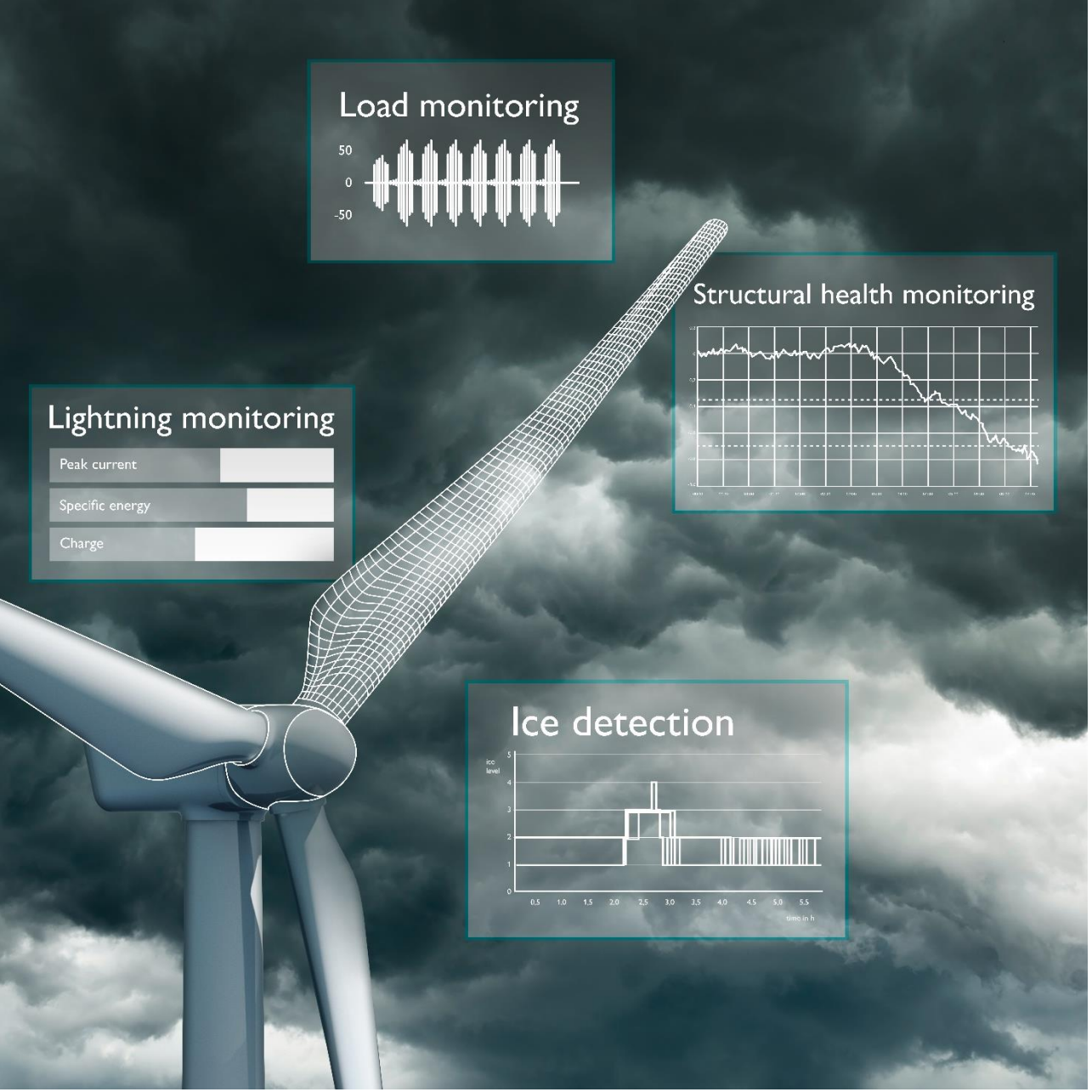


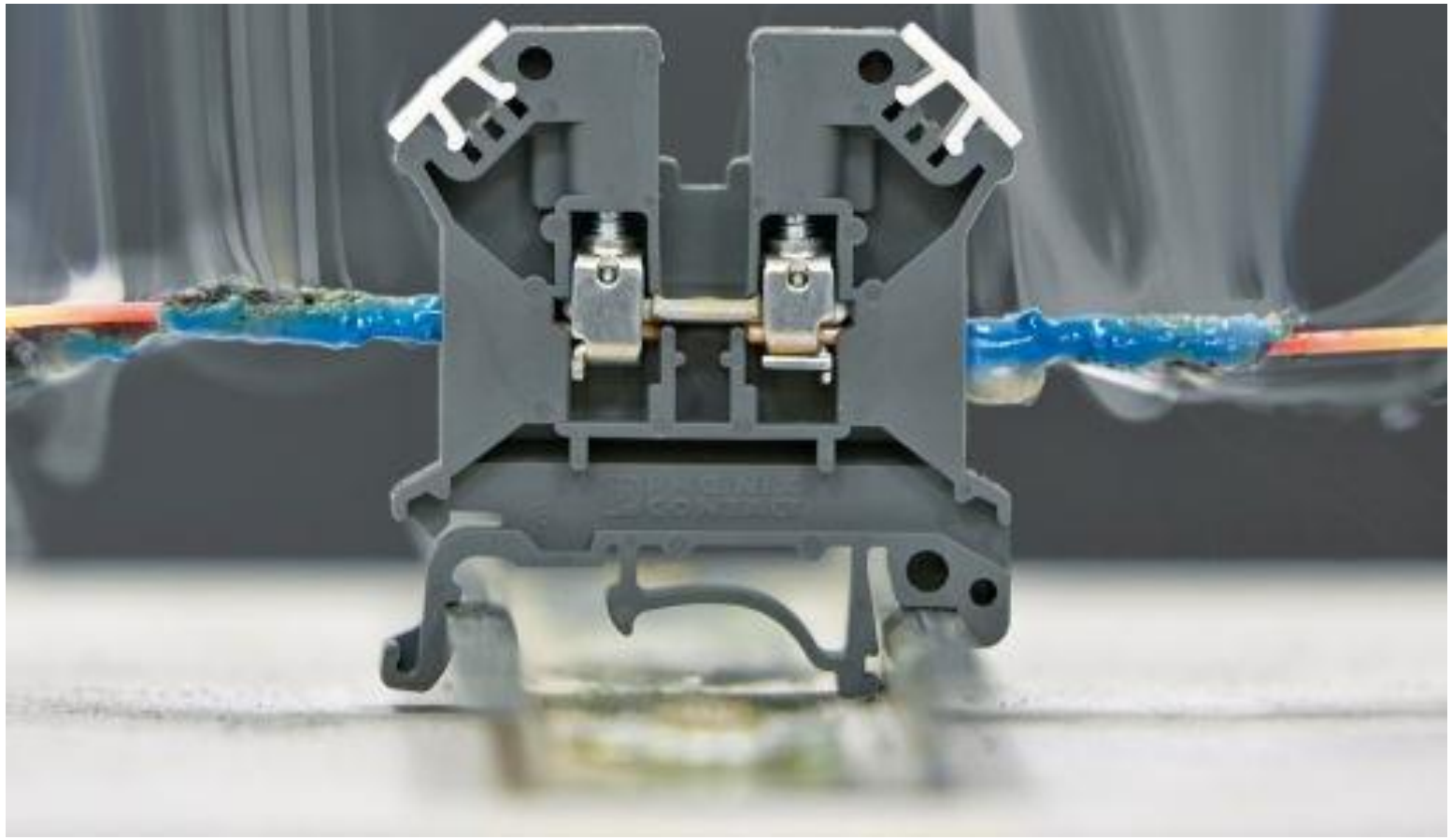
Welcome

Lightning Monitoring in Cold Climates? Is there any need?

PHOENIX CONTACT
INSPIRING INNOVATIONS

Rotor blade monitoring with Blade Intelligence

Phoenix Contact about us



Rotor blade monitoring with Blade Intelligence

Phoenix Contact about us

- **Founding year** 1923 in Essen, North Rhine-Westphalia, Germany
- **Turnover 2022** 3.6 bn. €
- **Number of employees 2021** 22,300 worldwide
- **Production sites** China, USA, Germany, Greece, India, Poland, Sweden, Switzerland, Taiwan/China, Turkey
- **Products** > 100.000 articles
- **Sales** Represented in more than 55 subsidiaries worldwide

Since Q2/2021 all Phoenix Contact operations globally are climate neutral

Phoenix Contact offers you creative solutions in the fields of connection technology, electronics and automation on the journey to a smart world.

