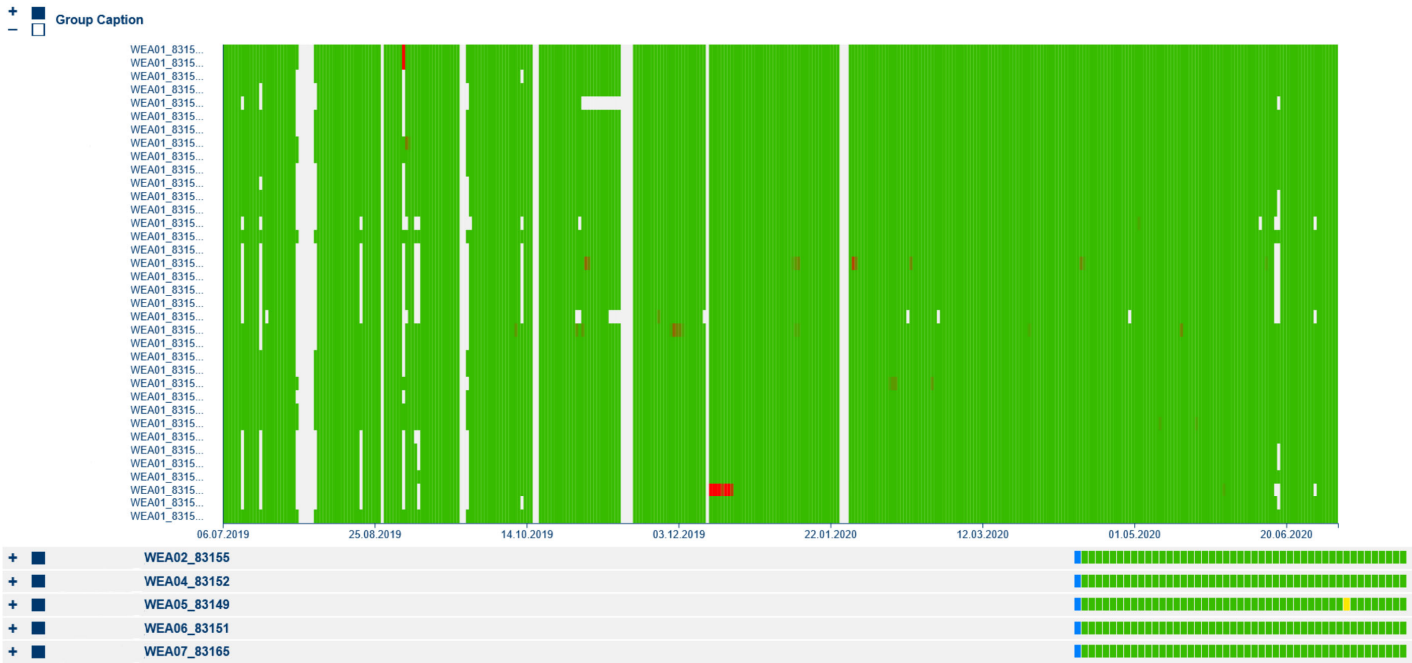

**By using AI-based methods like Big Data or machine learning, the "WINDcenter" detects abnormalities in the operating behavior of wind turbines early on.**
Image: STEAG Energy Services

Optimized Wind Turbine Monitoring

# Artificial Intelligence in Wind Power

Why would the wind energy sector be concerned with artificial intelligence? Because methods based thereon like e.g. Big Data and machine learning offer manifest advantages for the maintenance of wind turbines – in particular when abnormalities on turbines go unnoticed again and again in spite of remote monitoring although they may have a significant impact on the reliable turbine operation and thus on the revenue.
The WINDcenter offered by Steag is an appropriate solution.

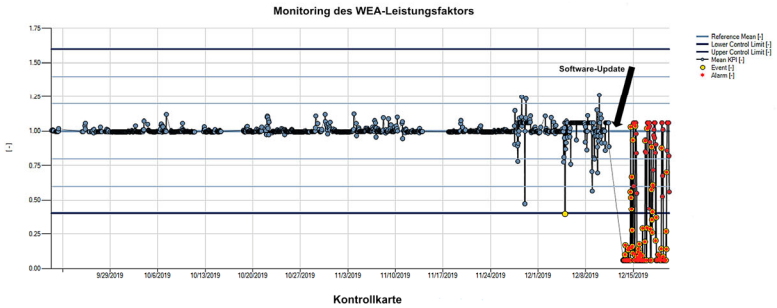
To be able to react to a deviating operating behavior of wind turbines in time, changes that may indicate impending damages and increased losses must be detected early and reliably. Such information immediately available from SCADA or condition monitoring system (CMS) data enables predictive maintenance strategies with fast and targeted reactions even before more serious problems arise.
The "WINDcenter" is a solution that is entirely independent of the plant technology; it monitors the operating condition of wind turbines or of individual plant components by means of Predictive Analytics and powerful software systems in real time without using additional, own sensors. All important parameters and monitoring results for a wind farm can be visualized




**The heatmap of a plant. The red area a few days after December 3, 2019 shows that the power factor Cos Phi has changed significantly compared to the actually expected operating value.** Image: STEAG Energy Services

on a dashboard at any time. The WINDcenter's functional principle, however, fundamentally differs from known solutions e.g. for remote monitoring as becomes obvious with regard to the modeling in predictive maintenance.

