Predictive Monitoring of Wind Farms:

Intelligent Solution for Early Detection

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The higher the availability of a wind farm, the higher the expected returns. However, keeping wind turbines (WT) on a high technical level is no easy task. This is exactly what has become the WINDcenter set by STEAG Energy Services (SES). In the interview, Fabio Wagner, head of WINDcenter, describes the peculiarities of the manufacturer-independent service and illustrates why wind farm operators benefit from the combination of intelligent IT systems and expert knowledge.

A high availability of WT is important in order to achieve a safe return with a wind farm project. Despite inspections, maintenance and servicing of plants, income is regularly lost due to production limitations or even equipment failures. How can this be avoided?

Fabio Wagner: Inspections of wind turbines are preventive maintenance measures designed to identify and correct emerging problems even before they occur. Such measures have long been one of the few ways to influence plant availability. Since there are more detailed evaluations of the technical condition of a plant, this has changed. In a first step, plant availability can be increased simply by requiring fewer or no inspections through in-depth analyzes. Another aspect is that service technicians can perform visual inspections and more detailed studies on gearbox bearings, e.g. with an endoscope during an inspection. Nevertheless, problems often remain unrecognized, e.g. the slight increase of a storage temperature by only a few degrees. It is therefore not surprising for me, if there are problems short time after an inspection even on tested components, because often the causes could be detected neither with CMS nor during a service operation.

Can we quantify possible reductions of earnings to get an idea of how high the losses can be due to unrecognized or unresolved issues?

Fabio Wagner: We have conducted on this topic calculations for various wind farms, with the loss by undetected or unresolved problems to an average of around 0.5 percent, as measured by annual energy output. Depending on the size and location of a wind farm and its market environment, these losses can amount to several hundred thousand euros per year. Mind you: these are losses that could have been avoided by very simple maintenance measures.

What experiences does SES have in the field of wind energy?

Fabio Wagner: The Energy Technologies division of STEAG Energy Services has taken on the entire project planning and implementation of STEAG`s wind farms, starting with the planning, the permits, the negotiations with the equipment manufacturers and the supervision of the construction

supervision. In addition, SES is responsible for the operation of the wind farms, so we have very sound and extensive experience in wind energy.

With the WINDcenter (WIND: Wind farm Integrated Neural Diagnostics), SES offers an intelligent, manufacturer-independent solution package for the monitoring and optimization of wind farms, with which the availability of WT can be further increased. What are the essential components of this solution package?

Fabio Wagner: We analyze the operating data available via the SCADA system from the wind turbines (WT) and to a certain extent carry out a high-quality evaluation of this data. Therefore, no additional sensor technology or measuring technology has to be installed in advance to obtain the operating data. In addition, we analyze the data of existing CMS of a plant. Generally speaking, our goal is to detect changes in the operational behavior of WT at a very early stage, before a problem or major damage occurs, which could lead to loss of revenues in both cases.

SES has decades of experience in developing and implementing high-performance IT technologies for the energy industry. Which technologies of SES are used in connection with the solution spectrum of WINDcenter?

Fabio Wagner: The IT expert systems SI®/PAM, SR::x and SR::SPC have proven themselves in the energy industry for decades. With the O&M system SI®/PAM, we cover the entire range of operations management and maintenance management for wind farms. The operating data that the SCADA system provides to a plant are collected, permanently stored and visualized via our SR::x data management system. This preserves valuable historic plant data. For early detection of process changes in plant operation, SR::SPC analyzes the data from SR::x on the basis of high-quality key performance indicators. Our experts at the WINDcenter then evaluate this information as part of a detailed root cause analysis in order to be able to give very specific recommendations for action. We therefore have the right to limit the cause of a problem to such an extent that the local service team in the wind farm can concentrate fully on troubleshooting or problem solving.

Could you make the operation of your system a little more precise?

Fabio Wagner: On the basis of data collected with SR::x, KPIs are configured and, in this context, attention is paid to which parameters of a wind turbine are to be included with regard to the process to be monitored or the reference values determined on the basis of the KPIs. The IT system learns how these parameters correlate with each other to generate a measurement to be observed. In the end, the system is able to identify and visualize deviations based on three proven methods of

statistical process control. However, this only happens when at least two of the three methods used detect relevant deviations. Then an alarm is automatically generated and we receive a message from the system. So, in most cases, before we can determine exactly how sensitive the system should be to deviations, we exclude false alarms from the outset. When we get a message, we'll start with root cause analysis and write a report with recommendations for fixing a problem.