A privately held company founded in 1923 that is vertically integrated and independent in its entrepreneurial decision-making freedom.

Headquarters Blomberg/Germany

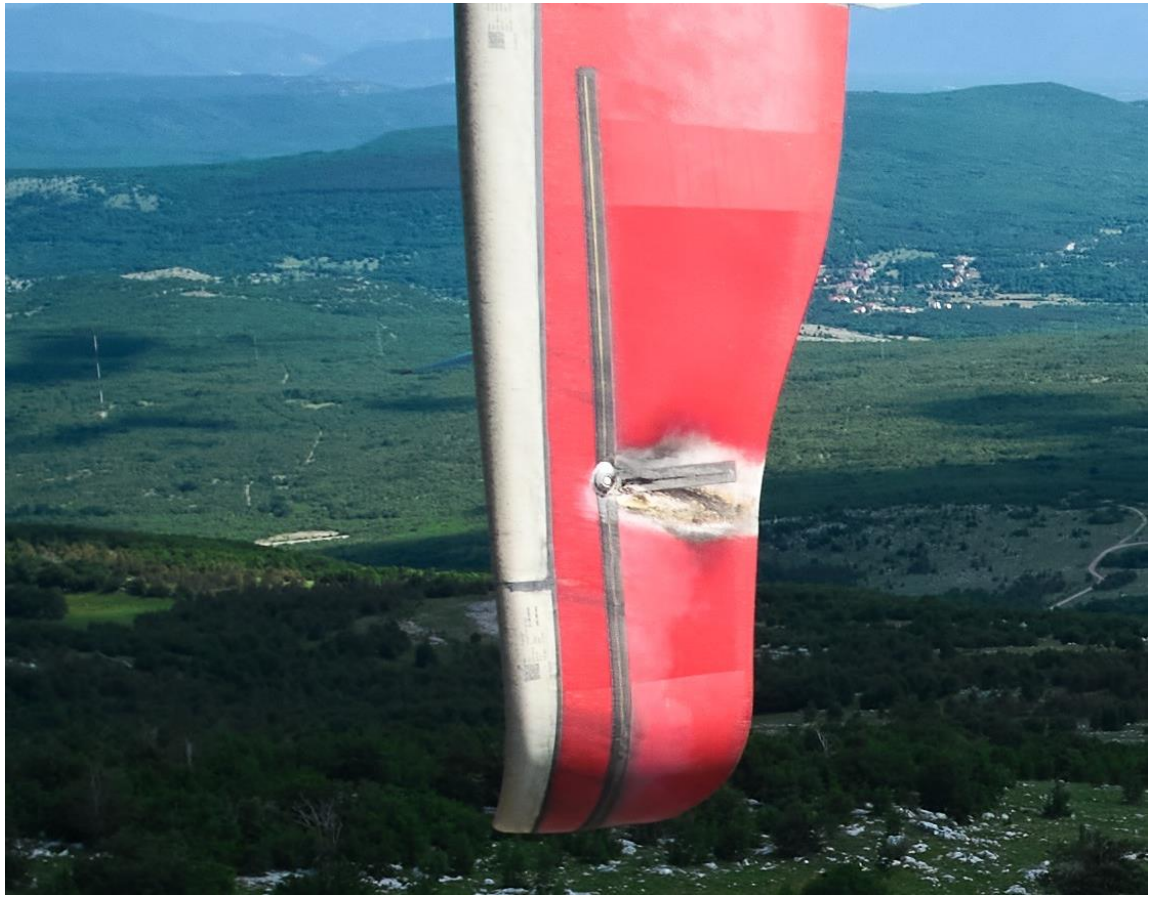
Group Center of Competence, Nanjing/China

