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Hack the error codes of a wind turbine

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Abstract

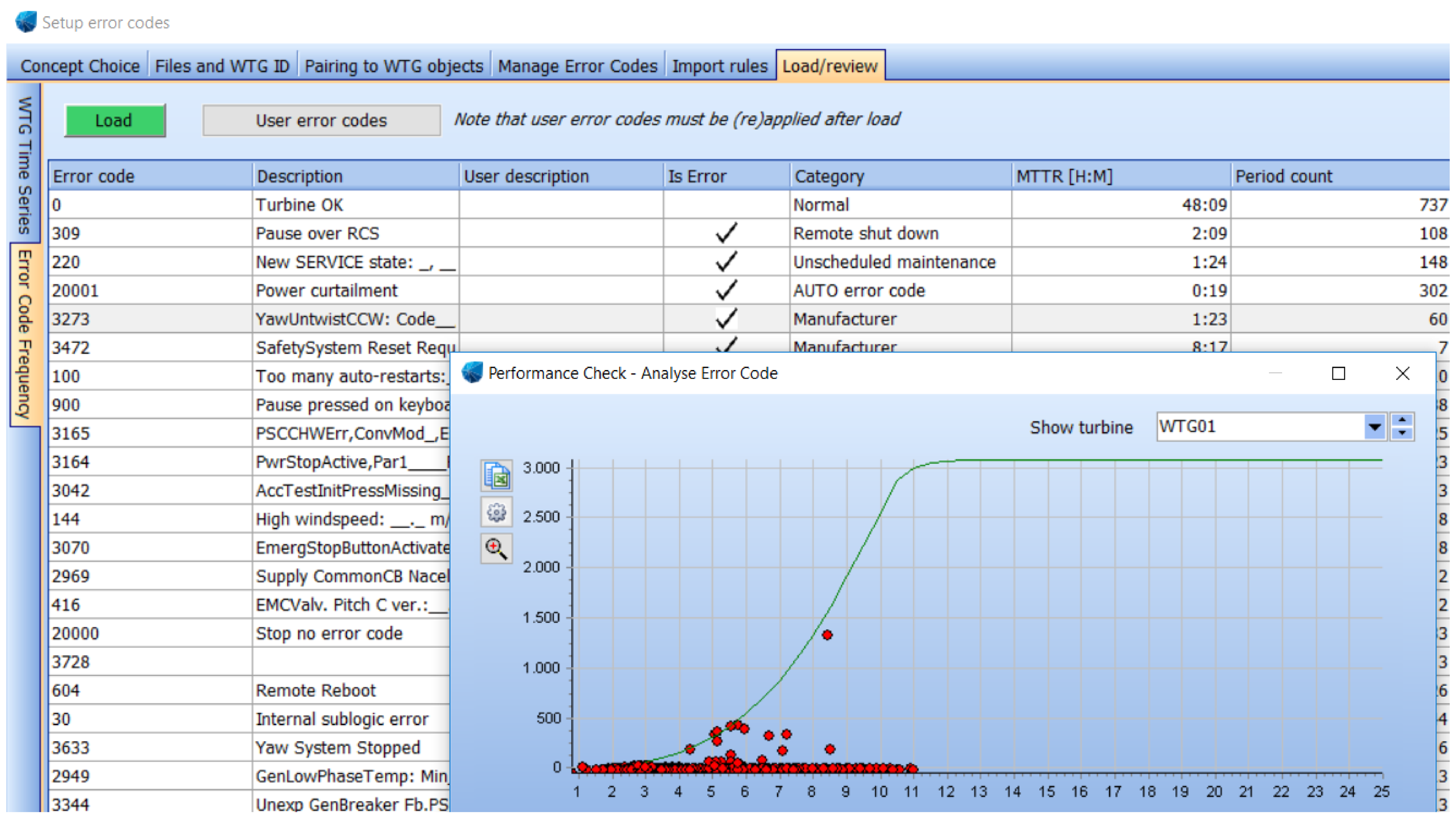
"You just have to analyze the SCADA data". The key to identify sub-optimal performance seems so easy. But at the same time everybody knows the challenge of integrating, the elusive and non-structured wind turbine error event and alarm logs with the production time series. Each manufacturer has individual error event and alarm logging methodologies, with close to no guidance on how to interpret these. Missing transparency or standardization of error logs limits the possibilities for translation and analyzing failures and consequently improve the performance.

Earlier publications and large investigations, such as RELIAWIND [2], investigated the critical main components in operating wind turbine and the average time to repair, with the focus of optimizing future wind turbine design. This and other investigations were mainly scientific, supported by large utilities or manufactures who have the knowledge for how to interpret the error events and merge it to the production SCADA time series. For the small to medium wind farm owners its practically impossible to get this deep level of insights into the turbines actual performance and be able to quantify the losses occurred with respect to each individual turbine error. EMD has developed a solution for "cracking" the code. Its efficiency is demonstrated by presenting an analysis of operational reliability from multiple wind farms with different wind turbine types.

Knowledge is Power

Understanding the consequence of each of the thousands of error/alarm codes and wind turbines logs provides a thorough understanding of your asset's real performance and gives insights to where improvements can be made with highest impact.

