Vollautomatisierte Betriebsdatenanalyse zur Optimierung großer Windkraftanlagenflotten

Elflein / Gray

November 2021

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- Company Introductions
- Automation & Scalability
- Section 1: SCADA Data Analytics
- Section 2: Component Failure Analysis

i4SEE TECH – Company Introduction

For owners and operators of renewable energy portfolios wishing to maximise the production of their assets, but faced with the pressures of high costs, risk and workload, i4SEE provides an optimisation service that will help to transform existing operational data into increased financial returns.

Unlike consultancies or software providers, we do not create additional effort for your organisation by delivering lengthy reports or complex tools. The i4SEE service provides you with direct access to a team of experienced professionals, using best-in-class software to analyse and optimise your fleet. We work with you to enable a transition to predictive operations and maintenance.

ENERGIEKONTOR – Operations Department

Total under management

- 107 wind farms, 493 WTG
  - 92 wind farms GER (758 MW)
  - 8 wind farms UK (95 MW)
  - 6 wind farms POR (64 MW)
- Annual energy production of 1,7 billion kWh
- Power supply for 425.000 households

- **Growth Potential:**
  → **More than 650 MW in our Scottish pipeline alone by 2025**

Own Portfolio

- 35 wind farms, 184 WTG
  - 28 wind farms GER (188 MW)
  - 3 wind farms UK (52 MW)
  - 4 wind farms POR (38 MW)
- Annual energy production of 500 Mio. kWh
- Power supply for 125.000 households
- 50 Mio. Euro electricity sales p.a.

- **Opportunity to take over some new wind farms into the own portfolio in the near future!**

- **<u>Pooling</u> resources as a keyword!**

Automation & Scalability

- Cost-effective operation of large-scale multi-GW portfolios will be critical to the success of the wind industry.
- Digitalisation and advanced analytics has a critical role to play.
- Centralised data acquisition and management has evolved over the last 10-years.
- We are only now beginning to see the true potential of Digitalisation and advanced analytics.

i4SEE and EnergieKontor have been working together closely since 2019 on the field of digitalization for optimized O&M.

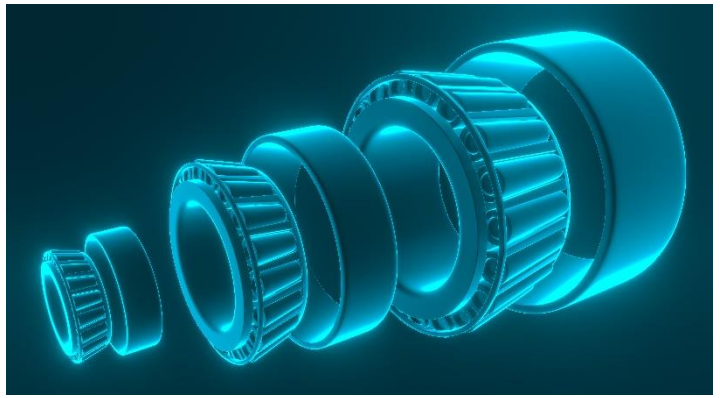
Overview

SECTION 1: SCADA

SCADA Data Acquisition → Performance & Condition Analysis → Predictive Maintenance

SECTION 2: COMPONENTS

Component Failure Database → Long term failure prediction → Optimisation of Logistics



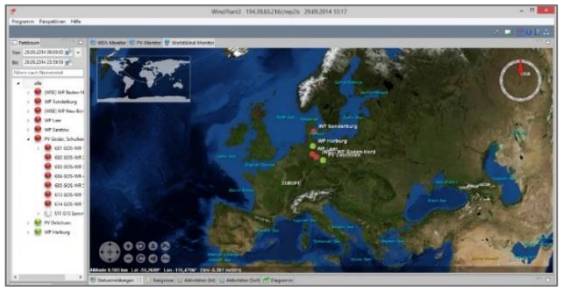
SECTION 1: SCADA

SCADA Data Acquisition

windfarms

OPC

ITS RePLANT SCADA



Azure

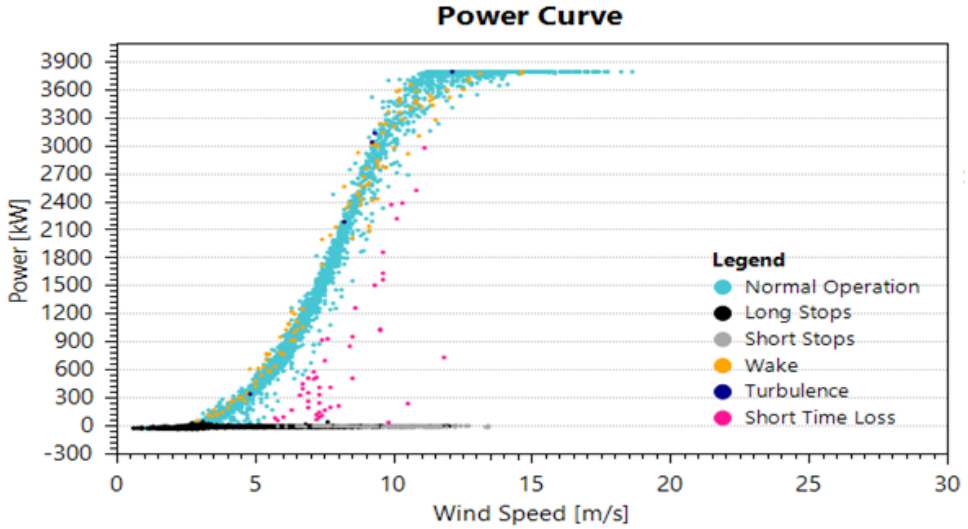
FTP
Server

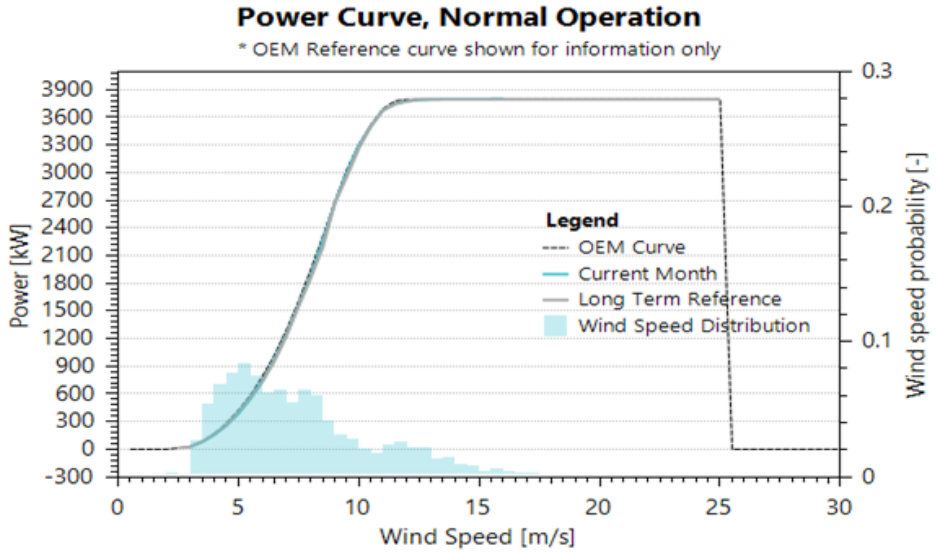
Example 1: High Precision Performance Analysis

- Fully automated performance analysis, including machine learning for state detection and classification.
- Based on IEC 61400-12 standard including Turbulence Intensity correction, extended with external weather data.

