WIND GUARDING, AN INNOVATION AIMING TO OPTIMISE THE PERFORMANCE OF WIND FARMS AND TO REDUCE THE COST OF WIND ENERGY

Axel Albers *), Gerhard Gerdes *), Knud Rehfeldt*), Jan Liersch**),Jörg Hermann**) ,Ingo Menz**)
*) Deutsche WindGuard GmbH, Windallee 15, D-26316 Varel Tel. ++49 4451 9515 0, e-mail: info@windguard.de
**) Dynamix GmbH, Taunusstr. 2, 12161 Berlin Tel: ++49 30 223 200-10, email:info@dynamix.de

ABSTRACT: The development of wind energy in the past decade has let to more professional work in manufacturing of wind turbines (WTs), in project development, in financing and in marketing. But the professional level of technical operation of wind farms has had a much lower progress. The state here often remains on the level of operation as for the 500kW class; the technical operator reacts mainly on fault messages and evaluates bills for services and repairs.
Technology has changed much since that time, modern WTs are far more tight dimensioned and are much bigger. The technical operation has to orientate towards industrial standards. In this paper the requirements of modern technical operation of wind farms are described as well as the needs for performance evaluation and performance monitoring.
Keywords: Monitoring, Operation and Maintenance, Optimisation, Performance

1 TASKS OF TECHNICAL WIND FARM OPERATION

The utilisation of wind energy is a fast growing industry. Due to the fact that wind farm developers and wind turbine manufacturers are these days very occupied with the acquisition of new wind farm projects and the erection and delivery of wind farms there is not much capacity left for the improvement of wind farm management systems. As a consequence the technical operation of wind farms has remained on a relatively low level. That's the point where the wind guarding comes into play. The Deutsche WindGuard GmbH aims to optimise the wind farm operation and thus to reduce the cost per produced kWh by means of an professional wind farm supervision.

Key approaches in order to achieve this intention are:

- 24 hour wind farm monitoring by remote control: immediate organisation of repair in case of wind turbine errors,
- professional organisation of maintenance: planning of maintenance according to the turbine condition and by keeping special site conditions into mind (e. g. maintenance of offshore wind farms is often impossible during high wind seasons) , check of maintenance work by professionals, avoidance of wind turbine stand stills due to maintenance during high wind periods, advance inspections before high wind periods,
- periodical on site inspection,
- databank supported documentation of failures and repairs as well as complete keeping track of turbine history, identification of errors in series production,
- condition monitoring: initiation of premature maintenance and avoidance of consequential damage by implementation of early fault detection systems,
- performance monitoring: periodical wind turbine power performance tests, identification of lacking wind turbine power performance
- periodical evaluation of the wind turbine's control system: statistical evaluation of rotor speed control, pitch angle or pitch control, yaw control, switching between generator levels
- testing and correcting of rotor balance in order to avoid unnecessary mechanical loads

2 CONTINUOUS TECHNICAL MANAGEMENT

2.1 Permanent supervision

The basic task of technical operation is the permanent taking care of a wind farm. This is performed by regular daily supervision via remote control and receiving fault messages by fax, SMS etc.. Direct reaction on faults is required either by remote control or measures on-site or by instructing repair.

The collection of relevant operational data from wind turbines is an important requirement for turbine maintenance and technical improvement. With such data as a basis, one can extrapolate a turbine's functional status. Therefore, an automatic data collection and evaluation system is a tool that allows operators to swiftly and effectively react to disturbances.

Figure 1 plots the statistical frequency of various status reports from a wind farm with nine turbines. The status reports that occur most frequently in the wind farm appear at the top of the display. A red bar graphically represents which turbines triggered which status messages most often. One can quickly recognize, for example, that turbine No. 5 probably has a problem with its rotor speed sensor (event No. 391 in line No. 5). Such graphical comparisons enable early problem identification and allow for timely reaction.

