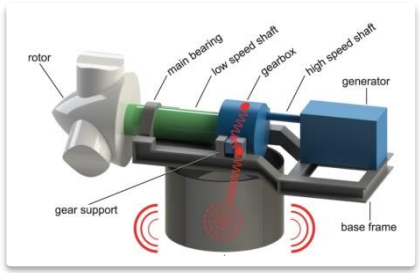
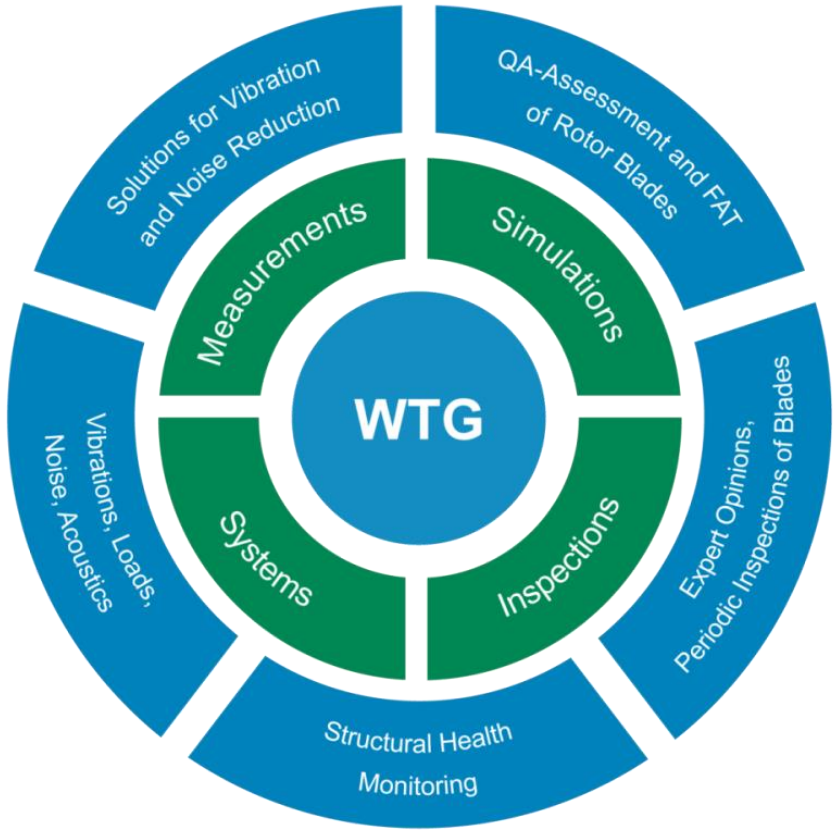
IDD.Blade® – Effects, impacts and regulations

