

Unlock the full potential of your wind turbines

Words: Bruno Pinto, CTO at Sereema



The phasing out of public subsidies and subsequent reduction of wind energy sale prices has triggered the need for going the extra mile when it comes to optimising the output of wind energy assets. Underperformance or non-optimal operation and power generation are a frequent issue on operating wind turbines. Access to powerful independent information completing the manufacturers scope is the only lever to keep an edge over operational optimisation of the machines.



Two main causes sum up the majority of optimisation issues:

- erroneous or incorrect settings on the turbine, causing it to produce less energy than expected
- lack of adaptation to the local wind conditions. In this case even if the turbine's parameters are set as expected, it might not be producing the maximum power possible

Incorrect settings occur as wind turbines are complex systems that need to be well tuned in order to perform up to their potential.

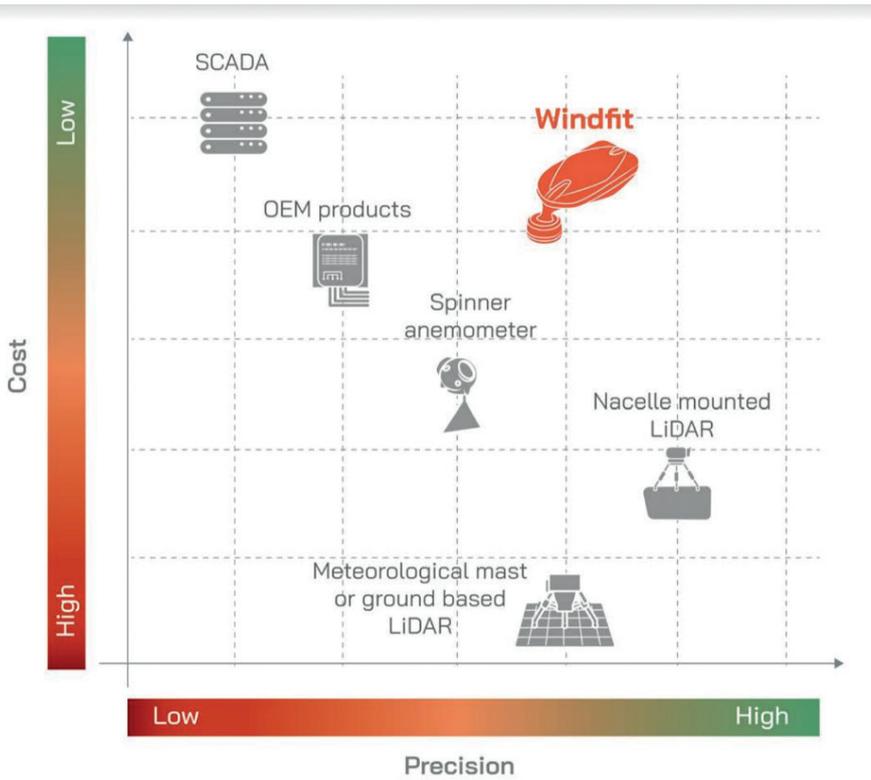
During the lifetime of wind turbines, non-optimal operation can occur, reducing the performance and therefore the power output the turbine is able to produce. These non-optimal behaviors can be present since the commissioning of the wind farm or can appear every time a parameter is changed or maintenance activity is performed on one of the key elements of the turbine.

Wind turbines can turn out to be ill-adapted to local conditions. Their settings and control parameters are defined under reference conditions that can strongly differ from those experienced on-site. The use of these

'worst-case scenario' parameters creates a suboptimal energy yield and therefore an optimising potential when adapting wind farms to the wind characteristics of each site.

So how to unlock the full potential of wind turbines?

Two options arise: making sure that the wind turbine presents no defaults during operation and that operating parameters are well adapted to the on-site conditions of the wind turbine. This can only be obtained if we have access to maximum relevant information on how the wind turbine operates. But surely nobody needs more meaningless or



Windfit technology comparison: Extracted from Yaw Misalignment White paper by Sereema, a comprehensive comparison of methods to measure YM on wind turbines

redundant data. The growing volume of data to look at and act upon makes it difficult to see an added value in solutions that provide yet again more information. And that's the reason why external independent information, bringing either additional or deeper analysis, is key to make sense of it all. With dedicated designed algorithms, data analysis extracts only the empowering bits and pieces, turning them into levers for operators.

The need for closer monitoring

Despite this unlocked potential, the most frequently available solutions to monitor wind farms either do not provide the necessary information to detect the underperformance and identify the root-cause or they lack the precision, accuracy and scalability required to be used by wind farm owners and operators at a large scale.

These monitoring solutions can be summarized in two main groups:

- analysis of the available SCADA data obtained from the turbine controller
- use of high precision measurement systems (LiDARs for example) to monitor a particular parameter of the wind turbine.

Both groups present important added value but also some drawbacks.

