Improving the operation and maintenance of wind farms: determination of wind turbine performance

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Abstract:

To improve the economic and technical wind farm operation is necessary an accurate determination of wind turbine performance. To do so it is necessary to estimate the unavailability and the efficiency of each wind turbine.

The first step consists in filtering the data set of the period to be studied. Two data sets are obtained, a first set where all data corresponds to time periods in which the wind turbines have worked properly, and the rest of data correspond to periods in which the WT have had some problems, and have to stop during part of the time.

The second set is useful to get the unavailability measured both in time and power, and the first one to get the efficiency.

In both cases a model to get the relationship between power and wind speed is needed. The CIRCE's AIRE (Renewable Energy Integral Analysis) group is working in automatic methods for filtering wrong data and characterizing the wind turbine behaviour.

Key words

Wind energy, power curve, power performance, data filtering, robust filtering

1. Introduction

The cost effective operation and maintenance of wind farms requires accurate and informed condition monitoring of the wind turbines. For the latest wind turbines, e.g. >700kW, there is limited data available to assess the long-term power performance of these machines. In addition, in Spain there are concerns in relation to the long-term operation in sites with highly complex terrain and high levels of turbulence intensity.

To assess the performance of a wind turbine two parameters have to be studied: unavailability and efficiency.

The unavailability can be measured both in time and in power. The first one is quite easy to get having the SCADA records, but in the second case it is necessary a production model in order to estimate the power losses.

To get the efficiency of a wind turbine the relationship between the wind mean speed taken either at the meteorological mast or at the nacelle and the power generated by each wind turbine must be found. So in both cases it is necessary to get a production model that relates power and wind speed.

But the best method to do this is not clear. There are some factors that complicate this relationship:

1. The time delay in the wind speed propagation and how this affects the correlation between mast and turbine wind speed;
2. The topography of the wind farm site;
3. The presence of nearby obstacles.

In the case that the wind speed at the meteorological mast is considered, and the turbulence produced by the turbine and the nearby turbines taking the measures at the nacelle.

Experience have shown that real measurements are prone to wrong data, being essential to have some sort of data check to protect the models against the influence of erroneous measurements. There are lots of possible circumstances that may affect the data quality:

- Sensor accuracy
- EMI
- Information processing errors
- Storage faults
- Faults in the communication systems
- Alarms in the wind turbine
- etc

Some of them introduce an error component in the data value. Others make the data disappear, and, depending on the measurement system, the data is replaced by top or bottom values. It is not usual to find a huge amount of wrong data, but they exist and they could affect seriously the results of either a modelling process or a wind resource assessment.

2. The need of filtering

Focussing the problem in wind power characterization, the most important data to consider are:

- Wind speed
- Power production

Wind speed can be affected by shade effect due to the presence of some obstacles. This effect makes the wind speed to decrease. In figure 1 it can be observed this phenomenon clearly (data in zone 1). Considering the power production, if the value of a power data is the mean value of the power produced during ten minutes by a wind turbine, it must be assured that the wind turbine has worked properly during those ten minutes. In other case, the data doesn't represent the normal working of the turbine (figure 1, data in zone 2). Sometimes, the effect of the different problems is not so clear. In Figure 1, data in zone 3 and zone 4 are probably bad, but this cannot be assured without considering more information.

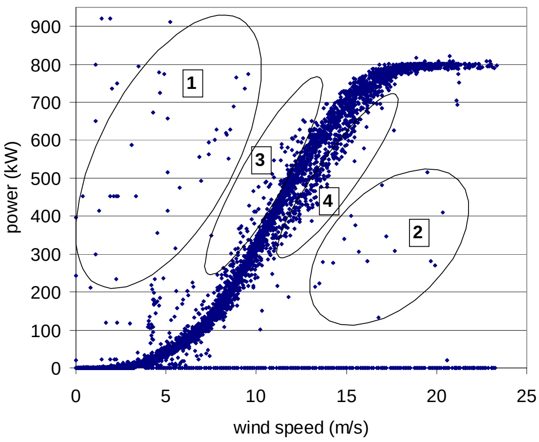

Figure 1: Original set of data considered

3. The determination of the WT performance process

The process to analyze the performance of a WT is the following:

1. Data filtering: to set of data are got, the wrong data are used to analyze the unavailability and the right ones to get the efficiency (or the model if historical data are considered)
2. Analyzing the unavailability: getting the percentage of time that the WT has been working right and getting the power losses (that implies the need of a P-v model)
3. Analyzing the efficiency: by comparing the production of the period to be analyzed with the theoretical production got from the P-v model

To do these tasks automatically some needs arise: getting an automatic filtering technique and getting a P-v model.

4. The filtering techniques

It can be thought that the problem of data power quality can be solved accurately. There are alarm records in the SCADA system of the wind farms. But usually this records don't exist for the whole period to be treated and other times it cannot be assured the accuracy of the alarms recorded.

In figure 2 it can be observed that some data en zones 1 and 2 have been not well filtered. So, despite of considering the alarms register some wrong data still remain.

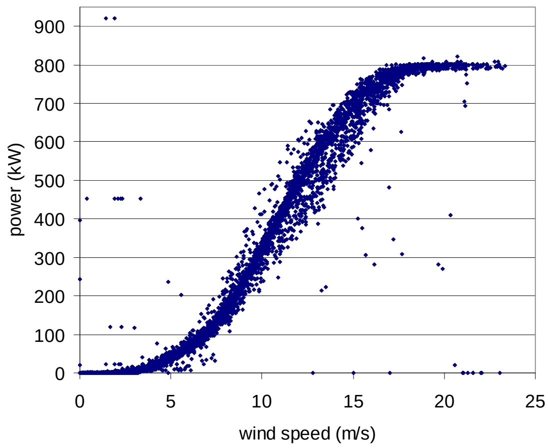

Figure 2: Data set after filtering those affected by the alarms recorded at the SCADA system

There are a huge amount of data filtering techniques, but their application in wind systems it is not well referenced. Moreover, data coming from wind systems are not common, i.e. the changes in the mean values of the wind speed are not easily characterized and this is reflected in the power data so the filtering of that data is not obvious, therefore, most people in the wind sector filter the data manually.

CIRCE's AIRE group is working in a method to filter wind data using the Least Median of Squares (LMedS) method. It allows detecting and rejecting bad measures simultaneously to the wind power curve estimation, working in a robust way. We validate the robust method for power curve characterization in real scenarios, comparing it with other methods. We use crude data of power generation and wind speed, where spurious measurements are plentiful. The results are tested using real data from wind farms in the Ebro valley in Spain.

5. Modelling the P-v relationship

Several studies have been carried out on this topic using Neural Network Techniques. These studies compare the use of NNs with relatively simple stochastic methods and conclude that the NN approach is superior, however, the stochastic methods chosen are overly simplistic.

In order to have a clearer model different stochastic methods that can be used to solve the problem are reviewed (bin method and polynomial regression). And, some modifications to all of them are proposed to get more accuracy.