Wind Solutions®

PRO Engine

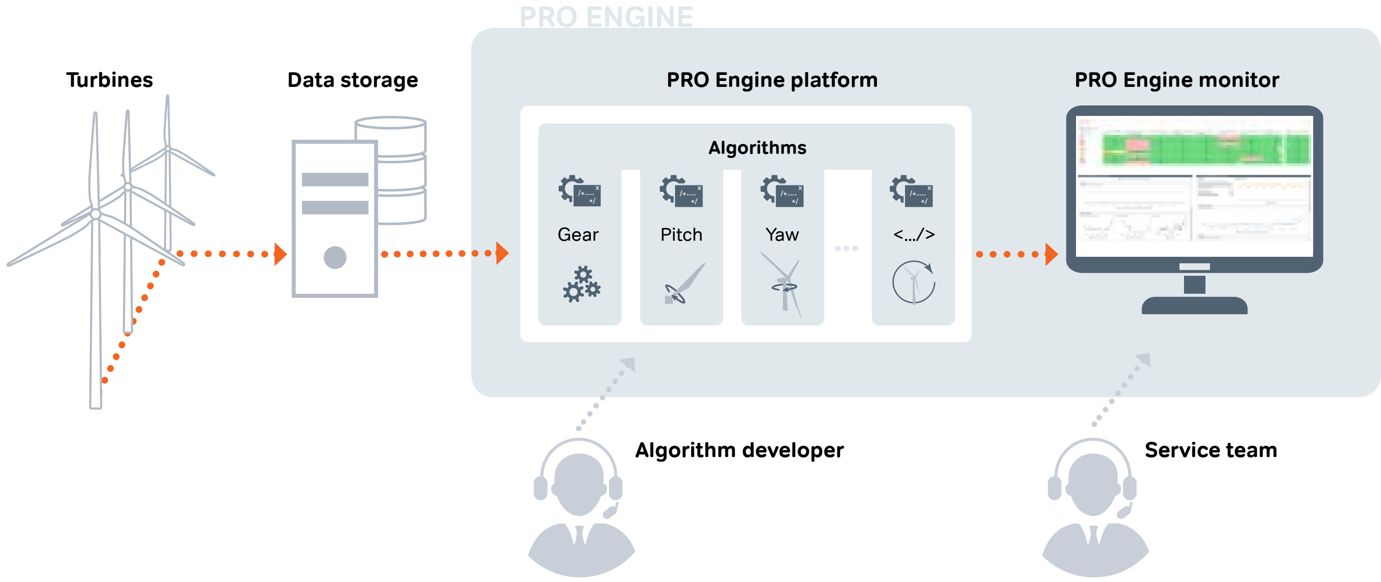
Improving turbine park performance through predictive maintenance

We innovate to integrate®

Optimisation through data-driven predictability

- Increase availability and reduce maintenance cost

The future wind park performance optimisation goes through machine learning and data mining analysis. PRO Engine is an open platform enabling wind park owners to handle and plan service of the turbines based on algorithms.



Key benefits

- Increased availability
- Improved service planning
- Avoidance of consequential errors
- Reduced storage costs
- Increased AEP
- Lower loads

Even well-running turbines experience problems once in a while. The question therefore is how turbine owners can predict turbine errors and avoid consequential production loss and costly unplanned service visits.

PRO Engine is a real-time data-handling engine for prediction, reliability and optimisation algorithms. The platform enables detection of problems before they result in wind turbine stop so predictive maintenance can be performed which in turn increases availability of the wind turbine.

Platform description
The platform comes in different versions; either fully equipped with turbine-specific algorithms ready for predictive maintenance or for the customers to add algorithms themselves.

