PO.0119

The Value of Improved Wind Power Forecasting in the Western Interconnection

Anthony Florita, Jie Zhang, Bri-Mathias Hodge
Bri-Mathias.Hodge@nrel.gov

NREL NATIONAL RENEWABLE ENERGY LABORATORY

NREL is a national laboratory of the U. S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Abstract

Wind power forecasting is a necessary and important technology for incorporating wind power into the unit commitment and dispatch process. It is expected to become increasingly important with higher renewable energy penetration rates and progress toward the smart grid. However, while there is a consensus that wind power forecasting can help utility operations with increasing wind power penetration, there is far from a consensus on the economic value of improved forecasts. In this work, the value of improved wind power forecasting is explored in the Western Interconnection of the United States. Expanding on the Western Wind and Solar Integration Phase 2 Study at NREL. Focus is placed on the sensitivities to uncertain wind power forecasts in power systems operation for medium and high-penetration wind scenarios. In particular, uniform and ramp-specific improvement scenarios are considered. A state of the art production cost environment is used to perform the generation and transmission (market) simulation, allowing for the realistic representation of operational dynamics.

Objectives

The outcome of the research will facilitate a better functional understanding between wind forecasting accuracy and power systems operation at various spatial and temporal scales.* Of particular interest are:

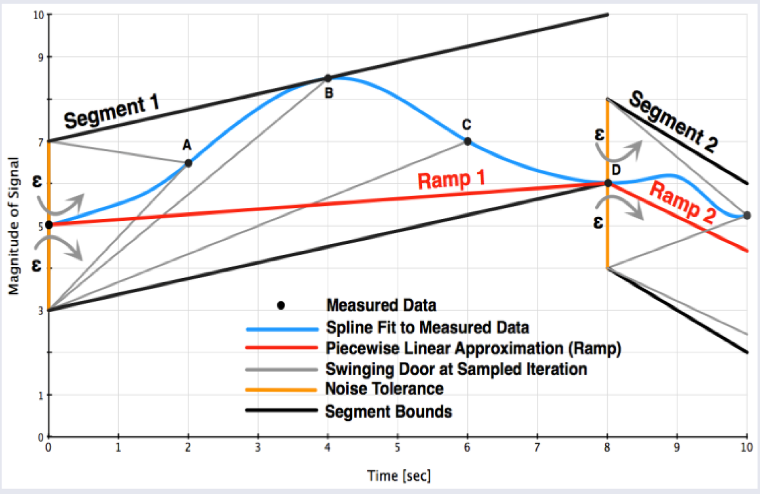
1. correlated behavior among variables (e.g. changes in dispatch stacks, production costs, or generation by type as a function of forecasting accuracy),
2. the relative reduction in wind curtailment with improved forecasting accuracy, and
3. the value of information (e.g. which subset of forecasts provide the most value from a system-wide perspective). Economic savings due to improved unit commitment, re-dispatch, and reserve levels will also be explored.

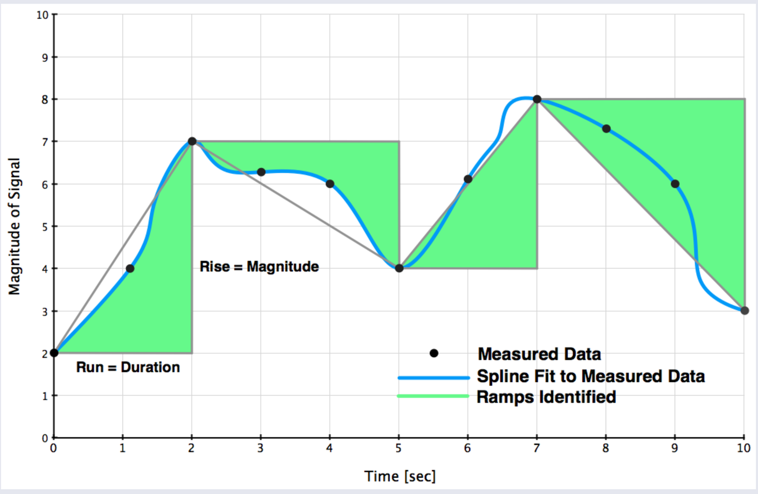
* From ongoing research, a subset of results from mid-term (4HA) forecasting improvements are included here.

