Monitoring the Performance of a Wind Farm Production

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Abstract:

Up until now little has been done in order to establish robust methodologies for the diagnosis of wind farm performance. Problems as simple as equipment malfunction, power curve depreciation, inefficient pitch and yaw control, among others, are often dealt as they appear, if noticed at all. The wind energy logistics of a common SCADA, and wind meteorology data from monitoring stations, can provide important and enlighten information, if analyzed carefully.

The study presented in this paper intends to investigate if simple but solid relations between basic operation parameters (like power production, wind speed and directions, etc…) could establish, by means of parametrical tests, a reliable basis to diagnose wind farm performance. The first approach is to find reference scenarios that could trace, at all times, the wind farm expected response, and then follow the occurrence of changes or trends on those scenarios, and, therefore, in the wind farm's behaviour.

A tracing of parametric relations to be investigated is given here. The general layout of the following steps in this study is presented, as well as the means on which it will be tested.

In addition, working with data from wind farm SCADA gives rise to several serious difficulties which analysts should anticipate. The author was no exception, and a set of the most common problems that can be encountered is also listed here, from personal experience.

Firstly rough results from the analysis based on real wind farm data are presented, only as an example.

Following developments of this work should allow the design of an interesting and userfriendly tool to continuously examine wind farm performance, evaluate warranty fulfilment, and plan for future enhancements on wind farm production, among other issues.

Keywords: Wind farm performance, SCADA, wind farm monitoring.

Introduction

Monitoring wind farm performance in order to improve its effectiveness is always an attractive challenge. The primary means of checking a wind farm's operational conditions, is to thoroughly analyse data that is provided by the SCADA system.

Relationships between power output of different turbines in a wind farm, nacelle orientation and wind speed, between wind speed and power output (that is the regular power curve), and other comparisons should demonstrate a tendency to remain constant within a certain period of analysis. These steady relationships can be referred to as reference scenarios that represent the plant expected behaviour, and therefore, that are expected to occur during normal operation.

Changes or trends in the predefined reference scenarios are bound to represent changes in the wind farm performance, and thus can help the operator to anticipate decisions and possible intervention.

The main problem in initiating this kind of analysis resides in the fact that the SCADA records often contain inconsistencies. Their use needs prior analysis and validation. Adding to this, studying a large amount of records results in a long process before any results can be obtained.

The methodology described in this paper was tested on two real wind farms. The results obtained are discussed, and future developments suggested.

Methodology

The task plan for the development of this study is as follows:

a) Study of tested wind farm operation and maintenance history;

b) Wind farm processing, “data mining” and consistency check;

c) Analysis of filtered data and application of proposed parametric relations;

d) Identification of consistent reference scenarios, patterns or indexes;

e) Study of the performance indicators through their variation throughout the wind farm operation history. Identification of significant changes or trends and proposed justifications with real causes.

The analyzed data set (7 years) is from two wind farms in operation located in Portugal. One of them comprises 17 wind turbines of 600 kW each, making a total of 10.2 MW of installed capacity. The other comprises 20 wind turbines with name-plate rating of 500 kW making a total of 10 MW of installed power. Both of the wind farms have two monitoring towers;

The proposed methodology to evaluate the wind farm power performance is based on strong relations between wind farm operating parameters.

The analysis will be based on three major groups: i) relations between monitoring towers and wind turbines, ii) relations between wind turbines and iii) relations between monitoring towers.

Figure 1 shows a schematic representation of the mentioned relations and major variables to be studied.