Rotor blade monitoring with Blade Intelligence

It must not always end like this

Rotor blade monitoring with Blade Intelligence

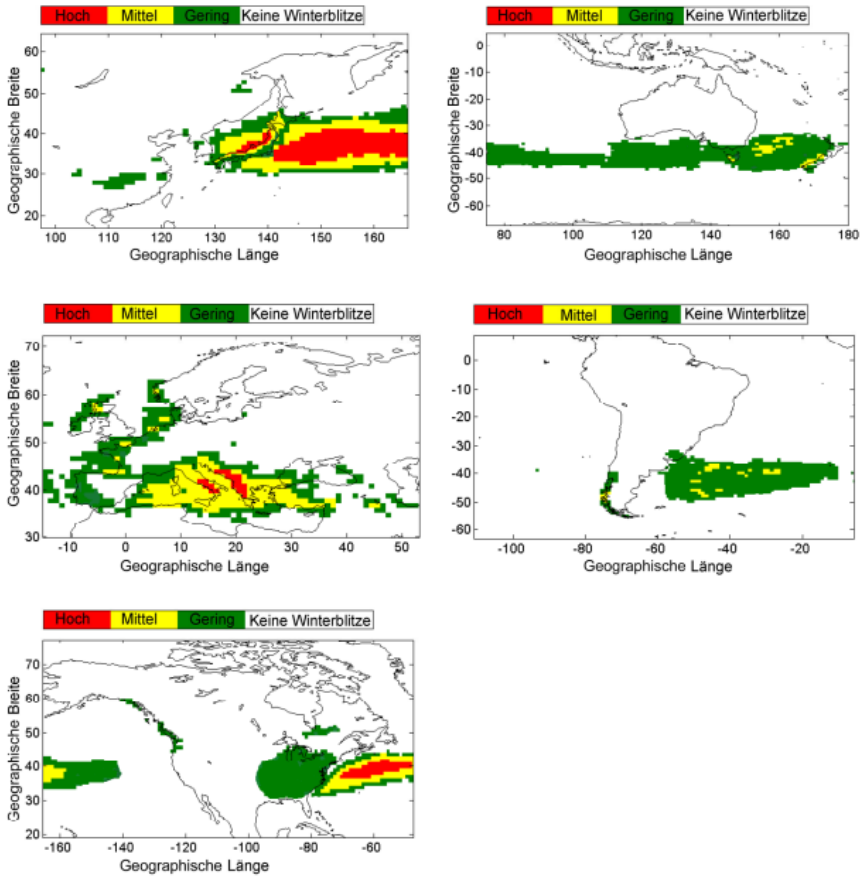
It starts here

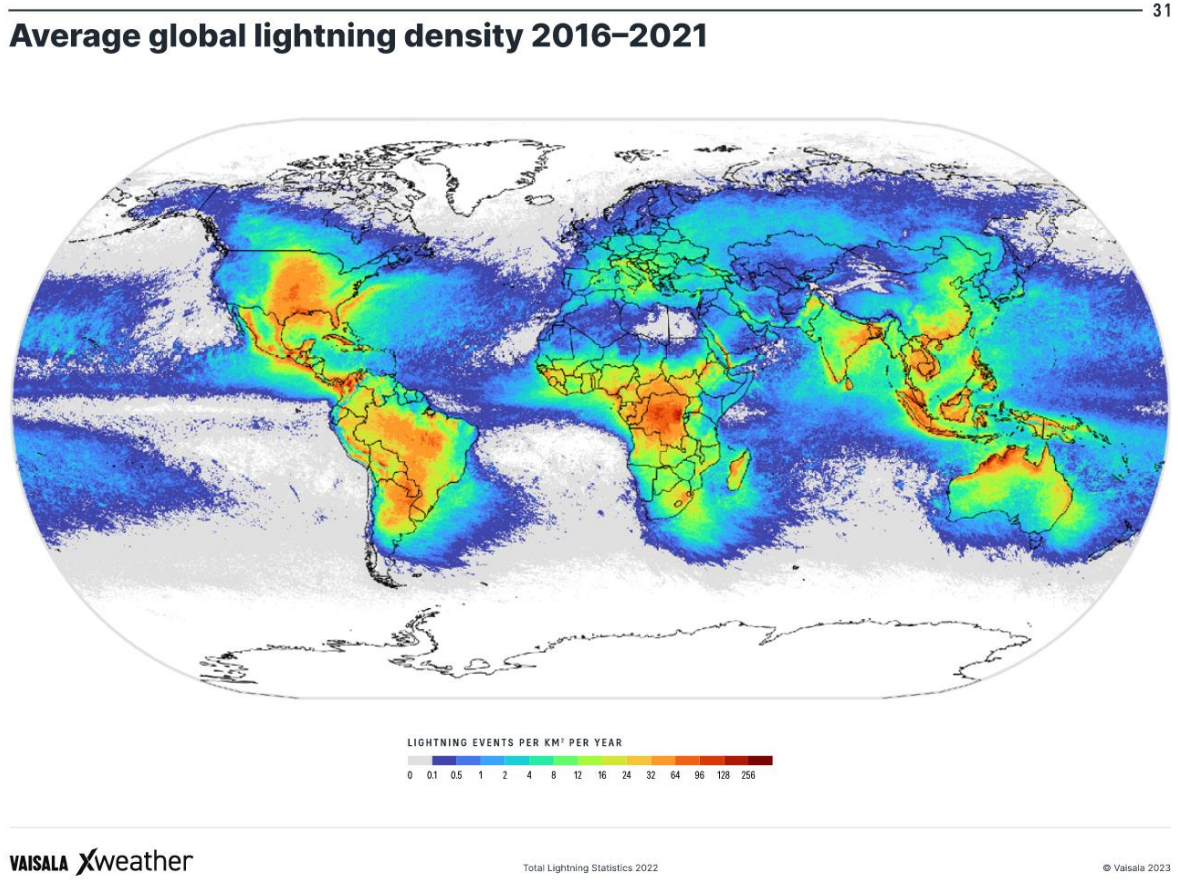


Rotor blade monitoring with Blade Intelligence

Lightning Density