Air density correction → Remove stops → Turbulence Intensity Correction → Classify & Remove Wake → Classify & Remove Icing → Classify & Remove Curtailment → Binned Power Curve

Example workflow used in i4SEE Performance™ - simplified



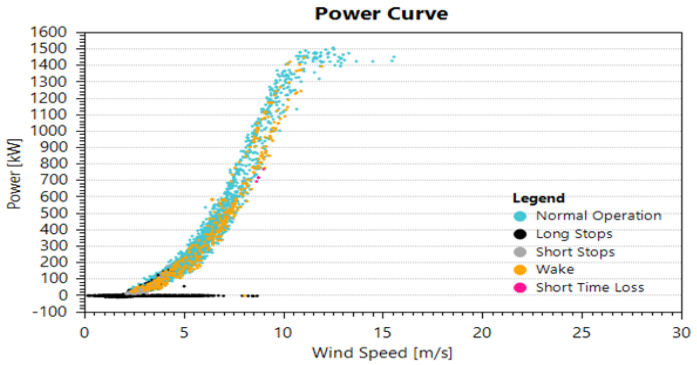


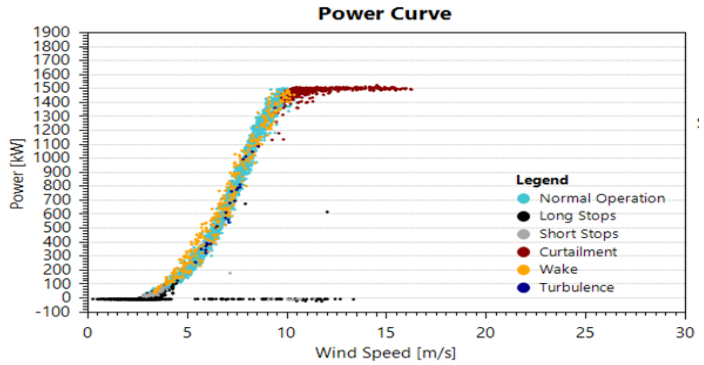
i4SEE Performance: Capabilities

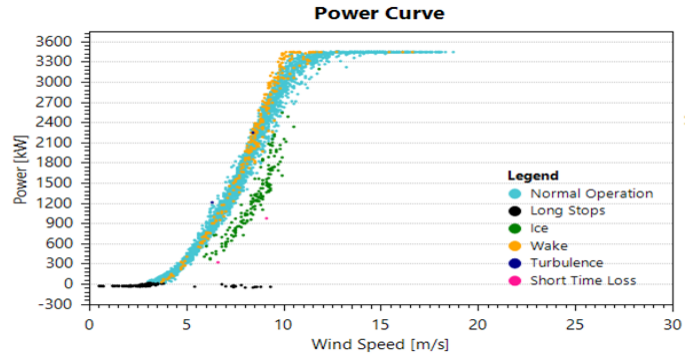
ISSUES DETECTED

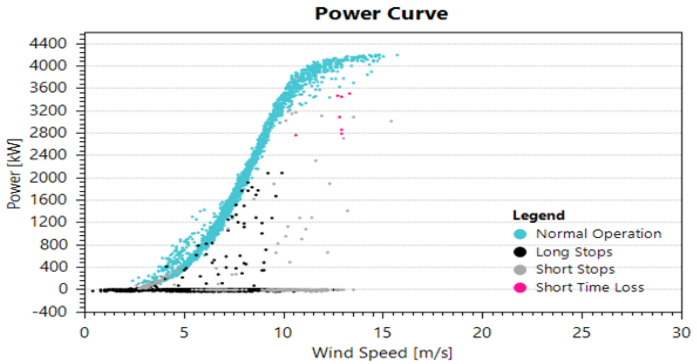
- Curtailment (grid, controller, noise settings)
- Software updates
- Control parameter setting changes
- Blade icing
- Wake effects
- Turbulence intensity influence
- Anemometer defects
- Yaw misalignment
- Pitch misalignment
- Blade degradation

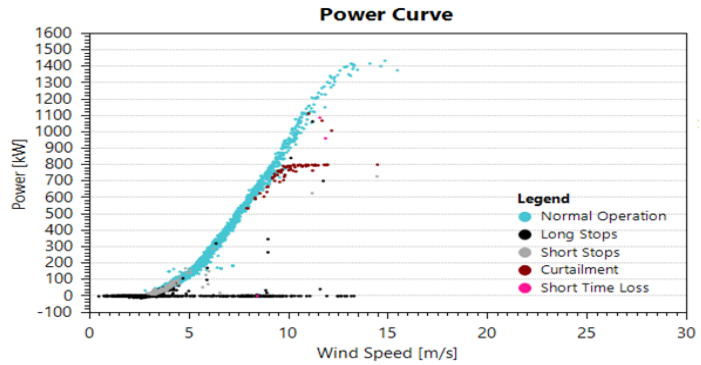
Huge Scale Performance Analysis!

