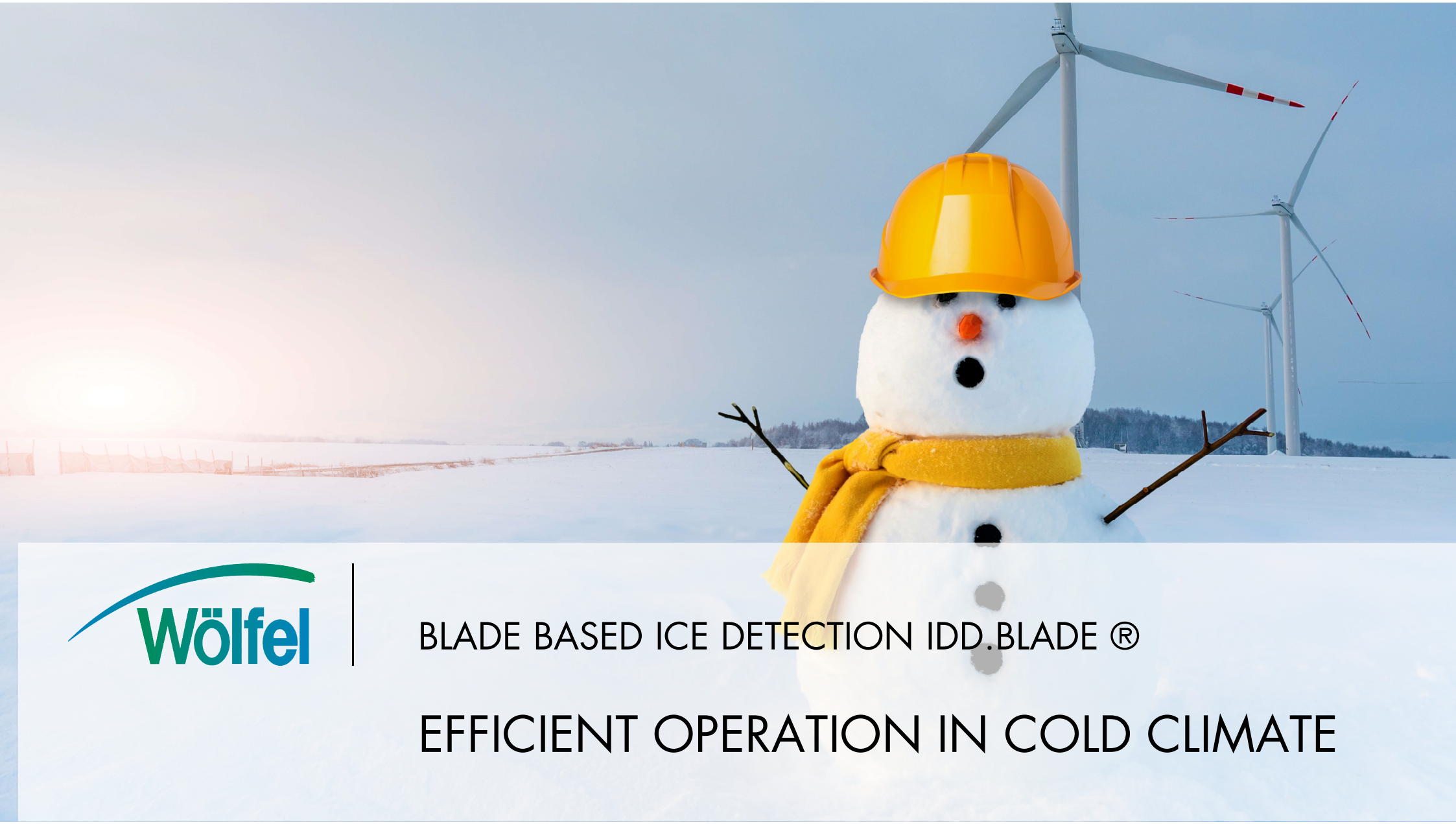
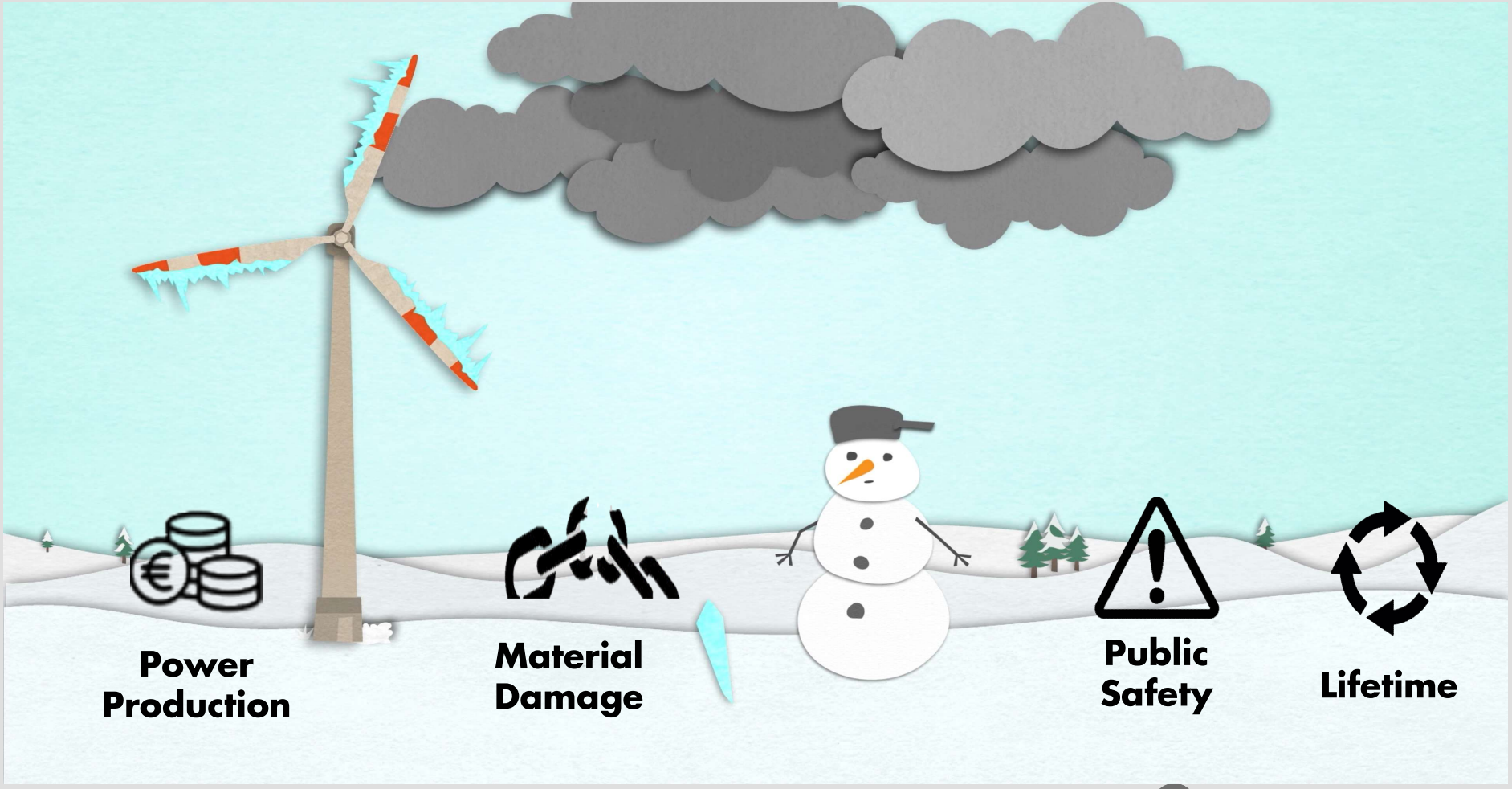


