Methods and Tools to Enable Preacting Maintenance Measures

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Agenda

- Introduction and Problem Description
- Preactive Maintenance
- Selected Components
- Example for Implementation
- Conclusion and Outlook

Introduction and Problem Description

Senvion Offshore Wind

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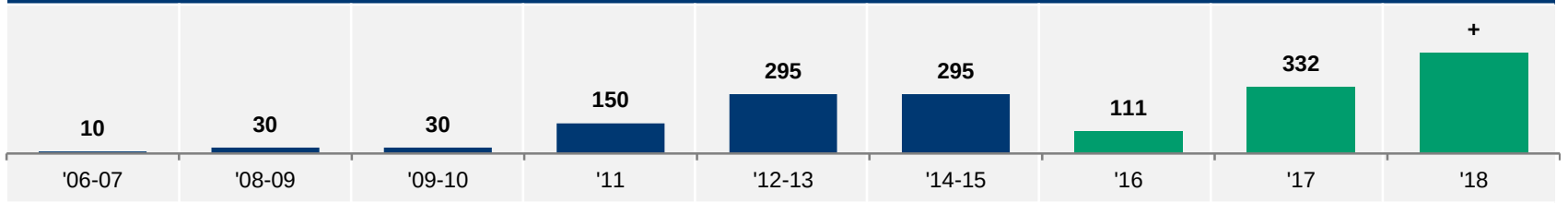
	Projects						Contracts Signed		
	Beatrice	**Thornton Bank I**	**Alpha Ventus**	**Ormonde**	**Thornton Bank II/III**	**Nordsee Ost**	**Norder-gründe**	**Nordsee One**	**Various**
Capacity	2x 5M (10 MW)	6x 5M (30 MW)	6x 5M (30 MW)	30x 5M (150 MW)	48x 6.2M126 (295 MW)	48x 6.2M126 (295 MW)	18x 6.2M126 (111MW)	54x 6.2M126 (332 MW)	6.XM152
Depth Distance	45m 23km	12-19m 30km	33m-45m 56km	33m-45m 9km	12m-28m 26km	22-25m 57km	3-11m 18km	26m-34m 47km	TBA
	sse	C-Power	e·on EWE VATTENFALL	VATTENFALL	C-Power	RWE	wpd	NORTHLAND POWER RWE	
									TBA
				Winner of the Renewable UK prize for Best Large Project '12	Before schedule delivery		Contract effective	Contract effective	In Negotiation

Order Book Additions (MW)



Introduction and Problem Description

The operation and maintenance of offshore wind turbines is complex and challenging

- Difficult to access
  - Waves are high during high wind periods (when the load on the turbines is high)
  - Complex planning for Jackup Barge operations (Main component replacements)
  - Limited capacity of helicopter access
- Time restrictions
  - Long arrival and transfer times to or between the turbines
  - Only summer suitable for bigger blade repair or major component replacement
- Challenging conditions
  - Significantly higher loads then Onshore
  - Salt, Water, Lightning
  - Dynamic loads

