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Current status and future advances for wind speed and power forecasting

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A B S T R A C T

This paper presents an overview of existing research on wind speed and power forecasting. It first discusses state-of-the-art wind speed and power forecasting approaches. Then, forecasting accuracy is presented based on variable factors. Finally, potential techniques to improve the accuracy of forecasting models are reviewed. A full survey on all existing models is not presented, but attempts to highlight the most promising body of knowledge concerning wind speed and power forecasting.

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1. Introduction

Wind power is one of the most rapidly growing renewable energy sources, and is regarded as an appealing alternative to conventional power generated from fossil fuel. This led to a collaborative effort to achieve 20% of U.S. electricity supplied from wind power by 2030 [1]. Although the integration of wind power brings many advantages, high penetration of wind power provides a number of challenges in power system operations and planning, mainly due to its uncertain and intermittent nature. In the electricity system the power supply must be equal to the power demand at all times. However, the variation of wind power output makes it difficult to maintain this balance.

One of the possible solutions to the balance challenge is to improve the wind speed and power forecasting. Research in the area of forecasting wind speed or the power produced by wind farms has been devoted to the development of effective and reliable tools and many different approaches have been proposed and reviewed in [2–13]. Accurate forecasting tools reduce operating costs and improve reliability associated with the integration of wind power into the existing electricity supply system [14–29].

There are different users of wind speed and power forecasts. These users not only need point forecasts but also the uncertainty of the forecast is essential for determining the size of the operating reserves necessary to balance the generation with load. For the market operator, the forecast of the total wind power production in a region is needed more than the individual wind plant forecast. For the system planner, it is essential to plan the installation of new wind turbines. The desired forecasting capabilities typically vary among user groups. This paper divides the forecasting methods into five categories: wind speed and power forecasting, spatial correlation forecasting, regional forecasting, probabilistic forecasting, and offshore forecasting.

A large amount of research has been directed toward the development of accurate and reliable wind speed and power forecasting models and many different approaches have been developed. However it is difficult to draw conclusions as to which model is the best because each model in use has significant site dependencies. Thus, a forecasting model may perform well at its site, but this does not guarantee that the model will work well at another site. This paper discusses forecasting accuracy based on variable factors that are used in the forecast.

Furthermore, several potential techniques for improving forecasting accuracy have been reported in the literature. These are also discussed and reviewed in this paper.

The paper is organized as follows. Section 2 presents an overview of existing wind speed and power forecasting approaches. In Section 3, the general forecasting accuracy is discussed. Some of the potential techniques to improve the performance of forecasting models are presented in Section 4. Finally, conclusions and future works are drawn in Section 5.

2. Overview of current wind speed and power forecasting

2.1. Wind speed and power forecasting

The basic role of wind speed and power forecasting is to provide information about the wind speed and power that can be expected in the next few minutes, hours, or days. Based on power system operation requirements, the forecast can be divided into four different horizons: very short-term (few seconds to 30 min), short-term (30 min to 6 h), medium-term (6–24 h), and long-term (1–7 days) [10,11]. Very short-term forecasts are used for turbine control and load tracking. Short-term forecasts are utilized for preload sharing. Medium-term forecasts are used for power system management and energy trading. Long-term forecast are used for maintenance scheduling of the wind turbines.

Research in the area of forecasting wind speed and the power produced by wind farms has been devoted to the development of effective and reliable tools and many different approaches have been proposed. These tools can be classified whether the terrain information at the location is used as an input or not. Two mainstream approaches are the physical and the statistical approach. In some models a combination approach is used in an attempt to integrate the advantages of both approaches. In this section an overview of existing wind speed and power forecast approaches is presented.

2.1.1. Physical forecasting approach

The physical approach to forecasting, in contrast to statistical approach, uses the detailed physical description to model the on-site conditions at the location of the wind farm [7,30]. The basic operation of a physical approach is illustrated in Fig. 1.

It carries out the refinement of the Numerical Weather Prediction (NWP) data to take into account the on-site conditions by the downscaling method, which are based on the physics of the lower atmospheric boundary layer. The downscaling method requires the detailed physical descriptions of the wind farms and their surroundings, including: description of the wind farm (wind farm layout and wind turbine power curve, etc.) and description of the terrain (orography, roughness, obstacles, etc.). Then, the refined wind speed data at the hub height of the wind turbines is plugged into the corresponding wind power curve to calculate the wind power production. If the on-line data is available, model output statistics are performed to reduce the error of the forecast. Contrary to the statistical approach, the physical approach does