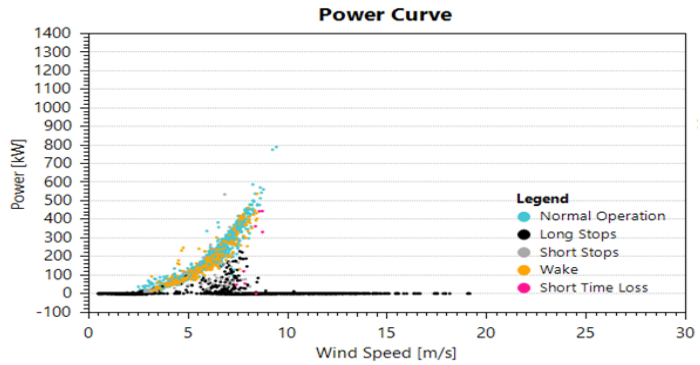


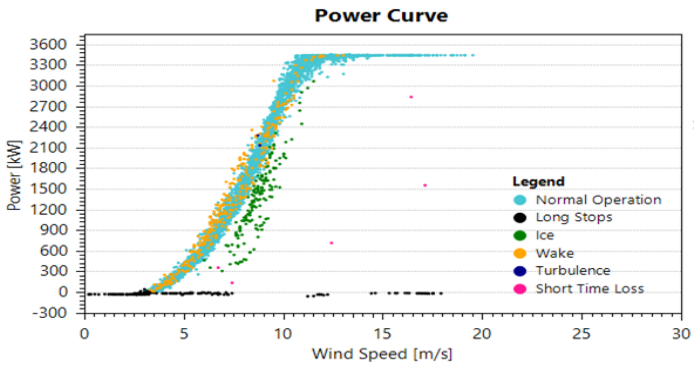


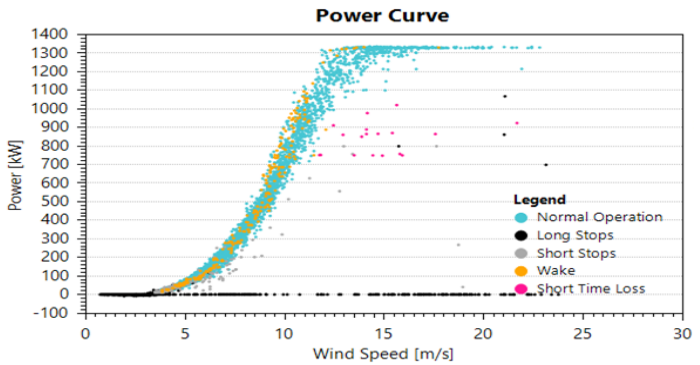


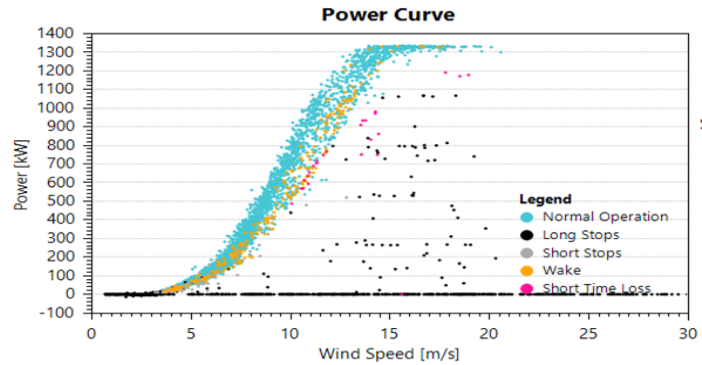






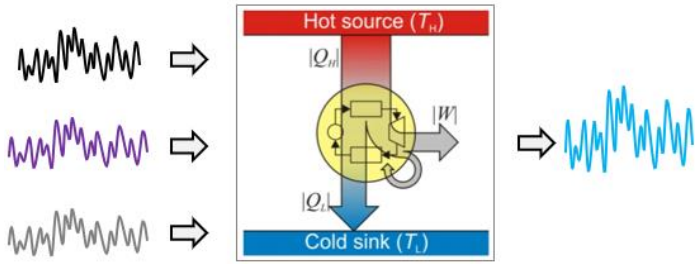




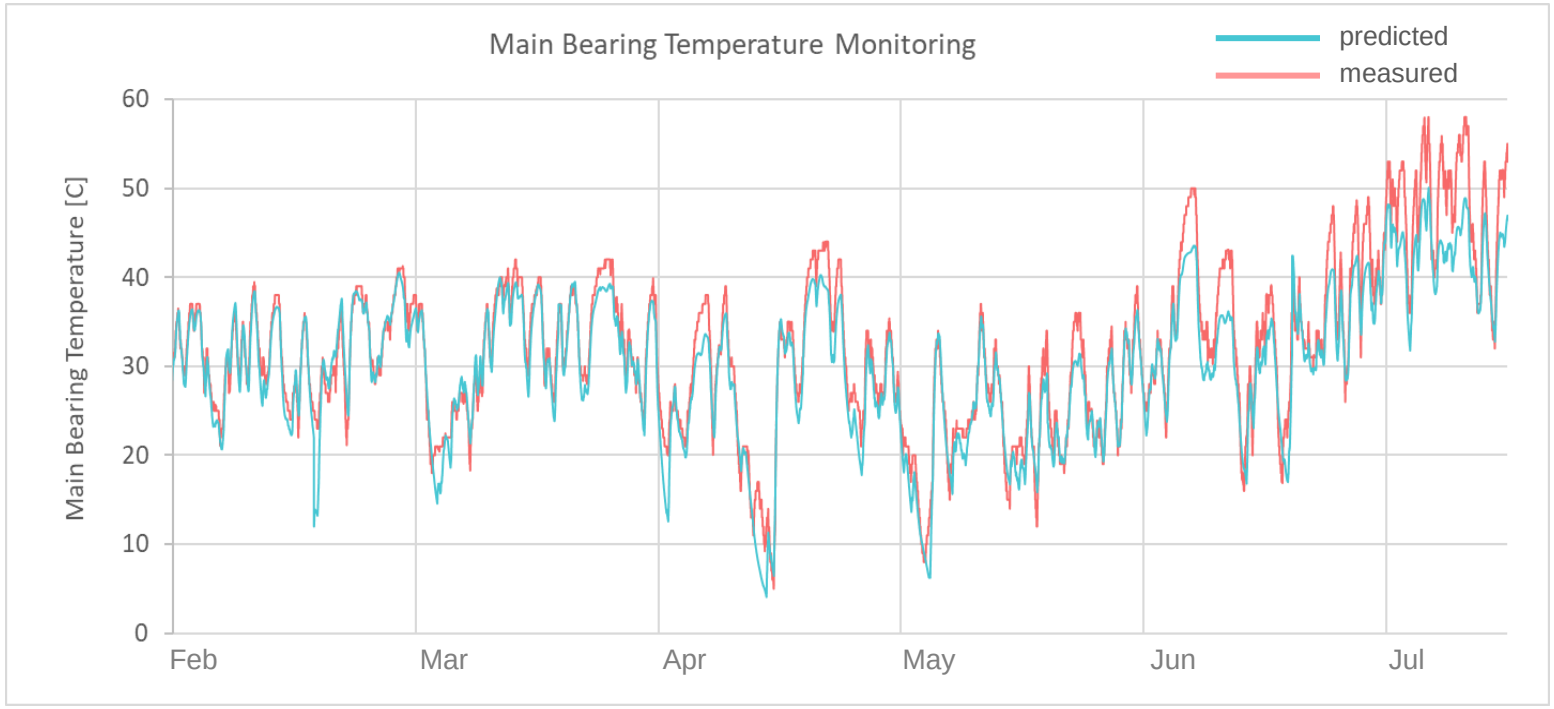


Example 2: Component Temperature Monitoring

- Fully automated monitoring of various electrical and mechanical components in turbine.
- Physics-based models used to produce extremely accurate simulation of healthy temperature behaviour.



