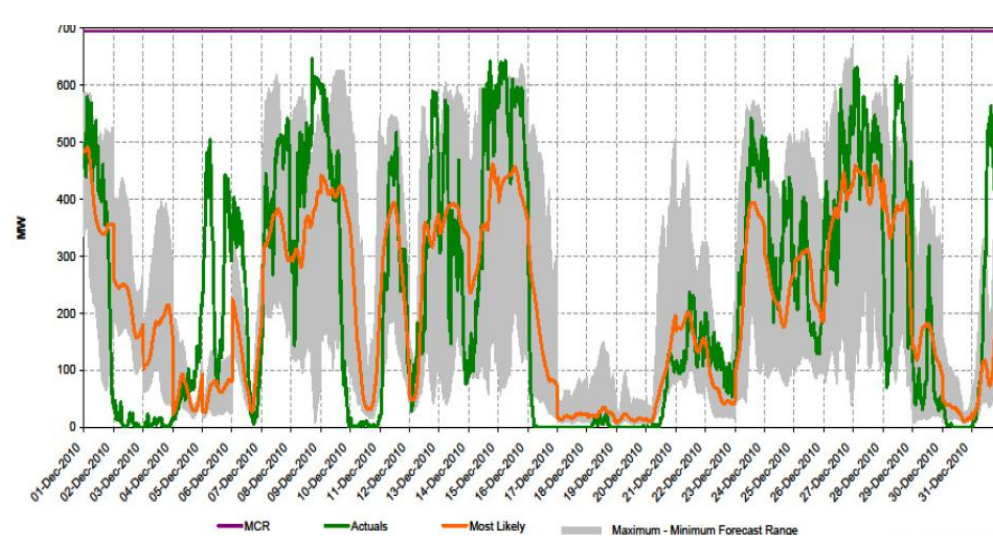
 **UWIG**
Utility Wind
Integration Group

UWIG Workshop on
Variable Generation Forecasting Applications
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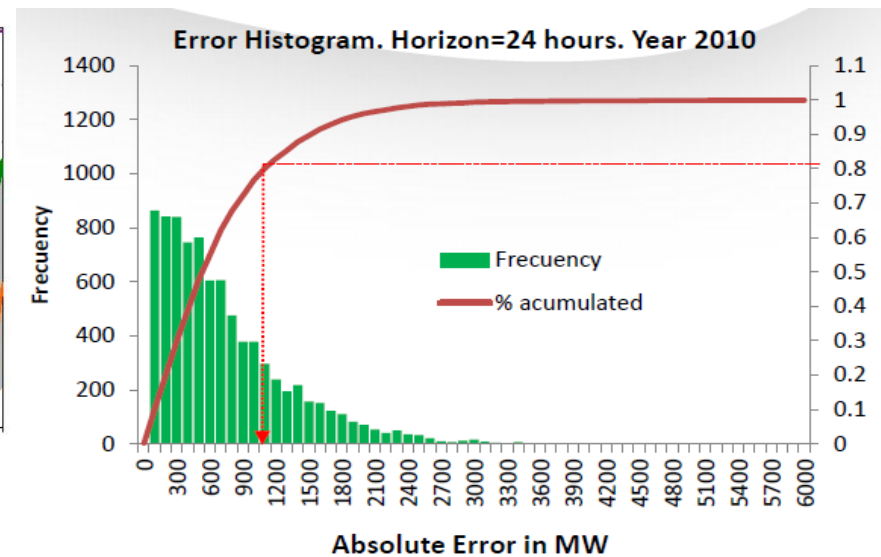
Outline

- Deterministic forecasts: *always wrong!*
- Probabilistic forecasts: *get it right!*
- Using probabilistic forecasts: *higher reliability and lower costs!*
- Illustrative example on PSO: *trading operations*
- Concluding remarks

Deterministic Forecasts



Source: Jacques Duschene, Wind power forecasting in Alberta, 2011
UWIG Forecasting Workshop

