

Condition Monitoring of Wind Turbine Drive Trains

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▶ PRESENTATION OUTLINE

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- ▶ **Why condition monitoring**
- ▶ **Key issues on condition monitoring of wind turbines**
- ▶ **Proposed condition monitoring methodology**
- ▶ **Wavelet – based methods**
- ▶ **SCADA data analysis**
- ▶ **The future for WT drive train condition monitoring**

Why condition monitoring

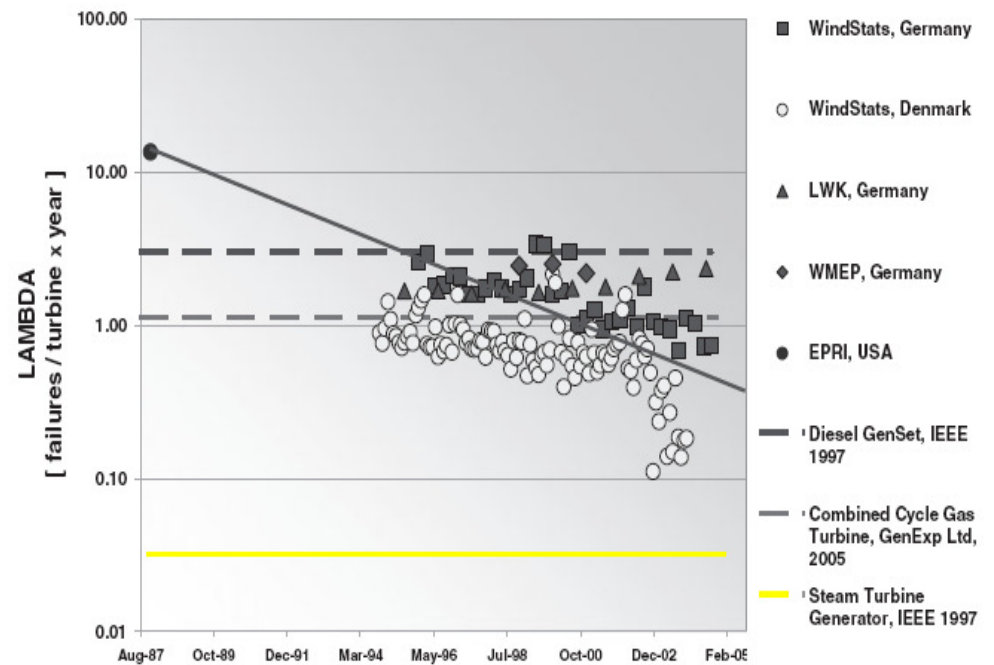
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1. Large wind turbine cost

TYPE	RATED POWER kW	HUB HEIGHT m	SWEPT AREA m ²	DIA. M	SPEED rpm	TOWER WT kg	NACELLE MASS kg	BLADE WT kg	EURO/ kW	EURO/ m ²	PRICE EURO
Nordex N-80	2500	60	5026	80	19		80,000		736.3	366.2	1,840,651
Nordex N-80	2500	80	5026	80	19	179,000	80,000		766.9	381.5	1,917,345
Nordex N-80	2500	100	5026	80	19		80,000		920.3	457.8	2,300,813
NEG Micon NM 2000/72	2000	64	4072	72	18	113,000	76,000	6,800	889.6	437	1,779,296
Enercon E-66/18.70	1800	65	3848	70	22	122,000	101,000	4,200	886.2	414.6	1,595,231
Enercon E-66/18.70	1800	85	3848	70	22	191,000	101,000	4,200	950.2	444.5	1,710,271
Enercon E-66/18.70	1800	98	3848	70	22		101,000	4,200	1036.8	485	1,866,215