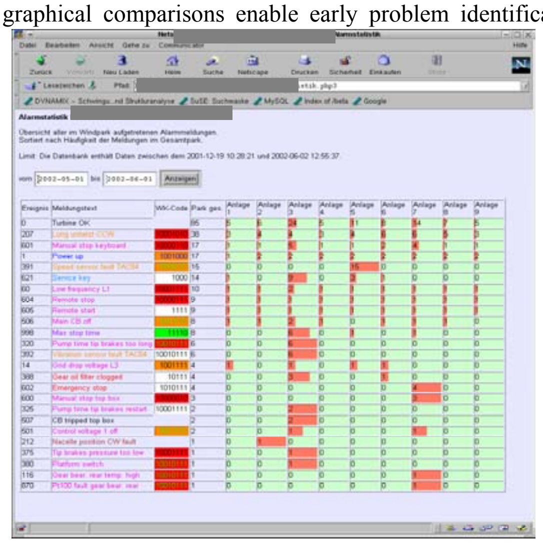
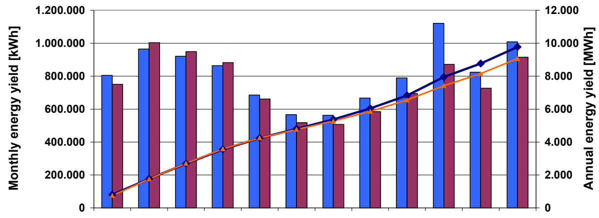


Figure 1: Status report for a wind farm with nine tur-

bines with a statistical analysis of fault messages.

2.2 Monthly reporting

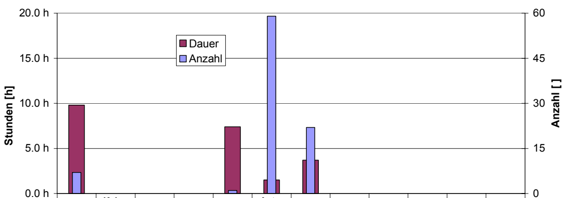
Detailed monthly reporting and assessment of operational results is also part of the basic tasks of technical wind farm operation. The energy yield has to be assessed in relation to the long term wind energy production. Figure 2 shows the comparison of real monthly to expected energy production, converted to long term energy yield by means of a wind or yield index.



	Jan	Feb	Mrz	Apr	Mai	Jun	Jul	Aug	Sep	Okt	Nov	Dez
Wind farm [kWh]	804.998	964.526	921.155	863.920	685.519	566.981	562.625	666.671	789.006	1.121.369	823.983	1.008.673
Prognosis [kWh]	749.983	1.003.654	948.508	882.333	661.750	518.371	507.342	584.546	694.838	871.304	727.925	915.421
Wind farm, cummulated [MWh]	805,0	1.769,5	2.690,7	3.554,6	4.240,1	4.807,1	5.369,7	6.036,4	6.825,4	7.946,8	8.770,8	9.779,4
Prognosis cummulated [MWh]	750,0	1.753,6	2.702,1	3.584,5	4.246,2	4.764,6	5.271,9	5.856,5	6.551,3	7.422,6	8.150,6	9.066,0

Figure 2: Monitoring the energy yield by comparison to long term wind resource development.

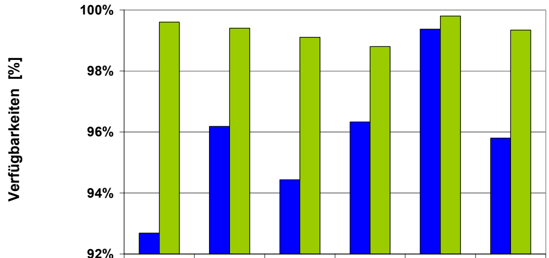
In addition an statistical analysis of fault data has to be provided, showing the number and duration of faults. As the fault codes are usually numerous, the single faults have to be summarised into fault groups, e.g. the grid failures have to be counted regardless of frequency, voltage, current, phase or upper or lower limit exceeding in one group.



