Wind Power Forecasting, Unit Commitment, and Electricity Market Operations

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***Abstract*—In this paper we discuss the use of wind power forecasting in electricity market operations. In particular, we demonstrate how probabilistic forecasts can contribute to address the uncertainty and variability in wind power. We focus on efficient use of forecasts in the unit commitment problem and discuss potential implications for electricity market operations.**

***Index Terms*—Wind power, probabilistic forecasts, unit commitment, operating reserves, electricity markets.**

I. Introduction

THE rapid expansion of wind power creates new challenges for operators of power systems and electricity markets. Wind power forecasting (WPF) can play a key role in handling the inherent uncertainty and variability in wind power in a cost effective and reliable manner. However, there is still a need for better forecasts geared towards the specific industry needs. Questions also remain regarding how to best make use of the forecasts in market operations, from determination of operating reserve requirements to unit commitment (UC) and dispatch. In this paper we give an overview of the main findings from a research project on WPF and electricity market operations conducted by Argonne National Laboratory in collaboration with INESC Porto.

II. Wind Power Forecasting

WPF models are complex systems that use input data from numerical weather prediction models, local meteorological measurements, SCADA data of wind power output, and terrain characteristics. A combination of physical and statistical models is used to produce forecasts from the very short-term to several days ahead in time. A detailed description of the state-of-the art in WPF is provided in [1].

The complexity in weather and wind to power conversion means that WPF will always entail a significant forecasting error. In general, the error increases with the forecast horizon. The main focus in the WPF industry so far has been on improving the accuracy of point forecasts, but we believe that probabilistic forecasts will become increasingly important as input to operational decisions. Physics-based ensemble simulations [2] and statistical quantile regression [3] are commonly used methods to estimate forecast uncertainty. We are also investigating the use of kernel density estimation for this purpose. Furthermore, we are analyzing different methods for generation of representative wind power scenarios [4] [5] as input to the decision problems in the electricity market.

III. Unit Commitment and Market Operations

The commitment of generating units to provide energy and operating reserves is a key procedure for system operators to ensure that sufficient capacity is available to handle unexpected supply and demand deviations in real-time. In ISO/RTO markets in the United States the system operator runs a centralized UC as part of the market clearing procedure. WPF information could enter the UC process either through the bids from the market participants or directly from the system operator's own forecast [6]. Currently, the market bids are used to clear the day-ahead market, whereas the system operator typically relies on its own forecast for adjustments in unit commitments closer to real-time.

Stochastic UC formulations [7]-[12] are being proposed as a means to reduce operating costs in systems with a high share of wind power generation. We are investigating the use of probabilistic forecasts for this purpose. It is clear that the quality of the WPF is of high importance for the robustness of the resulting commitment decisions. An alternative to a stochastic UC is to use probabilistic WPF to dynamically estimate operating reserve requirements [13]-[15].

In comparing the different commitment approaches it is important to carefully consider the implications for the electricity market. A stochastic UC will commit additional resources in an implicit manner. This may distort prices for energy and reserves, and thereby increase the need for uplift payments for generators to cover their full operating cost. In contrast, the use of dynamic reserves would be better aligned with current market designs which have explicit operating reserve requirements and prices. Furthermore, it is important to consider the frequency of commitment decisions and the overall timeline for bidding and scheduling of resources in the electricity market. In general, moving operational decisions closer to real-time will facilitate the use of better forecasts among market participants as well as the system operator.

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