PO.119

# Holistic analysis of turbine performance indicators

Natural Power

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## Abstract

Advanced turbine performance analysis techniques offer the opportunity to accurately predict future performance based upon past performance and also to identify and rectify any underperforming turbines ensuring that future performance is maximised. A new methodology based on machine learning algorithms is utilised to normalise the power for complex flow conditions such as turbulence, shear, veer and inflow angle for a given turbine type. Flow parameters are modelled through both the use of VENTOS CFD modelling coupled with on-site observations concurrent to wind farm operation and coupled mesoscale-CFD model VENTOS/M to quantify the uncertainty reduction through on-site observations.

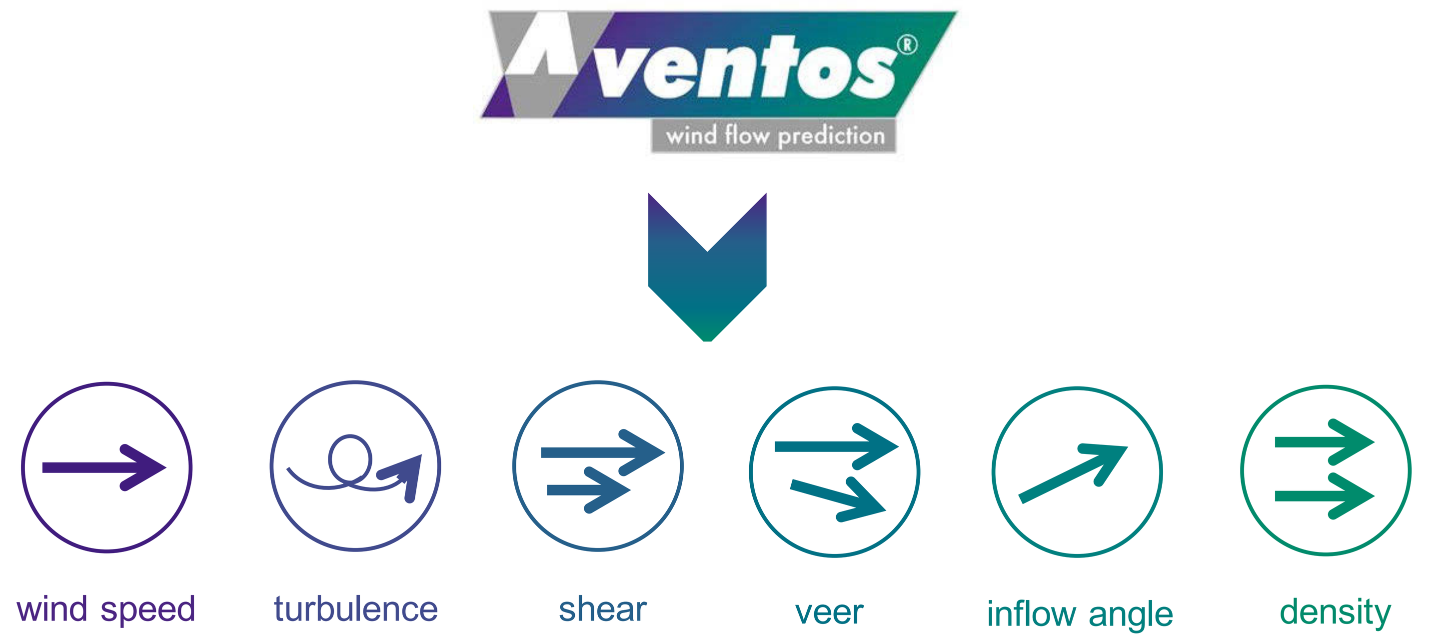
After this initial analysis, automated tools are provided to use in a deeper investigation into the SCADA data to identify the key indicators leading to individual turbine underperformance. Strategic maintenance campaigns are derived through benchmarking of turbine performance indicators to determine an optimised maintenance strategy that will deliver the highest potential gains in performance. A case study is presented to show the results and describe the on-going maintenance campaign.