Preactive Maintenance

Overview Offshore Maintenance strategies

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Corrective maintenance

Replace **after** it breaks

Replace the component after failure

- Leads to unplannend stops
- High maintenance costs and downtime

Preventive maintenance

Replace **before** it breaks

Replace the component after a defined period of time

- Planned stops (downtime)
- Wear margin not fully used

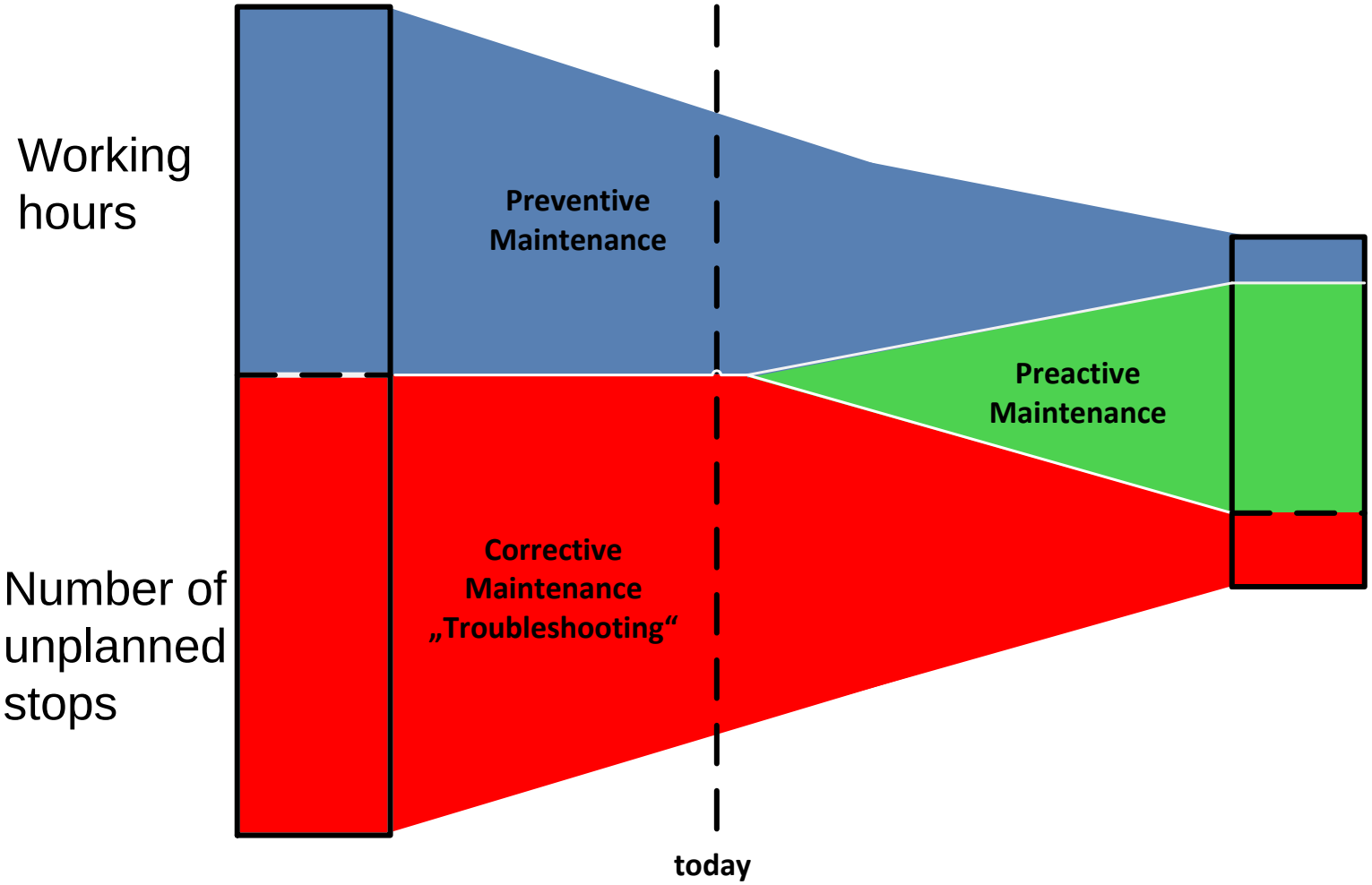
Preactive maintenance

Replace **just before** it breaks

Failure prediction and replacement of the component just before the breakdown

- Fewer / shorter planned stops
- High availability and lower costs

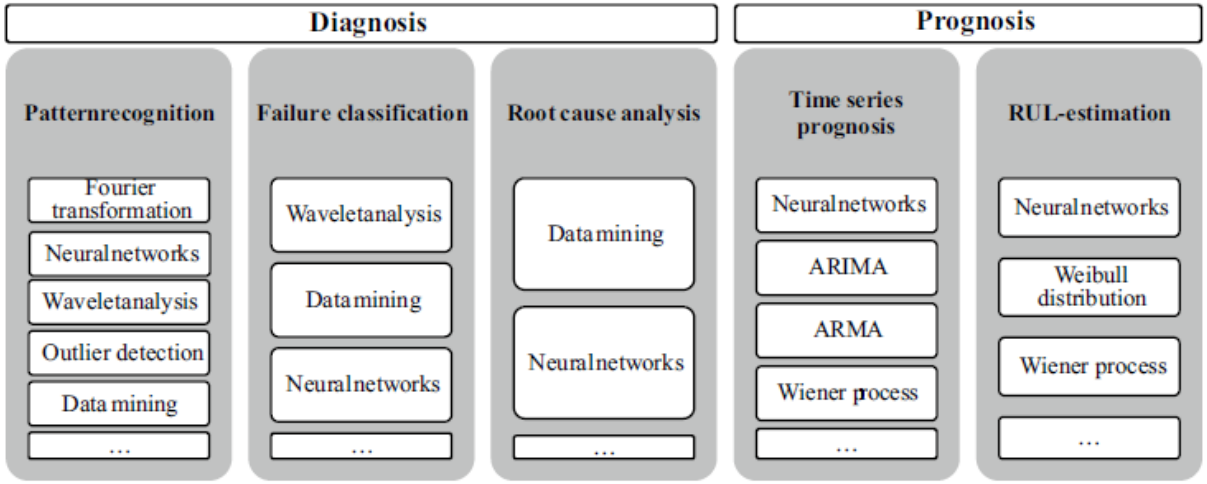
Aim of preactive Maintenance



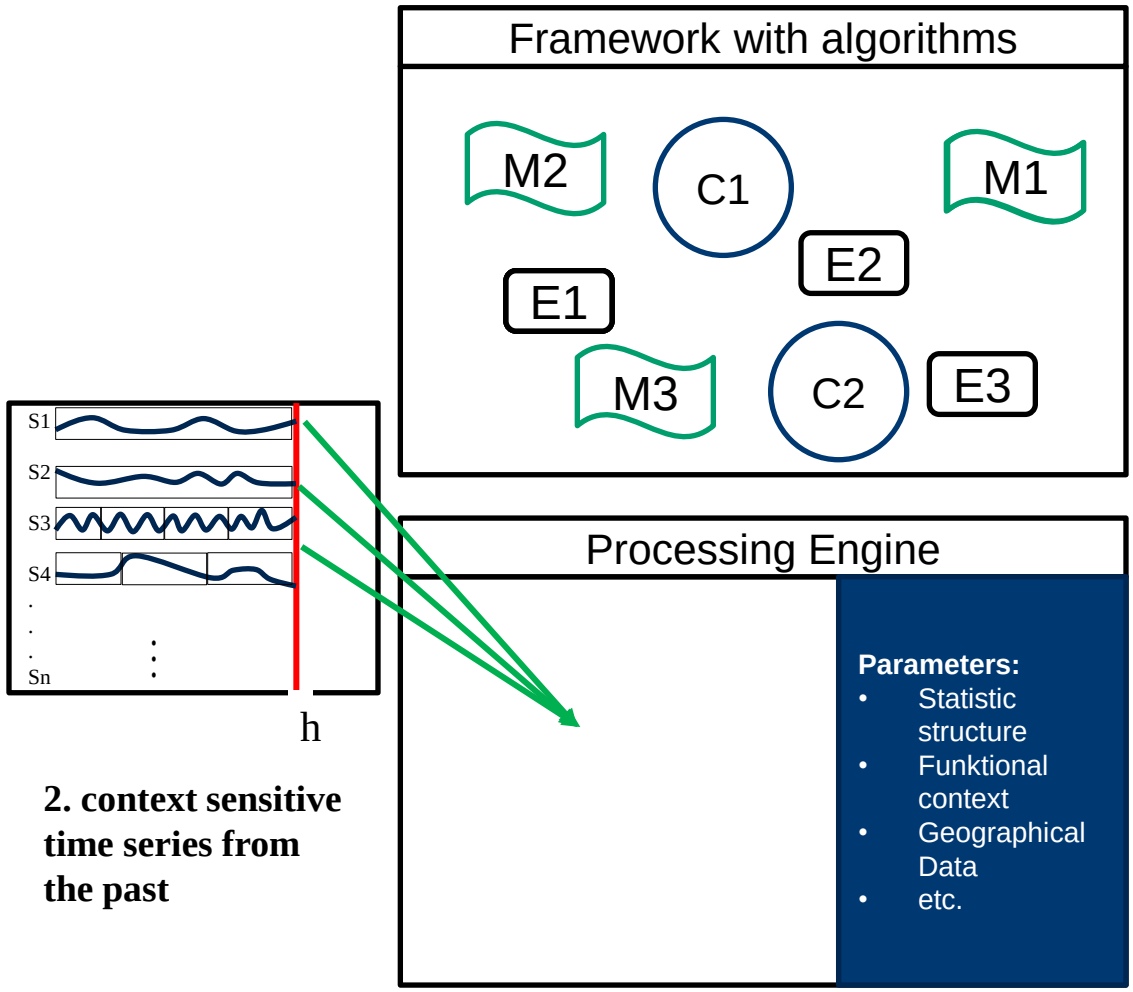
Aim:
Only preventive visit per year and as less as possible unplanned stops