Why condition monitoring

2. Wind turbine reliability

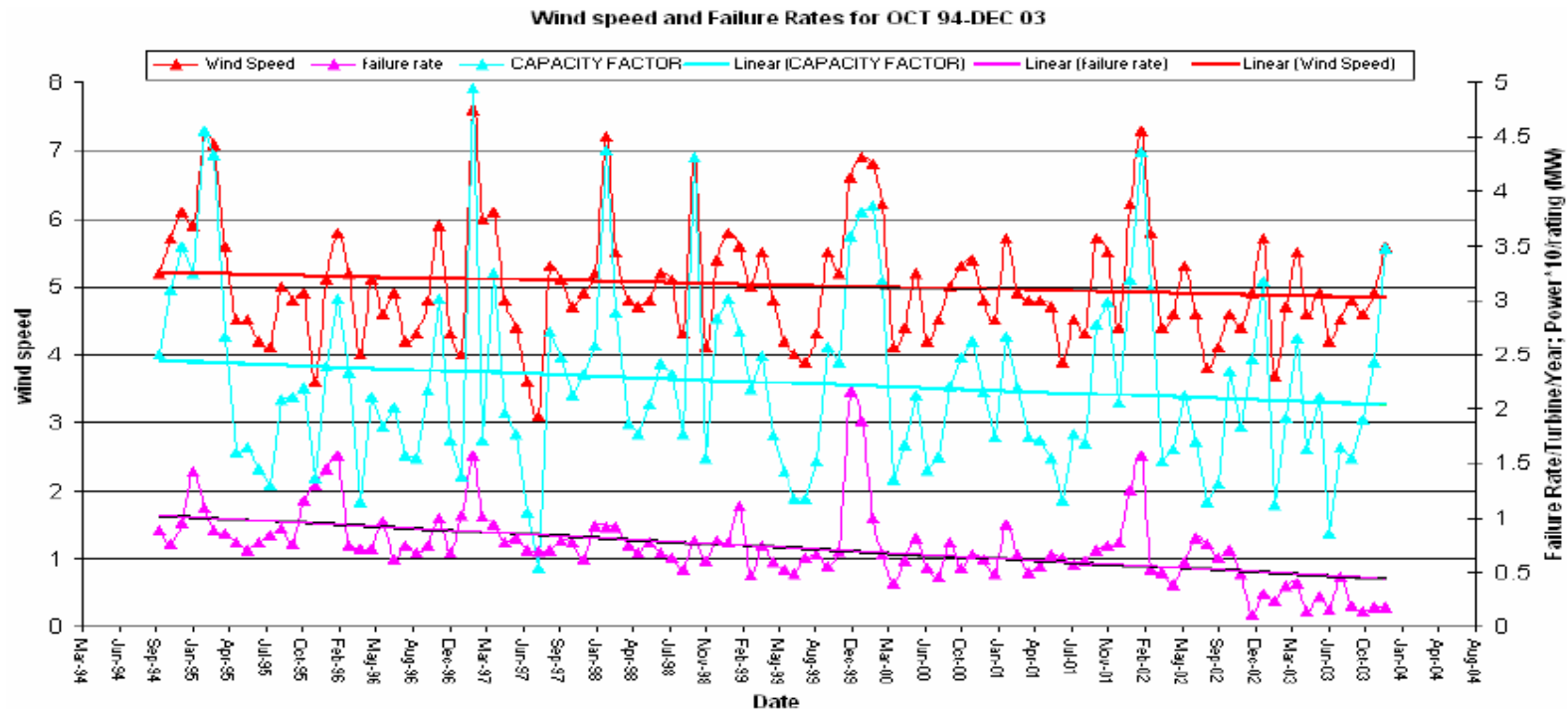


With thanks to Durham University

Why condition monitoring

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3. move to offshore wind farms - need for effective and proactive condition monitoring of wind turbines, particularly with weather restricted maintenance



Key issues on condition monitoring of wind turbines

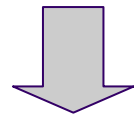
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Fiber optic blade monitoring

Auteur(s):

