

A Method for Short-Term Wind Power Prediction With Multiple Observation Points

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Abstract—This paper presents a method to improve the short-term wind power prediction at a given turbine using information from numerical weather prediction and from multiple-observation points, which correspond to the locations of nearby turbines at a particular wind farm site. The prediction of wind power is achieved in two stages; in the first stage wind speed is predicted using our proposed method. In the second stage, the wind speed to output power conversion is accomplished using power curve model. The proposed wind power prediction method is tested using real measurements and NWP data from one of the wind farm sites in Australia. The performance is compared with the persistence and Grey predictor model in terms of Mean Absolute Error and Root Mean Square Error.

Index Terms—Adaptive filtering, networked systems, prediction, renewable energy, wind power.

I. INTRODUCTION

WIND power is undergoing the fastest rate of growth of any form of electricity generation in the world. Wind power provides a clean and cheap opportunity for future power generation, and many countries have set the ambitious goals for wind power development [1]. As wind power technology has become mature, it can now be considered as a valuable supplement to conventional energy sources. However, the drawback is that wind is a highly fluctuating resource. The maximum penetration of wind power in electricity networks is limited by its intermittency. Due to this intermittent nature of wind and built-in uncertainty, the efficient and cost-effective integration of wind power into the electricity grid has become the greatest challenge.

However, this challenge is not insurmountable. An accurate prediction system can make it possible for grid operators to schedule the efficient and economic power generation in order to meet the demand of utility customers [2] and to absorb a large fraction of wind power in electrical systems. Accurate prediction of the wind turbine's power output is useful for generators, schedulers, transmission operators, network managers, and energy traders [3]. Short-term wind power prediction contributes to power system security and stability, and it reduces the reserve demand. It is an important tool for utilities to ensure a favorable trading performance on the electricity markets. The improved prediction ability allows dispatchers to optimize portfolios to

generate higher revenues and decrease costs in various power markets [4]. Accurate and reliable predictions of power generation are of importance to electricity transmission and also essential to competitive renewable energy supply.

Our system for the prediction of wind power is based on measurements from multiple observation points. These measurements are transmitted over communication channels to our designed predictor. In fact, our system is an example of a networked state estimation system. Such systems have attracted a lot of attention in recent years; see, e.g., [5]–[7]. The multiple observation points in our case are the locations of nearby turbines. Our focus is to improve the wind prediction at a given turbine in a wind farm using measurements from nearby turbines and data from numerical weather prediction (NWP) at that wind farm.

In the earlier research, similar type of study was carried out for only one nearby data point, (see, e.g., [8], [9]). Reference [8] focused on wind direction prediction using one nearby observation point while [9] proposed a speed prediction model based on spatial correlation models in one of its sections using data from one long-distance site. However, our study is based on the data from multiple-observation points (i.e., turbines) inside the wind farm, in particular the information from NWP. The objective of this study is to propose a complete wind power prediction system capable of predicting the wind speed, direction, and power simultaneously rather than predicting the individual wind quantities. Furthermore, the prediction of wind power is based on the proposed direction dependent power curves to optimize the maximum wind power production. In addition, the wind power prediction is coupled with the wind speed and direction prediction to combine the benefits of both. The model is flexible enough to incorporate more information from nearby points and can be extended to the entire wind farm.

The prediction of wind power may be considered at different time scales within wind farm operation framework in order to predict the expected generation of power, to avoid any damages to wind turbines, and to improve the efficiency of a wind farm to increase the power production. The objective of this study is to improve the power prediction at 5- and 10-min prediction scales. In particular, 5-min dispatch interval is very important for the Australian national electricity market and also for electricity market operator. However, the effective use of such type of prediction may vary depending on the market structure of the electric power industry [10].

NWP models are generally accepted as an accurate technique for wind power prediction for the long-term prediction scales. These models are area averaged predictions and usually provide wind predictions for a grid of surrounding points around the wind farm with a spatial resolution of a few kilometers. In our case, NWP data is used as a supplement, being an additional

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