Wölfel

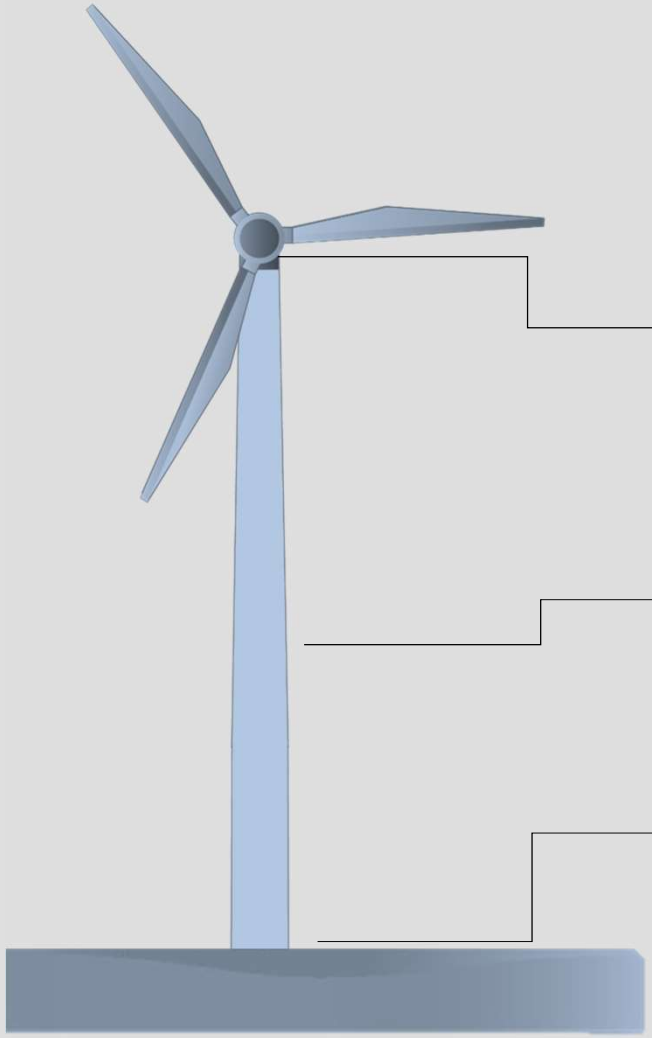
BLADE BASED ICE DETECTION IDD.BLADE ®

EFFICIENT OPERATION IN COLD CLIMATE

IMPORTANCE OF BLADE MONITORING IN COLD CLIMATE



CONDITION MONITORING PORTFOLIO



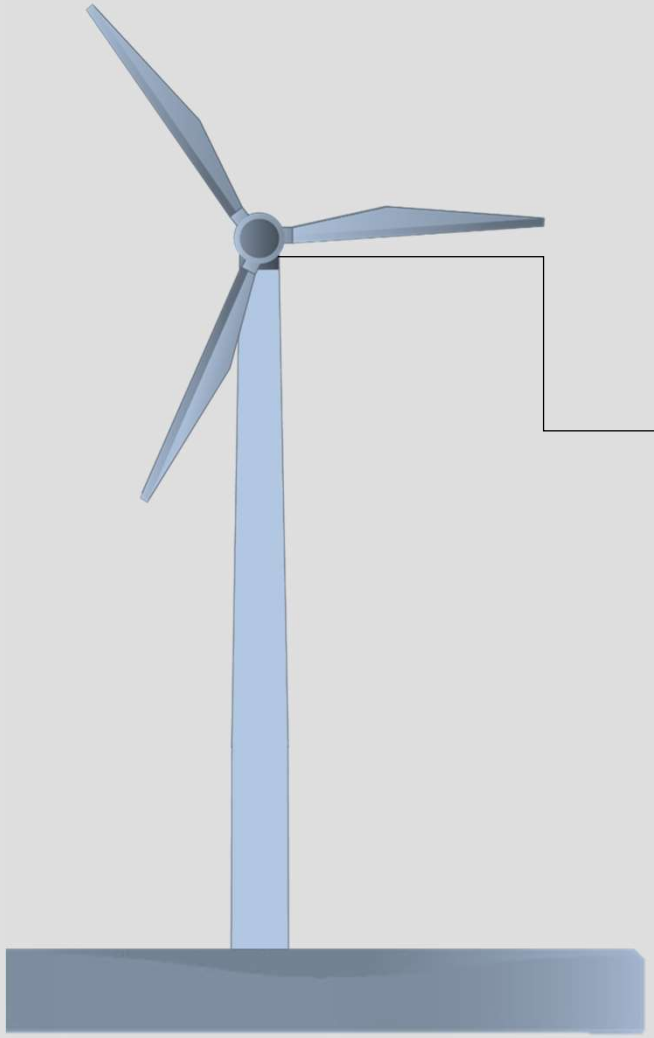
SHM Blade
Vibration-based Blade Monitoring