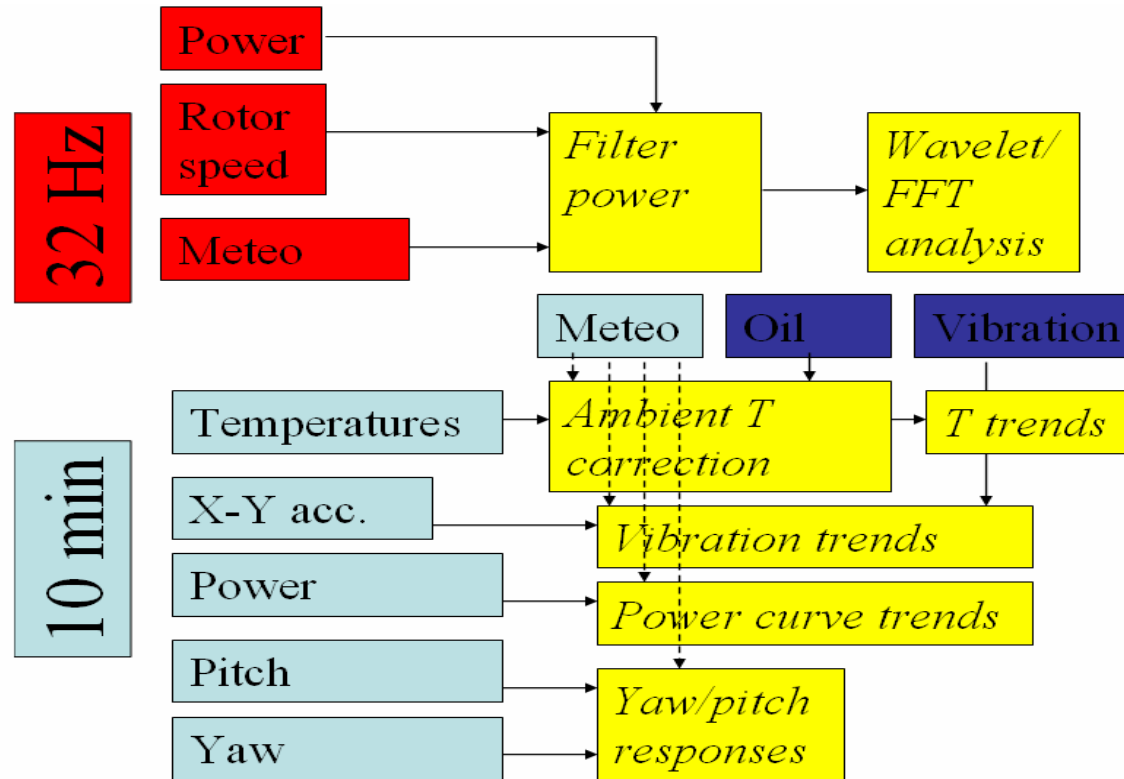
[Rademakers, L.W.M.M.](#); [Verbruggen, T.W.](#); [Werff, P.A. van der](#);
[Kortering, H.](#); Richon, D.; Rey, P.; Lancon, F.



1. The reliability, robustness and cost effectiveness of the sensors and instrumentation
2. The approach with respect to the sensor configuration and integration during the manufacturing process;
3. The data analysis and presentation of the results

Proposed condition monitoring methodology

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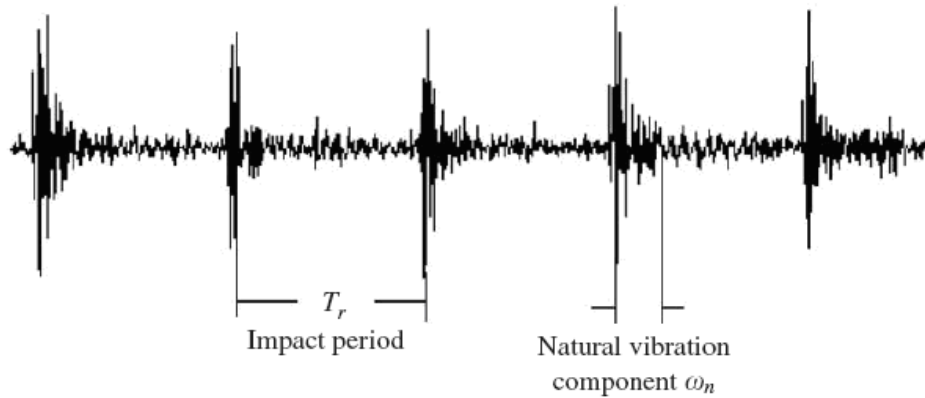
CM Technology Diagram