Is there a concrete example of the use of the above-mentioned IT solutions?

Fabio Wagner: Let me give you a typical example of a problem that a CMS alone would not recognize. At a wind farm commissioned at the end of August 2014, we first created a database with the data management system, which enabled us to create the first models after two months. About an alarm from SR::SPC we were alerted in early November to an abnormality that showed in a first model, an increase in transmission oil pressure above its set point. Whenever we become aware of such abnormalities through SR::SPC, we plot all related variables to form correlations. In this particular case, we noticed that the normal 42 degrees cooling water temperature fluctuated at some point. In this context, we also identified a correlation between the variation in cooling water temperature and the outside temperatures at the site of WT. The alarm of SR::SPC initially pointed us only to an increase in transmission oil pressure. By evaluating the data, we finally found the correlation described. We analyzed why the cooling water temperature followed the ambient temperature of the wind turbine during its course. As a cause, we identified a three-way valve in the cooling system of the plant. This valve ensures that the cooling water is passed through an air cooler and also passes through a bypass with the transmission oil in a heat exchanger. Since the three-way valve was defective, the flow rate of the cooling water was not regulated, but passed completely through the air cooler. For this reason, the cooling water temperature followed the ambient temperature. The result: the gearbox oil temperature was not regulated, as the cooling water was not passed by the heat exchanger, the viscosity of the oil increased and thus the transmission oil pressure. Therefore, we have recommended that the three-way valve be immediately repaired or replaced.

What would have happened if the problem had not been resolved?

Fabio Wagner: We could see that at a plant in another wind farm in which SES's IT systems were not installed. There was the same problem in the first year of operation, but the three-way valve was not replaced. With the onset of winter, temperatures dropped and the cooling water temperature dropped to -10 degrees with an outdoor temperature of -20 degrees. The result: As the transmission oil pressure massively increased, WT throttled its performance to around 40 percent to avoid

transmission damage. There was a loss of revenue until the problem was resolved, and this in a particularly windy season.

These examples illustrate the special strengths of WINDcenter . Which other decisive advantages benefit operators of wind farms in this context?

With the collection and storage of WT data, we not only build a valuable asset history, but are primarily able to monitor a large amount of process data through our IT solutions. In the event of changes in the operating behavior of a system, we can react quickly due to automatic alarms, whereby the qualified analysis of SCADA and CMS data only generate relevant warning or alarm messages.
Since the experts of WINDcenter evaluate the data taking into account all factors influencing a specific alarm, we use a root cause analysis to very specifically identify the cause of a problem or a process change. Finally, our results lead to a corresponding documentation with a recommended action to quickly remedy a problem, so that the losses of around 0.5 percent of the annual energy yield described above can often be averted. However, the WINDcenter offers a number of other advantages that we have not yet been able to evaluate economically.
Thus, with our solutions it is possible to see very early on when a wind turbine is no longer able to do what it should actually do. The strategies in wind farm operation can thus be adapted very quickly. In addition, there is better planning of human resources and, of course, the avoidance of consequential damage to a system due to problems not detected in good time.

The advantages mentioned have thus also effects on the maintenance of wind turbines?

Fabio Wagner: Right. With the WINDcenter, existing maintenance strategies for wind turbines can be decisively improved, because now instead of a reactive or preventive maintenance, a predictive and therefore state-based strategy can be realized. Not only can longer standstill periods be sustainably reduced, but also additional costs resulting from unplanned service. For offshore wind energy in particular, predictive maintenance is therefore a real economic alternative, especially since planned logistics on the high seas can significantly improve the overall logistics and therefore the availability of spare parts.

The WINDcenter is a comprehensive service offer. Can your IT expert systems be used without the described services?

Fabio Wagner: We are just as flexible as the IT systems we use. Our offering is modular so customers get exactly what they need. If a customer commissions the WINDcenter with the

monitoring of his wind farm, he does not have to deal with the IT technology or the cause analysis of a plant problem. He gets a comprehensive service from us instead. However, if a customer does not want to give up his data, he can also buy our IT solutions and use them on the basis of training. In addition, any other model is conceivable between these two possible solutions.