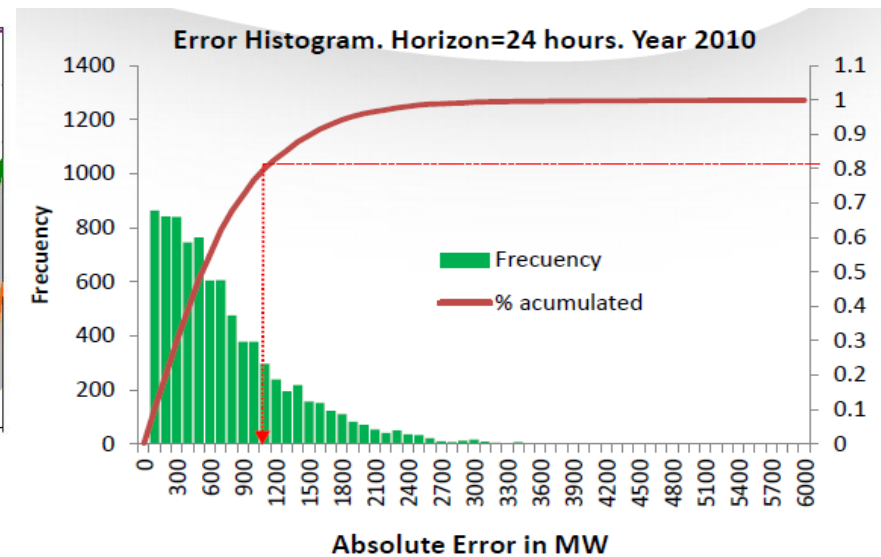
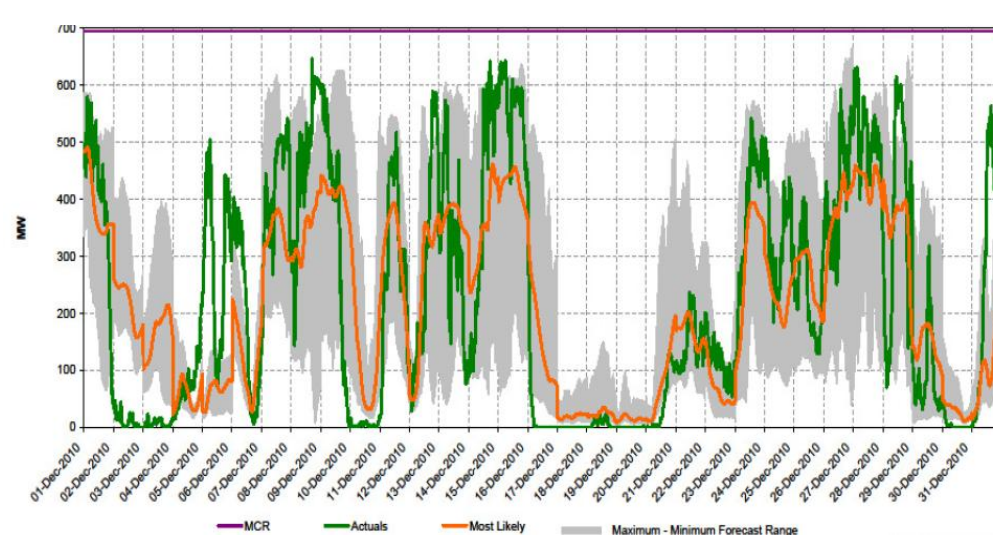


Source: Jorge Ribot Vallejo, Wind generation forecasting system
SIPREOLICO, 2011 UWIG Forecasting Workshop

- Traditional forecasts provide a *central tendency* indication
- Forecasts used in decision making *as if* they accurately represented individual future outcome *realizations*
- Users don't get the full value of the forecast

THE FORECAST IS *ALWAYS WRONG!!!*

Deterministic Forecasts



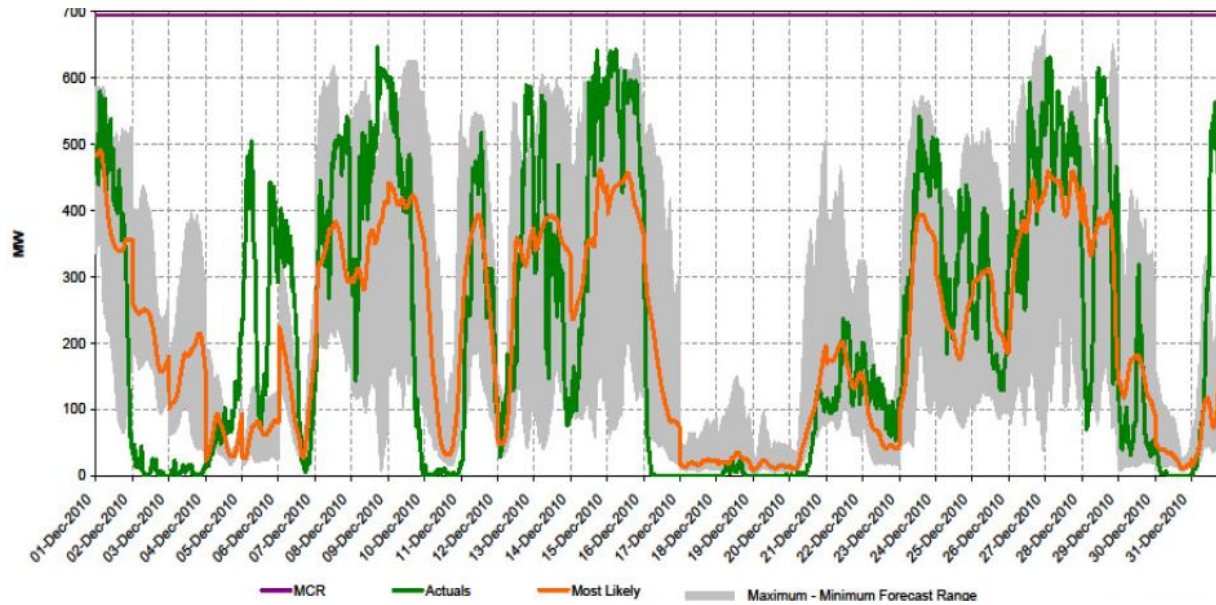
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Probabilistic Forecasts