Reliable ice detection for rotor blades to increase availability and yield

Wölfel

Wind energy systems





Blade monitoring

IDD.Blade®

Ice detection

SHM.Blade®

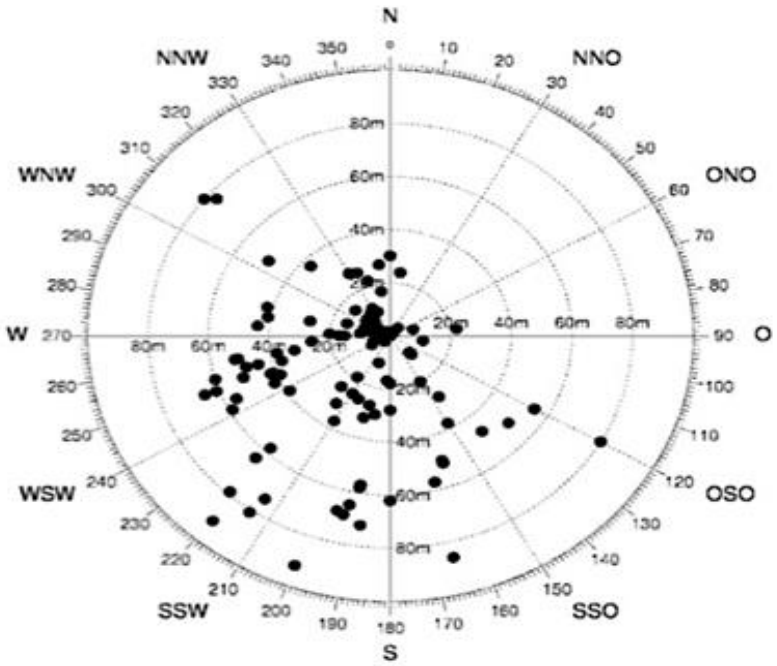
Damage indication

SHM.Blade®

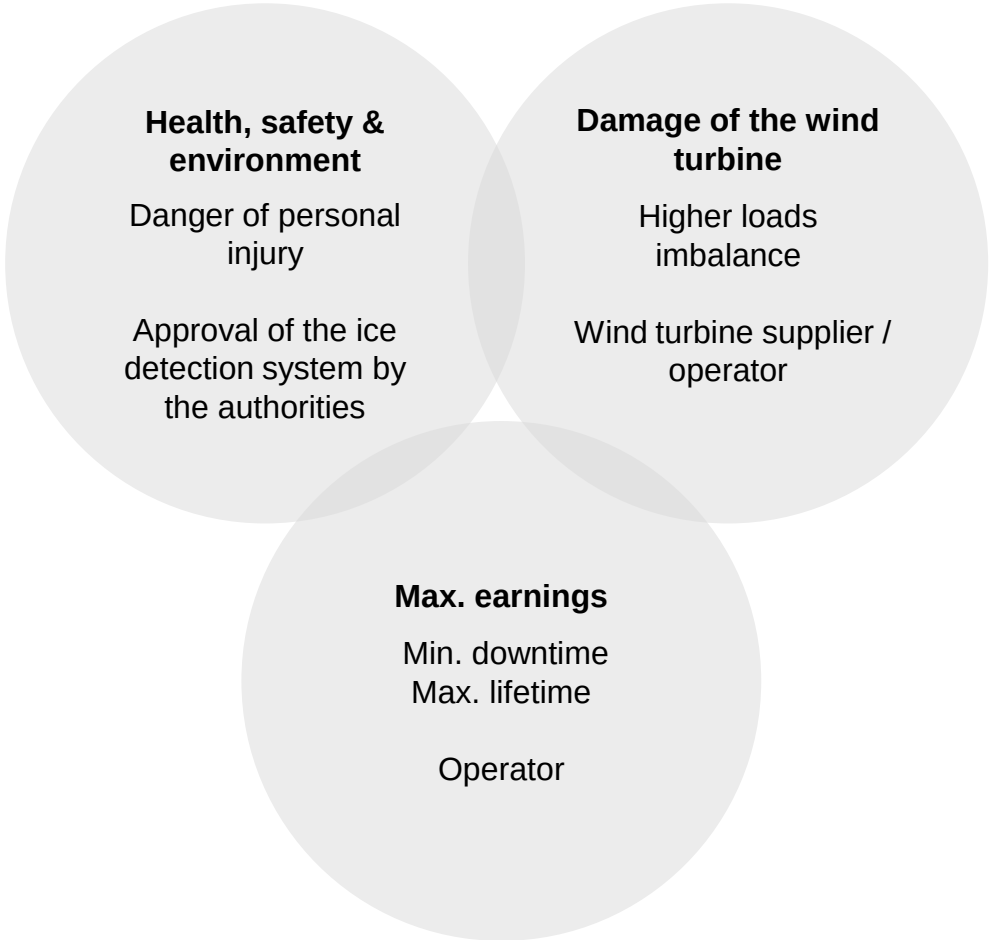
Imbalance detection

Type Certificate TC-GL-015A-2013

Ice throw of a wind turbine: 50 m hub height, 40 m rotor diameter



Ice on rotor blades



Study of economic loss due to icing of rotor blades

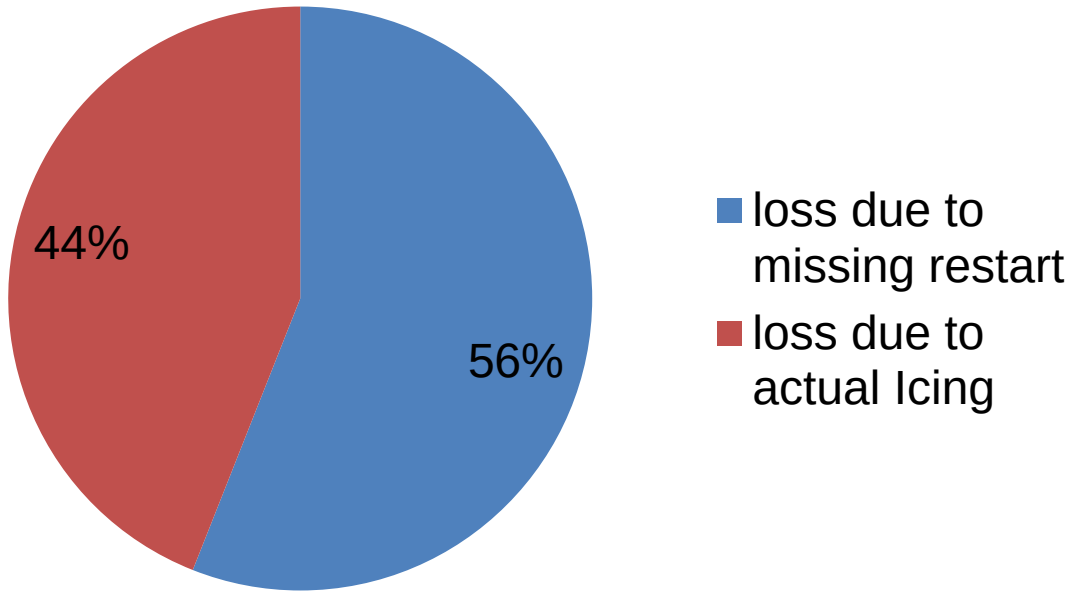
Technikakademie Weilburg

Southern Germany
6 WTG of 3 MW class
4 winter seasons
Metrological ice detection system

Quelle: T.Jung et all: Wirtschaftlichskeitsstudie von Eiserkennungssystemen an Windenergieanlagen, Weilburg, 2015