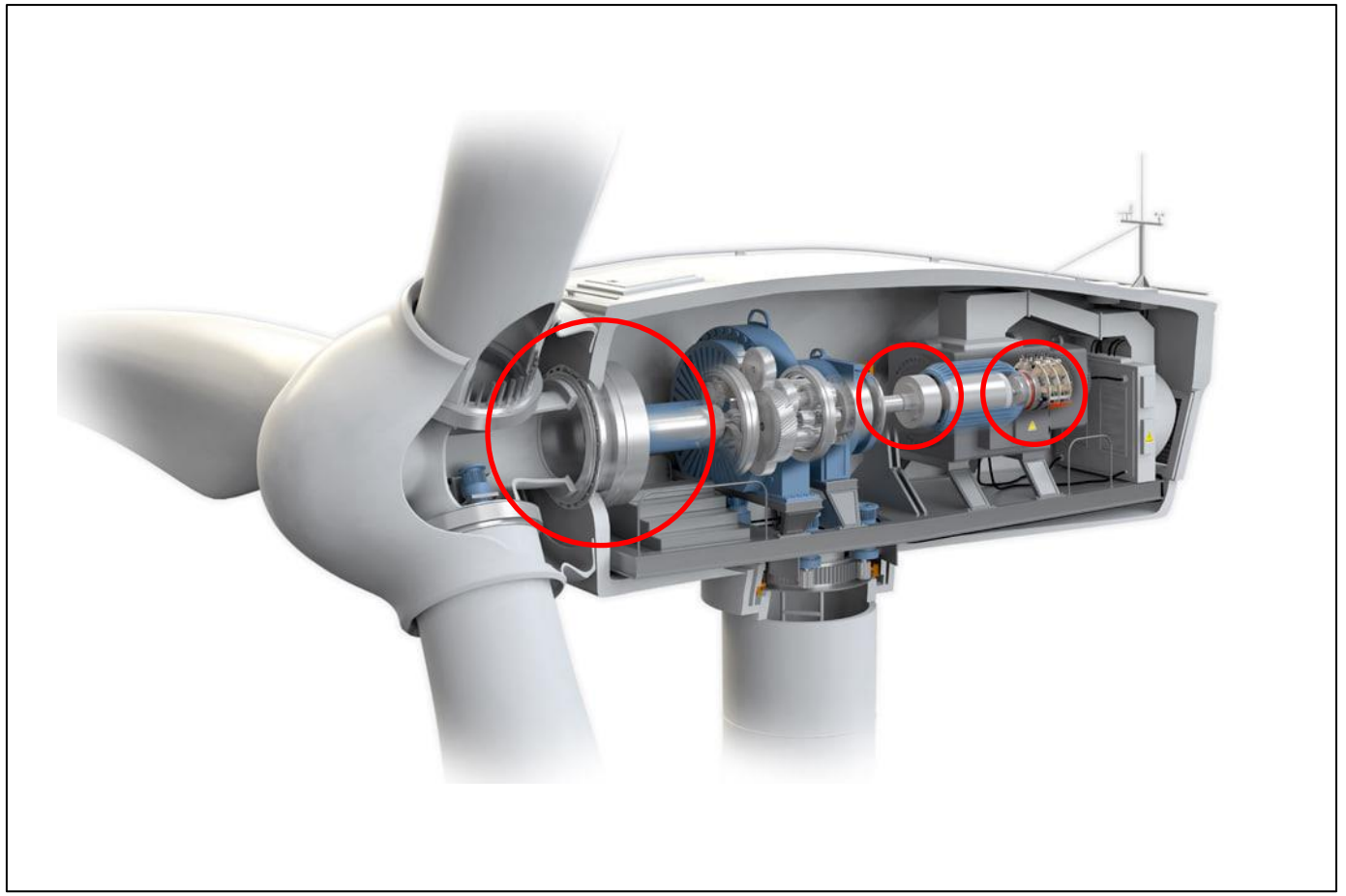
Physics-based temperature model

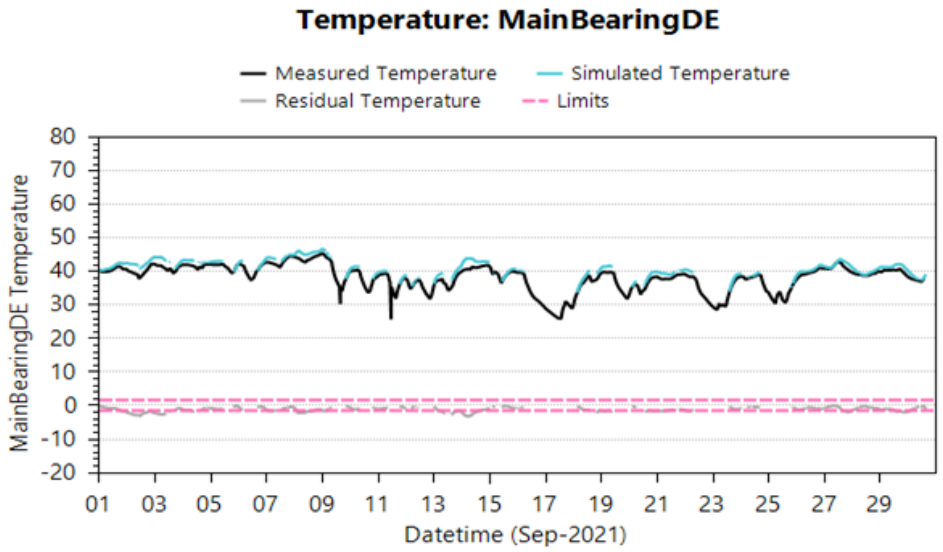


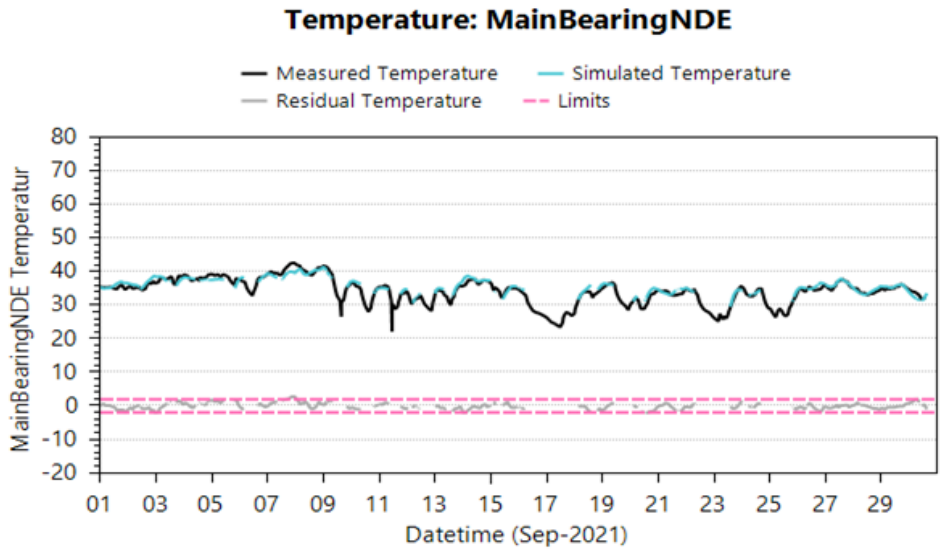
i4SEE Heat™ Capabilities

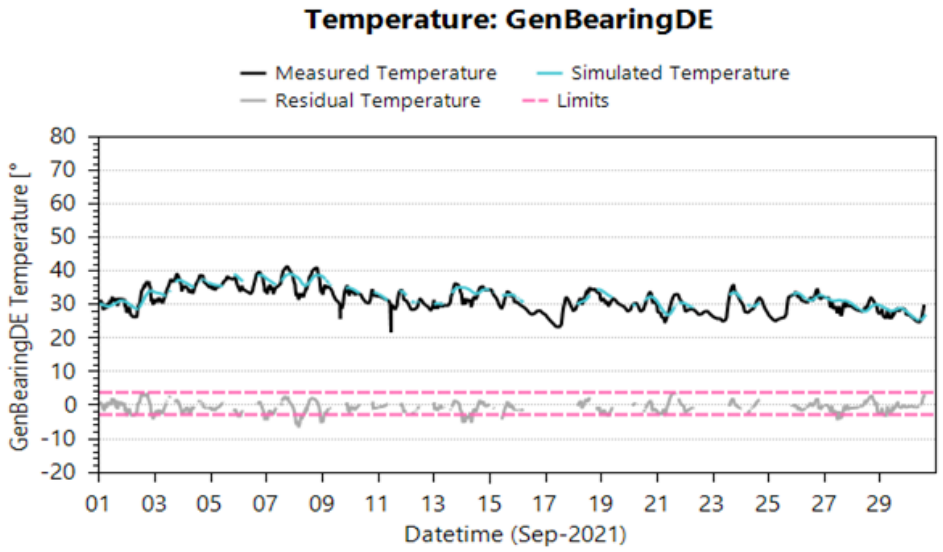
ISSUES DETECTED

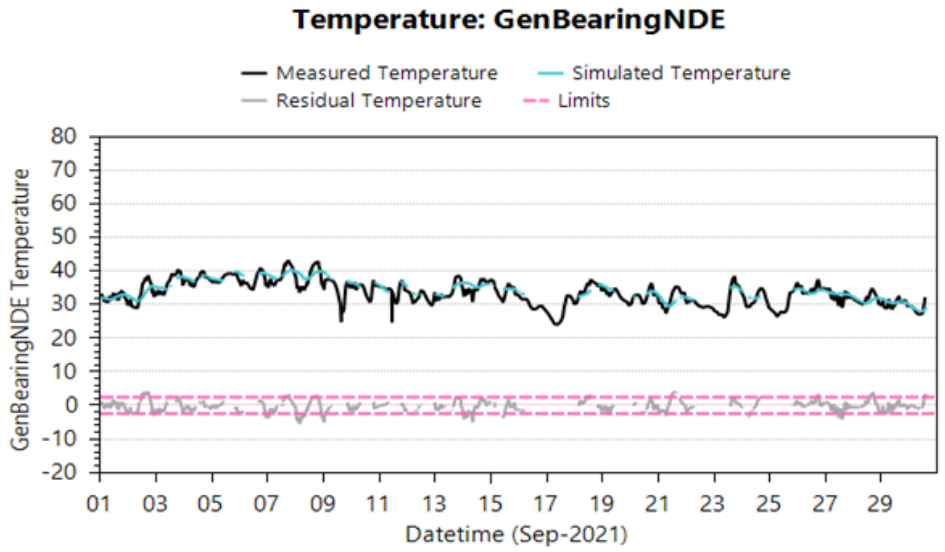
- Damage to the bearing running surfaces
- Degradation in the grease quality
- Faults affecting the grease supply system
- Loose or faulty temperature sensors
- Main shaft misalignment
- Poor bearing installation
- Degradation of generator winding insulation
- Degradation of transformer winding insulation
- Faults in transformer cooling system