Wavelet – based methods

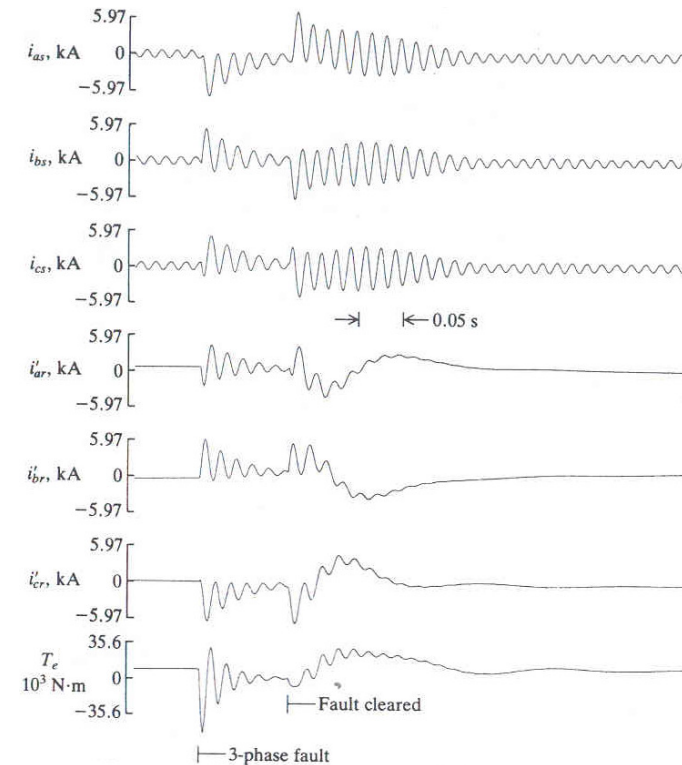
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1. Possible non-stationary signals from wind turbines

- Typical vibration signal of rolling bearing with fault



- Dynamic performance of an induction motor during a 3-phase fault at the terminals