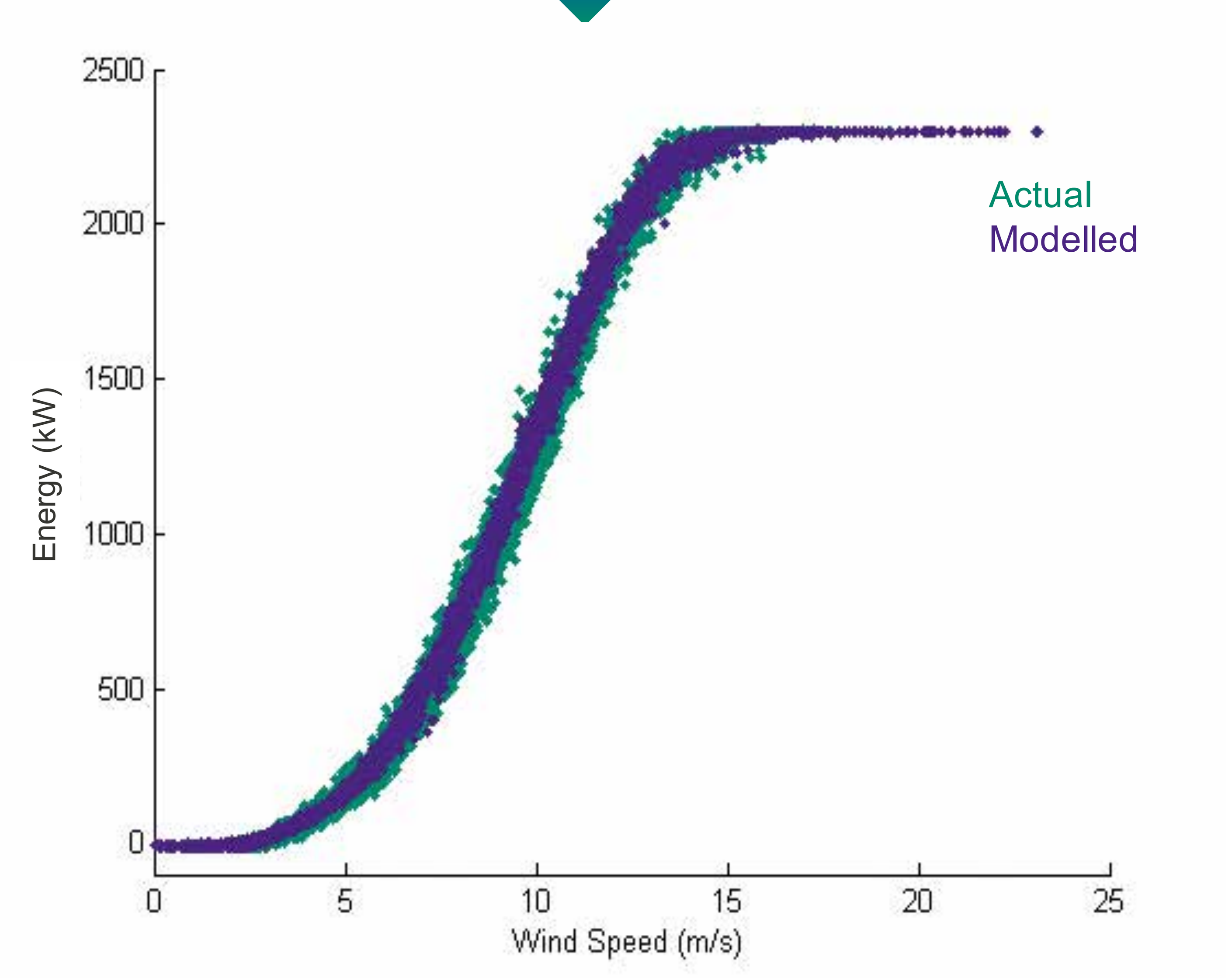
## Methodology

**Power generation and flow conditions are used to generate a turbine specific multi-dimensional power curve.**

VENTOS CFD is paired with on-site observations where available, or VENTOS/M a mesoscale-coupled CFD model where on-site observations are unavailable, to obtain time series of detailed flow conditions at each turbine. Machine learning algorithms use this data to develop a multi-dimensional power curve by determining the turbine's most probable response based on the flow conditions.