SHM Tower
Vibration-based Tower Monitoring

SHM Foundation
Vibration-based Monitoring of Onshore Structures

- Specialized for monitoring of the complete structure
- References throughout the whole wind industry
- Supplier to more than 10 OEMs
- Global install base: 1,800 systems

WÖLFEL BLADE MONITORING



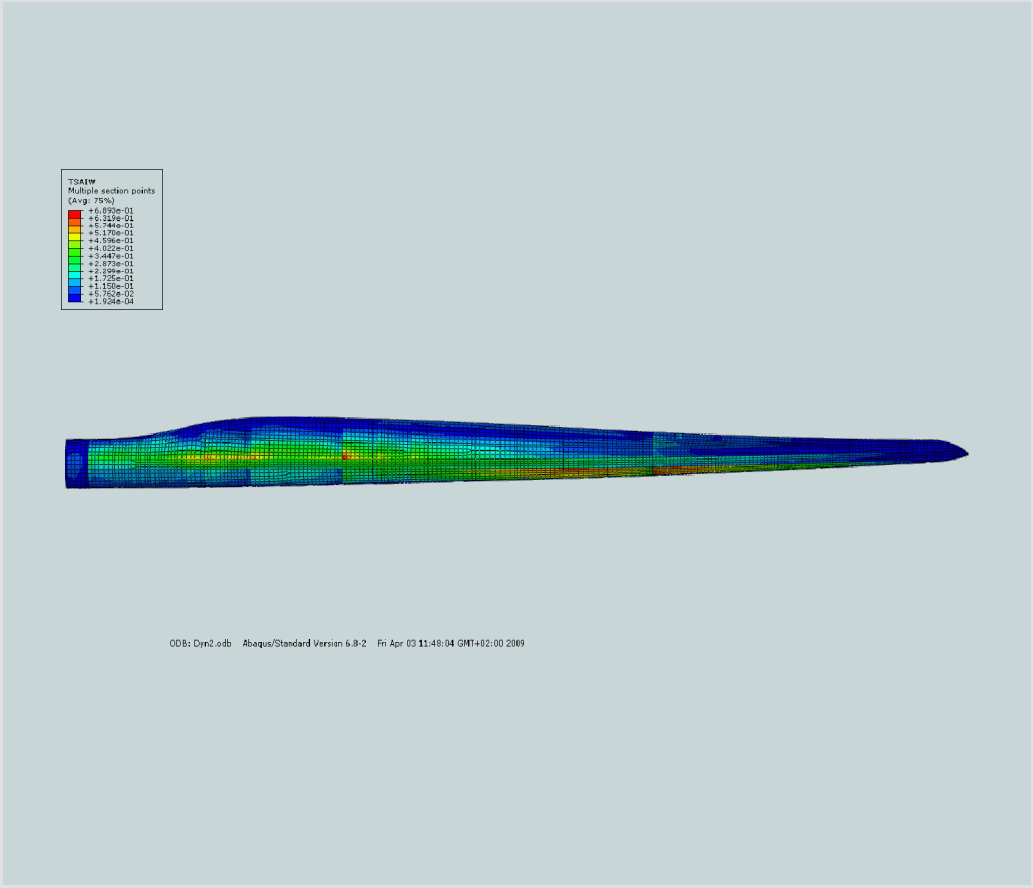
SHM Blade

Vibration-based
Blade Monitoring

Ice Detection → Damage Detection → Rotor Unbalances → Pitch Angle Monitoring

IDD Blade

VIBRATIONS PROVIDE INFORMATION ABOUT ICING



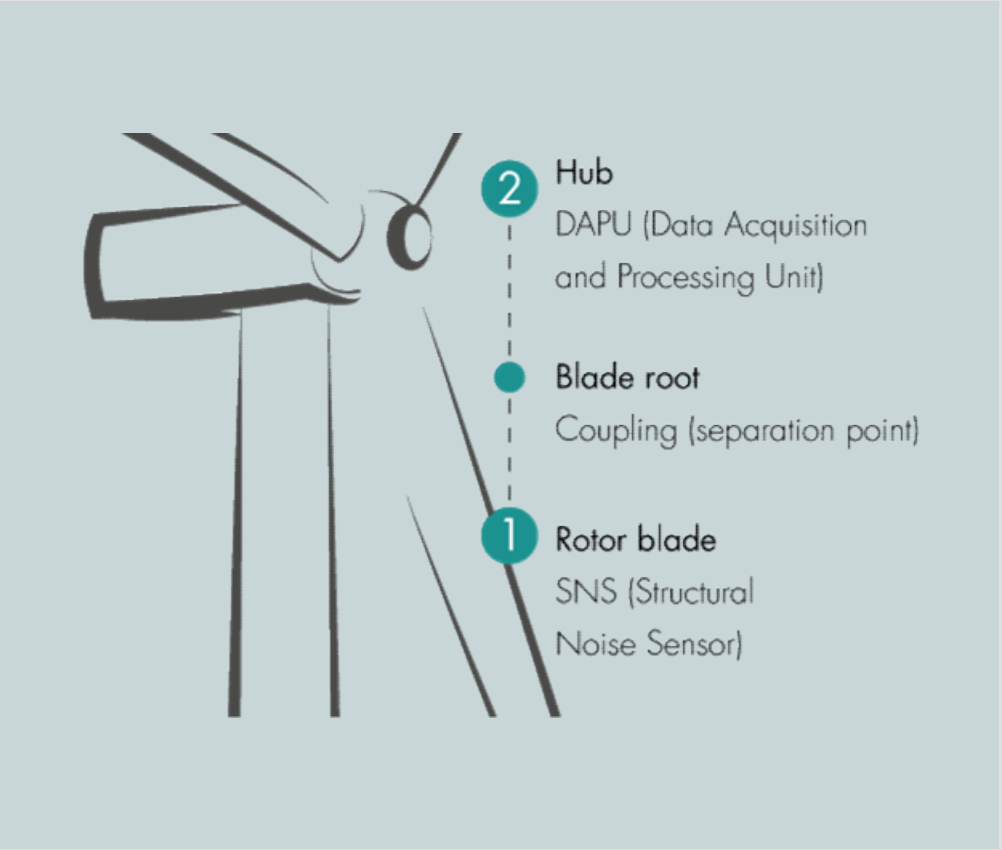
Structural damages and ice change the natural frequencies:

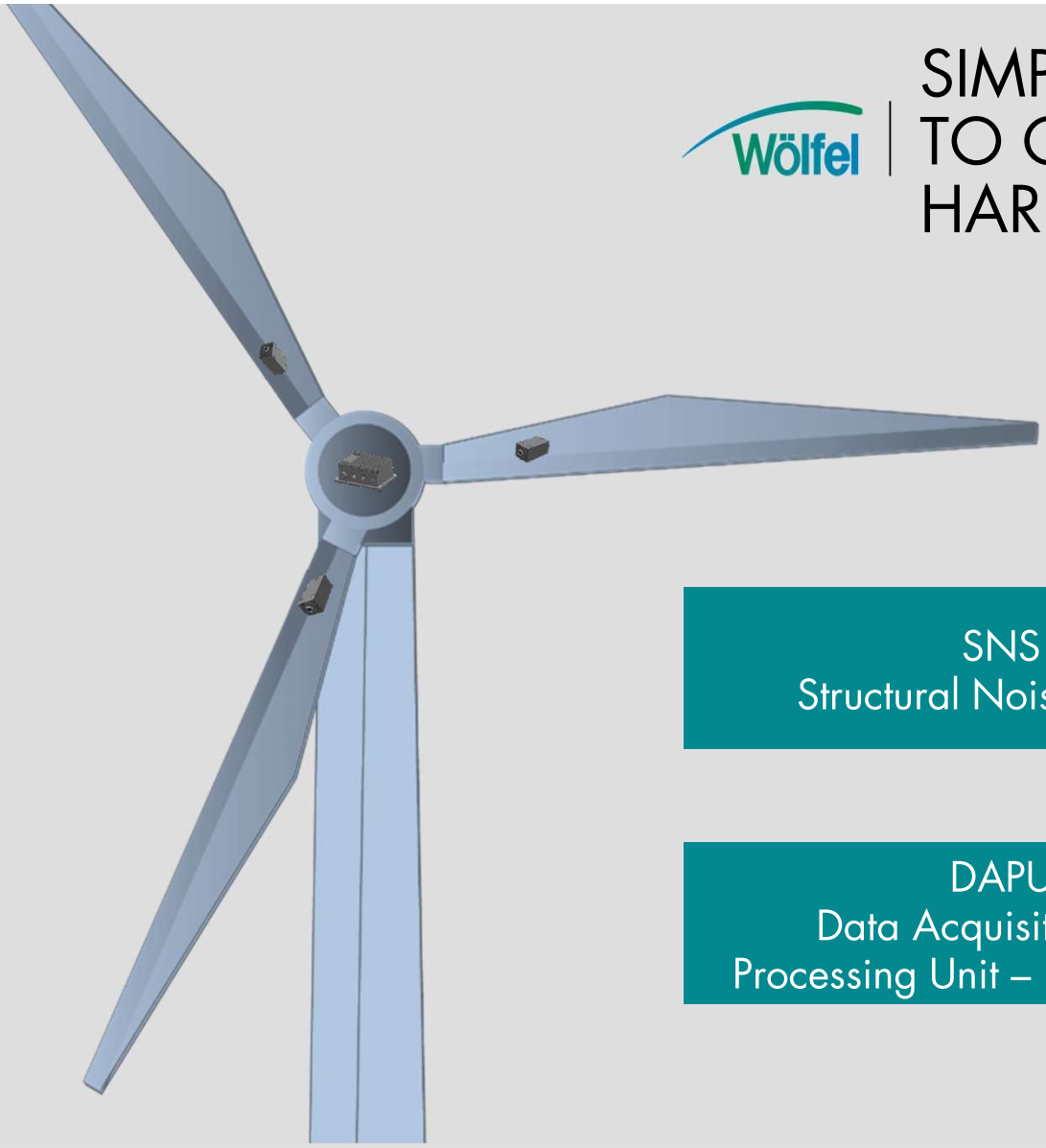
- Structural damages reduce the stiffness
- Ice increases the rotor blade mass

→ Rotor blade vibrations give us information about the state of the structure

SIMPLE AND RELIABLE DUE TO COMPACT AND ROBUST HARDWARE

- Structural Noise Sensors (SNS) measure vibration and sound in each rotor blade.
- The sensor signals are stored in the hub by the Data Acquisition and Processing Unit (DAPU).
- The data is evaluated automatically using the EOC and operating data provided by the wind turbine control system.
- Condition indicators are calculated.
- The WTG control system receives messages on the state of the system, damage and icing.