For this investigation 630 years of operational wind turbine data have been analyzed in less than a week with our software solution PERFORMANCE CHECK, giving access to the lost production for each individual error code.



As example the above figure highlights events with an error code of 3273. This code represents all the events connected to cable CCW-untwist.

Losses, can be grouped according to [1], aggregated to monthly, annual or combined losses, Potential production can be normalized to represent a long term mean, in order to asses the future expected NET production with, smallest possible uncertainty.

Methods

Primary interest of the investigation is a fact-based quantification of expected losses during the process of pre-construction yield assessment. The methodology for calculating the losses follows the principles given in IEC 61400-26-2 [1] and [4], by establishing the historic power curve from the SCADA data which describes the optimal performance of the WTG. For all events which have no optimal performance, either marked by error codes or identified through user defined filter algorithms, the lost production can be stablished based on the historic power curve and the nacelle wind speed. The inconsistency of the nacelle anemometer during non-operation is overcome by applying correction factors. Work is ongoing to align the tool with the process described in the German Technical Guideline 10 [3] and obtain certification.

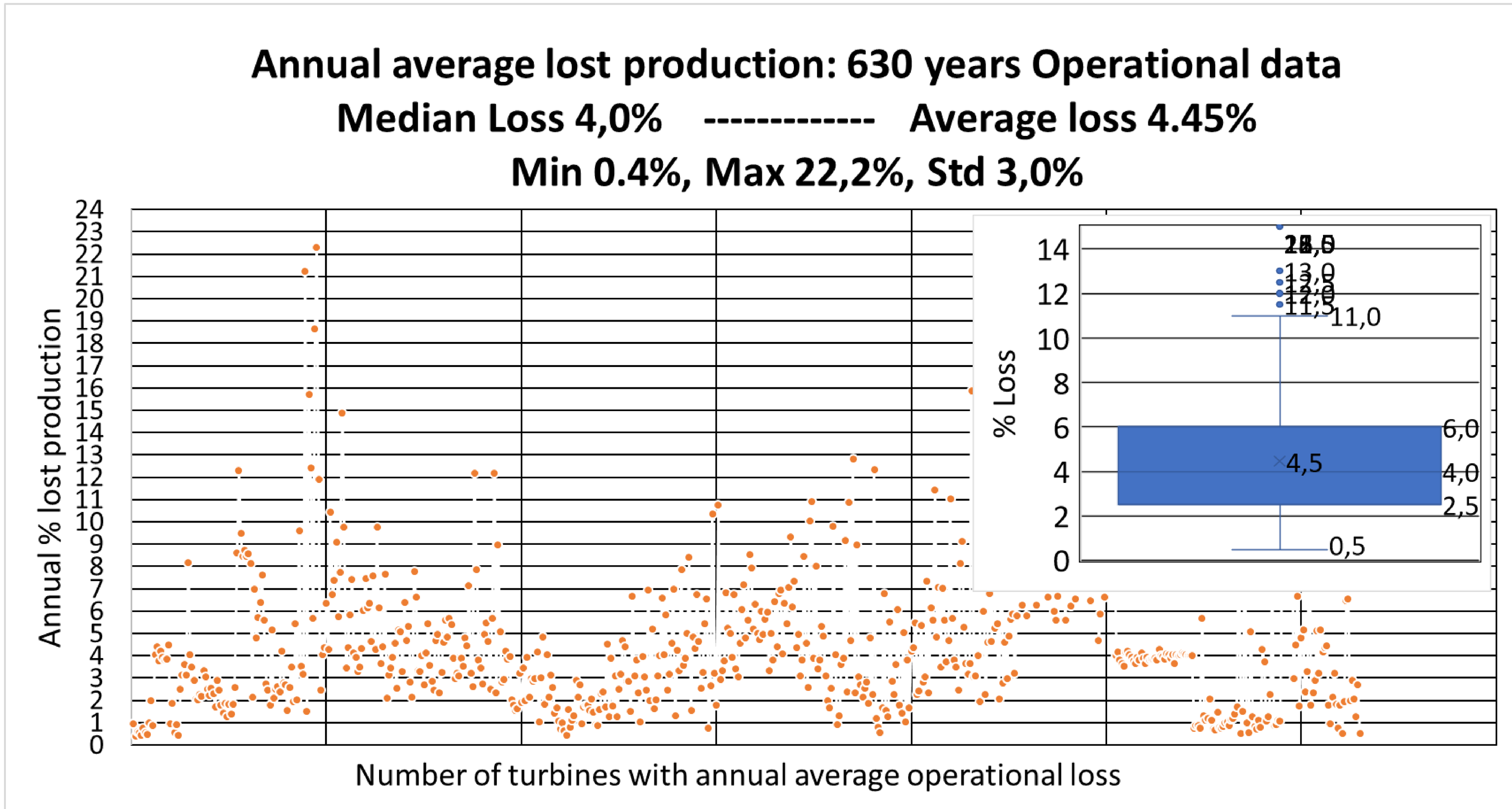
Results

The analysis is not limited to the contractual technical time-based availability, but shows how much production is lost due to individual turbine faults or environmental site conditions.