	Bedienerstopp	Keine Kommunikation	Bremse	Cut-Off-Wind	Hydraulik	Auto-Wartung	Netz	Pitch	SPS	Temperatur	Elektr. Fehler	Mech. Fehler
Dauer	9.8 h	0.0 h	0.0 h	0.0 h	7.4 h	1.5 h	3.7 h	0.0 h	0.0 h	0.0 h	0.0 h	0.0 h
Anzahl	7	0	0	0	1	59	22	0	0	0	0	0

Figure3: Classification of fault messages into fault groups. The large number of different messages has to be reduced to relevant groups. The depicted duration is the total for all faults quantified for a group.

The availability of wind turbines is usually depicted by the turbine's control system. The assessment of availability is in this case done on base of definitions given solely by the turbine manufacturer or in agreement with the wind farm operator. This definition usually does not enclose all standstills regardless of it's reason. As it is essential for the wind farm owner to know the duration of total non-operation, all standstill times have to be analysed. Figure 4 shows the comparison between availabilities reported by the control system and those calculated from standstills.



	WEA 1	WEA 2	WEA 3	WEA 4	WEA 5	Mittel
Alle Stillstände	92.7%	96.2%	94.4%	96.3%	99.4%	95.8%
Betriebsführung	99.6%	99.4%	99.1%	98.8%	99.8%	99.3%

Figure 4: Availability of a wind farm distinguished between availability reported by the turbine control system and availability calculated from all standstills.

2.3 Periodical inspection

Wind turbines should be operated successfully over a minimum lifespan of 20 years. Therefore it is not sufficient to limit the technical operation to remote supervision and reaction on reported faults. The condition of a wind turbine has to be assessed by periodical inspection, the wear and tear of mechanical parts, of greasing, leakages, corrosion, cable breakage, electrical faults, rotor blade connection, bolts etc. have to be documented.

Further on the success and quality of maintenance and repairs have to be supervised, the results of the performed work and the keeping of safety standards has to be checked. Even small faults have to be repaired to prevent from continuous decay of components.

2.4 Maintenance management

To avoid larger losses in energy production, maintenance and repair have to be organized preventively. Maintenance has to be planed in times when low wind speeds are forecasted, repair has to be planned depending on the condition of the wind turbine and it's components.

The knowledge on the status of condition and exchange of components is important to be traced over the entire lifetime of a turbine. Thus the status has to be recorded in a data bank, together with all relevant information about the turbine and it's main components (e.g. serial numbers). The analysis of this data will allow the evaluation of the complete wind turbine history with all it's components (e.g. mean time between failures, number and extend of component exchanges, status of components).

2.5 Condition monitoring

To recognise possible faults in the wind turbine components state-of-the-art condition monitoring systems should be provided for modern wind turbines. The aim is to prevent from long standstills by unexpected breakdowns and reduction of energy losses. The early detection of faults allows to organise spare part procurement in due time and repairs in low wind speed seasons. Further on larger damages can be prevented if repair or replacement of critical components is carried out in time.

Condition monitoring will be an essential part in all large modern wind turbines and it will be absolutely necessary in offshore wind turbines. The early detection is necessary to prevent from long breakdown times in bad weather seasons.

3 Performance evaluation and performance monitoring

The analysis of the technical performance of a wind farm and it's wind turbines is essential to achieve optimum energy yield. In case of missing performance the turbine parameters have to checked and adjusted.

3.1 Power performance evaluation

The performance of a wind farm should be evaluated at start of operation. Each turbine should be checked, to analyse it's individual performance. A comparison of the energy production of single WTs in a wind farm, as shown in fig. 5, does not allow final conclusions on reasons for higher or lower production. It has to be distinguished between production differences resulting from different wind resources at the different sites within a wind farm, between losses by shading by neighbouring turbines and between different technical performance. To isolate the reasons, a performance check should be carried out by analysing power performance and/or technical availability.