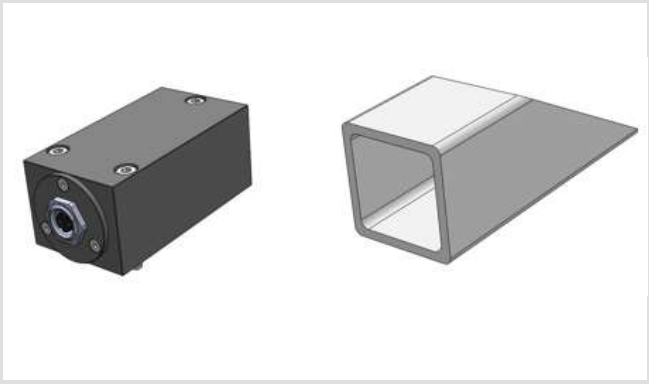


SIMPLE AND RELIABLE DUE TO COMPACT AND ROBUST HARDWARE

SNS
Structural Noise Sensor

DAPU
Data Acquisition and
Processing Unit – Interface PLC

SIMPLE AND RELIABLE DUE TO COMPACT AND ROBUST HARDWARE

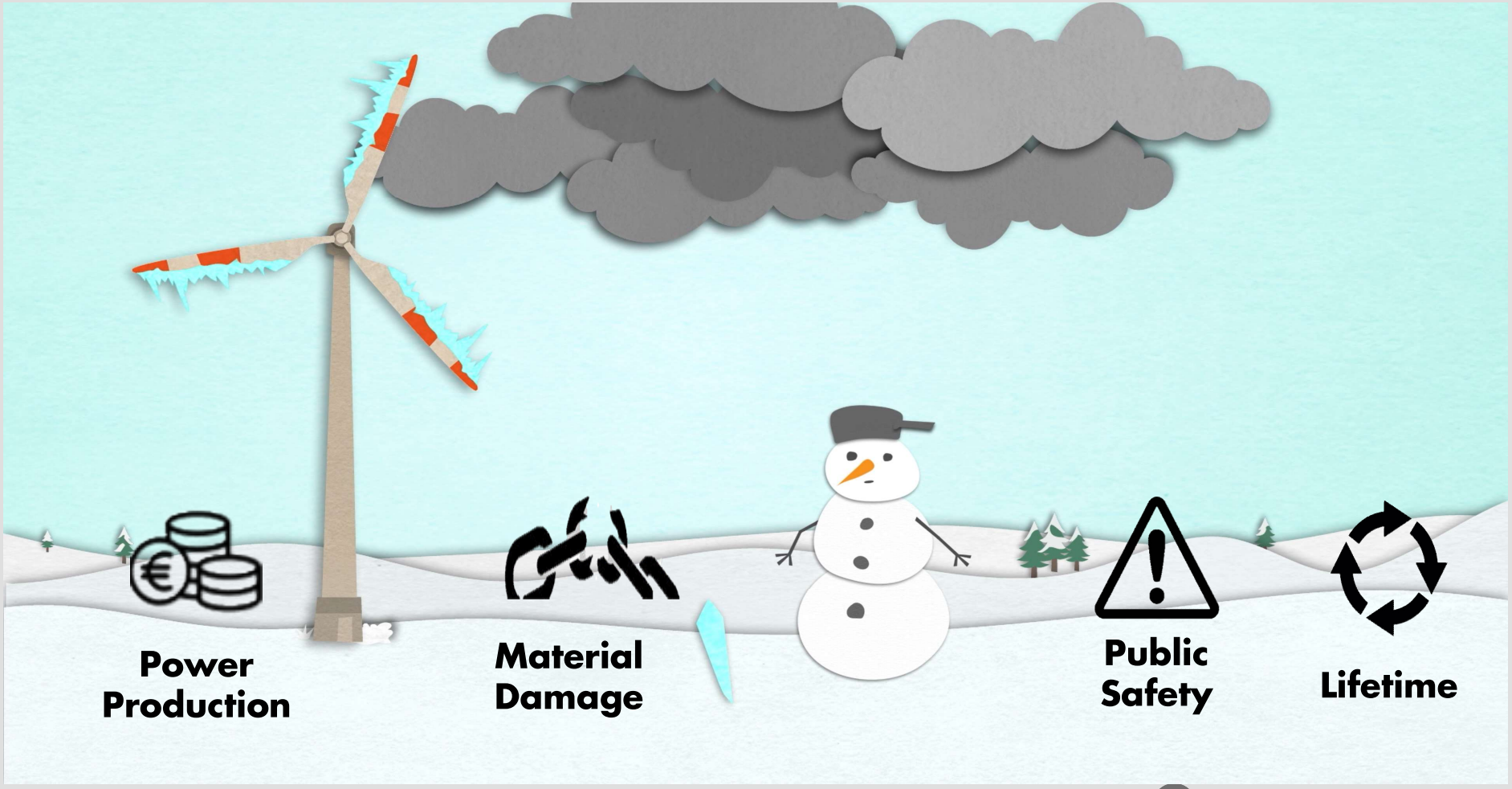


Structural Noise Sensor (SNS) with mounting adapter

Metal-free cable with optical fibers or guaranteed lightning protection

Data Acquisition and Processing Unit (DAPU)

IMPORTANCE OF BLADE MONITORING IN COLD CLIMATE



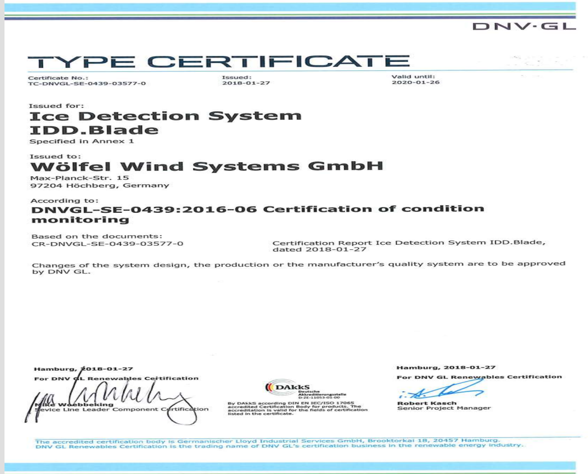
PUBLIC SAFETY BY AUTOMATED STOP AND RESTART

Public Safety

- **Hazard** to people as a result of flying ice chunks must be prevented.
  No ice throw!