Technikakademie Weilburg

Losses depending on operating conditions 2012-2015



Ice detection technologies

Metrological	• No direct and quantitative ice detection at the rotor blade • Not approved for automatic restart of the WTG
Visual	• No automatic ice detection • Not approved for automatic restart of the WTG
Power curve	• No direct and quantitative ice detection at the rotor blade • Automatic restart of the WTG not possible
Rotor blade vibration	• Direct and sensitive ice detection at the rotor blade • Automatic restart of the WTG possible

Blade monitoring – Physical basics

1. **Rotor blade vibrations provide** information about the state of the structure
   - Damage of the structure
   - Ice
   - Imbalance

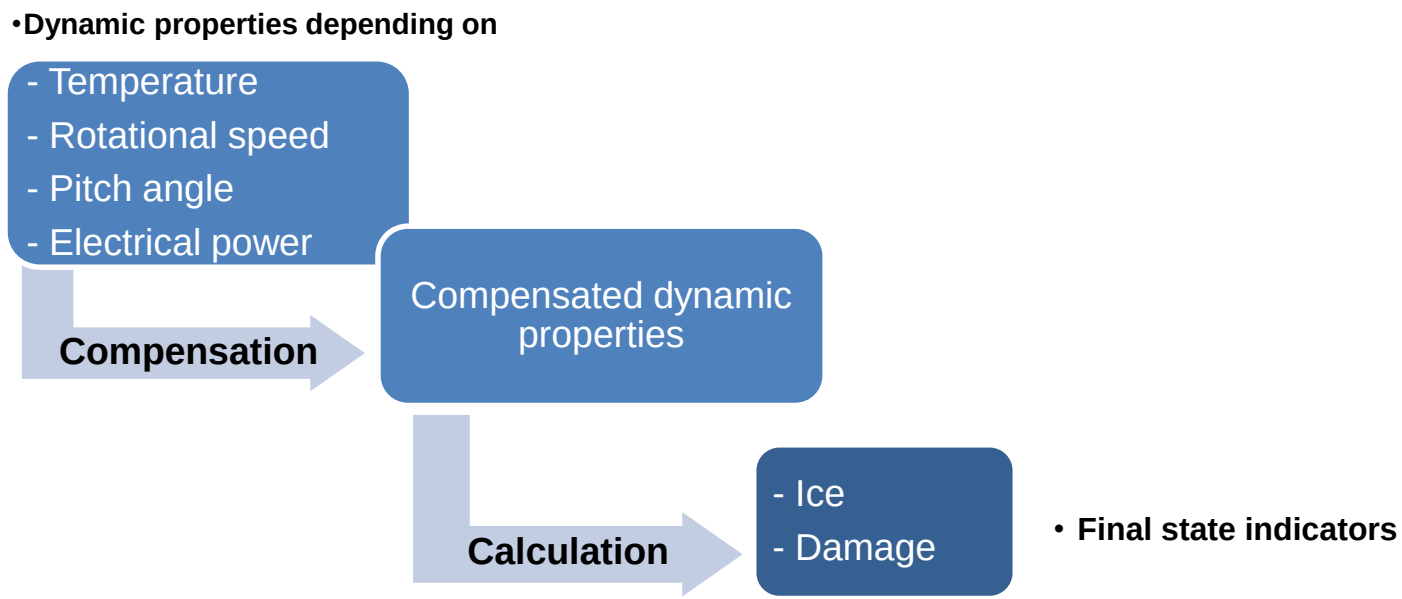
2. **Structural damages and ice change the eigenfrequencies**: $\omega = \sqrt{k/m}$
   - Structural damages reduce the stiffness k
   - Ice increases the rotor blade mass m
   - Imbalance influences 1 Ω (periodic excitation)

3. **Vibration monitoring for detection of changes in the state of rotor blades:**
   - Detection of changes in eigenfrequency
   - Detection of changes in the dynamic response

Blade monitoring

For reliable and sensitive detection of rotor blade changes there are two sophisticated challenges:

2. Compensation of influences from operation and environment



IDD.Blade ®

· Ethernet by WTG supplier
· Wireless bridge by Wölfel

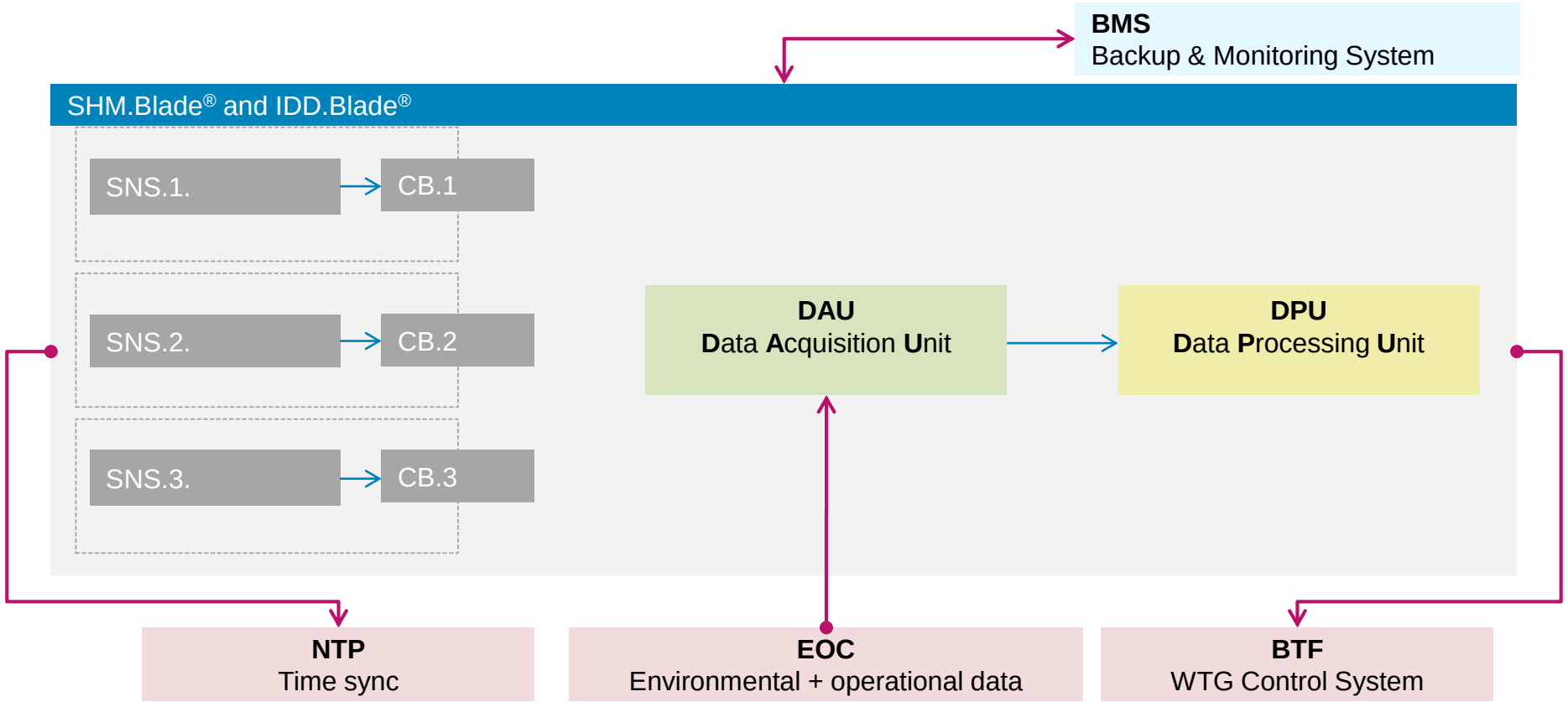
4. Nacelle
DPU (**D**ata **P**rocessing **U**nit)

3. Hub
DAU (**D**ata **A**cquisition **U**nit)

2. Blade root
CB (**C**onnection **B**ox)

1. Rotor blade
SNS (**S**tructural **N**oise **S**ensor)

IDD.Blade ®



IDD.Blade ®

Main features

Basis

1. Ice detection by an Ice Indicator based on Eigen frequency changes of the blade
2. Individual Ice detection on each Rotorblade
3. Automatic restart when all blades are ice free
4. Individual project specific settings of the icing thresholds