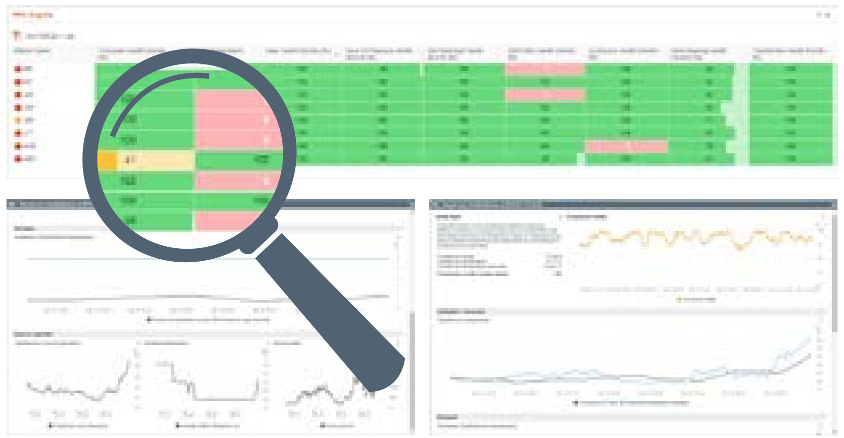
PRO Engine includes Python and Matlab™/Octave algorithm development support. The platform has a dynamic engine where additional algorithms can be directly deployed without any deep software knowledge from the customer's side.

The platform provides easy overview of the individual wind turbine components' health status by use of the Pro Engine monitor. From the turbine health monitor, the customer can get information about possible root causes and which spare parts and tools to bring.

Finally, PRO Engine contains detailed information of the individual wind turbine components for the customer to observe the measurement and model data that underlie the health calculations.

Health monitoring
We use our high expertise within wind to develop algorithms and we apply machine learning methods to calculate a health value between 100% and 0%. A value of 100% indicates a perfectly healthy system as opposed to 0%, which indicates a system failure.

When the value reaches 50% it is indicated on the PRO Engine surveillance as yellow and when 20% is reached it gets red.



This approach allows monitoring of fairly complex systems, and predictive maintenance can be planned just by reacting according to the colours.

A new approach

Moving from traditional SCADA monitoring with human interpretation of data to algorithm monitoring based on data.

Traditional SCADA:

- Individual sensors
- Thresholds based monitoring
- No utilization of system knowledge
- Reactive approach

PRO Engine:

- Combining sensors
- Conditions based monitoring
- Utilizing statistics and mathematical models including system knowledge
- Proactive approach

Case:

Transformer cooling failure

Prediction of main transformer cooling failure by use of machine learning in PRO Engine gave enough time for the service crew to plan and perform the service and avoid unnecessary long down time.

The main transformer is one of the largest electrical components of a wind turbine and it is very essential that the conditions of this components is continuously monitored.

This is in most wind turbines done by some fixed thresholds where a warning is given when the temperature reaches 115°C and the wind turbine is stopped if it reaches 120°C.

With this traditional method, predictive maintenance is not possible and latent problems, which can result in a wind turbine stop, are not detected and fixed before they result in down time.

By applying machine learning methods and making use of existing sensors, monitoring can be implemented, which enables the service crew to fix the errors before they result in a wind turbine stop.

An algorithm, which compares the measured main transformer temperature with a modelled one, was implemented in PRO Engine. The modelled one is based on active power and ambient temperature, and by applying machine learning methods it calculates a health value.

