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AI SUPPORTED MAINTENANCE AND RELIABILITY SYSTEM IN WIND ENERGY PRODUCTION

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ReliaWind

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Abstracts

The paper describes the result of the research in the fields of supervision, failure detection and prognosis, control, maintenance planning and decision support performed for ensuring high level availability of wind turbines and wind farms. This activity is realized in the frame of the EU 7th Framework project ReliaWind: Reliability focused research on optimizing Wind Energy systems design, operation and maintenance: Tools, proof of concepts, guidelines & methodologies for a new generation. Wind turbines are relatively complex electro-mechanical systems, their smooth functioning is an important economical factor. The handling of this complexity is supported by various, applied artificial intelligence techniques and solutions as described in the paper.

Objectives

ReliaWind project's main goal is to usher in a new generation of more efficient and reliable wind turbines, providing practical results to be used in wind turbine design, operations and maintenance. The project aims to achieve better efficiency for wind turbines, through the deployment of new systems with reduced maintenance requirements and increased availability. To this end, the project proposes architecture directed at a modular design more immune to environmental conditions, permitting the replacement of components simply and quickly; to improve monitoring systems for components and thus achieve more accurate diagnosis; and to develop preventive maintenance algorithms for failure anticipation. These new technologies will be integrated in future generations of wind turbine components, wind turbines and wind farms.

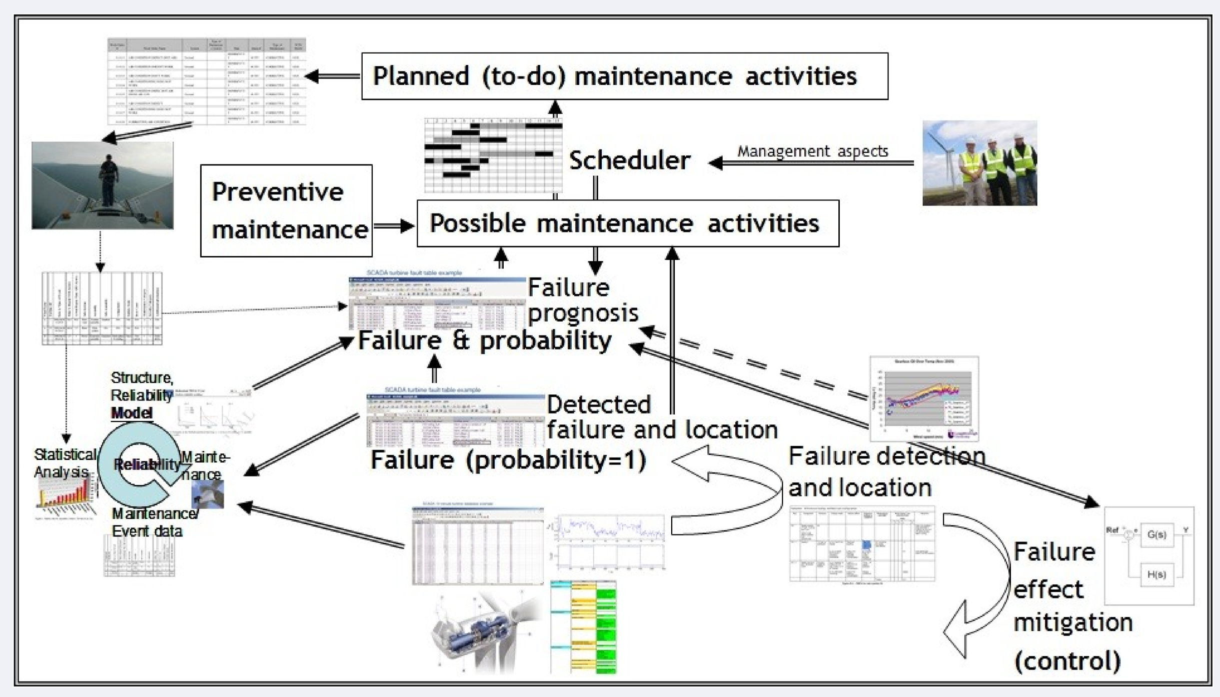
Ten partners are taking part in this ambitious project, each of them leaders in technical and operational disciplines in the wind power generation value chain. This includes the Wind Industry itself, Gamesa and Alstom Ecotecnia are wind turbine producers, LM Glasfiber is producer of blades, Hansen Transmissions of gearboxes, ABB of generators and SKF of bearings for the turbine. Technology experts are Garrad Hassan as an engineering consulting firm and Relex Reliability Software and Services serving with a software and reliability modeling knowledge. Academia is represented by Durham University, UK and SZTAKI, the Computer and Automation Research Institute of the Hungarian Academy of Sciences.