DIN EN IEC 61400-24 (VDE 0127-24):2020-11
EN IEC 61400-24:2019

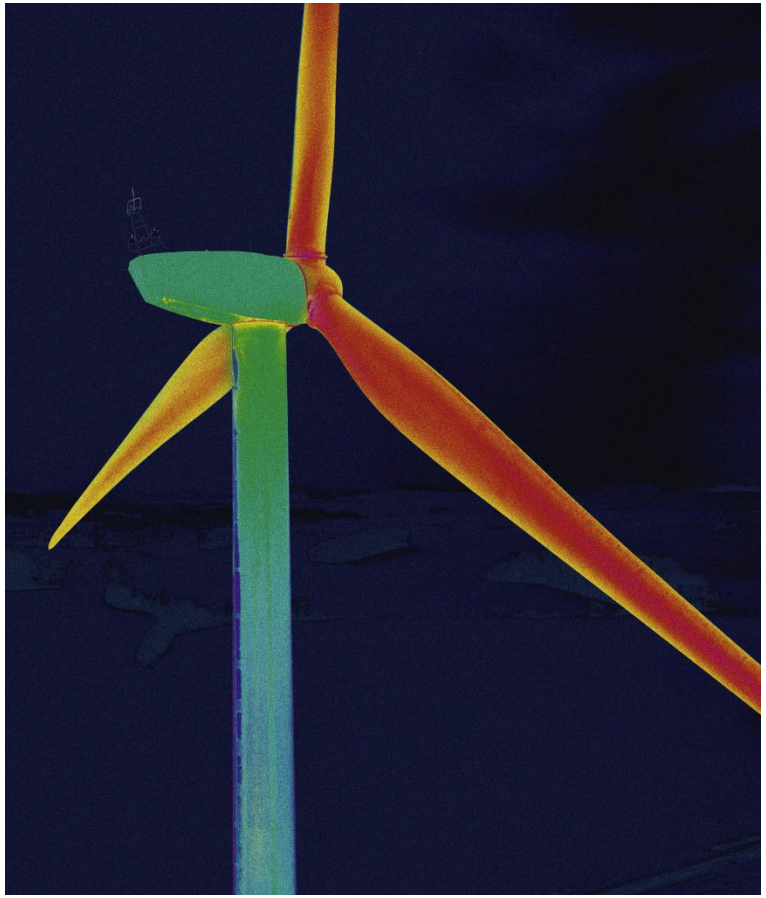




Rotor blade monitoring with Blade Intelligence

Additional Challenges

- Additional conductive elements in the blade like anti icing systems
- No Lightning assesmant for those windfarms