- **Regulations** vary per country
- **State of the art** technology with increased security level.
- **Automatic Restart** certified

https://www.americanexperiment.org/2018/02/mn-wind-turbines-shut-safety-concerns-ice/



DNV·GL

TYPE CERTIFICATE

Certificate No.: TC-DNVGL-SE-0439-03577-0
Issued: 2018-01-27
Valid until: 2020-01-26

Issued for:
Ice Detection System IDD.Blade
Specified in Annex 1

Issued to:
Wölfel Wind Systems GmbH
Max-Planck-Str. 15
97204 Höchberg, Germany

According to:
DNVGL-SE-0439:2016-06 Certification of condition monitoring

Based on the documents:
CR-DNVGL-SE-0439-03577-0 — Certification Report Ice Detection System IDD.Blade, dated 2018-01-27

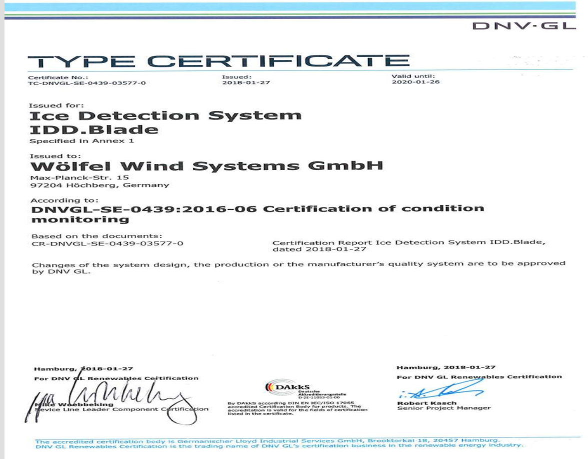
Changes of the system design, the production or the manufacturer's quality system are to be approved by DNV GL.

Hamburg, 2018-01-27
For DNV GL Renewables Certification
Mike Woebbeking
Service Line Leader Component Certification

DAkkS Deutsche Akkreditierungsstelle D-ZE-11053-01-00
By DAkkS according DIN EN IEC/ISO 17065 accredited Certification Body for products. The accreditation is valid for the fields of certification listed in the certificate.

Hamburg, 2018-01-27
For DNV GL Renewables Certification
Robert Kasch
Senior Project Manager

The accredited certification body is Germanischer Lloyd Industrial Services GmbH, Brooktorkai 18, 20457 Hamburg.
DNV GL Renewables Certification is the trading name of DNV GL's certification business in the renewable energy industry.



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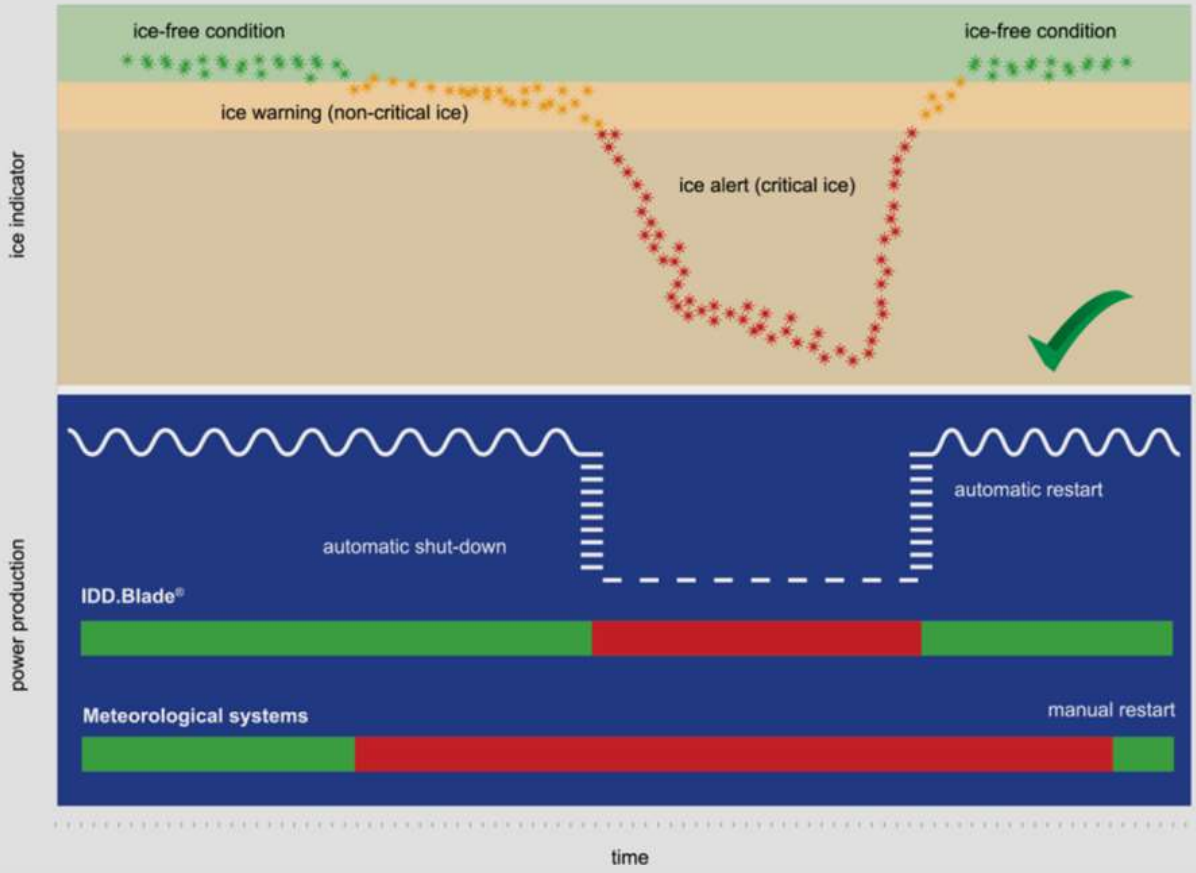
AUTOMATIC RESTART INCREASES YIELDS EVEN FURTHER

Power Production



FAST AND SAFE ICE DETECTION WITH IDD.BLADE

Ice detection directly on the rotor blade

- Ice detection by measuring the vibration behavior of the rotor blade
- Individual on each rotor blade
- Automatic restart of the plant
- Individual/site-specific sensitivity setting
- Ice detection in all operating conditions and also in standstill (all pitch angles)
- Min. wind speed ~ 2.5 m/s → Ice detection below the activation wind speed
- Updating ice indicator ~ 5 min → Automatic restart of the plant at any time

AERODYNAMIC UNBALANCE IS A RELEVANT FACTOR

mic rotor unbalance (AU)…

uces the aerodynamic efficiency of the wind turbine and as a sequence its power output.

ds to very large increases in loading on the drivetrain, blades l tower.