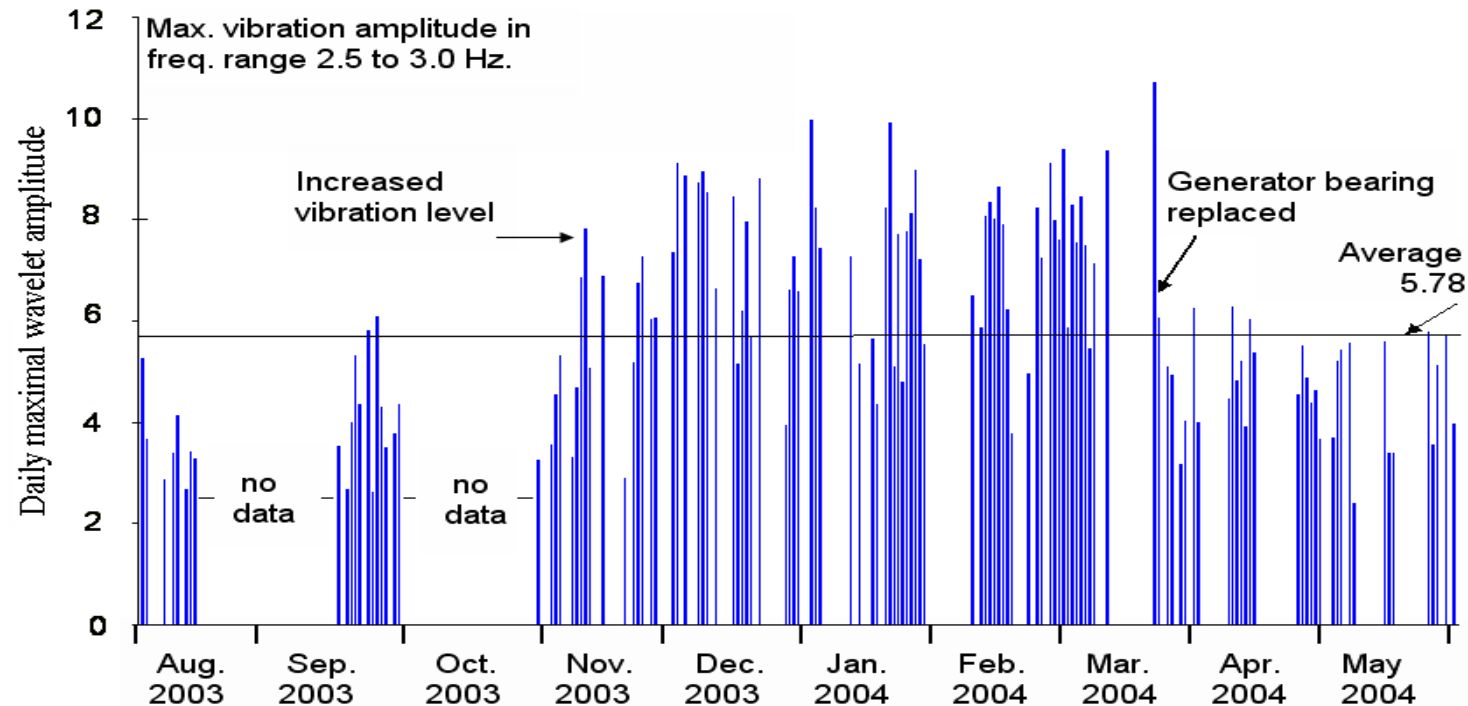


2. The advantages of the wavelet – based methods

- ▶ Bearing problems, shaft misalignment, etc, cause cyclic variations in the EM field in a generator
- ▶ Wavelet can pick out variations effectively, even if speed of generator is varying
- ▶ Examine magnitude of the wavelet filtered variations – indicator of possible bearing wear or shaft misalignment

3. Applications to Pitch Regulated Variable Speed Wind Turbines

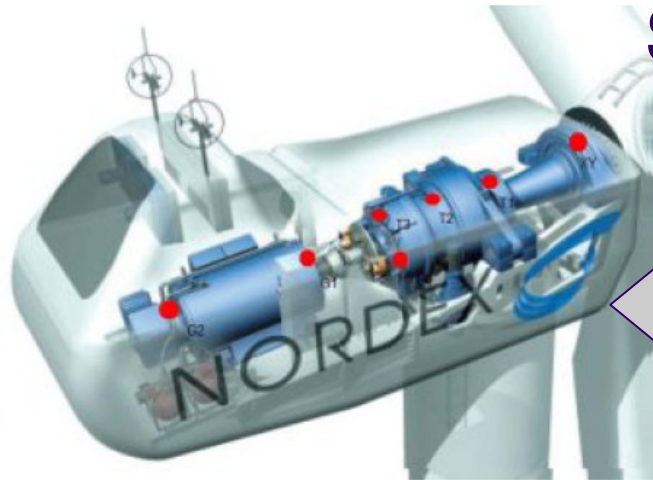
- Wavelet analysis of the electrical power signal sampled at 30Hz in a GE wind turbine.