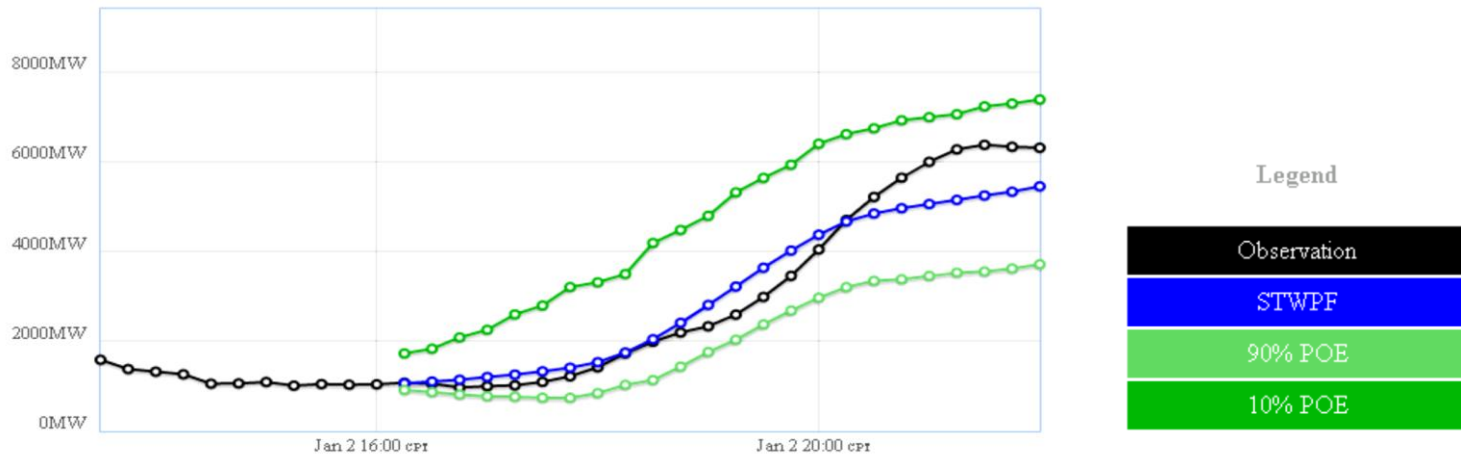


Source: Jacques Duchesne, Wind power forecasting in Alberta, 2011 UWIG Forecasting Workshop

- Available wind power is a *dynamic, stochastic process*
- Multiple metrics must be used to describe it, *continuously updated*
- Autocorrelations and cross correlations are critically important

GET THE FORECAST (ALMOST) *RIGHT MOST OF THE TIME!!!*

Probabilistic Forecast Information



Source: David Maggio, Using probabilistic information in real life, 2011 UWIG Forecasting Workshop

- **Statistics: time-varying, updated**
 - Expectations, moments
 - Percentile information: bounds for *normal operations*
 - Probability information: likelihood of *complex events*
- **Scenarios: focus on most important aspects**
 - Random scenarios: lots of them!
 - Challenging conditions: reliable operations
 - Representative conditions: economic normal operations
 - Set of scenarios need to be consistent with the forecast statistics!