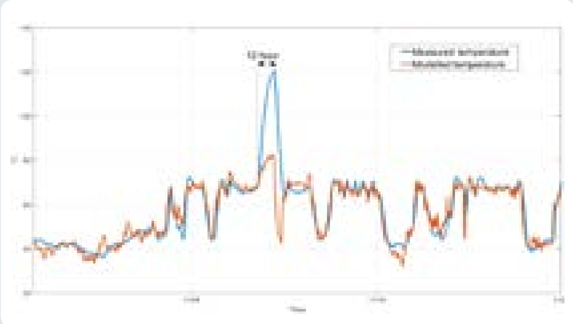
Sequence of events

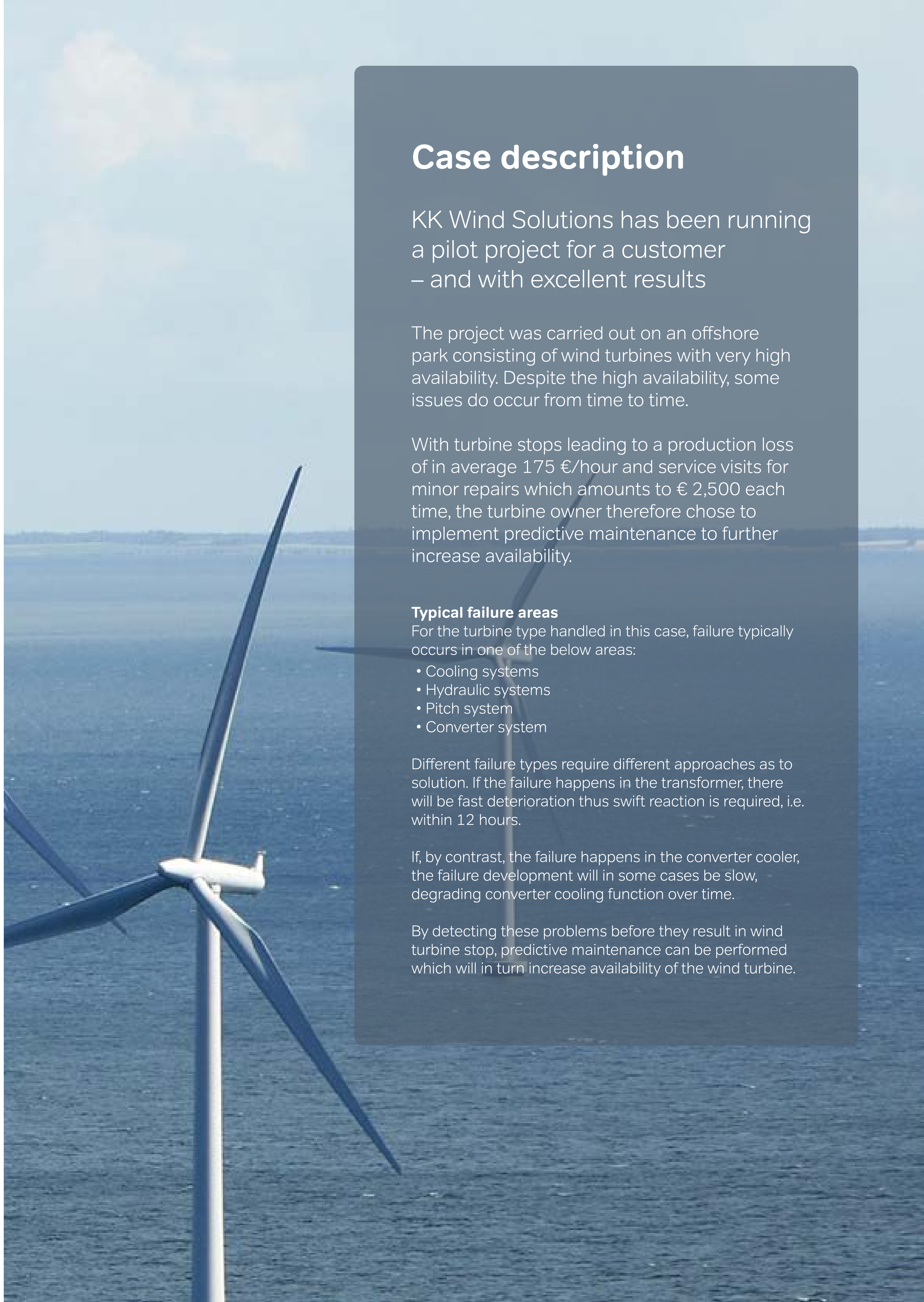
A comparison of measured and modelled transformer temperature revealed a component failure approx. 12 hours before a wind turbine stop.

Not until the temperature limit was reached 12 hours later it was detected by the wind turbine controller.

The root cause was a defective cooling fan in the transformer room.

The below figure shows an algorithm detecting a failure in the transformer room cooling system approx. 12 hours before the wind turbine controller stopped the wind turbine.