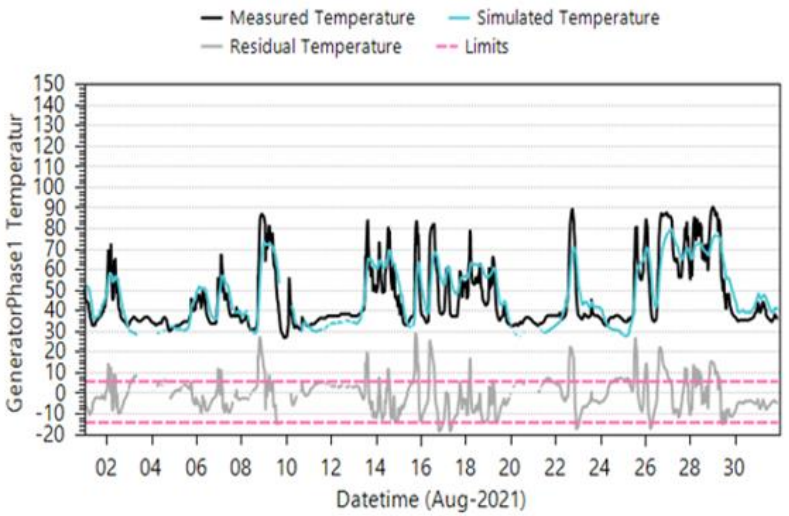

Temperature: MainBearingDE
Measured Temperature
Simulated Temperature
Residual Temperature
Limits
MainBearingDE Temperature
Datetime (Sep-2021)


Temperature: MainBearingNDE
Measured Temperature
Simulated Temperature
Residual Temperature
Limits
MainBearingNDE Temperatur
Datetime (Sep-2021)

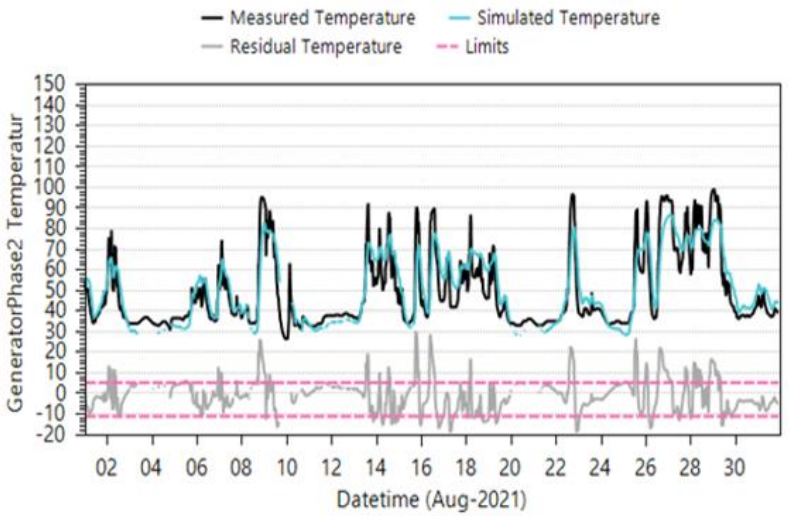

Temperature: GenBearingDE
Measured Temperature
Simulated Temperature
Residual Temperature
Limits
GenBearingDE Temperature [°
Datetime (Sep-2021)


Temperature: GenBearingNDE
Measured Temperature
Simulated Temperature
Residual Temperature
Limits
GenBearingNDE Temperature
Datetime (Sep-2021)

