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Application of a control algorithm for wind speed prediction and active power generation

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Abstract

The main objective of the work described in this paper is to offer a new method of prediction of wind speeds, whilst aware that the method develops predictions in time-scales that can vary from a few minutes to an hour. This is needed because wind energy generation is increasing its participation in energy distribution and has to compete with other energy sources that are not so variable in terms of generated active power. It is important to consider that active power demand can vary quite rapidly and different sources of electricity generation must be available. In the case of wind energy, wind speed predictions are an important tool to help producers make the best decisions when selling the energy produced. These decisions are crucial in the electricity market, because of the economic benefits for producers and consequently their profitability, depends on them. The algorithm presented in this paper is based on an artificial neural network and two types of wind data have been used to test the algorithm. In the first, data was collected from a not very windy area; in the second data was collected from a real wind farm located in Navarre (North of Spain), and the values vary from very low to high speeds. Although the algorithm was not tested with typical wind speed values measured on offshore wind farm applications, it can be concluded from the first set of results presented in this paper that the algorithm is valid for estimating average speed values. Finally, a generic algorithm for the active power generation of a wind farm is presented.

Keywords: Short-time wind power forecasting; Prediction algorithm; Artificial neural network; Wind power generation; Doubly fed induction machine

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1. Introduction

Recently there has been a growing trend towards the production of wind energy and as a result new problems in the field of energy management and operation have appeared on the electricity market. Thus, one of the most important facts of wind energy production is related to the non-predictable wind speed.

Taking into account this fact and also that wind is a result of solar radiation it is important to consider the heating of the air that occurs due to radiation. As the Earth surface is not heated uniformly (the heating effect depends on the latitude), pressure differences occur in the atmosphere and the air flux tries to balance them out, causing the movement of important air mass—the wind.

Based on this principle, several wind farms have been built with hundreds of kW installed. Wind is considered as one of the most difficult meteorological phenomena to be predicted and so in general any benefits obtained from wind farms are not optimum. Therefore, the use of statistical methods for reliable predictions (with errors maintained between pre-defined limits) becomes necessary, enabling the wind speed in the near future (a few hours) to be more accurately predictable and the efficiency of the wind farm improved.

On the other hand, the geographical location of wind farms is another fundamental question. Because wind energy is disperse, intermittent and not regular in terms of the amount of generated power it is important to consider that when a 'good location' is identified and used, a generator can work 6000 h per year and the amount of energy produced can be similar to the energy produced by a generator working at full power for 2200 h per year. Therefore, before a wind farm is built the local wind conditions must be evaluated exactly and the predictions analysed.

2. Problem description

The study described in this paper develops a simple and robust algorithm that describes short-term wind power forecasting. At the moment in Spain, a large amount of energy is produced by hydro-electric plants but to meet the overall electricity needs the electric companies have to compensate the fluctuations in demand with other types of energy production. As wind energy varies during day time depending on the wind speed hitting the generator blades, the possibility of predicting wind energy production in the following hour becomes crucial for wind farm owners in order to work efficiently on the electricity market. These predictions will help producers take decisions for the sale of energy and thus to increase production and profits.

If an accurate prediction of the wind speed for the following hour can be evaluated, the total amount of active power that can be produced by each generator on a wind farm can be determined and therefore, the amount of energy that could be sold during the next hour would be known too.

In order to analyse the amount of energy that is going to be produced by a generator (produced active power), the wind speed prediction and some aero-dynamical test results of the generator are needed. So, it is important to consider the mechanical power, P_m,