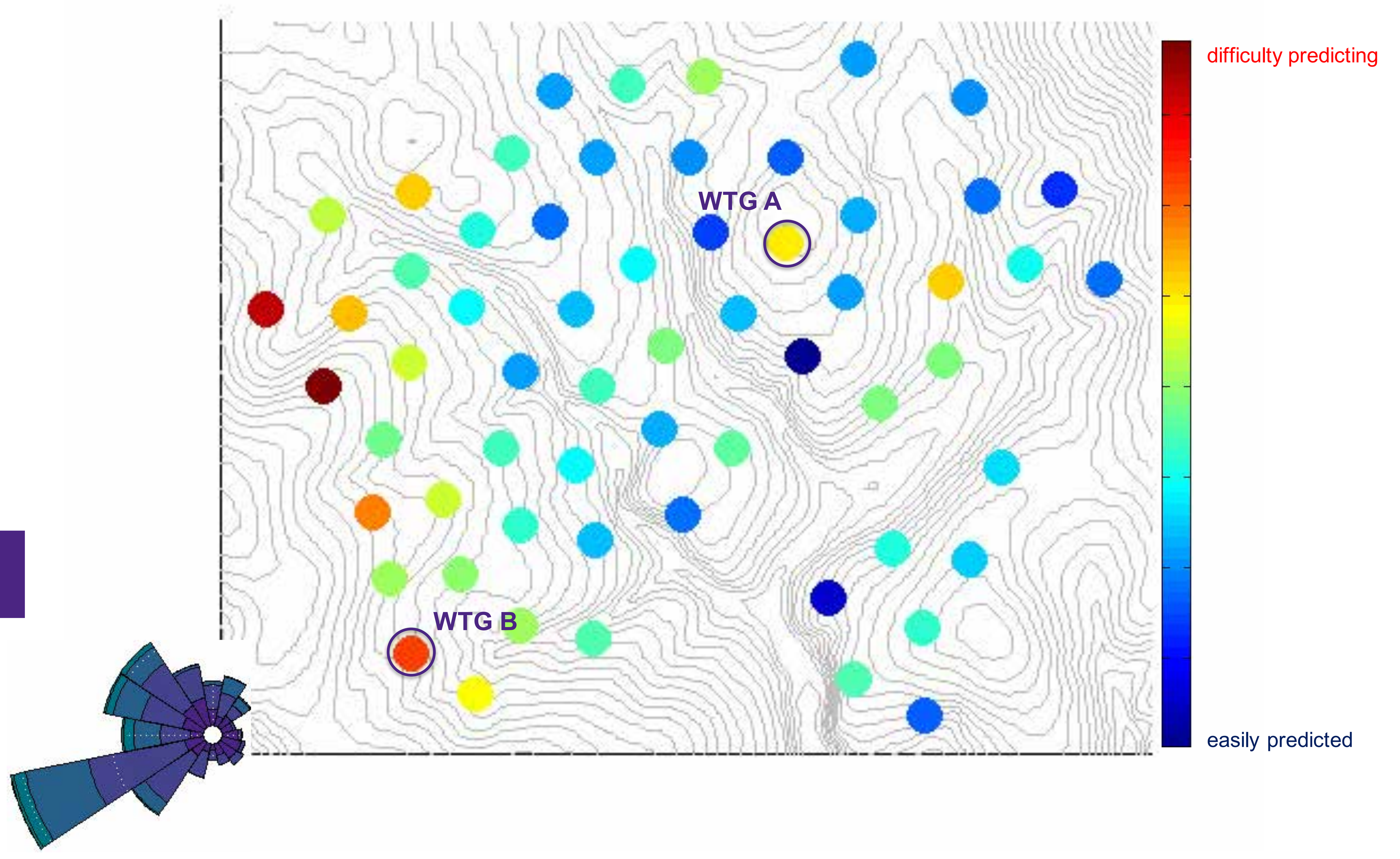
The results are then compared to the SCADA data to determine the most probable causes for deviation from the modelled power.