Preactive Maintenance

- Usage and combination of different type of data for the estimation of the system condition
- Linking of different diagnostic and prognostic models for predicting the remaining useful lifetime
- Dynamic adjustment of maintenance intervals and reduction of reactive measures
- Prioritization of maintenance measures and automatic initiation of logistic processes



PdM with PreInO: Concept of processing engine PE-Basic conception at the beginning

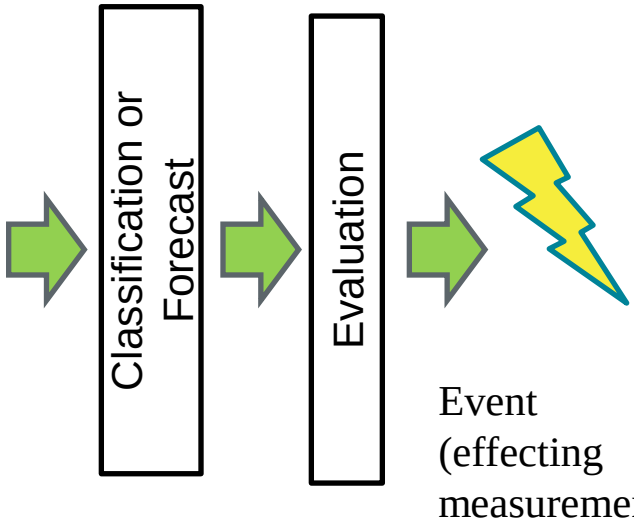


1. Framework methods and tools

3. Data's for input, processing and output

output = classification and /or forecast

2. context sensitive time series from the past



Event (effecting measurements)

Selected Components

Methods for determination of the system condition

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1. Structure-borne noise and vibration measurement
2. Thermography
3. Oil analysis
4. Ultrasonic
5. Visuel Inspections
6. Inspection due to DIN 31051
7. SCADA monitoring