Further the operative project members, a "Reliability Panel" has been established in order to interact with top-level experts in reliability worldwide, not necessarily from the wind energy sector, such as aerospace and other sectors where reliability is paramount. Its mission is to share conclusions, establish guidelines, etc. The first invitation to join the "Reliability panel" has been issued to NREL, the US National Laboratory. A "Users Working Group" has also been established in order to interact with top wind farm owners worldwide. Its mission will be to share experiences in wind farm operation and maintenance, providing feedback on "best practice". The first invitations to potential members will be issued shortly.

The project results improve the reliability of wind turbines and wind farms and have enhancement effect directly on Mean Time Between Failures (MTBF) and on Mean Time to Repair (MTTR) resulting improved availability of facilities of energy production. Finally the relative cost of energy by kWh is decreased. All of the target measures are differentiated whether considering onshore or offshore installations.

Methods

An important part of the ReliaWind project is the WP3 that is targeting to develop the Logical Architecture of an Advanced Wind Turbine Generator (WTG) Health Monitoring System (AWTGHMS). It is not only an architecture design but active also in the field of idea approval. The Fig. below shows the architecture of the AWTGHMS. The different components of the system are developed in consecutive tasks comprehend by the Task 3.0 for guaranteeing the overall consistency of the monitoring architecture. Logical architecture definition of required hierarchical system breakdown guarantees a common WTG & Wind farm level integration from a diagnosis, prognosis & health monitoring point of view.