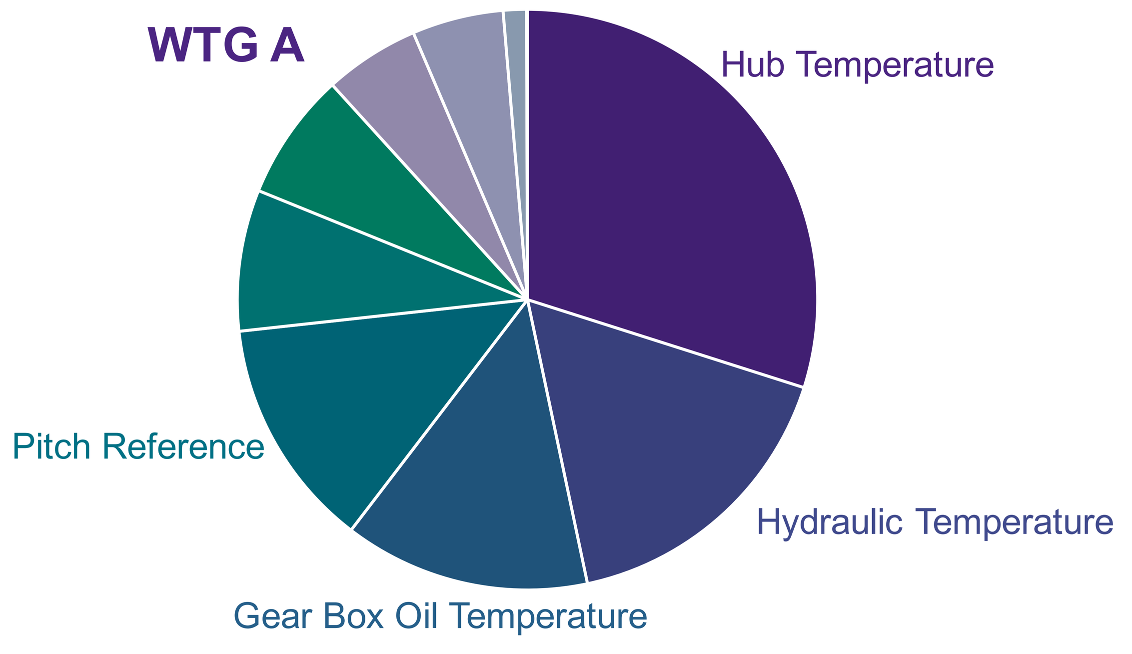




## Case study

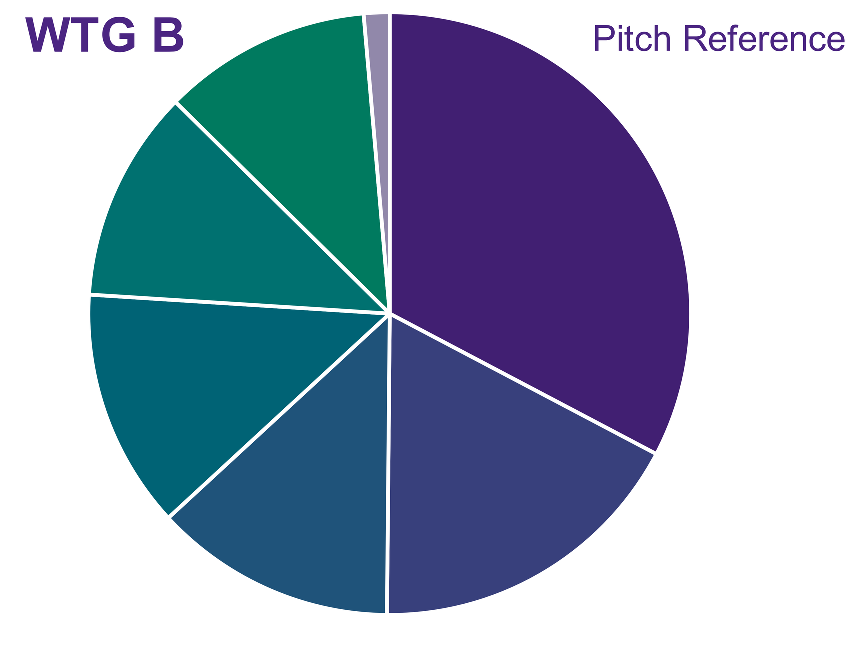
When run over an entire site, as shown in the layout map below, the turbines can be ranked for how well the model predicts their energy generation. Turbines which are difficult to predict (i.e. have a high standard error when the predictions are compared to the actual generation) are not operating as expected and are likely candidates for internal issues such as yaw misalignment or component inefficiencies.




Additional analysis using principal component methods looks to identify probable causes for inefficiency. Below show the results for two such turbines identified in the map above.




- The principal component analysis at WTG A showed the likelihood of the underperformance to be related to turbine component issues
- Recommendations are made for a turbine inspection targeting the hydraulic unit




- The principal component analysis at WTG B pointed primarily to mechanical signals and did not present a case for likely component degradation
- This turbine is therefore a candidate for yaw misalignment test or pitch optimisation
- A ZephIR DM mounted unit was installed and identified a 3.7˚ yaw misalignment which has since been rectified

## Results

There is currently much discussion within the industry on the topic of optimising wind farm maintenance and servicing. This new methodology determines energy underperformance indicators, allowing operators to target specific turbines for yaw alignment investigations and highlighting component faults at early stages to maximise the output of the wind farm over its lifetime.