Case description

KK Wind Solutions has been running a pilot project for a customer – and with excellent results

The project was carried out on an offshore park consisting of wind turbines with very high availability. Despite the high availability, some issues do occur from time to time.

With turbine stops leading to a production loss of in average 175 €/hour and service visits for minor repairs which amounts to € 2,500 each time, the turbine owner therefore chose to implement predictive maintenance to further increase availability.

Typical failure areas
For the turbine type handled in this case, failure typically occurs in one of the below areas:

- Cooling systems
- Hydraulic systems
- Pitch system
- Converter system

Different failure types require different approaches as to solution. If the failure happens in the transformer, there will be fast deterioration thus swift reaction is required, i.e. within 12 hours.

If, by contrast, the failure happens in the converter cooler, the failure development will in some cases be slow, degrading converter cooling function over time.

By detecting these problems before they result in wind turbine stop, predictive maintenance can be performed which will in turn increase availability of the wind turbine.

Case:

Converter cooling failure

Predictive algorithms utilize the existing sensors to detect converter coolant failure before resulting in wind turbine stop.

The converter cooling system is an essential part of the converter system that has to ensure stable temperature condition of the power stacks in order to keep a high availability and life time of the converter.

The coolant temperature is managed by the wind turbine controller by controlling a valve and a number of fans. The cooling system performance can degrade over time, for instance if the external radiator gets dirty or if one of the fans fails.

Thus, a latent failure in the cooling system can result in a wind turbine stop at a demanding condition (e.g. high power and high ambient temperature).

Detecting these problems before they result in wind turbine stop allows predictive maintenance to be performed - thereby increasing availability.

Furthermore, the service department now gets the opportunity to switch from time-based maintenance with regular cleaning of external cooling radiators to an approach where it is done when needed.

Sequence of events

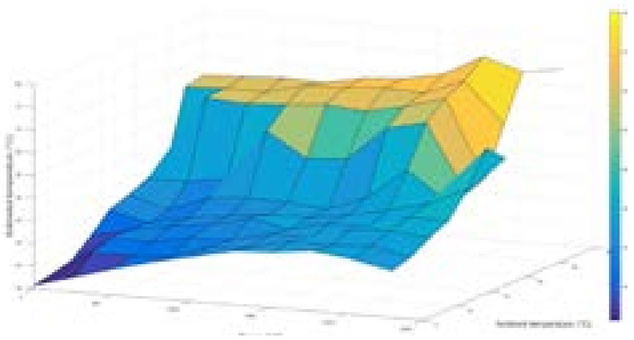
A comparison of measured and modelled converter coolant temperature showed that cooling power was reduced thus fluctuating temperature put unnecessary stress on the power stacks.

The root cause proved to be a dirty external radiator, which could have resulted in wind turbine stop when the ambient temperature increased.

Previously, service was carried out as time-based maintenance or in case of wind turbine stop.

Algorithm principle & design

- Design and implementation in Matlab™/Octave.
- Machine learning methods (Regression, Neural network, etc.).
- Historical data used for model training and verification (alarm statistics).
- Sample frequency range (10 ms – 10 min).
- Dynamic/static models.



The picture shows a dirty external cooling radiator in an offshore wind turbine.

Available algorithms

We offer the following algorithms and continuously develop new algorithms based on our extensive turbine knowledge.

- Pitch
- Main bearing
- Gear box
- Generator
- Converter
- Yaw
- Power performance
- Hydraulic systems
- Cooling systems
- Transformer
- Electrical panels

KK Wind Solutions®

HQ
KK Wind Solutions A/S
Bøgildvej 3
DK-7430 Ikast

Phone +45 96 92 43 00

E-mail main@kkwindsolutions.com
Web www.kkwindsolutions.com

About KK Wind Solutions

Building on more than 35 years of experience in electrical systems for wind, KK Wind Solutions' capabilities span development of state-of-the-art technologies, high quality lean manufacturing, cost-efficient supply chain solutions and flexible service of turbines.

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