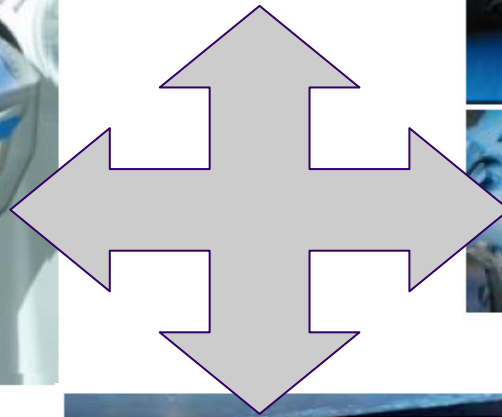
SCADA data analysis

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Sensor Locations

SCADA data



Examples of Location Details



EMC-based installation of a VIBRO-WEB® XP under a 2500 kW generator

db PRÜFTECHNIK



SCADA data analysis

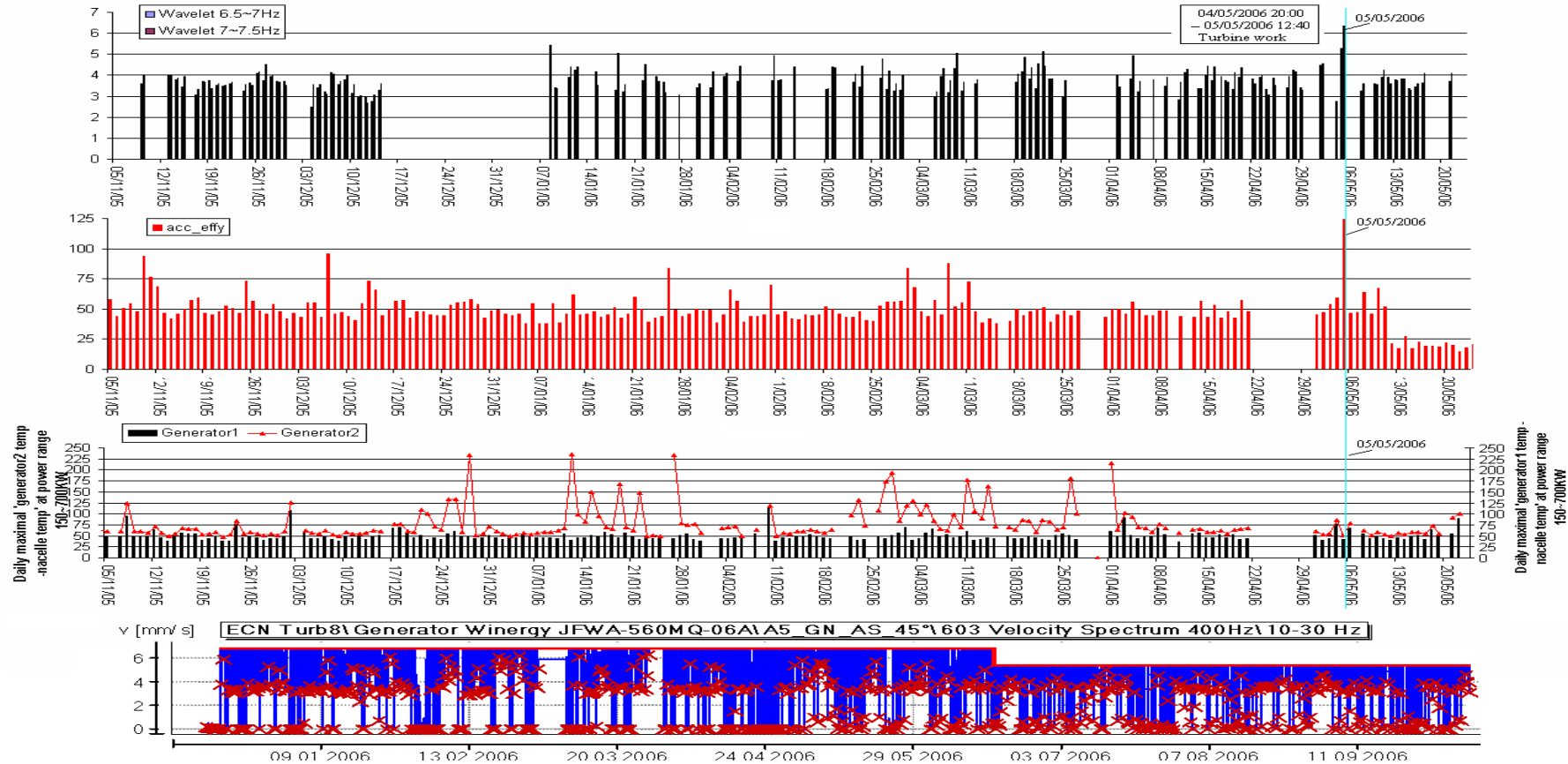
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1. Analysis on temperature, pitch angle, yaw direction and acceleration:
effect of ambient temperature changes;
trending effects;
temperature lag effects.
2. Monitoring methods
trend of deviation;
trend of daily maximum