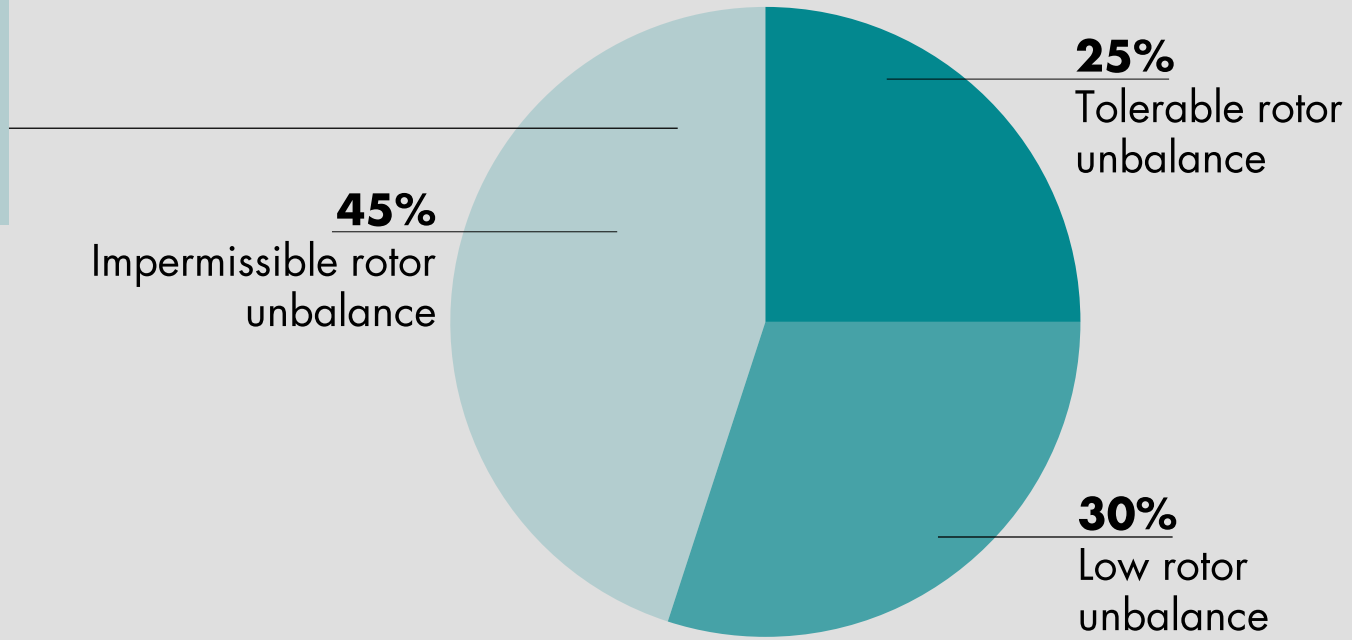
ds to increased vibrations and as a consequence to higher se emission.

Material Damage

NEARLY 50 PERCENT OF WIND TURBINES SUFFER FROM UNBALANCE ON THE ROTOR

15% each

– Mass unbalance
– Aerodynamic unbalance
– Combined unbalance



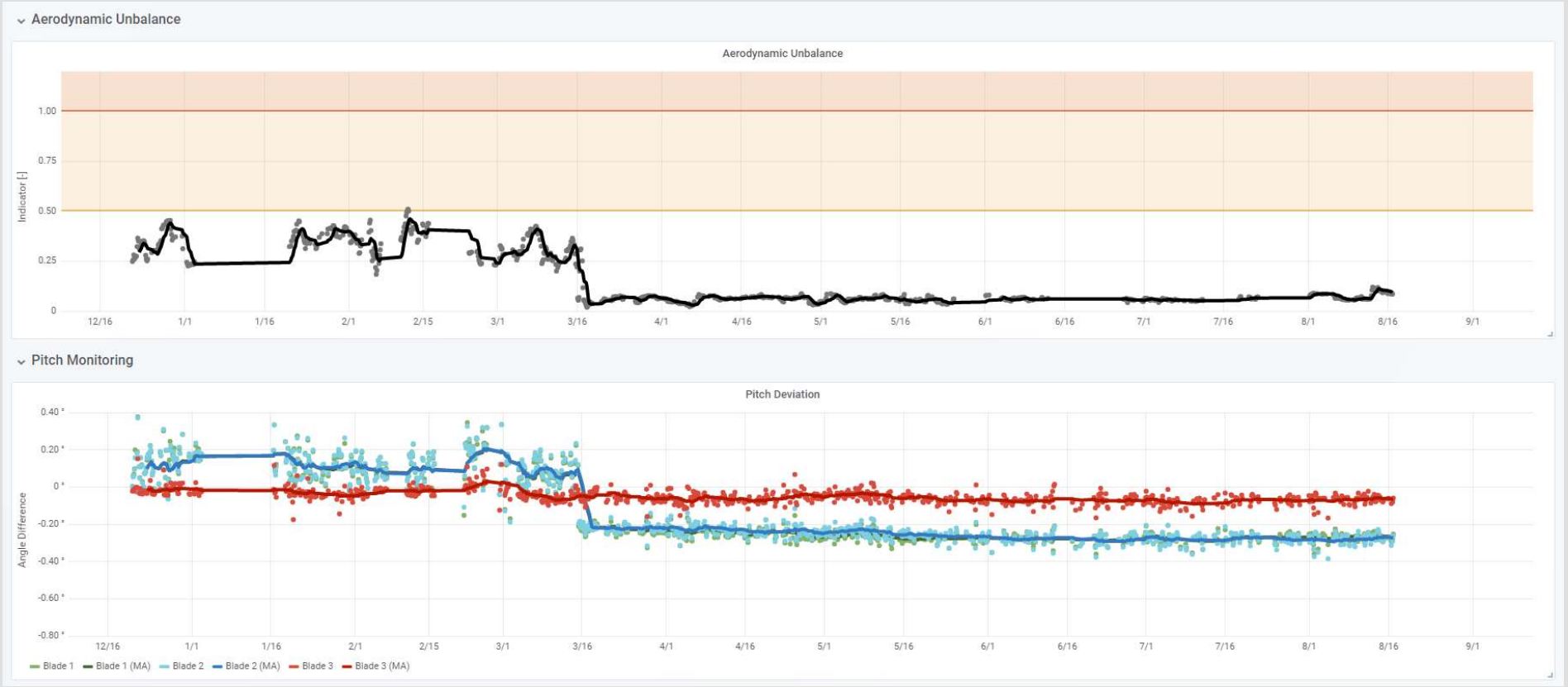
Source: Auswuchten von WEA-Rotoren (Dr. Christoph Heilmann et al., WID Whitepaper: Bundesverband WindEnergie BWE 03/2015)