Use of Probabilistic Forecasts

- Adapt business processes and decision making approaches to fully utilize the information in the forecasts
- More transparent and explicit management of uncertainty
- Adaptive ancillary service requirements
 - Based on off-line studies
 - Dependent on system conditions
- Multiple scenario/probabilistic approaches to economic dispatch, unit commitment and trading decisions
 - On line use of scenarios generated by probabilistic forecasts
 - Robust decisions

GOAL: IMPROVE *ECONOMIC PERFORMANCE AND RELIABILITY*

3-unit Illustrative Example

Purpose

Understand Optimal Bidding Strategies in Trading

- 3 Cycle Decisions

Day-Ahead: 12 hours prior to start of the day, 48-hour decision horizon (hourly for Day 1, bi-hourly for Day 2).

Hour-Ahead: 30 mins prior to start of the hour, 2-hour decision horizon (eight 15 min periods).

Real-Time (5-Min-Ahead Dispatch).

- Only the Wind Forecast changes by Cycle.

- Previous decisions will be honored and adjustments of generators made towards fulfilling previous decisions.

Generators adjusted to fulfill Day-Ahead Sales commitment.

Generators will be backed down to provide necessary reserves.

Assumptions

3 Units (2 Gas, 1 Dispatchable Wind)

✓ Marginal Cost.

Wind < Gas 1 < Gas 2

Red < Blue < Brown

(based on fuel cost and unit heat rates)

✓ No ramp limit modeled by unit.

10 Min OR capability based on max capacity.

✓ Start-up cost modeled by unit.

\$500 for gas.

✓ Max/min gen modeled by unit.

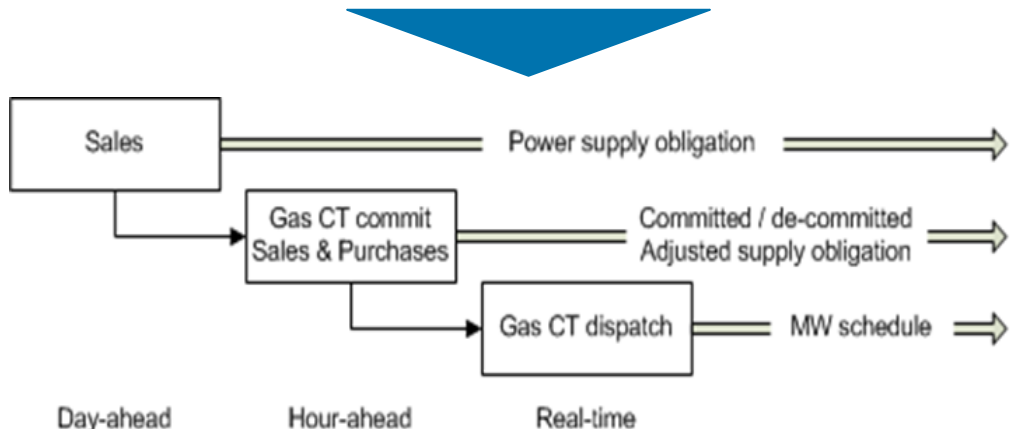
300/150MW for gas.

wind is dispatchable up to the forecast value.

System Requirements

✓ Regulation: None.

✓ 10 Min Operating Reserves: 50MW ramp up/down from online units within 10 mins for Day Ahead and Hour Ahead.



3-unit Example: Deterministic Forecast and Realization



Forecast Wind (1)

