Optimising flow of maintenance information to boost turbine efficiency

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ABSTRACT

Reliability based maintenance enables significant reduction of maintenance cost in combination with improved availability. For the accomplishment of this strategy appropriate failure statistics are required. The generation of a common database provided by a large group of operators will, due to its size, enable statistically reliable predictions concerning the success of operational concepts. Furthermore, based on anonymous benchmarking and weak-point analyses, operators have the opportunity to test and, if necessary, optimise maintenance procedures and the performance of their wind farms. However, the common way documenting faults and maintenance activities is currently not suitable for standardised and automated evaluations.

Keywords: Wind turbine, reliability, availability, failure rate, maintenance strategy, database, reliability based maintenance

I. BACKGROUND

Maintenance of wind turbines is currently being planned and carried out mainly to statutory requirements and rough guidelines from manufacturers. Unplanned maintenance measures due to sudden, not recognized malfunction of components can cause serious economic losses especially offshore. It is obvious that reliability of WTs and subassemblies needs to get improved. Otherwise, availability, especially for offshore application, will not reach suitable results [1, 2, 3]. However, the current maintenance organisation is still dominated by unplanned and corrective measures and should be shifted to more preventive measures in the near future.

A detailed documentation of all maintenance measures of a large population of plants and a purposeful structured database are necessary to extract sound conclusions out of operational experience. Out of a well structured and detailed data collection general extensible methods for the comparison of maintenance strategies on basis of reliability indices and cost items can be developed.

The Goal of optimised maintenance should be to improve the ratio of unplanned to planned measures. The development shows that more and more independent service companies tackle the market and especially offshore large operators (e.g. utility companies) are aiming at organizing their service and maintenance themselves to have better understanding about their cost drivers as well as hands on their revenue.

II. MAINTENANCE ORGANISATION

The increasing future demands on reliability and profitability of wind energy use, and thereby the quality of maintenance, require an appropriate and sufficient data management. The necessity of gathering more and especially more detailed data, while reducing maintenance effort should be the long-term goal.
Necessary steps have to be introduced for operation and maintenance of wind turbines to bring available knowledge together and to use experience for improvements. At this point, information coming from databases, statistical methods as well as sound statements are needful.
For this purpose, however, it is necessary to acquire a lot of information at different locations. This is possible only through a semi-automated and highly simplified data management.

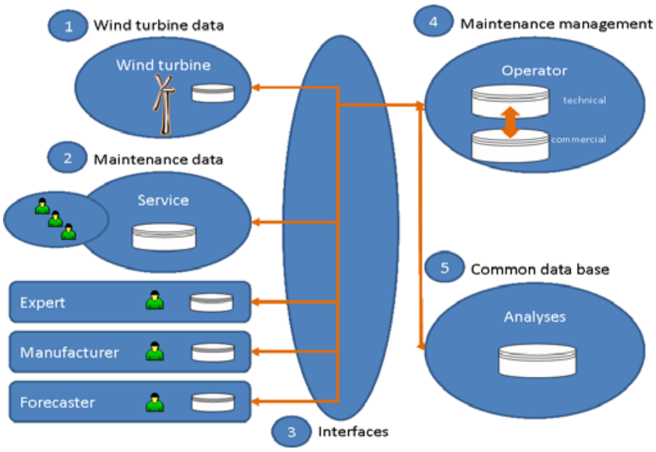

Figure 1: Data flow of different players in maintenance processes

A. Wind turbine data

Nowadays operating or in-service data are already recorded from SCADA systems and are automatically transferred to the operating company. Besides external conditions (e.g. wind and power time series), operational data including working life characteristics has to be recorded and stored. The continuous turbine status differs strongly from turbine type to turbine type, but is necessary to record especially in connection with occurrence of events. In the majority of cases while the turbine status changes the turbine stays in operation (Fig. 2 upper graph). Parallel, all time series (operational and external) are recorded in 5 min. intervals and additionally for every status change (Fig. 2 lower graph).