Methods

Due to the computational expense required of simulation models of Western Interconnection, including current and future scenarios, a design of experiments (DoE) was performed and output analyzed using response surfaces to assess various sensitivities:

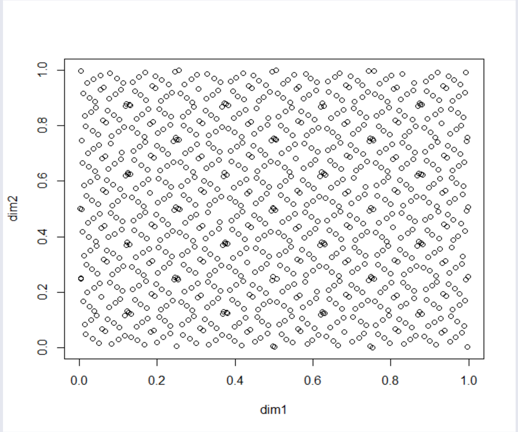
1. Distinguish between ramping and non-ramping time periods using the Swinging Door Algorithm on bus-level (WWSIS-2) wind power production.



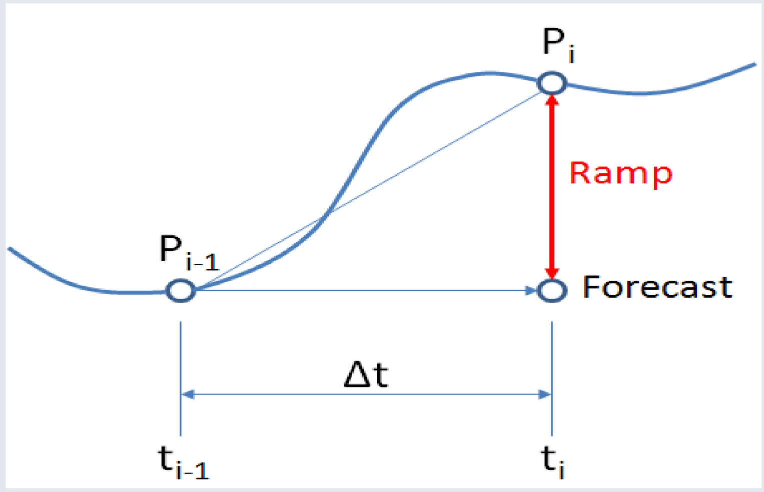


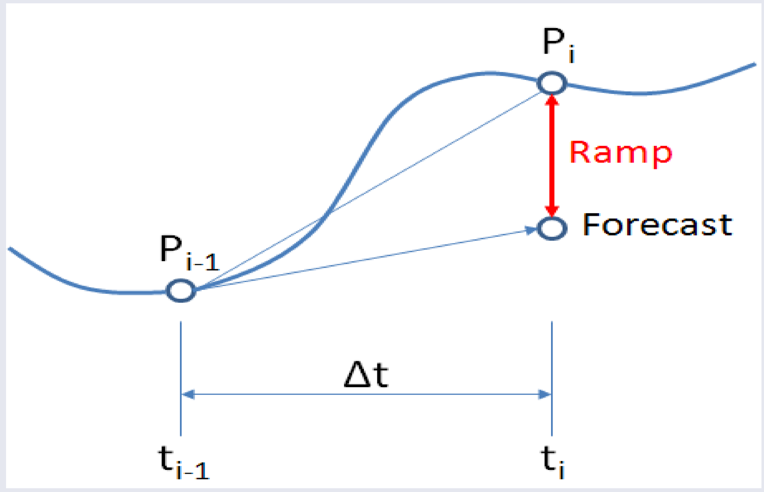
2. Sobol sequences to intelligently explore the space of uniform improvements (0 to 100%)* during non-ramping periods, ramp improvements (0 to 100%)* during ramping periods, and the change of plant output (10 to 30%)* required to define a ramp. All of these wind power forecasting improvements influence system cost and performance.**

*tradeoffs in performance for wind power forecasting within forecast itself.