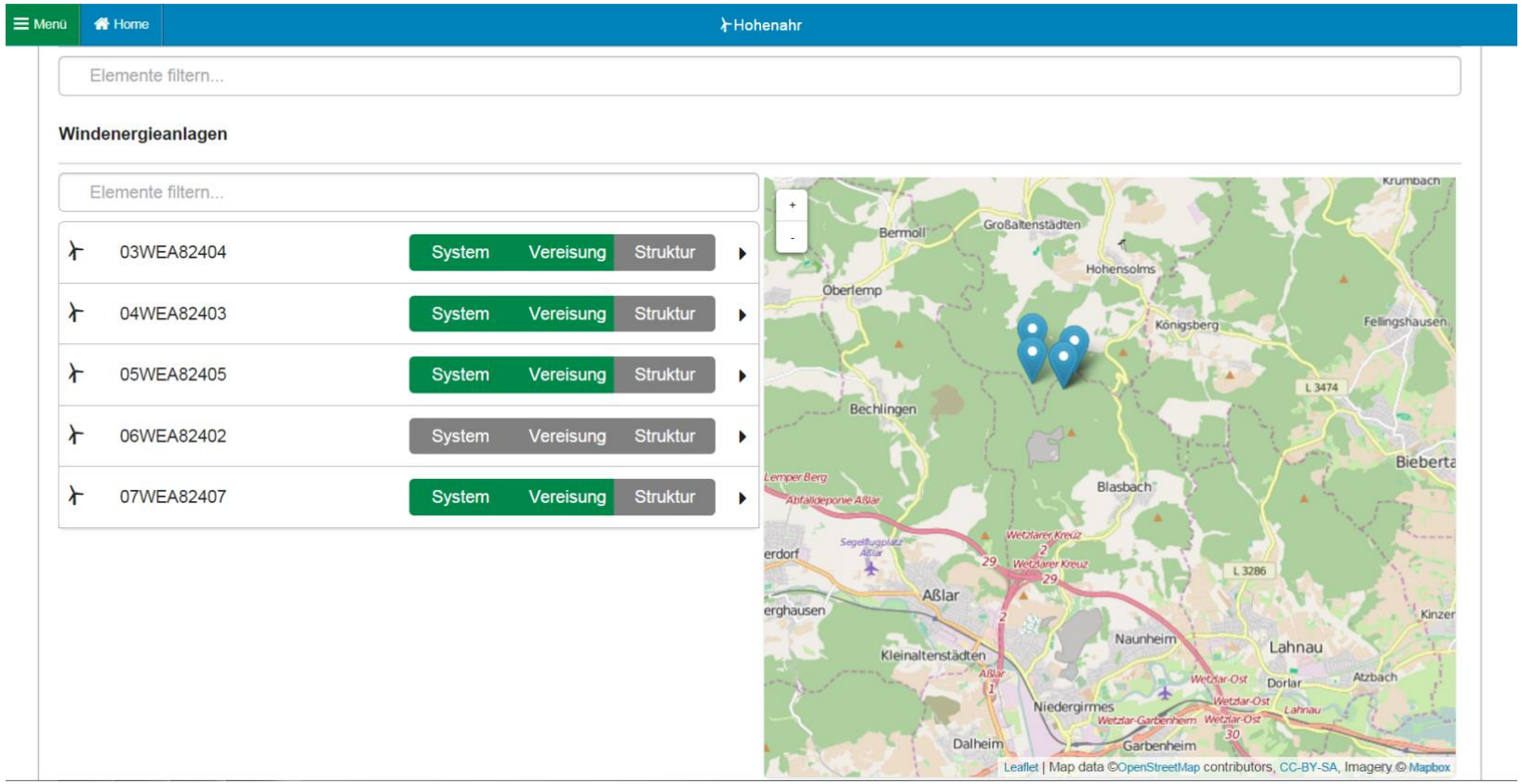
Example Thresholds for a 50 to 60m rotor blade → Leading edge covered with Ice

1. Ice Warning: 10 kg ~ 3 mm Ice - 0.75 % deviation of Ice Indicator
2. Ice Alarm: 40 kg ~ 6 mm Ice - 1.50 % deviation of Ice Indicator

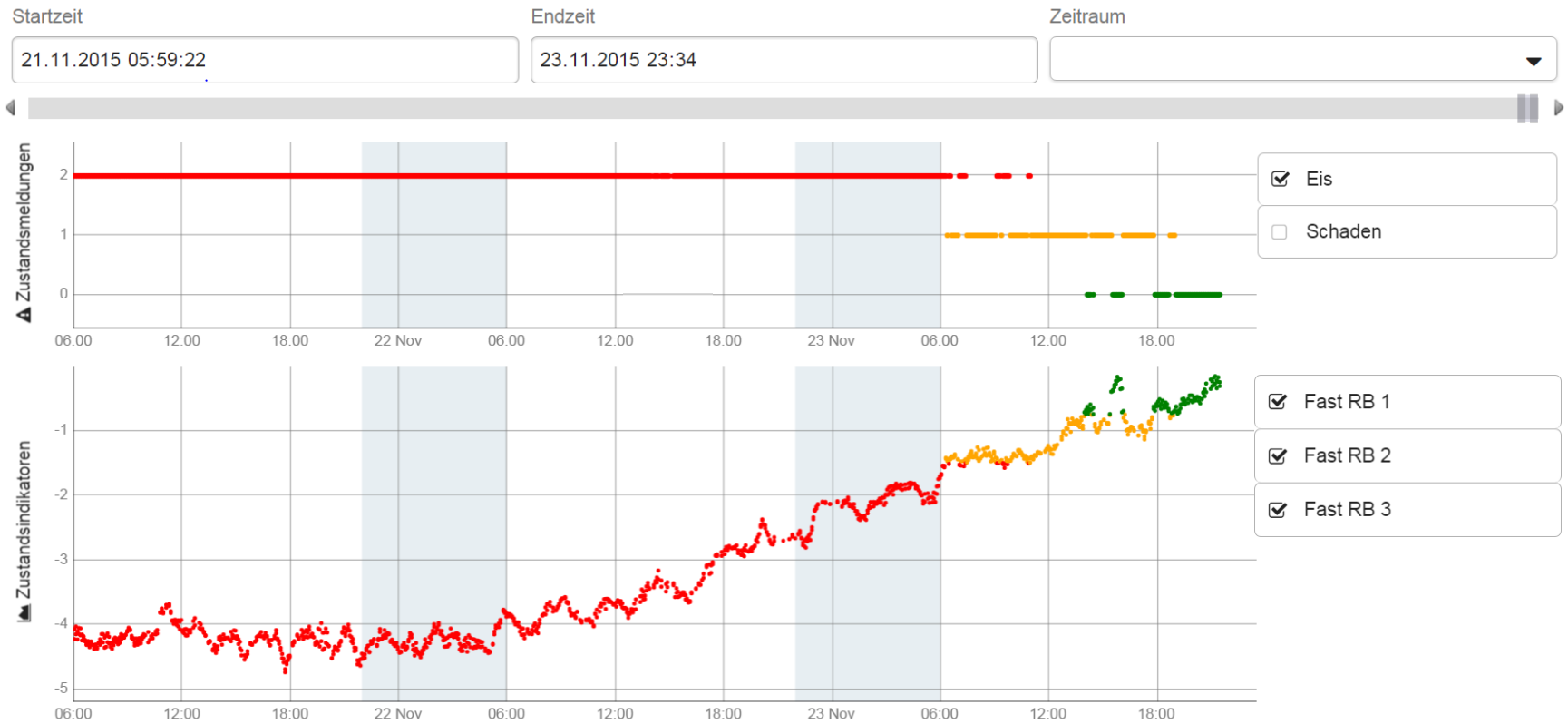
Performance of IDD.Blade®:

1. Ice detection in any operating mode and standstill (any pitch angle)
2. Min. wind speed ~ 2.5 m/s → Ice detection at standstill of the turbine
3. Updating status Indication ~ 5 min → Automatic restart always possible

IDD.Blade ® – Web monitoring



IDD.Blade ® – Web monitoring

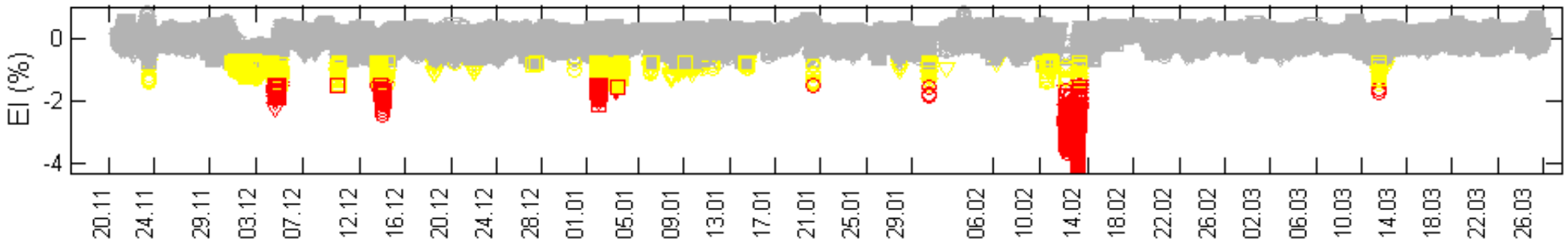


Monitoring example IDD.Blade®

Winter season 2014/15 in the region of Southern Germany

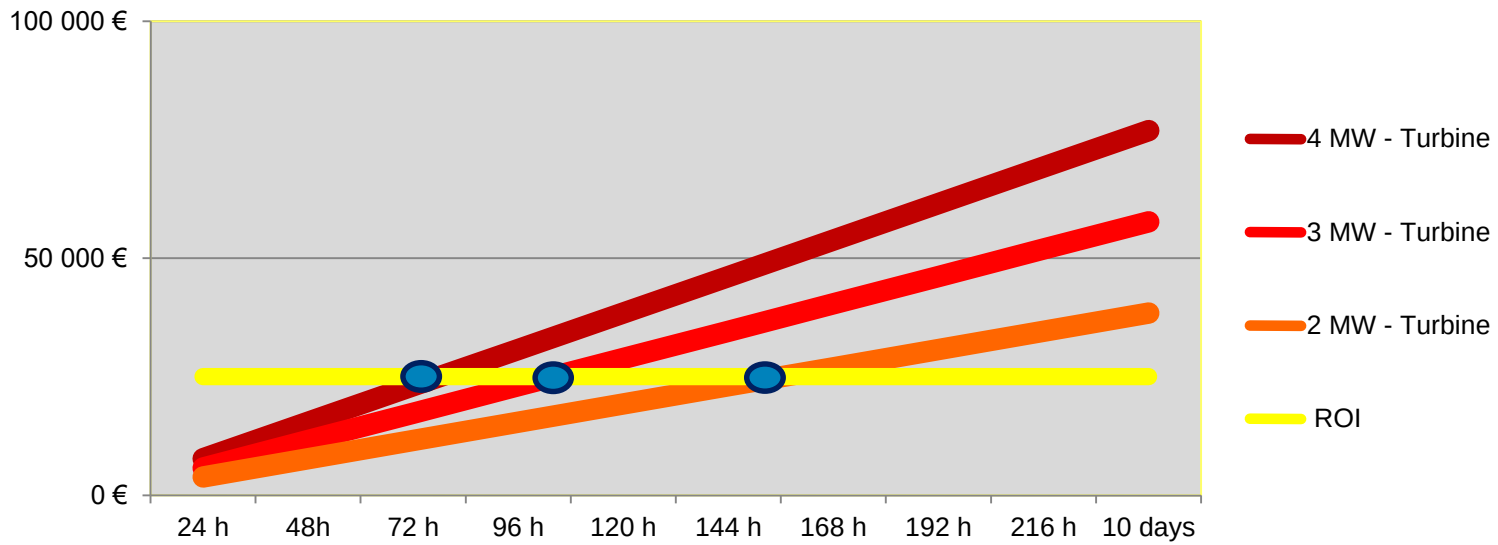
Temperature below 4°C		≈ 50 days	
Warning	(non-critical ice)	≈ 21 days	
Alarm	**(critical ice)**	**≈ 6 days**	**possibility of dangerous ice throw**