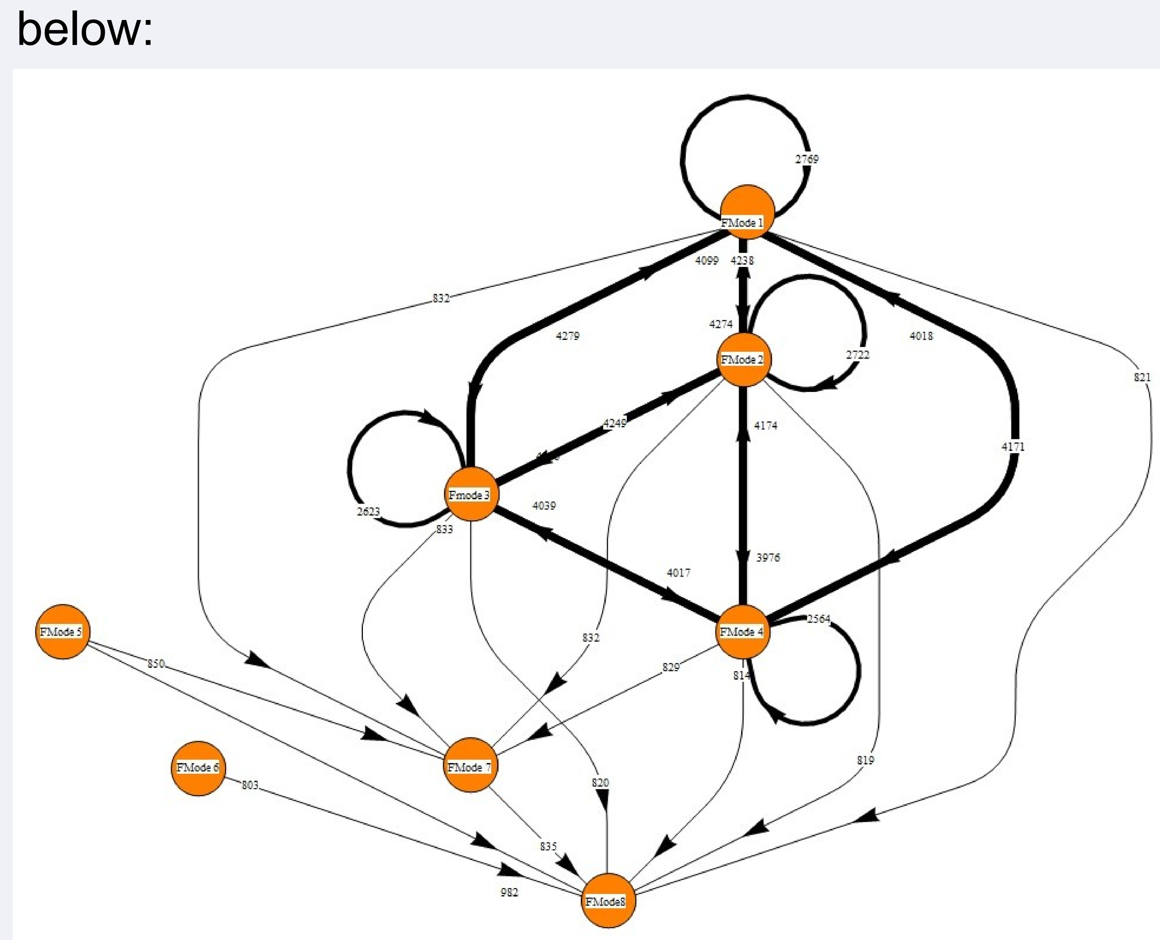


Typically, any wind power plant component, which needs to exchange information with other components and actors, is equipped with a so-called intelligent electronic device (IED), which can send data to external receivers and receive data from external senders. Therefore the information exchange is already implement in currently working WTG systems, but these information models are proprietary and cannot be used in a research project like ReliaWind. To overcome the problems of the proprietary data models a standard data model is proposed to use, which is based on the IEC 61400-25 standard.

Data analysis applying artificial intelligence techniques was performed based on the follwing wind turbine data

- Work orders (some thousand records)
- SCADA data from central databases
- Alarm information (some ten thousand records)
- Wind information (some million records)
- Energy information (some million records)

At the beginning of the data analysis phase clustering of the work orders was carried out. This analysis is a very simple way to find out dependencies between failures. if two failure modes occurrence is close to each-other frequently they probably influence each other, e.g. they may be dependent. All work order pairs – or failure mode pairs – in a dependency group represent an edge in a dependency graph shown below:



Results

The final stage of the failure related workflow addressed in the project is the automated generation of short-term maintenance schedules on the regional office level. The scheduler must make a series of interrelated decision: it has to select the maintenance mode to apply, assign the maintenance task to resources, and determine a suggested execution time or decide to postpone the task. The objective of the scheduler is to minimize the total failure and maintenance related cost, which is made up of the following components:

- Production loss due to failures
- Production loss due to maintenance
- Cost of leaving a failure unrepaired in the short-term horizon
- Maintenance costs, including spare parts, hired services, and labour cost

Maintenance schedule by team

Team	Turbine	Task	Start time	End time
1	WF 2, T23	0003	2/24/10 9:30	2/24/10 12:00
1	WF2, T15	0001	2/24/10 12:00	2/24/10 13:30
1	WF1, T15	0005	2/24/10 14:30	2/24/10 16:30
2	WF3, T08	0002	2/24/10 9:30	2/24/10 15:00
-	WF3, T06	0004	-	-

A small sample schedule (left) and the predicted power output of a turbine (right) if this schedule is applied. The upper line in the diagram represents the maximum production assuming a healthy turbine, whereas the lower line stands for the actual production. Degradation is due to failure in periods 1-4 and stopping the turbine for maintenance in periods 5-8.

Conclusions

Wind turbines are relatively complex electro-mechanical systems, their smooth functioning is an important economical factor. This is why monitoring and diagnosis of wind turbines and wind farms gained extreme importance in the past years. Concentrating on monitoring, diagnosis and maintenance issues the novel logical architecture of an advanced wind turbine health monitoring system harmonized with the recent standard series on communications for monitoring and control of wind power plants was introduced. Wind turbines have several built-in sensors and SCADA systems serve with huge amount of data. This allows applying artificial intelligence techniques for analysing the dependencies among data.

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