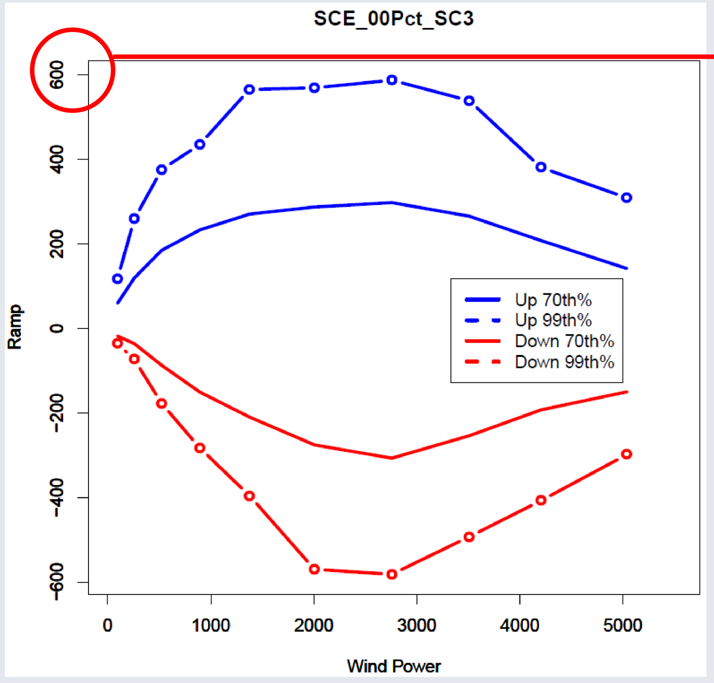
**tradeoffs in the amount of reserves required, production costs, etc. as a function of wind power forecasting improvements.