Scoring Model

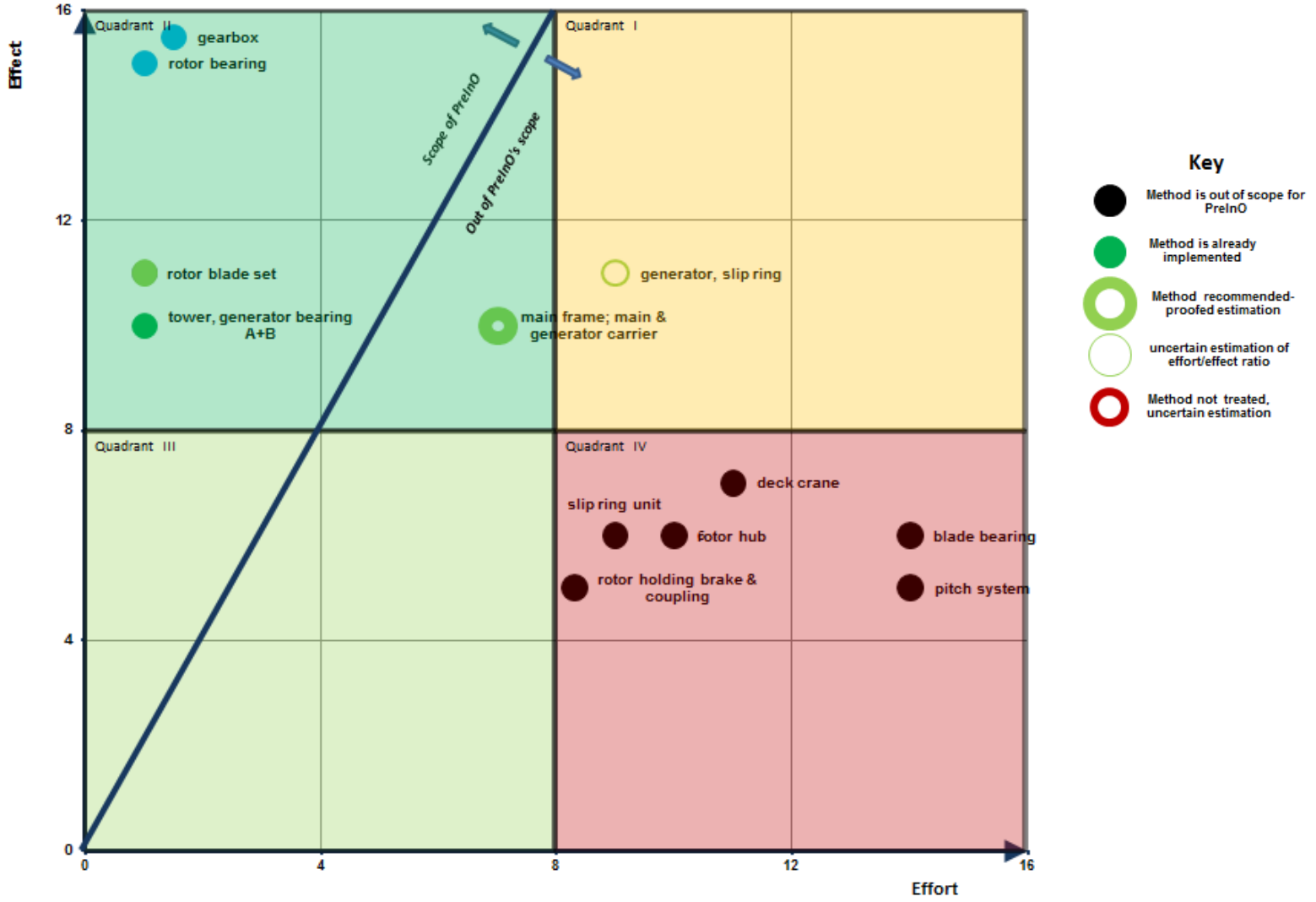
I setup matrix / one per PdM method (7 matrices)

Component	Effort	Effect	Scoring	Quadrant
Rotor bearing	Scoring 1-16	Scoring 1-16	Addition effort/ addition effect	Placement in diagram
Gearbox	Scoring 1-16	Scoring 1-16	Addition effort/ addition effect	Placement in diagram
Component 3	Scoring 1-16	Scoring 1-16	Addition effort/ addition effect	Placement in diagram
Component n	Scoring 1-16	Scoring 1-16	Addition effort/ addition effect	Placement in diagram

II setup diagramm / one per method (7 diagrams)

Quadrant II **Small effort** **Big effect**	**Quadrant I** **Big effort** **Big effect**
Quadrant III Small effort Small effect	Quadrant IV Big effort Small effect

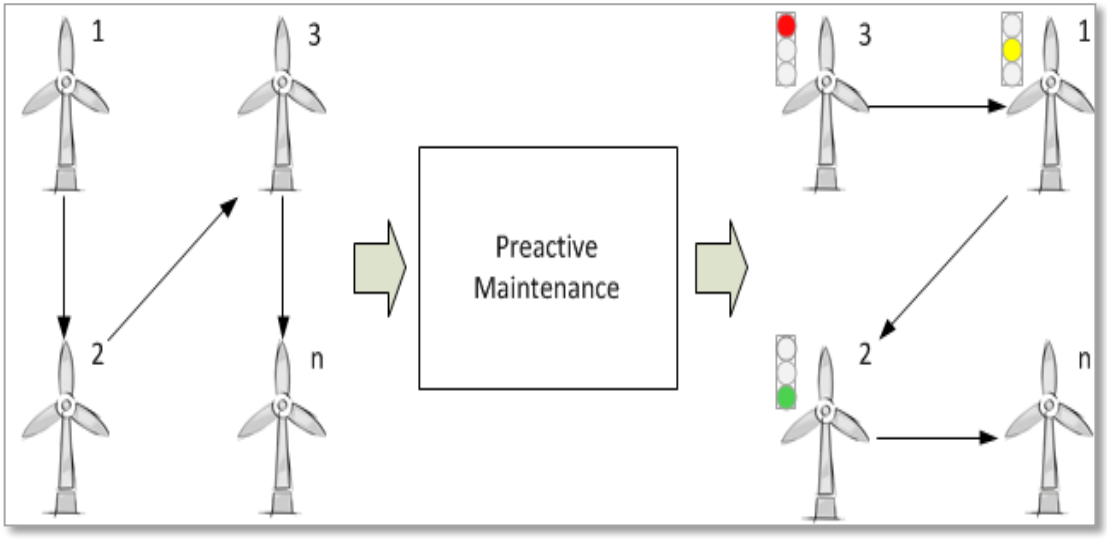
Diagram: Structure-borne noise and vibration measurement