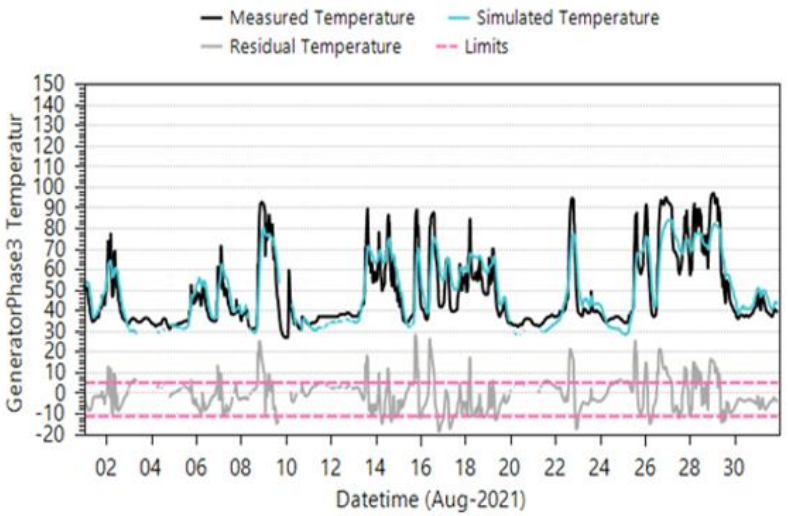
Temperature: GeneratorPhase1



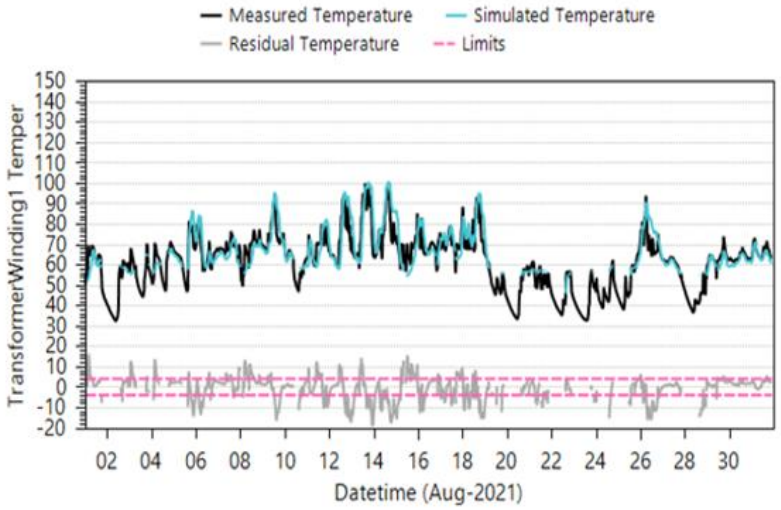
Temperature: GeneratorPhase2



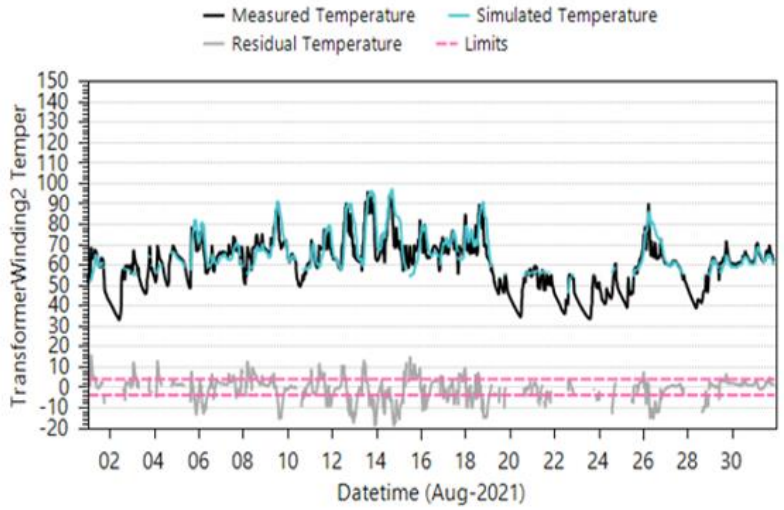
Temperature: GeneratorPhase3



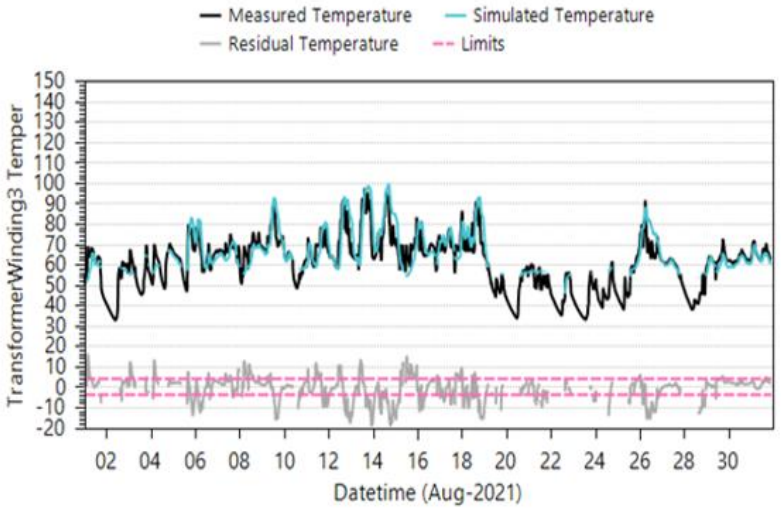
Temperature: TransformerWinding1



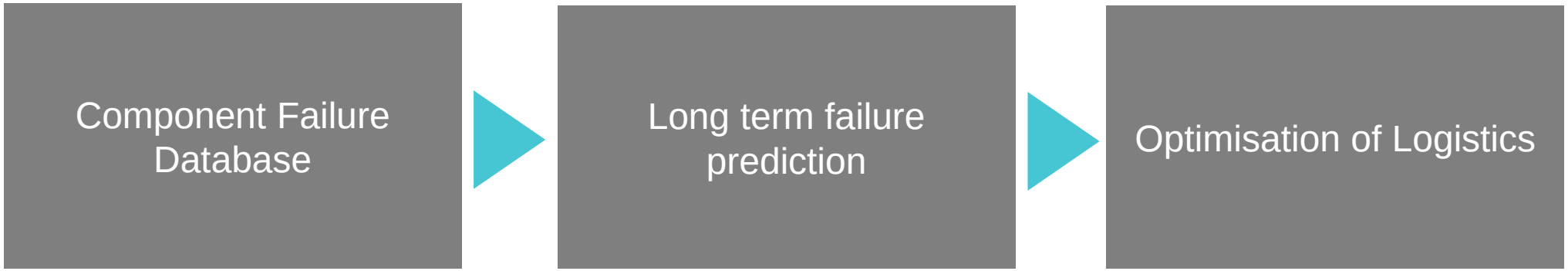
Temperature: TransformerWinding2



Temperature: TransformerWinding3



SECTION 2: COMPONENTS



Challenge: Component Failure Databases

- Different WTG types with “countless“ different gearboxes, generators, blade types …

- Poor data basis from the past as a potential showstopper
- Handwritten reports, no possibility of digital reading …

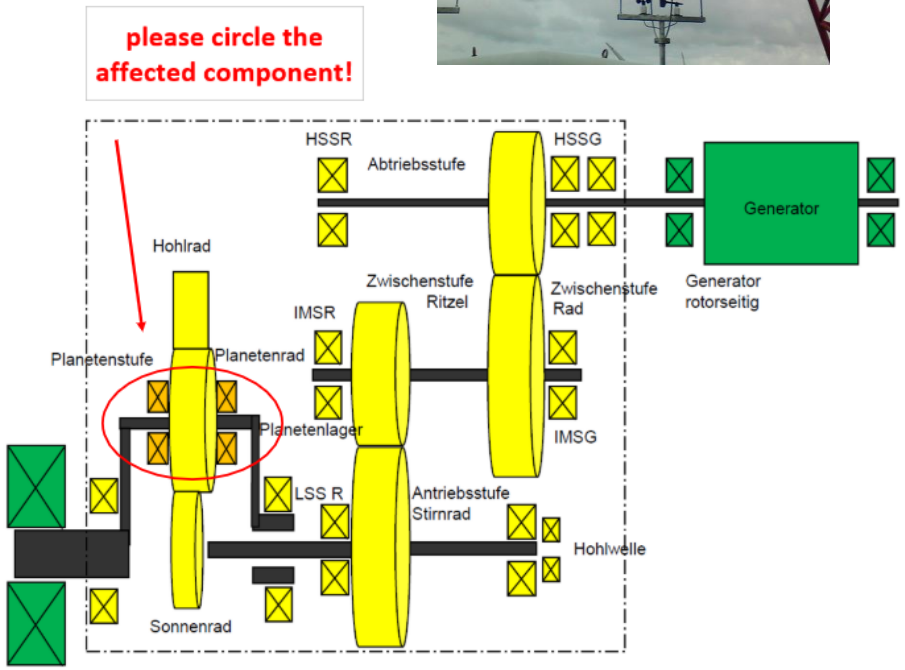
  → transfer into digital structure is time-consuming!

- Standardised input data a prerequisite for a functional concept

  → a failure database must be established into the company!

- Pragmatic approach needed for the short term: **simple taxonomy**!

→ This knowledge opens up great opportunities for detailed but efficient databases in the future!

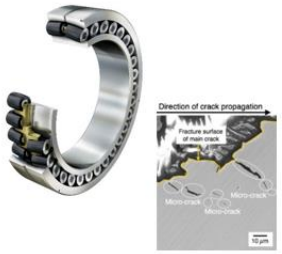


Long Term Component Failure Projection

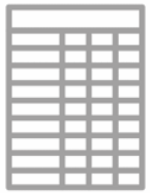
- **i4SEE Damage** in combination with **i4SEE Life™** software application for statistical life assessment.
- Developed in cooperation between i4SEE, EnergieKontor and Graz University.
- Statistical methods for dealing with small data samples and quantifying uncertainty.