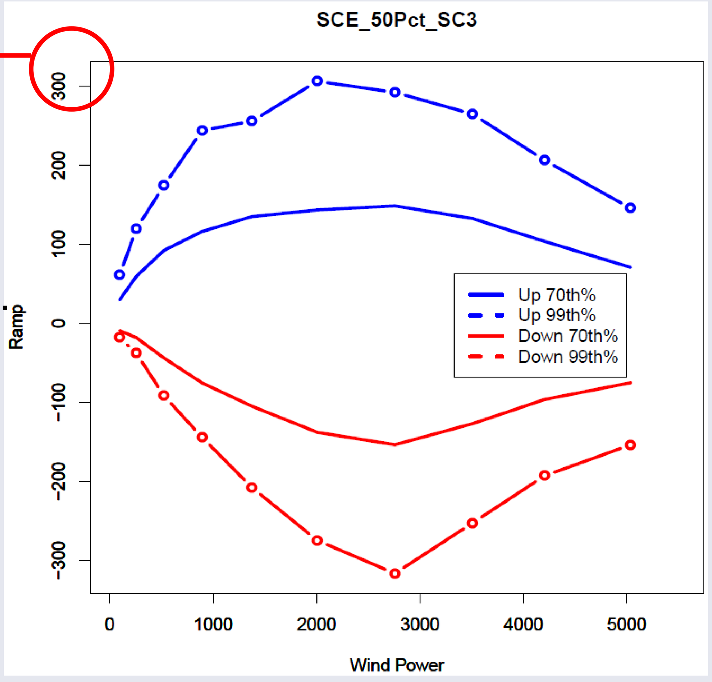


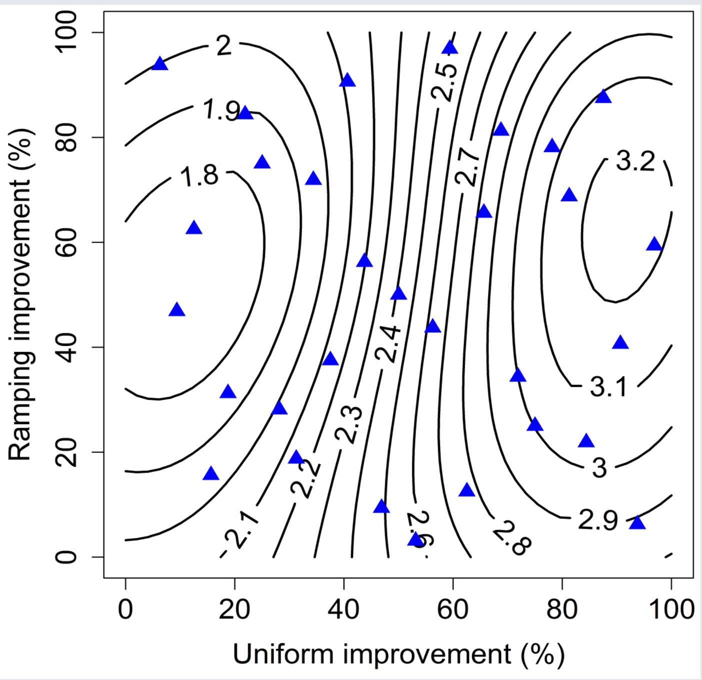
3. Ongoing development of probabilistic models for variables of interest. Temporal and spatial models are currently being compared and contrasted with measured data at scales of interest to market impact.

Results

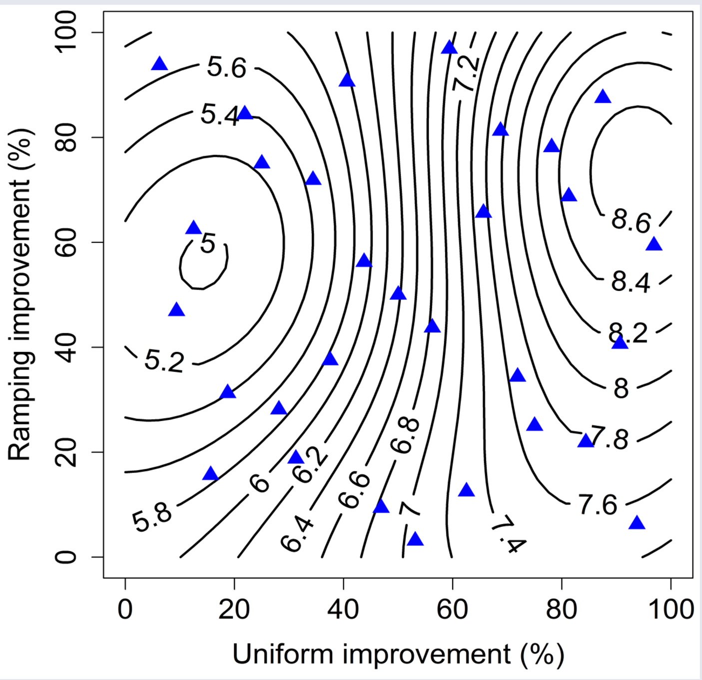


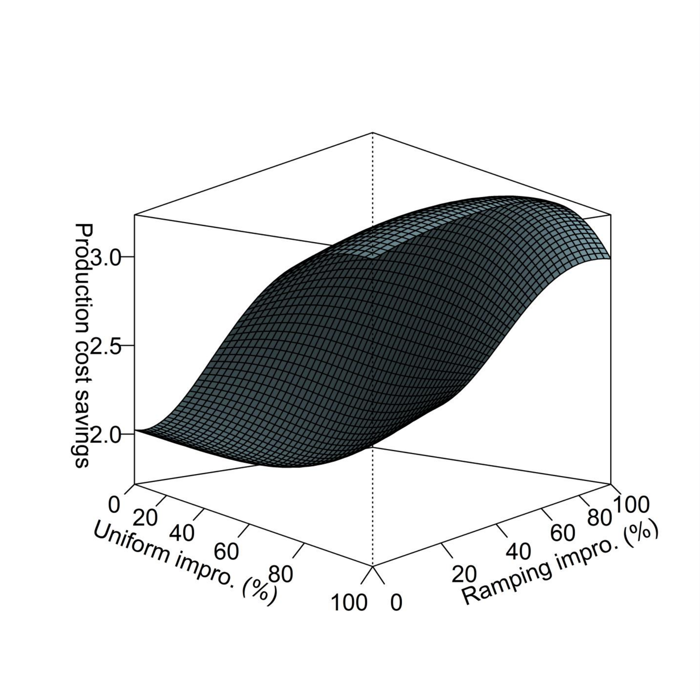
Short-term (~1HA) flexible reserve reductions (e.g. org. and 50% uniform improvement in high wind scenario)