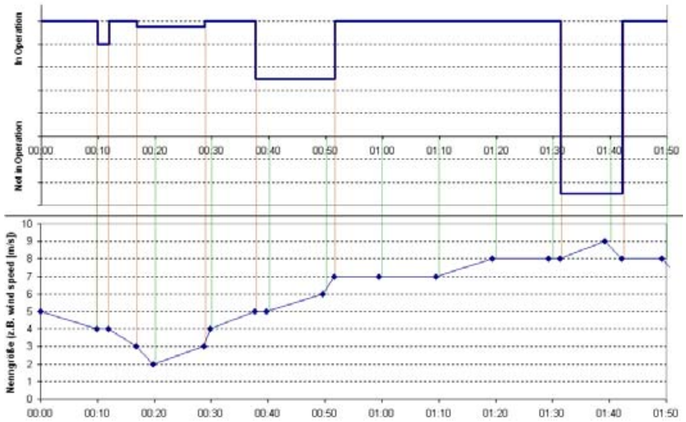

Figure 2: Combination of turbine status and operational condition

B. Maintenance data

As discussed before, data from the control system are more or less self-generated time series, whereas many relevant maintenance data generated by service personnel or experts are not in digital form for the moment.
So far, these data is at least for operators limited, mostly as written reports from manufacturers or service companies briefly described, with encoded description. The reports are usually not detailed enough and without any failure analysis. A consequence of this lack of structure is the difficulty to carry out an optimised maintenance, since the necessary information is collected insufficient. It is therefore essential to pursue a standardized form of data. The biggest challenges are systematic collection of data, uniform description of sub-assemblies and description of operating conditions, malfunctions and failures equally.
All conditions of the wind turbine and actual states respectively must therefore be documented uniform. The data set shall record items like date and time of occurrence, time of restart, all efforts, as well as a set of attributes describing all kind of events.
Gathering all these data will cause some additional effort, but there are possibilities of electronic aid, which not only enables the service staff noting attributes, but also helps finding appropriate descriptions by offering lists of standardized items (List of Values). Current work is aiming at adapting an existing designation system for event attributes from VGB PowerTech (EMS – Ereignis-Merkmal-Schlüsselsystem) to the necessities of wind energy use [4]. The set consists of items like type of event, failure cause, failure mechanism, failure pattern etc.
To overcome the increasing effort, new IT technologies need to support data collection and maintenance work respectively. Electronic support for digital designation of sub-assemblies (Reference Designation System for Power Plants' (RDS-PP) [5]) per barcode or Radio Frequency Identification (RFID) is indispensable, so that the identification of sub-assemblies with further important core data can be read in. For description of

inspection results and failures, software should provide certain List of Values in accordance with above mentioned guideline.

C. Interfaces

Due to numerous players in the maintenance process of wind turbines, a coordination of different modules by suitable interfaces and communication protocols is a basic requirement. Because of the large amount of data to be processed in future, a largely automated data transfer has to be realised. These challenges are solved with the help of so-called middleware. In the given case, Web services take the role of middleware. The transport protocol for this broadcast is the SOAP (Simple Object Access Protocol). This is based on well known standards such as XML (for the representation of the data) and Internet protocol IP for the transport layer TCP (TCP/IP) (to transfer the data). The contents of the SOAP document itself are subject of a separate working group within the 'Foerdergesellschaft Windenergie und andere erneuerbare Energien' (FGW), which specify the definition of the various attributes and information to be transmitted. The document to be sent is called "global service protocol" (GSP). The GSP is supposed to represent the common protocol standard for communication in the future maintenance of wind turbines.

D. Common database

The different strains of wind turbine components, e.g. because of the technical concepts in use or different site characteristics, but also the use of identical and similar components from different manufacturers will lead to different lifetime expectations of the components and thus to a spread of results. Therefore, a common data base of as many as possible wind farm operators will broaden the statistical basis and harden the results [3, 4] However, all participants have to use the mentioned uniform designation of components, operating conditions and failures as well as the same structure for data storage. Also there is a need to gain many parameters, data and additional information, more than currently usual, making electronically supported reporting by service teams necessary. Only through a large amount of information, weak points can be identified clearly and statements on the failure probability of certain components get meaningful and only such a large data base allows improving and optimising maintenance strategies.

The common data pool enables future operators of offshore wind farms statistically reliable predictions concerning the success of operational and system concepts. Furthermore, based on anonymous benchmarking and weakness analyses, operators and manufacturers have the opportunity to test and, if necessary, to optimise the performance of their offshore wind farms. As a result of a common data base weak points can be identified, components can be qualified in cooperation with manufactures and suppliers and statements about the probability of failure behaviour can be made.