SCADA data analysis

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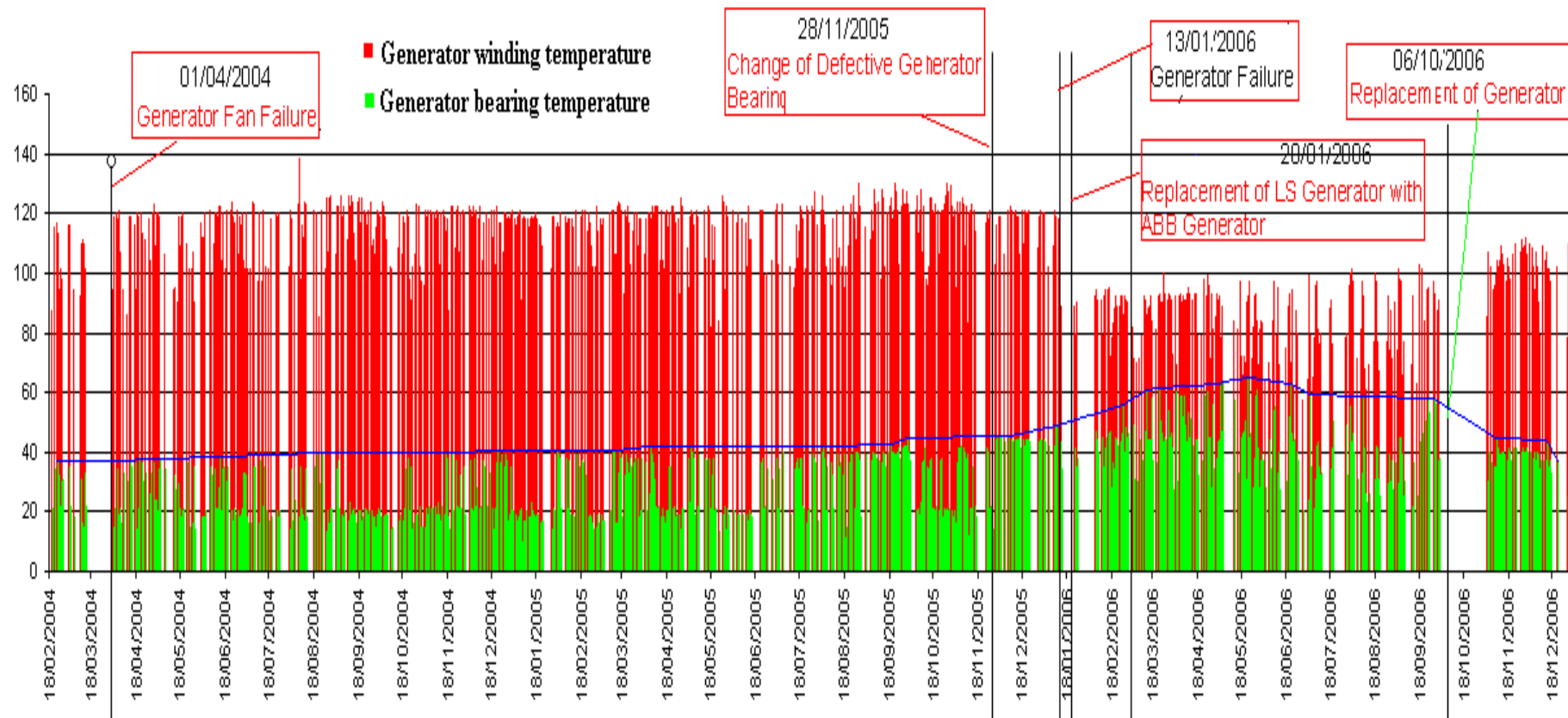
- Applications to Nordex Pitch Regulated Variable Speed Wind Turbines