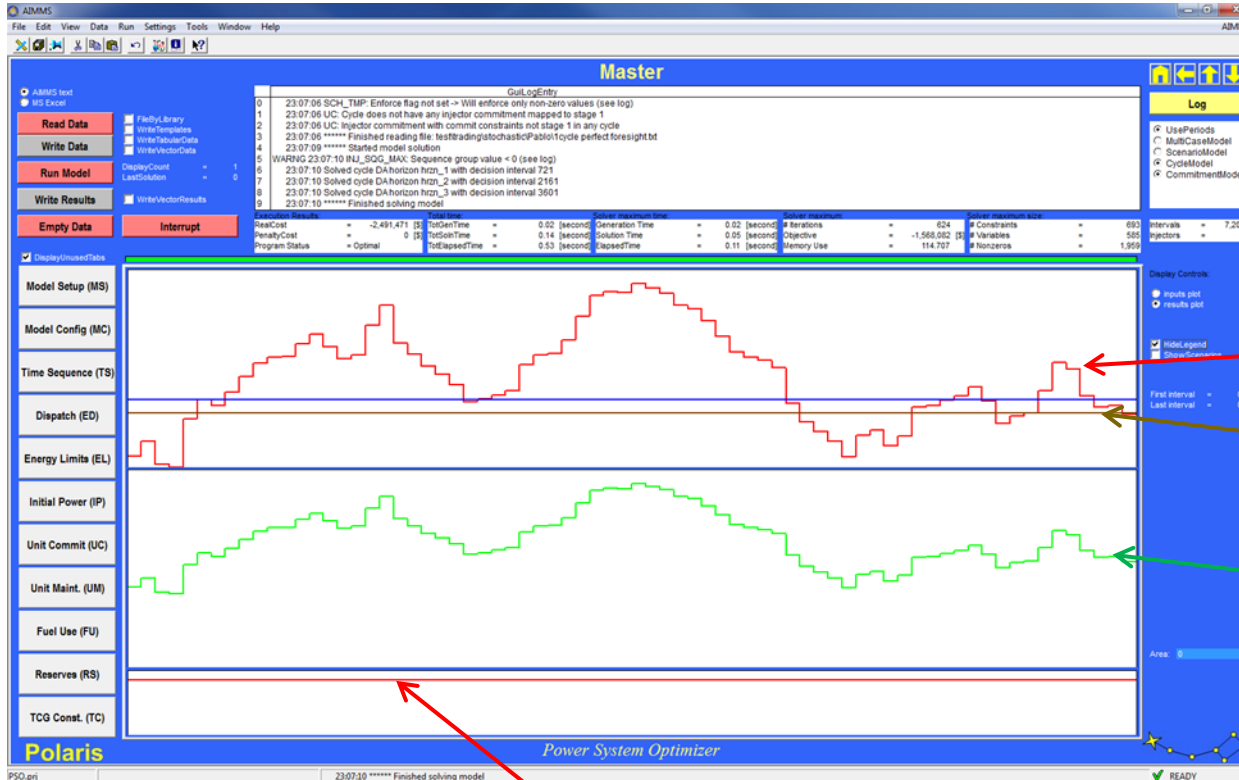
Deviation from Forecast Wind (2)

Forecast Wind (1)

Realized Wind (3)
(3) = (1) + (2) above

3-unit Example: Perfect Foresight Deterministic Approach

Day-Ahead Results (Financial commitment to sell in Day-Ahead Market)



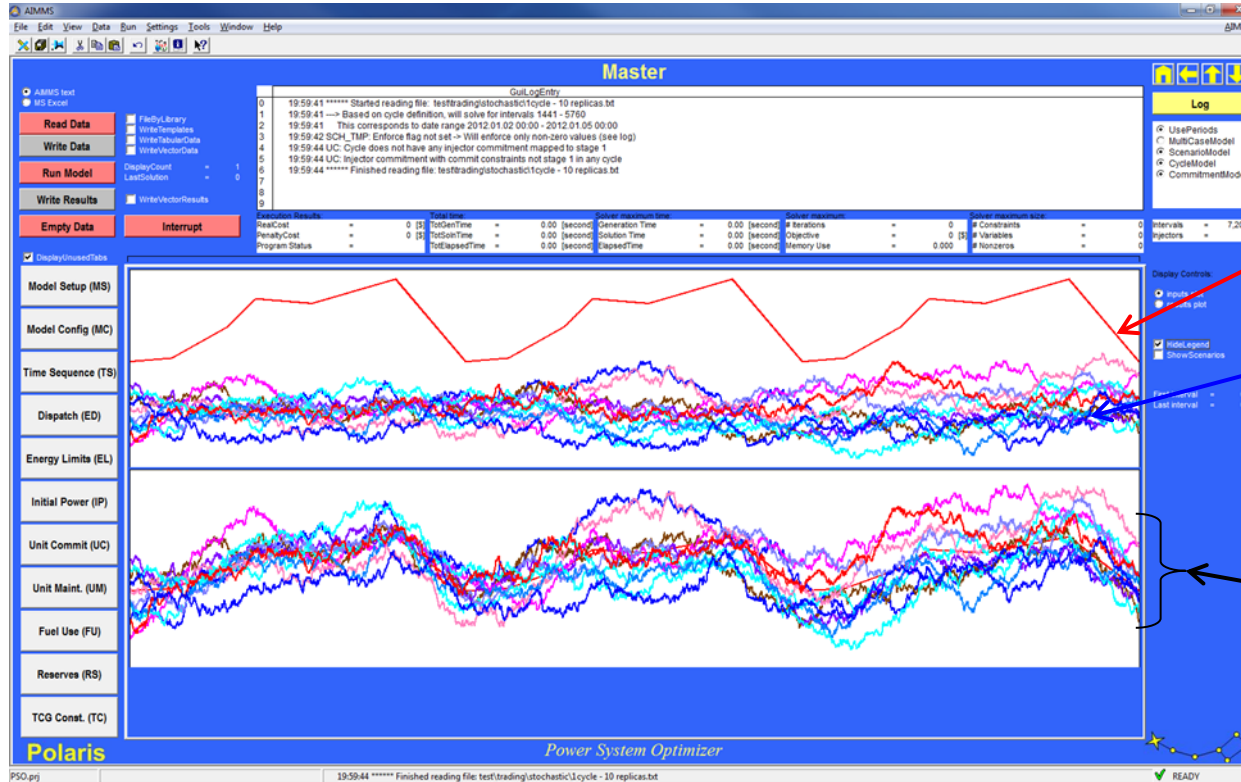
Anticipated Wind

Gas 2 generation held back to secure 50MW of 10 Min OR.