Example for Implementation

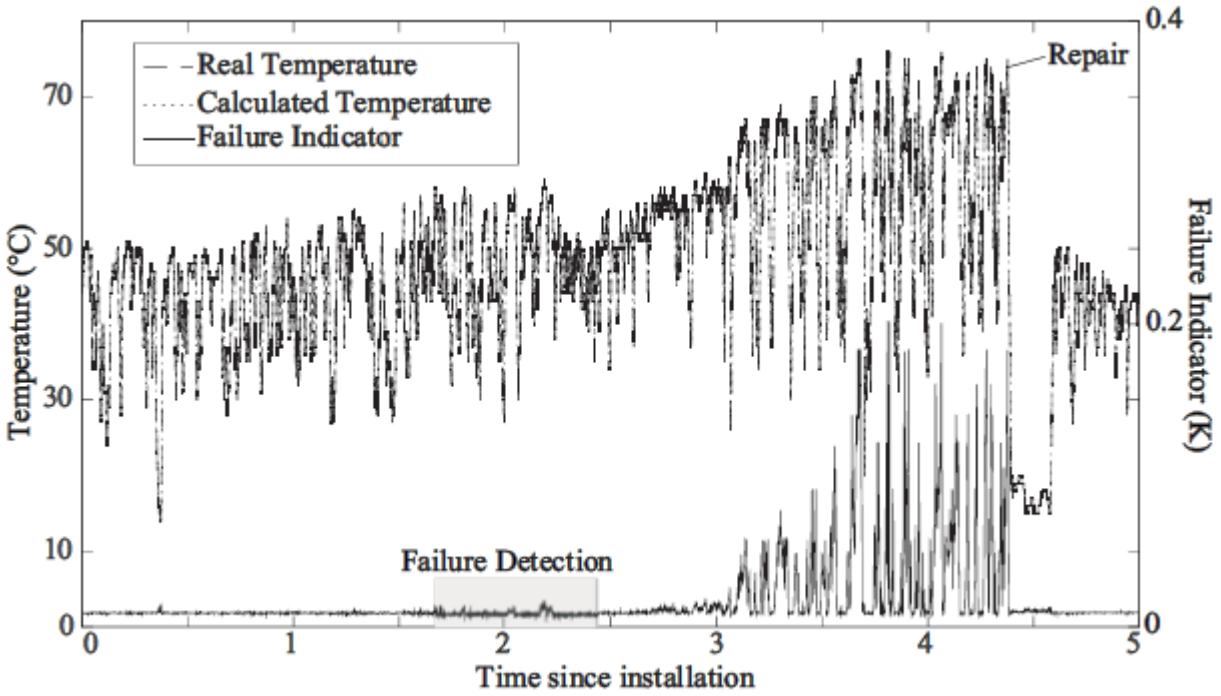
Example for preactive maintenance

- Aggregate information of the general condition of a wind turbine
  - possible deduction of maintenance priority automatically
- Question: Which is the most suitable sequence for maintaining the wind turbines?
  - Scheduling based on the knowledge about the condition of each wind turbine
- Annual maintenance scale
  - Dynamical adjustment based on information about the behavior of the wind turbine



Neural network

- Is able to learn complex relationships between input and output data and to calculate the future behavior of an output variable
- Difference between the calculated and actual temperature is used as error indicator



Conclusion and Outlook

Conclusion and Outlook

- Preactive Maintenance
  - Linking of corrective and preventive maintenance
  - Usage and combination of different type of data and methods / models for diagnosis and prognosis
  - Condition based ruling and prioritization of necessary maintenance measures
- Enabler for:
  - Optimal planning
  - Risk reduction
  - Cost reduction
  - Availability improvements


Source: Senvion GmbH

Thank you

Senvion GmbH
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