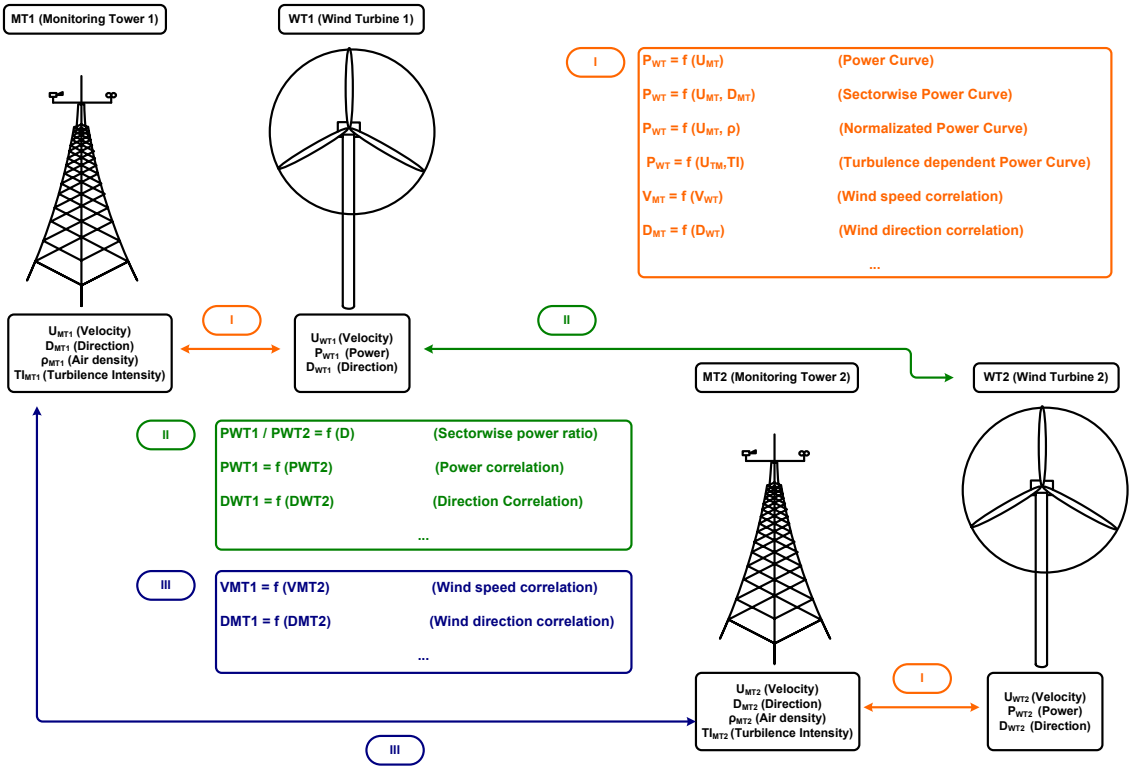

Figure 1 – Schematic representation of the proposed methodology

All of these relations are basic in principle. The difficulty resides in handling the non – linearity and discontinuities of wind turbine operation in order to obtain a clean and constant reference scenario from a mainly scattered correlation.

First results

Unexpectedly, wind farm SCADA is not always a simple and reliable way to understand the plants operation. Several problems related to the consistency and clearness of data can be found and must be overcome before any analysis can be started.

Some of the major faults usually found are:

- Non-concurrent files;
- Absence of a maintenance log;
- Inconsistency of the wind turbines operation status records;
- Inconstant acquisition rate;
- Out-of-range records.

Some preliminary analyses are presented here. The case study is that of two neighbouring wind turbines of a wind farm composed of 17 600 kW machines.

Figure 2 shows the cross plotting of the power output of two neighbouring wind turbines. The data corresponds to total operation range and previously filtered for inconsistency and errors, although non–running periods are still present.

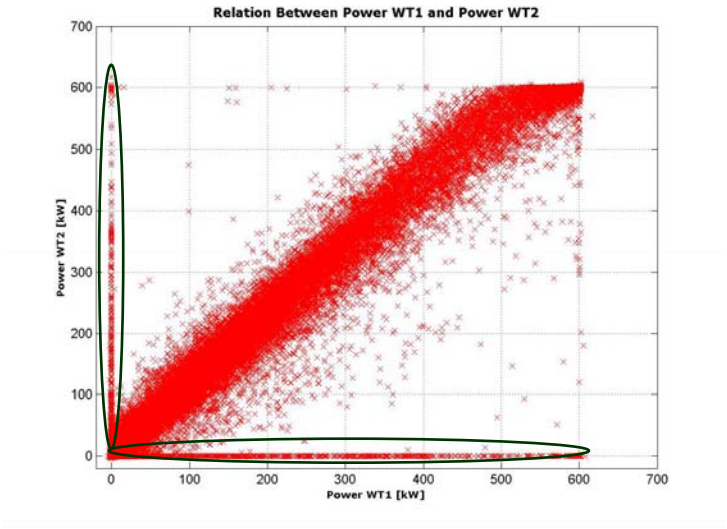

Figure 2 – Power cross correlation between two neighbouring wind turbines

A good correlation between the production of the two turbines is already identified. Still, the non–running periods of data and the upper and lower boundaries of the operating range (in the cut–in and cut–out region) can be excluded for a more reliable relation. Figure 3 presents the cross plot obtained in this way. A proposed linear pattern for this power correlation is shown in figure 4.