SCADA data analysis

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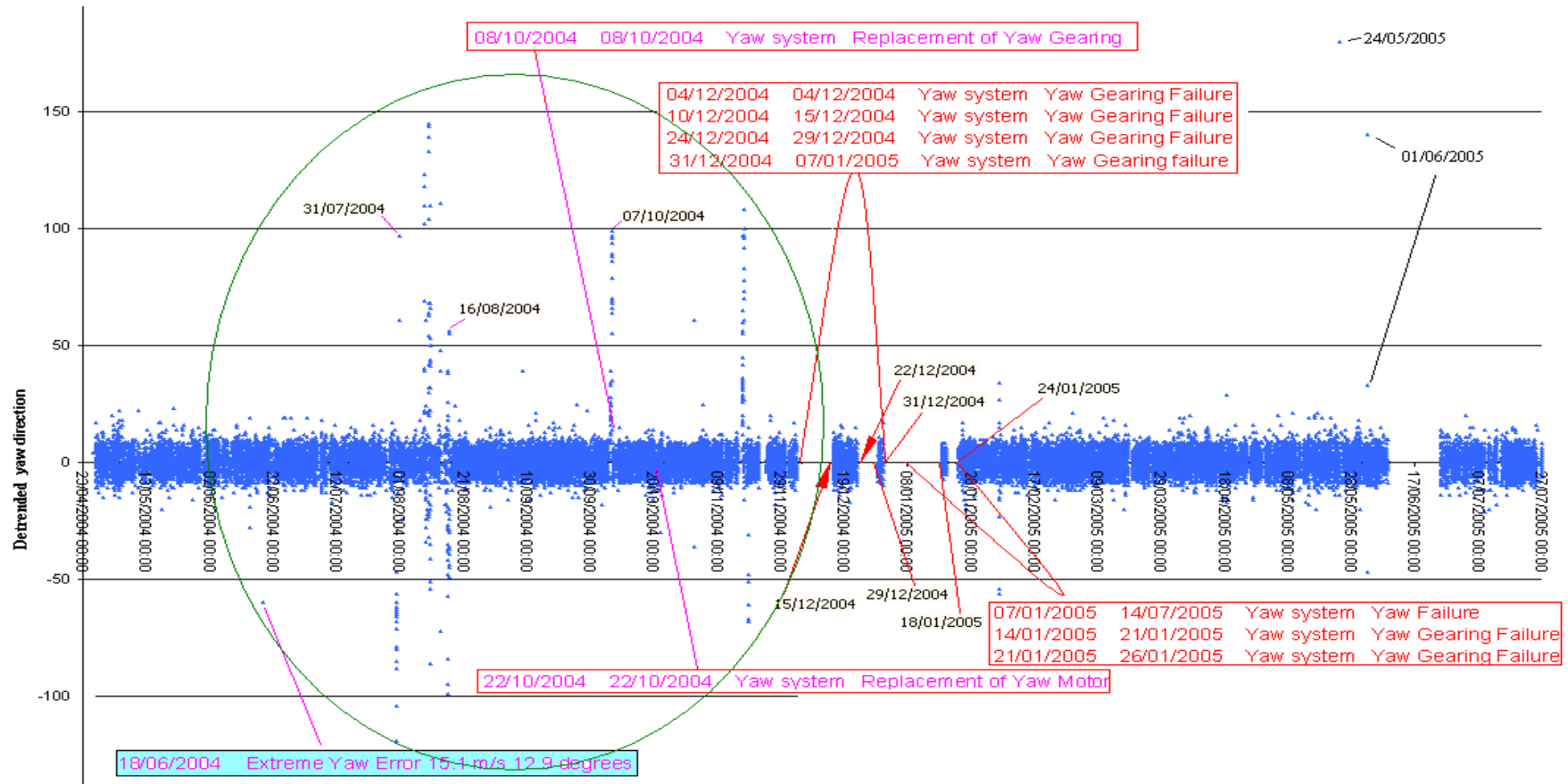
Applications to temperature analysis



SCADA data analysis

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Applications to yaw direction analysis



▶ The future of drive train condition monitoring for wind turbines

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- ▶ High/medium frequency analysis of the power signal
- ▶ Vibration monitoring
- ▶ Intelligent trending of SCADA signals
- ▶ Need to restrict CM to a few key parameters otherwise there is the danger of data overload for operators



Thank you !