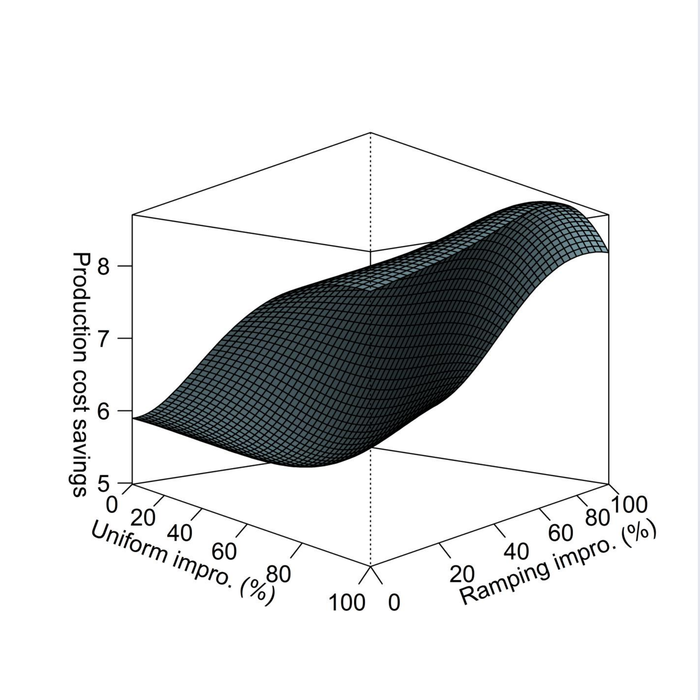


Mid-term (4HA) production cost savings for DoE with support vector regression (e.g. low and high wind scenarios)





Mid-term (4HA) response surface development to infer sensitivities (e.g. low and high wind scenarios)



Conclusions

- For medium-penetration wind scenario: improvements from 0.34% to 3.6% equate to production costs savings of $32.0 Million to $339 Million.
- For high-penetration wind scenario: improvements from 1.7% to 9.7% equate to production costs savings of $198 Million to $1.13 Billion.
- Results follow the adage: "Economics are changed by commitments, reliability is changed by the dispatch."
  - Short-term (1HA) forecast improvements have small impacts on system-wide costs
  - Mid-term (4HA) forecast improvements have moderate impacts on system-wide costs, but wind power forecasting improvements at this timescale can be readily achieved with existing technology.
  - Longer-term (DA) forecast improvements have large impacts on system-wide costs, but wind power forecasting improvements at this timescale are hard to achieve
- The savings from the technology are a strong function of gas prices, thus uncertain in savings from forecasting improvements tracks uncertainty in gas

References

1. Lew, D., Milligan, M., Jordan, G., and R. Piwko, "The Value of Wind Power Forecasting," *Proceedings of the 91st American Meteorological Society Annual Meeting, the 2nd Conference on Weather, Climate, and the New Energy Economy*, 2011, Washington, D.C.
2. Bristol, E., "Swinging door trending: Adaptive trend recording?," *International Standards for Automation, 1990.*
3. Florita, A.R., Hodge, B-M., and K. Orwig, "Identifying Wind and Solar Ramping Events." *Proceedings of the 5th Annual IEEE Green Technologies Conference*, 2013, Denver, CO.
4. Zhang, J., Hodge, B-M., and A.R. Florita, "Joint Probability Distribution and Correlation Analysis of Wind and Solar Power Forecast Errors in the Western Interconnection," *Journal of Energy Engineering*. (accepted for publication)