HIGH PRECISION IN THE DETECTION OF AERODYNAMIC UNBALANCE

lade unbalance detection helps to avoid severe damages by ing turbines which add increased fatigue loads on the entire e, especially on the tower and nacelle, as well as on the ain components.

e of SHM.Blade pitch angle monitoring will lead to an ed life expectancy of the structure and the drive train nents.

A SELECTION OF SUCCESSFUL PROJECTS: DETECTION OF AU BY PITCH ANGLE MISALIGNMENT



TOWER MONITORING

SHM Tower

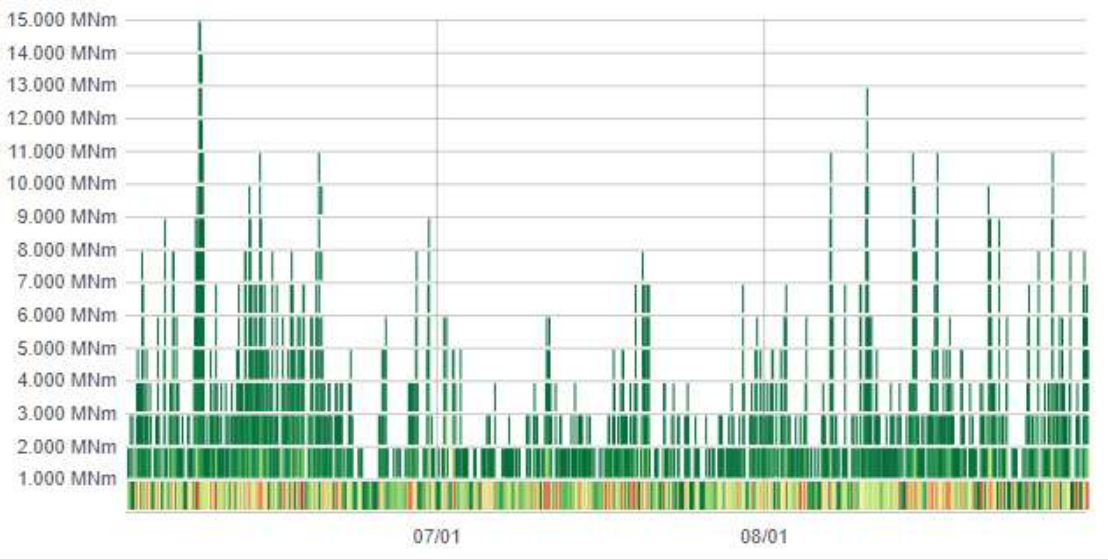
Vibration-based
Tower Monitoring

Lifetime → Natural Frequencies | Rotor Unbalances | Moments, Loads and Stresses

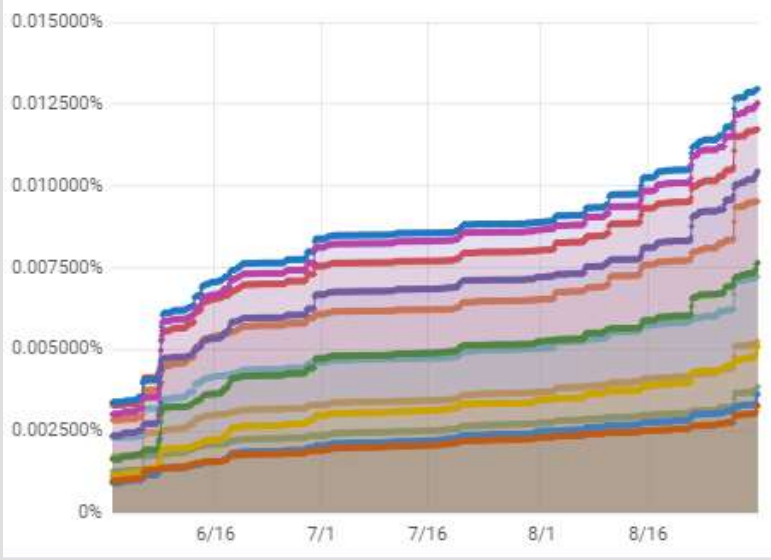
Lifetime

LIFETIME MONITORING

Bending Moments in Tower Segments



Lifetime Consumption in Tower Segments



STRUCTURAL INTELLIGENCE IN REAL LIFE: LIVE ACCESS TOOL TO SUPPORT DECISION-MAKING

DO YOU WANT TO AVOID UNNECESSARY DOWNTIMES?

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