Turbine

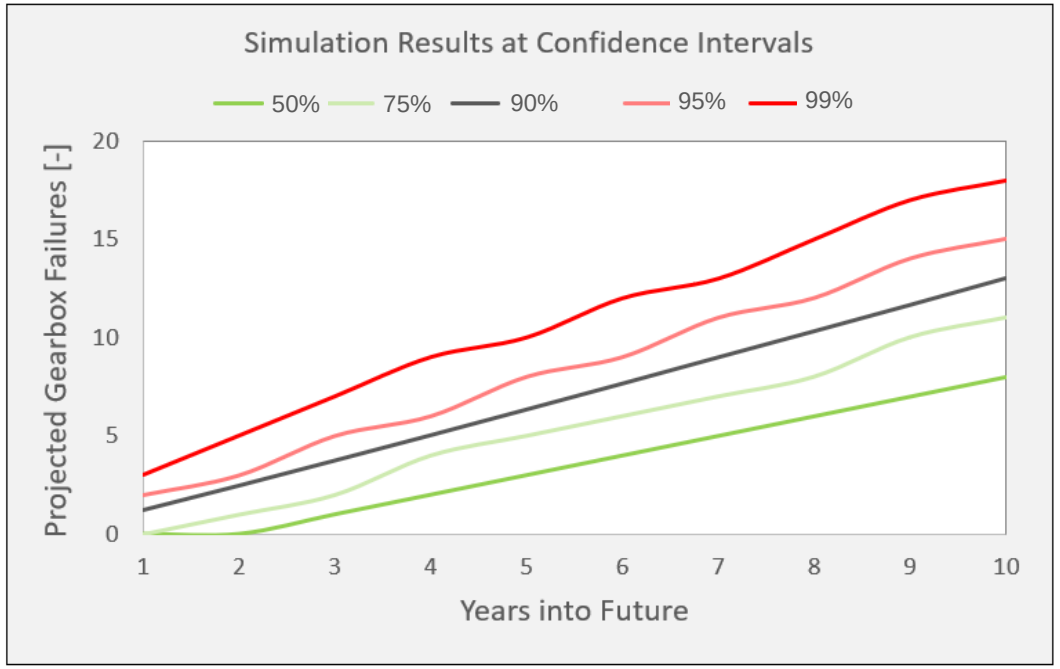
Component



Failure Modes

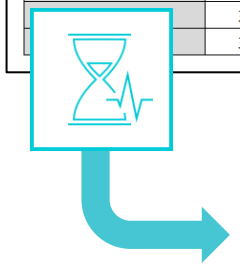


Observations



Import to Financial Assessment

Years into Future	Confidence [%]				
	avg	75	90	95	99
1	3	4	6	6	8
2	7	8	10	11	13
3	10	12	14	15	17
4	13	15	17	19	21
5	17	19	21	23	25
6	20	22	25	26	29
7	23	26	28	30	33
8	27	30	32	34	37
	30	33	36	37	40
	33	36	39	41	44