III. TEST AND DEMONSTRATION SYSTEM

In order to show on the one hand the integration of already existing structures (databases, software modules, etc.) on the part of operators and service companies by means of suitable interfaces and on the other hand the simplification and optimization of maintenance expenses due to the high degree of automation, a functional test and demonstration system for data collection, transmission and storage is required and in the development stage.

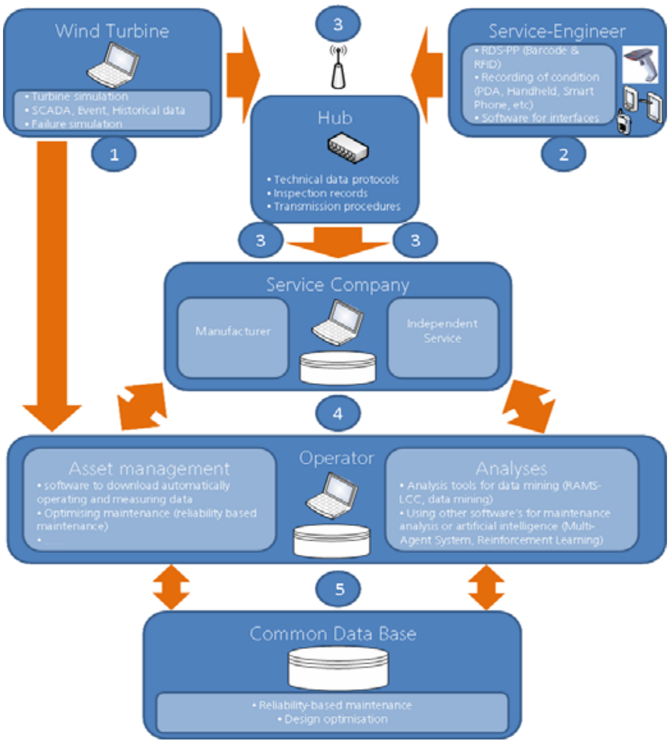

Figure 4: Maintenance strategies

This test and demonstration system for reliability based maintenance procedures will be set up in the project ‘Erhöhung der Verfügbarkeit von Windenergieanlagen (Improving wind turbine availability) – Phase 2’ [6], which is funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and has started at the beginning of 2011.

IV. RELIABILITY BASED MAINTENANCE

The uniform labelling of components, operating systems and the systematic storage of errors and data initially enable the management a largely standardized and electronically supported logging. As a result, the monitoring process can be simplified, the financial and technical reporting improved and cooperation with similarly oriented businesses enabled. This detailed documentation of all maintenance measures of a large population of plants and a purposeful structured database are necessary to extract sound conclusions out of the operational experience. After a certain period and with adequate statistical basis some reliability characteristics such as failure rates, repair times, etc., with respect to technical concepts (e.g. generator or gearbox-type), the operating conditions (e.g. wind conditions or ambient temperatures) or the plant age can be determined with an optimized maintenance information flow. This way of documenting and collecting data and information provides a number of possibilities for optimizing availability of wind turbines both in design & construction and in operation & maintenance, which result in higher turbine efficiency. Reliability based maintenance, with knowledge of

- reliability characteristics of components (damage, change),
- usable condition description (wear out, fatigue),
- material cost, labor cost and additional costs (service, extraordinary costs),
- and opportunity costs (costs due to downtimes)

in consideration of operational conditions helps organizing maintenance more effectively.

However, main object of the reliability oriented strategy is to predict the probability of failures for certain components or subassemblies. This prediction allows to prior notice failures likely to occur and prioritise work as well as preferring measures or merge with other work. Thus, reliability based maintenance strategy can transform unscheduled outages into planned maintenance activities and reduce or even avoid downtimes as well as maintenance costs.

V. OUTLOOK

As mentioned above a large database for results with strong validity is indispensable. To obtain a large statistical basis for analyses, information has to be stored in a standardized form [7, 8, 9]. Even databases like WMEP reach their limits of statistical capacity due to the parameter diversity. Hence, a common and broad database as well as a standardized data structure is absolutely essential. Empirical experience with as many as possible WTs of similar design running under similar operational conditions should get evaluated jointly, to increase the statistical basis.

The developed test and demonstration system will show how to connect different data sources and to simplify data collection and transmission in terms of structure, depth and electronic help. The implementation of standards already used in other industries for labelling components or describing procedures and measures enables operators to participate in the common database.

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