Total quantity sold Day-Ahead.

Anticipated to be a price taker in the market (\$60/MWh).

3-unit Example: Forecast Uncertainty



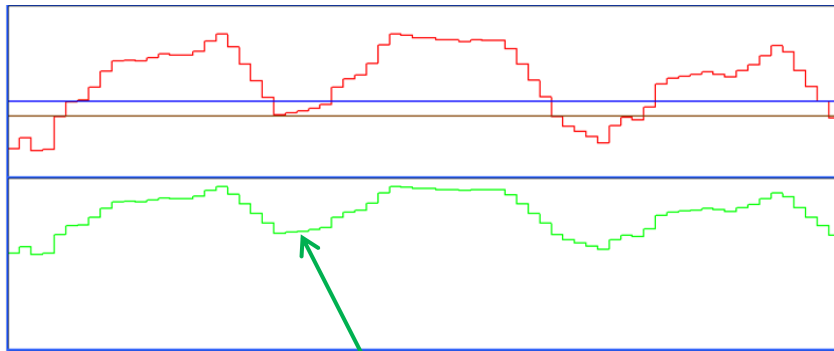
Forecast Wind (1)

Sample deviations from Forecast Wind (2)

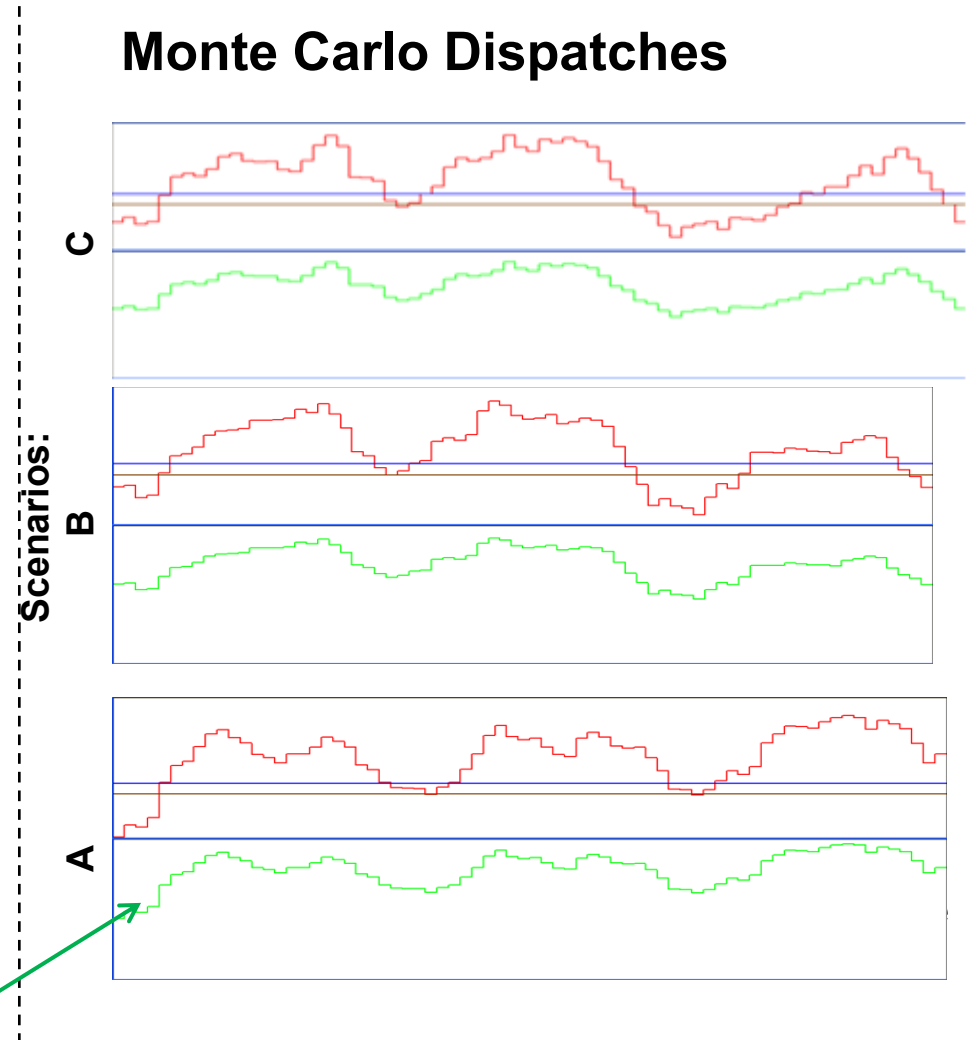
Sample wind realizations

3-unit Example: Deterministic Monte Carlo Approach

Dispatch with Forecast

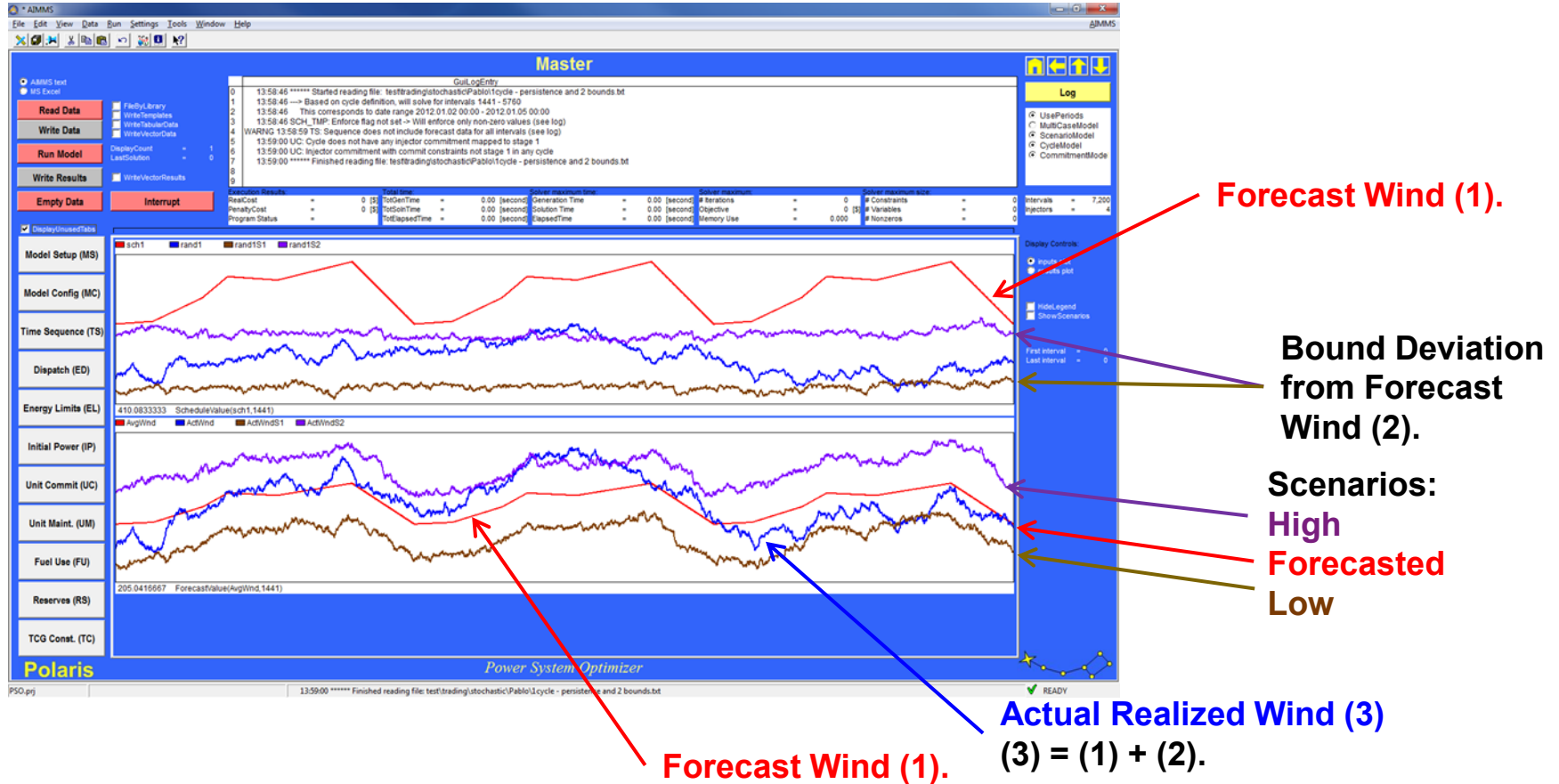


Monte Carlo Dispatches



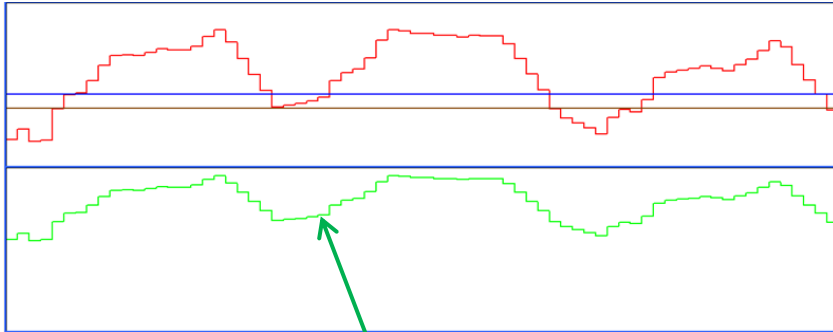