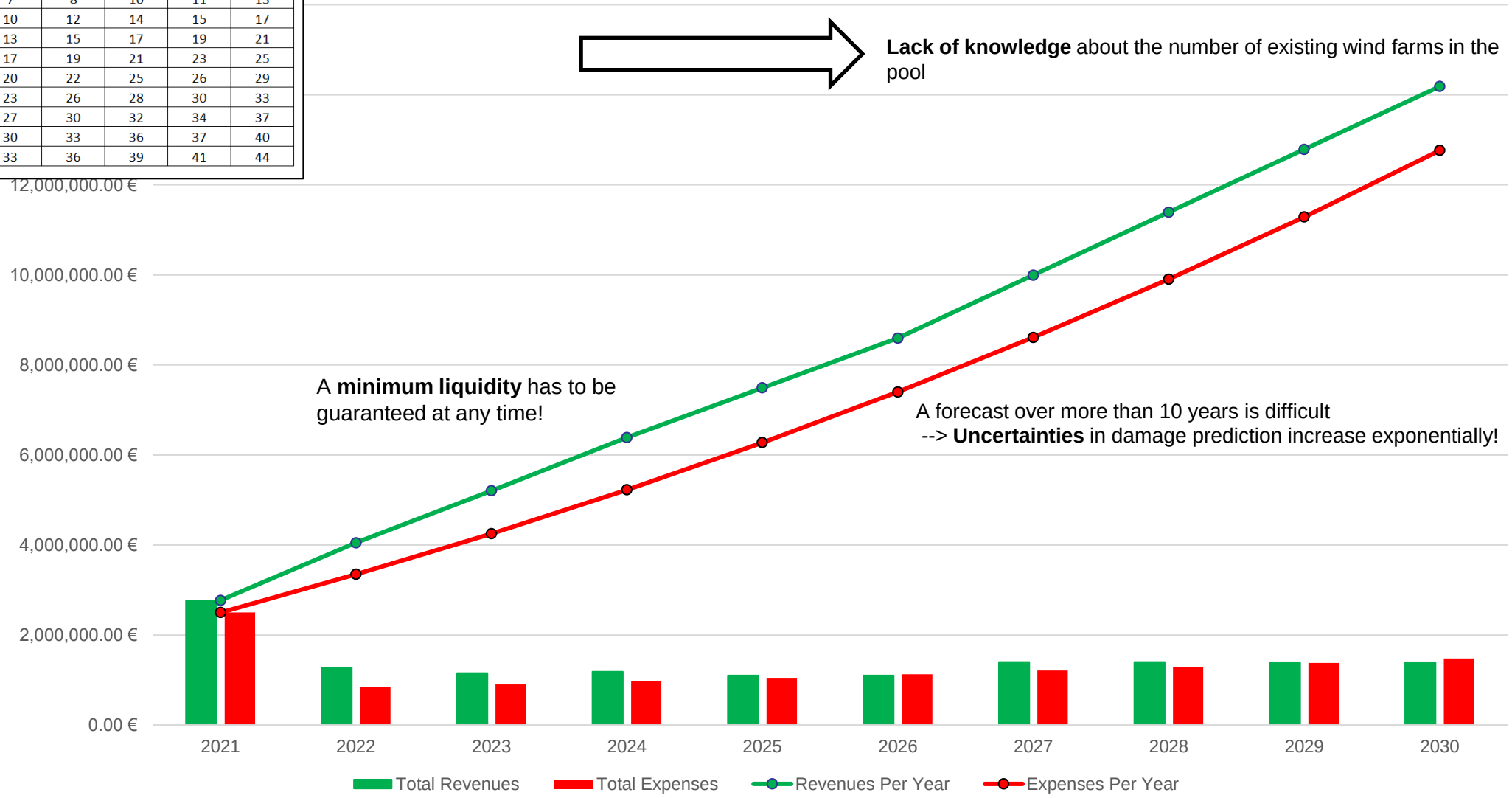


Revenues and Expenses for EK Pool Company

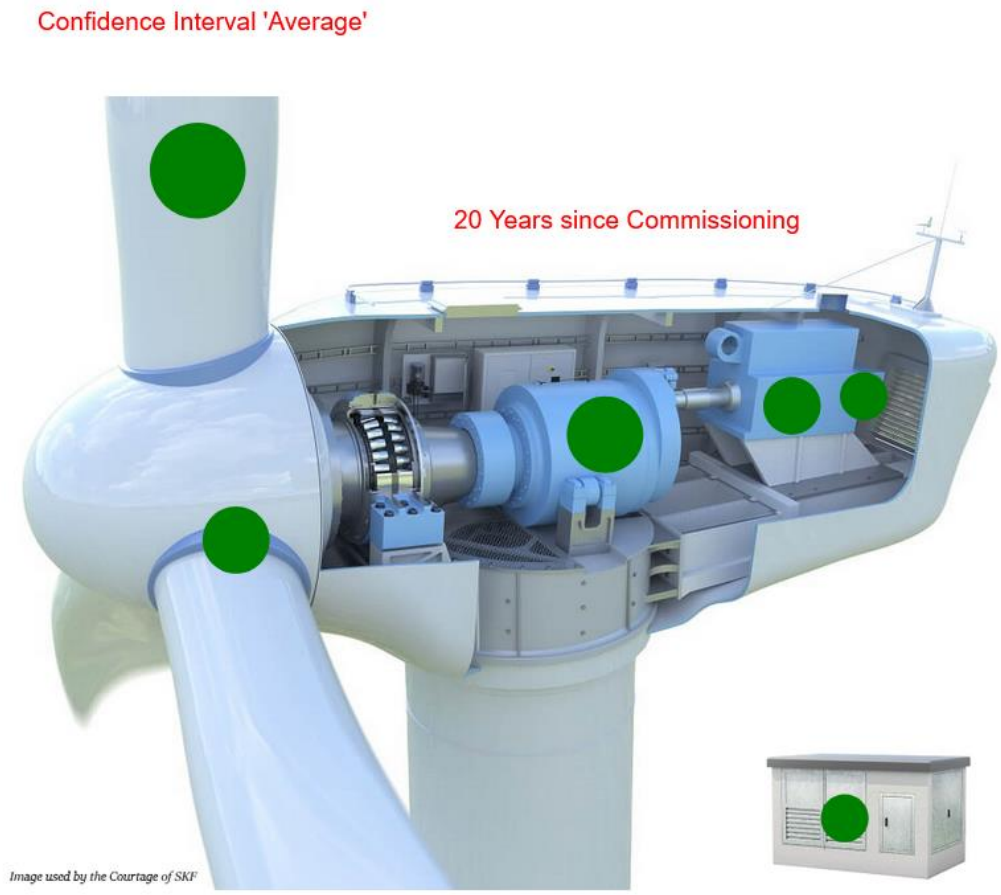
Lack of knowledge about the number of existing wind farms in the pool

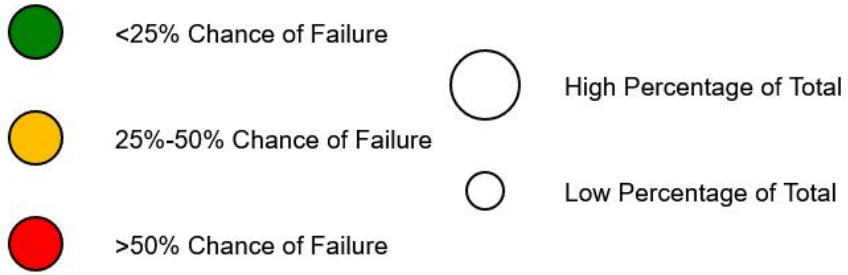
A **minimum liquidity** has to be guaranteed at any time!

A forecast over more than 10 years is difficult
--> **Uncertainties** in damage prediction increase exponentially!



Failure Prognosis Dashboard I





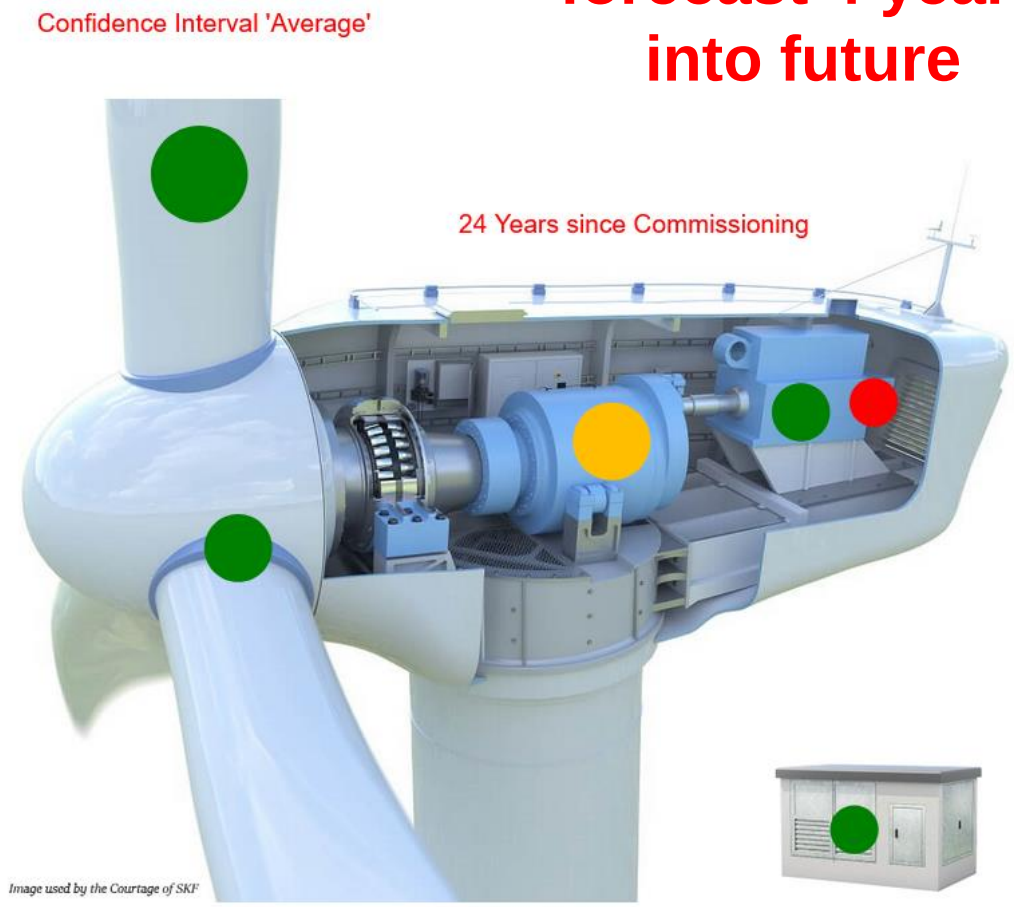
	Age	Costs of Replacement (incl. Logistics, Crane etc.)	Prorated Costs of Total	Total Projected Reserve Costs for Selected Year
Transformer	20	30,000.00 €	5%	
Converter	20	60,000.00 €	9%	
Generator	16	70,000.00 €	11%	
Gearbox	20	130,000.00 €	20%	
Blade Bearings	20	80,000.00 €	12%	
Rotor Blades	20	275,000.00 €	43%	
				0.00 €

- Problems with the many (sometimes confusing) reports from different sensors and software

  → **SOLUTION**: Digital Turbine to combine every measured signal and analysis

Failure Prognosis Dashboard II

forecast 4 years into future



- <25% Chance of Failure
- 25%-50% Chance of Failure
- >50% Chance of Failure

- High Percentage of Total
- Low Percentage of Total

	Age	Costs of Replacement (incl. Logistics, Crane etc.)	Prorated Costs of Total	Total Projected Reserve Costs for Selected Year
Transformer	22	30,000.00 €	5%	
Converter	24	60,000.00 €	9%	
Generator	24	70,000.00 €	11%	
Gearbox	24	130,000.00 €	20%	
Blade Bearings	24	80,000.00 €	12%	
Rotor Blades	24	275,000.00 €	43%	
				125,000.00 €

- Different component conditions
  - → Possibility to forecast financial resources

Summary

- Using SCADA data and component failure data, a current, near-term and long term view of a large portfolio can be gained.
- The entire process of data acquisition, analysis and results delivery can be fully automated.
- This allows predictive analytics to be deployed at large scale, for multi-GW fleets, with minimal cost / effort.
- Acceptance and full adoption of such technology within working process yields high financial gains.

THANK YOU!