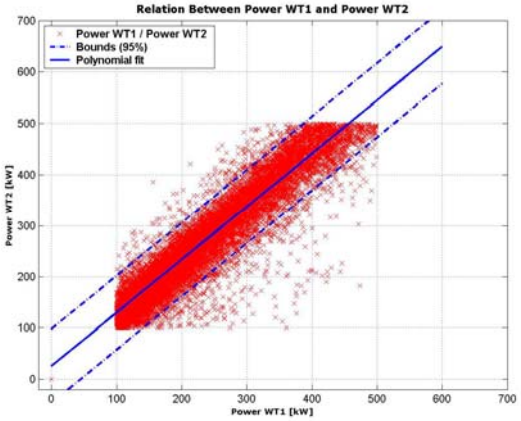

Figure 3-Filtered power correlation cross plot

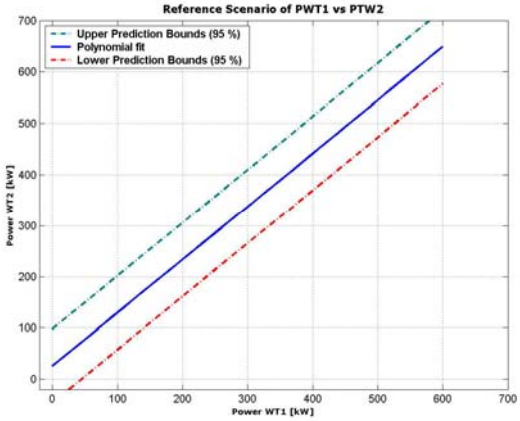

Figure 4-Pattern for the filtered power correlation

Aiming to understand the behaviour of both wind turbines as a function of the direction of the incoming wind, a relation between its power ratio and the wind direction was investigated

The following figures show this sectorwise power ratio. Once again figure 5 shows all the data set.

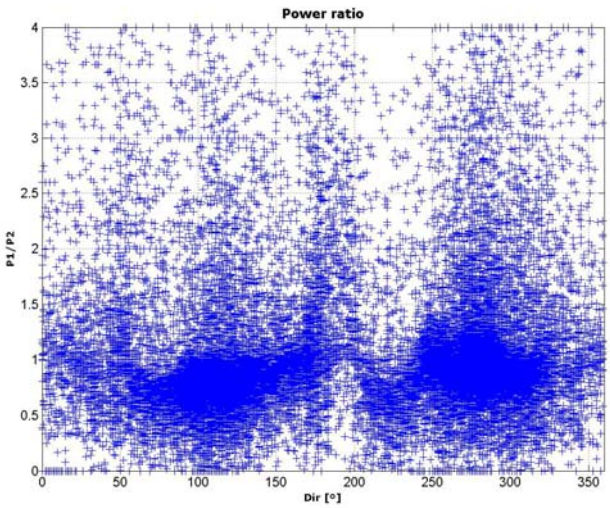

Figure 5- Sectorwise power ratio.

In figure 6 the data was filtered from non–running periods and limited operation range, and in figure 7 a proposed pattern for the sectorwise power ratio is finally presented.

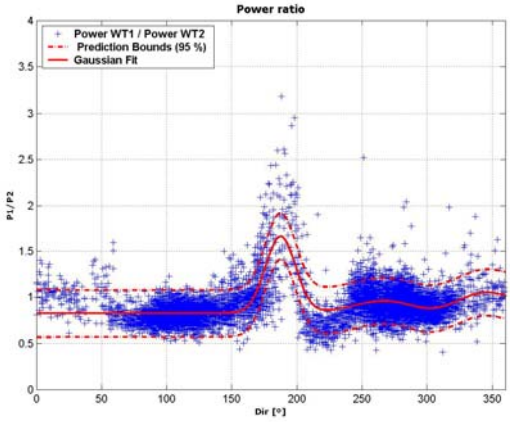

Figure 6 – Plot of filtered sectorwise power ratio

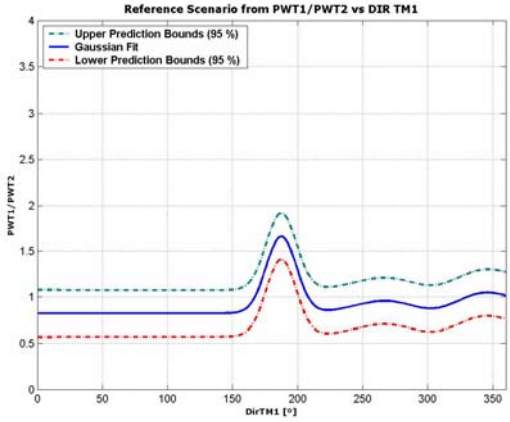

Figure 7 – Pattern for the filtered sectorwise power ratio

Final remarks

Simple parametrical relations can help to monitor the performance of a wind farm on a continuous basis. By following changes or trends in reference patterns one can be alerted to changes in the wind farm's behaviour.

A methodology for this purpose is proposed in this paper and the author as presented a plan for its test an implementation.

Some examples of analysis were already presented and typical difficulties which arise from this kind of studies were also discussed.

References

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