Ice indicator



Economic efficiency

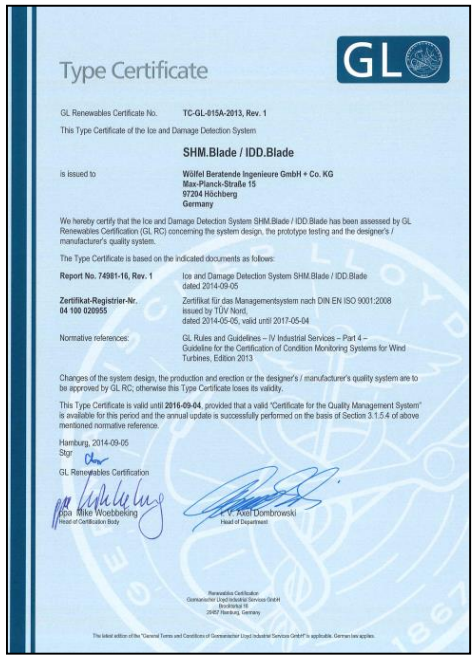
Short amortization period of ice detection systems
with automatic restart function



Certification SHM.Blade®/IDD.Blade®

GL Type Certificate

1. SHM.Blade: Structural Health Monitoring
2. IDD.Blade: Ice Detection Device



Type Certificate

GL

GL Renewables Certificate No. TC-GL-015A-2013, Rev. 1

This Type Certificate of the Ice and Damage Detection System

SHM.Blade / IDD.Blade

is issued to

Wölfel Beratende Ingenieure GmbH + Co. KG
Max-Planck-Straße 15
97204 Höchberg
Germany

We hereby certify that the Ice and Damage Detection System SHM.Blade / IDD.Blade has been assessed by GL Renewables Certification (GL RC) concerning the system design, the prototype testing and the designer's / manufacturer's quality system.

The Type Certificate is based on the indicated documents as follows:

Report No. 74981-16, Rev. 1	Ice and Damage Detection System SHM.Blade / IDD.Blade dated 2014-09-05
Zertifikat-Registrier-Nr. 04 100 020955	Zertifikat für das Managementsystem nach DIN EN ISO 9001:2008 issued by TÜV Nord, dated 2014-05-05, valid until 2017-05-04
Normative references:	GL Rules and Guidelines – IV Industrial Services – Part 4 – Guideline for the Certification of Condition Monitoring Systems for Wind Turbines, Edition 2013

Changes of the system design, the production and erection or the designer's / manufacturer's quality system are to be approved by GL RC, otherwise this Type Certificate loses its validity.

This Type Certificate is valid until **2016-09-04**, provided that a valid "Certificate for the Quality Management System" is available for this period and the annual update is successfully performed on the basis of Section 3.1.5.4 of above mentioned normative reference.

Hamburg, 2014-09-05
Stgr

GL Renewables Certification

ppa. Ilka Woetbeking
Head of Certification Body

i.V. Axel Dombrowski
Head of Department

Renewables Certification
Germanischer Lloyd Industrial Services GmbH
Brooktorkai 18
20457 Hamburg, Germany

The latest edition of the "General Terms and Conditions of Germanischer Lloyd Industrial Services GmbH" is applicable. German law applies.