Surely, each wind farm is unique and has different operational challenges, which becomes quantified in terms of lost production during a post construction analysis. Some of the wind farms under investigation have seen excessive lost production due to a complete gearbox replacement program, hazardous environmental conditions in high wind speed or very warm climate.

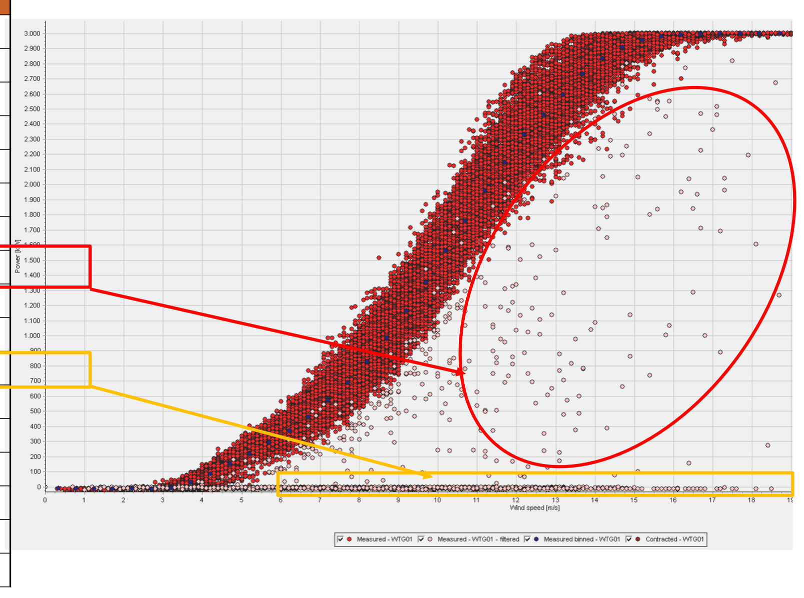
Of all WTGs under investigation 4.5% experienced lost production in excess of 10%. Most of these WTGs were subject to excessive icing loss due to very restrictive local H&S regulations or other permission-related restrictions like bat curtailment.

Results contd.



The median of all analyzed WTGs is 4%, the arithmetic mean is as high as 4.5% but drops to 4.1% if WTGs with losses in excess of 10% are excluded from the analysis. Clearly this number is higher than the usual availability warrantees of 98 or 97%. Parts of this discrepancy can be possibly explained turbine stops or partial performance without an error code. In our analysis these events sum up to average of 0.75% annual lost production. This is of specific important as these losses might not be caught in a traditional time-based availability investigation.

Turbine loss description	Average of Loss [%]	Average of MTTR [Hours]
Unscheduled maintenance	1,25	7,5
Load shutdown	1,02	8,8
Ice detection	0,87	3,8
Bat stop	0,71	2,2
Stop by operator	0,67	6,0
Shadow related shut down	0,67	0,6
Maintenance	0,42	2,9
[USER] Partial performance	0,41	0,6
Remote Stop	0,36	0,8
Repair	0,36	3,4
[USER] Stop without error code	0,35	0,7
Manual Stop	0,24	1,0
Temperature sensor error shut down	0,24	3,9
Manual yaw operation	0,21	3,7
Pitch general error	0,18	2,7
Environment	0,11	1,3
Storm shutdown	0,07	0,9



The above list shows the most common causes of lost production found across the different wind farms along with the mean time to repair.

Any pre-construction assessment should as minimum include lost production due to maintenance, which is most likely covered by availability, and stops related to environmental conditions like e.g. high wind speed hysteresis. Please note that electrical losses have not been considered in this work and need to be added.

Please note, that these findings are presumably conservative, as a majority of the projects under investigation have been brought forward to us as consultancy task, which implies technical issues. A larger unbiased investigation may result in lower annual average losses.

Conclusions

It has been successfully demonstrated that an interpretation of elusive and cascading error codes is possible. The impact is manifold:

- The general performance of the asset can be assessed by determining the lost power.
- Depending on the agreed liabilities a better quantification of claims is enabled, e.g. for grid losses.
- The efficiency of the O&M team can be quantified as the mean time between failure (MTBF) and the related lost production per error code can be analyzed.
- As the lost production per error code becomes visible the economy of a focused O&M effort can be evaluated
- The significantly reduced uncertainty of a post-construction assessment allows re-financing under improved conditions. In the context of asset transfers post-construction analysis can de-risk transactions.

Losses could be quantified as follows:

- On average the losses of 4% can be expected, which exceeds standard availability losses.
- Only the best 25% operating wind turbines experienced on average 1.5% to 2.5% losses. Please note that these WTGs were subject to a very high service strategy.
- 25% of operating wind turbines experienced above 6% annual loss.

References

1. IEC 61400-26-2
2. ReliaWind Project Nr 212966, Juan Bueno Gayo, Final Publishable Summary of Results of Project ReliaWind,
3. TR 10 – Bestimmung der Standortgüte nach Inbetriebnahme, FGW, 2018.
4. Post-Construction Production Assessment of Wind Farms, Report 2016:297, Energiforsk, 2016

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