Using SCADA data, and mainly from its large availability, is a low cost and scalable solution. Nonetheless, it lacks the precision and accuracy required for a detailed analysis of the wind turbine. Furthermore, the SCADA

system was not designed for performance nor optimisation: the necessary information to identify underperformance issues is, in the majority of cases, not accessible which strongly reduces the scope of issues that can be found with this approach.

On the other hand, expert systems are designed to precisely measure certain parameters, such as the wind flow and turbine vibrations, therefore lacking the complete view necessary to really understand how the turbine operates. In addition, their complexity and high cost deem them not suitable for long-term and continuous monitoring.

In recent years, the use of independent and continuous monitoring systems has largely increased, mainly due to their added value when compared to the standard available solutions described above.

As an illustration, Sereema's system, Windfit, combines IoT (Internet of Things) and Cloud technologies to bring a new approach to the way we monitor and optimise currently operating wind farms.

Windfit technology

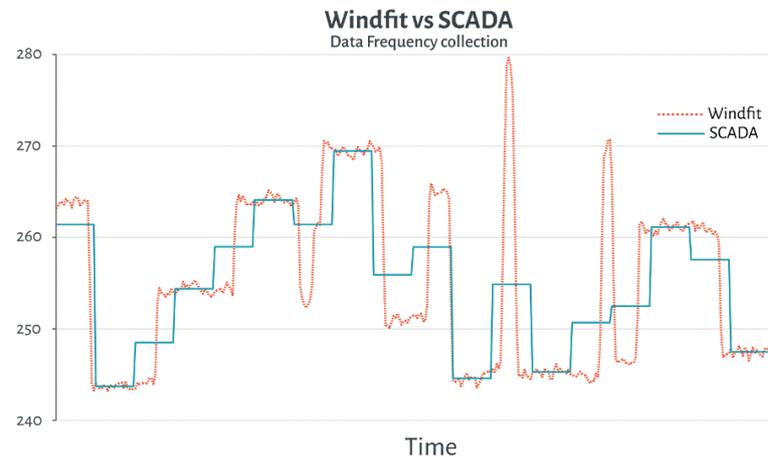
Windfit is a continuous monitoring system that consists of a data acquisition box with embedded sensors that is installed on each wind turbine. The box is installed on the turbine anemometry mast on top of the nacelle.

Windfit measures continuously and at high frequency, acquisition frequency up to 100 Hz, multiple key parameters of the wind turbine:

- all turbine movements and vibrations using sensors such as accelerometers, gyroscopes and magnetometers
- external conditions impacting the turbine by measuring the wind speed, wind direction and turbulence intensity
- the power output of the turbine
- the environmental conditions, such as air temperature, pressure and humidity.

Data is pre-processed locally using embedded computing capacity and then transmitted through the mobile network to a cloud database that stores all historical measurements. The stored data can then be analysed and transformed into precise performance indicators using data analysis algorithms developed in-house.

The strong added value is not in simply acquiring high frequency data but in combining it with the right processing capacities and algorithms. By doing so, one can ensure that the quality of the information obtained creates actionable and reliable results for a wind farm owner or asset manager. Windfit indicators can



Windfit vs Scada data frequency: SCADA systems have not been designed for performance optimization. Independent systems will likely pick up what's really happening

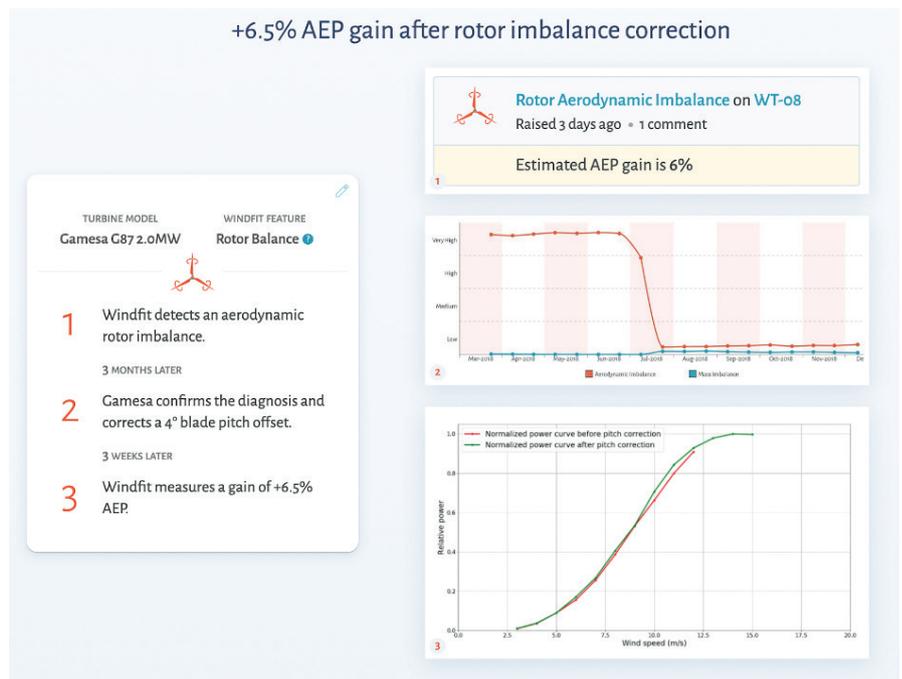
be used to monitor the overall operation and the key elements of the wind turbine, such as the rotor and the blades, the yaw system or the foundation, among others.