On the basis of existing performance values, digital twins are generated from historical, sensor-based data (SCADA, CMS) and continuously compared to the current data. Two complementary methods are used for the modeling in order to obtain reliable indications of abnormalities but also of creeping changes on a wind turbine while at the same time preventing false alarms.




**The in-depth analysis with additional statistical process control showed a clear correlation between the software update carried out on the SCADA system and the changed power factor leading to the limited reactive power control.**

## High Quality KPI by Experts

The HQ-KPI approach (HQ-KPI: high quality key performance indicator) is based on expert knowledge, with selected measurements and important characteristics being monitored for the purpose of the early detection of specific faults in critical plant sections. On the basis of historical data, models for displaying the plant behavior in the normal state can be created by means of neural networks. Experts define the input variables required for such models. The application of additional methods for statistical process control using the software "SR::SPC" finally allows to identify anomalies and abnormalities respectively beyond any doubt.

## Autonomous Modeling with Machine Learning

This process is entirely automated using Big Data technologies. In doing so, intelligent algorithms detect the previously unknown dependencies or correlations of the data in a fully self-contained way by means of machine learning, including all available measurement channels, and form corresponding models autonomously. Thus all measurement channels are both input and target variables and are not explicitly specified as in the HQ-KPI approach. The results (deviations between expected value and actual value) are displayed in a heatmap.

## Uninterrupted Monitoring with "Smart Data"

The AI-based expansion of the software system for statistical process control ("SR::SPC ML") combines the advantages of both methods, resulting in a monitoring of all available measured values and data respectively without great initial effort. This way, a large number of previously unspecified data can be processed and changes in the operating behavior of the wind turbines can be identified automatically.

Statistical methods for monitoring selected measured variables add to the procedure for checking abnormalities and also critical trends in order to trace their actual causes, which are not always obvious, in a very targeted way.
The potentials the described methods for monitoring wind turbines offer in practice can be explained using a concrete example.

## Limitations due to Software Update

Among other things, the WINDcenter monitors an onshore wind farm with a total of 18 plants (total output approx. 43 MW) in Germany. At the end of 2019, the wind turbine manufacturer updated the software of the SCADA system at the wind farm. The update, however, was faulty as it did not fulfill all parameters of the technical specifications of the so-called grid code for a safe grid stability. As a result, the reactive power control of the wind turbine at the wind farm was partially limited, which was not noticed by the persons responsible for the update at first.

## Automatic Alerting of the WINDcenter

A short time after the software update, the WINDcenter received an automatic alarm on all wind turbines at the wind farm, which also contained the corresponding heatmaps in the attachment. Thus it became evident that the power factor Cos Phi had significantly changed compared to the actually expected operating value.
An in-depth analysis with additional statistical process control with the previously formed high quality KPIs for the wind turbine converters ultimately showed a clear correlation between the software update carried out on the SCADA system and the changed power factor that finally led to a limited reactive power control.
Owing to the immediate evaluation of the system messages, the experts of the WINDcenter were able to promptly inform the plant manufacturer in order to replace the faulty software. Without the early automatic alerting by the WINDcenter, the plants would probably have remained on the grid with limited reactive power control for a longer period of time.


**Everything at a glance: All important parameters and monitoring results for a wind farm are visualized on a dashboard ("SR::ViewPort" by Steag).**

## Specific Indication of Possible Causes

The example emphasizes the WINDcenter's level of performance, especially with regard to the reliable identification of abnormalities in the operating behavior of wind turbines, which sometimes are not detected by SCADA systems or CMSs. In this specific case, even a software update on the SCADA system itself was the cause of a problem. Due to the automatic alarm that already contained the crucial indications for a detailed analysis, a fast reaction was possible and measures for targeted rectification could be taken.

## Valuable Insights Also for Post-Renewable Energy Law Plants

But even if the WINDcenter has not been applied for online monitoring so far, the further processing of existing wind turbine data can yield valuable insights. This can be relevant when important decisions, like e.g. on the ongoing operation of wind turbines after the 20th year of service life, are to be made. The respective SCADA and CMS data provide the basis for a retrospective analysis of the wind turbines at wind farms and thus for a first, general overview of the technical plant condition.
Among other things, such a detailed analysis allows to detect even previously inconspicuous changes or problematic trends in specific plant sections. Consequently e.g. the economic efficiency of an ongoing operation with a full maintenance contract or alternatively in the case of individually rendered services of an independent service provider can be assessed as well.
In the context of the certified type test required for the ongoing operation, the WINDcenter is also able to carry out an assessment of the power-generating wind turbine components in addition to the structural strength analyses of a plant.

## Positive Effect on LCOE

The potentials of the WINDcenter range across the entire value chain in the field of wind energy, from the development right up to the ongoing operation of wind turbines after the 20th year of operation and thus have a positive effect on all factors of the levelized cost of energy (LCOE). Thus the investment and financing costs are reduced by proving a powerful monitoring system, the operating costs are decreased by means of optimized maintenance strategies, and the annual energy production is increased by preventing unplanned plant shutdowns and by optimizing the times of service operations.