TÜV NORD expertise assessment

1. Special requirements by loca approval authority

RheinlandPfalz
STRUKTUR- UND GENEHMIGUNGSDIREKTION NORD

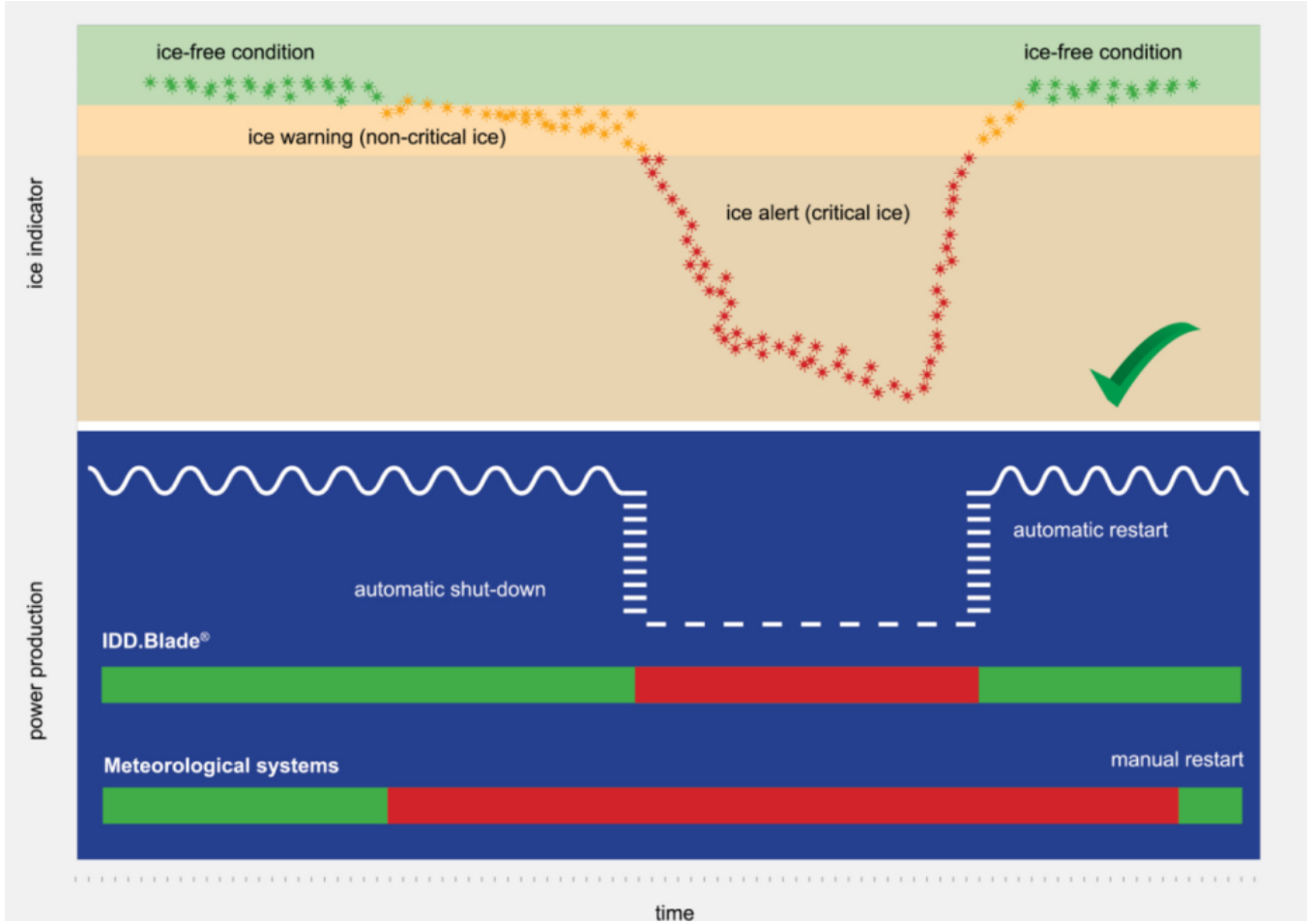
2. Development of turbine type specific critical (dangerous) ice-mass method

3. Test of the IDD.Blade system as a black-box method with multi-body simulation

4. IDD.Blade was accredited as a state-of-the-art ice detection system – also approved for automatic restart under ice-free conditions

IDD.Blade®

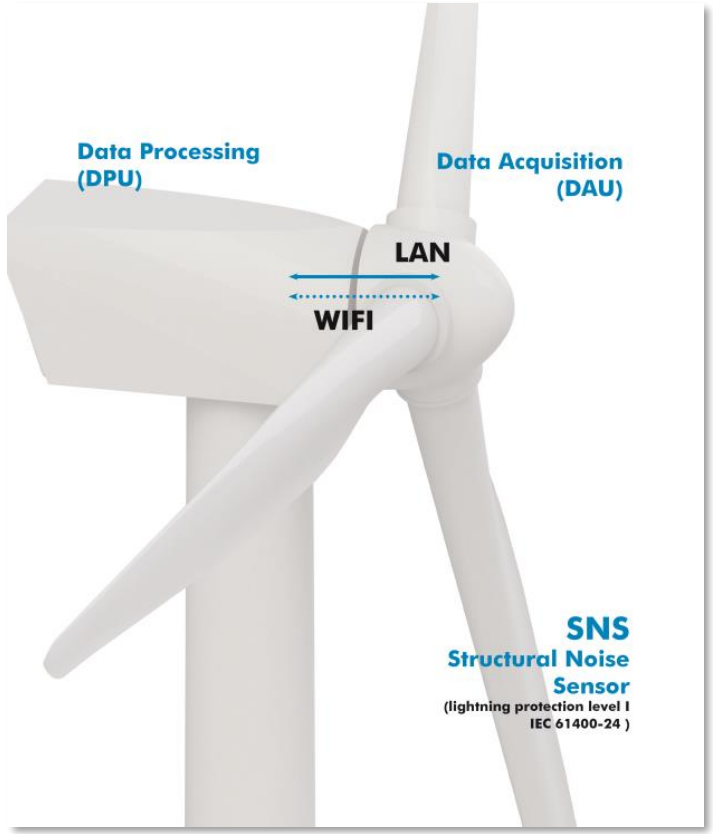
1. Exact ice indicator
2. Clear signaling
3. Automatic restart
4. Reduced downtime



SHM.Blade® and IDD.Blade® – Damage and Ice Detection Systems

Efficient blade monitoring:

1. Automatic restart
2. GL certified
3. TÜV proven ice detection performance
4. Short payback period
5. Best-in-class icing tresholds optimize energy yields



Thank you for your Attention!

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