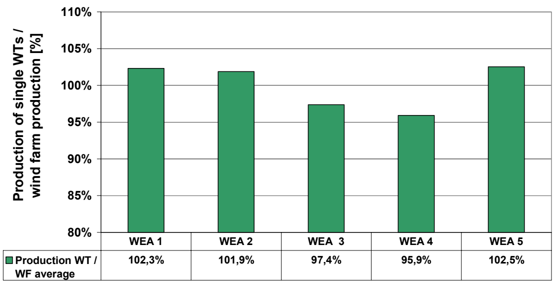


Figure 5: Example of production differences between single WTs in a wind farm.

The power performance testing could be done by testing one or two WTs by means of a free stream wind speed measurement on a meteorological tower, according to IEC standards. The remaining WTs are tested by nacelle anemometer measurements, see fig. 6. A correction function is derived from the free stream measurement.

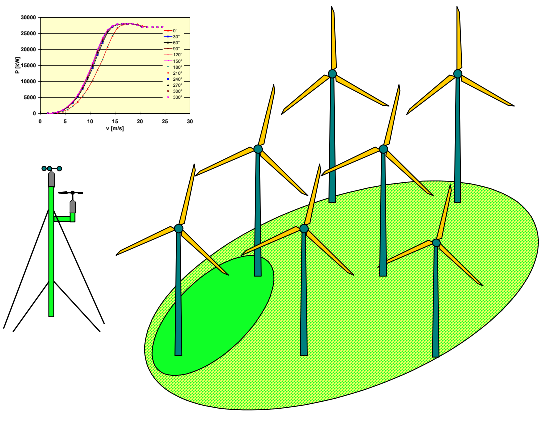


Figure 6: Schematic diagram for wind farm performance evaluation. One or two WTs are tested by means of a free stream wind speed measurement on a meteorological tower. The remaining WTs are tested by nacelle anemometer measurements.

The performance testing by nacelle anemometer should be converted into a continuous monitoring procedure. Further on faults and availability should be checked regularly and should be improved if necessary

3.2 Check of main turbine parameters

The observation of insufficient technical performance requires the analysis of the possible reasons. These will mainly lie in pitch control, speed control for speed variable WTs or generator switching for fixed speed WTs, yaw control, dirty or roughened rotor blades or insufficient aerodynamics or in technical availability.

To improve the performance, the most reasonable parameters have to be checked and, if necessary, to be adjusted. The example of checking the pitch control of a turbine by comparing measured values with the theoretically required values is depicted in fig. 7.

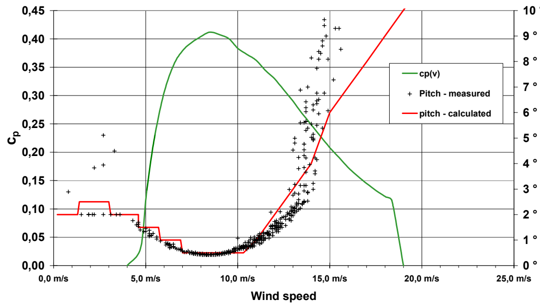


Figure 7: Example for control system verification. Analysis of the pitch angle control system of a wind turbine.

The following procedures are necessary for comprehensive turbine operational management:

Short-term Balancing: Evaluations of imbalances related to mass and aerodynamics,

and examinations of the dynamical behaviour of the turbines

Recurrent inspections and vibration measurements

Permanent supervision and monitoring of wind turbine dynamics

An automatic monitoring and data acquisition tool like the DYNAMiX 'WONDER' (Wind Turbine Data Acquisition and Evaluation)

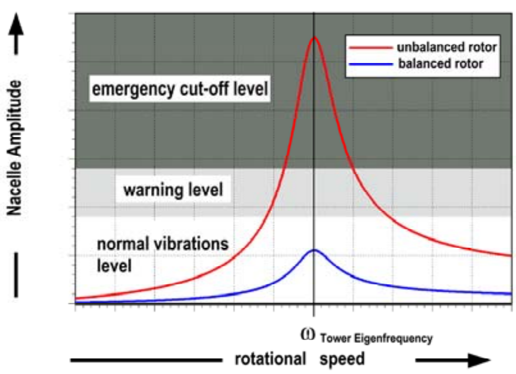


Figure 8: Vibration control of a wind turbine.