3-unit Example: Uncertainty Bound Scenarios

Wind forecast uncertainty bounds to introduce caution in the dispatch solution



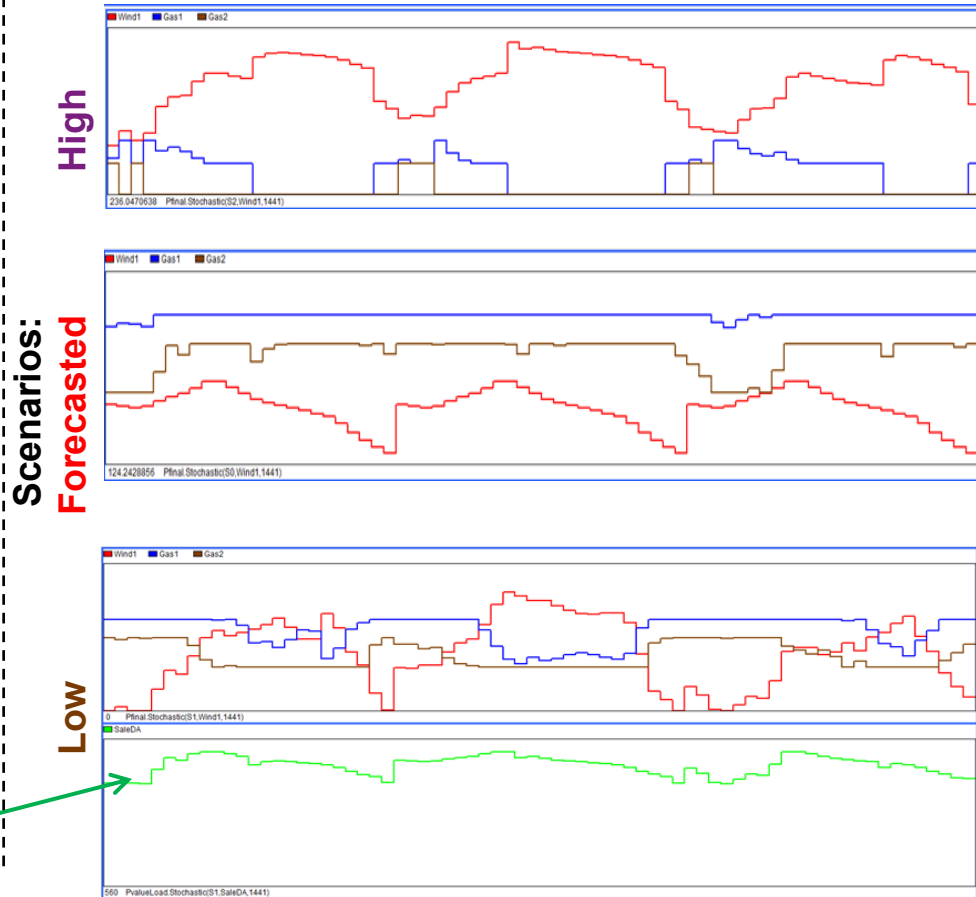
3-unit Example: A Probabilistic Dispatch Approach

Dispatch with Forecast



Total quantity sold Day-Ahead

Probabilistic Dispatch



Generation schedule varies by Scenario; Quantity sold Day-Ahead is the same

Concluding Remarks

- Current use of forecasts is inconsistent with what forecasts are, and does not extract all the potential forecast value
- Intelligent use of probabilistic forecast information can significantly improve market and system operations
- Technology is ready for some applications
 - Dispatch and commitment of small systems
 - Market participant problems
- Research questions remain
 - Market design
 - System size
 - Scenario selection
 - Ancillary service requirements

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