The selection of the information that is acquired by Windfit was made with the performance monitoring and optimisation in mind. This means that the sensors used allow for a complete and detailed analysis of the operation of the wind turbine. Combining the environmental parameters around the turbine i.e. wind intensity and turbulence, air density, and how the turbine reacts to those conditions in terms of power output, vibration levels, yaw strategy, among others, provides an overall understanding on the interaction between the turbine and the wind, with the key information on the turbine performance and operation.

Independent monitoring systems

Equipping wind farms with independent monitoring systems provides key advantages when compared with the information available in the standard SCADA data:

- **Improved operation and performance:** data acquisition and processing are conceived and designed to identify underperformance or non-optimal operation of the turbine. Major issues such as Rotor imbalance, Yaw Misalignment, Power Curve degradation, that have been known to be the main causes for underperformance, can be identified and corrected as soon as possible.
- **Early fault detection:** issues and deviations are identified as soon as they appear and alerts are sent out to the asset manager or O&M teams to correct the fault.
- **Increased lifetime:** solving issues that lead to increased loads and efforts on the turbine can increase, in the long-term, the lifetime of the turbine's main components: main bearing, foundations, blade bearings. This can be particularly important when a lifetime extension is envisioned for the wind farm.
- **Adapted to on-site conditions:** the information available unlocks our understanding of the wind turbine behaviour and its interaction with the local



Windfit use case: use case of rotor imbalance detection and correction by Windfit

wind conditions. The control strategies and parameters currently defined under reference conditions can be redefined and optimised using the available operational data; Strategies can be defined on a wind turbine level compared to the turbine model level most frequently used today, allowing for a better performance and lifetime of the turbine.

- **Long-term trend analysis:** the more historical data is available the better we can understand the evolution of the operation of the turbine over time. We can separate long-term degradation, caused by the natural aging of the turbine and therefore impossible to correct, from short-term or event driven degradations that are mainly caused by human interventions or software changes; the last ones can and should be corrected.
- **Access to historical events:** the unlimited store capacity of cloud servers allows for the owner to access the complete detailed

history of the wind farm. For example, when unpredictable conditions impact the turbines such as storms and lightning: the monitoring system can detect if the turbine suffered any damage and if an on-site check should be performed.

A smarter and brighter future for the industry

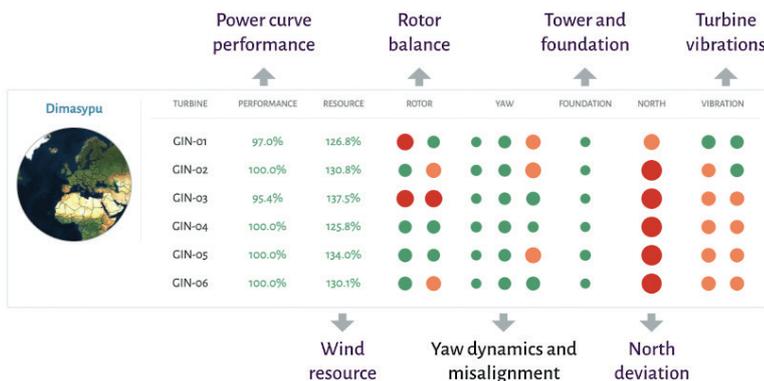
Keeping a close eye on the operation and performance of wind turbines is becoming increasingly important for wind farm owners and operators, especially in a market where each extra kWh produced can be key for the wind farm profitability.

How frequently non-optimal behaviour occurs on operating wind turbines creates the need for a close and detailed monitoring of the turbine's operation. Furthermore, their full potential can only be accessed if this monitoring is done continuously and on the long-term. The most frequently used solutions and technologies do not fully answer that need.

Windfit, the independent monitoring system, based on the IoT and Cloud computing technologies, allows for a deeper understanding and root-cause detection of underperformance or non-optimal behaviour on the monitored wind farms. In addition, understanding the turbine's environment makes it possible to adapt its operating parameters to the local wind conditions making the way it extracts the energy from the wind smarter: a real giant with a brain!

This provides an added value on the short-term with a higher performance and energy yield and on the long-term with an increased lifetime expectancy and lower uncertainty for the future.

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Windfit web interface overview: all indicators and actionable results available online