Rotor blade monitoring with Blade Intelligence

Repair vs Replacement

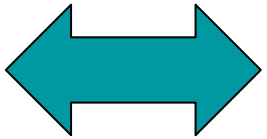
Cost of one blade change

Blade: 300.000 €

Crane: 70.000 €

Preparation & Service: 30.000 €

Total cost 400.000 €



Repair with working platform

Service team: 250 € / h x 16h = 6.000 €

Working platform: 5.000 €/ d x 3d = 15.000 €

Total cost: 15.000 €

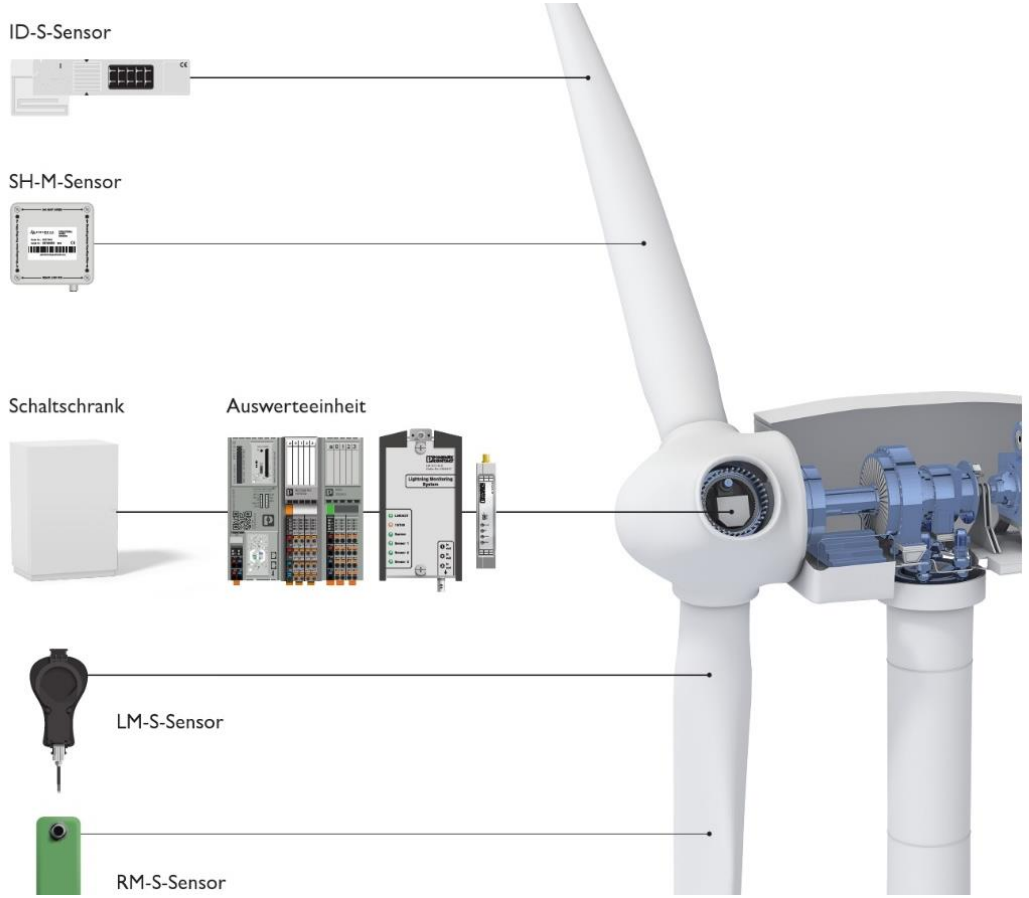
Savings: 400.000 € - 15.000 € = 385.000 €.

The exact cost depends on the type of WTG, the type of damage, etc.
This calculation is based on average data from various turbines

Knowing your blades with Blade Intelligence

- The modular design allows the individual systems to be combined as required.

- Sensors specially developed for mounting on the rotor blade supply all data, for processing in a common evaluation unit.



Blade Intelligence

More than

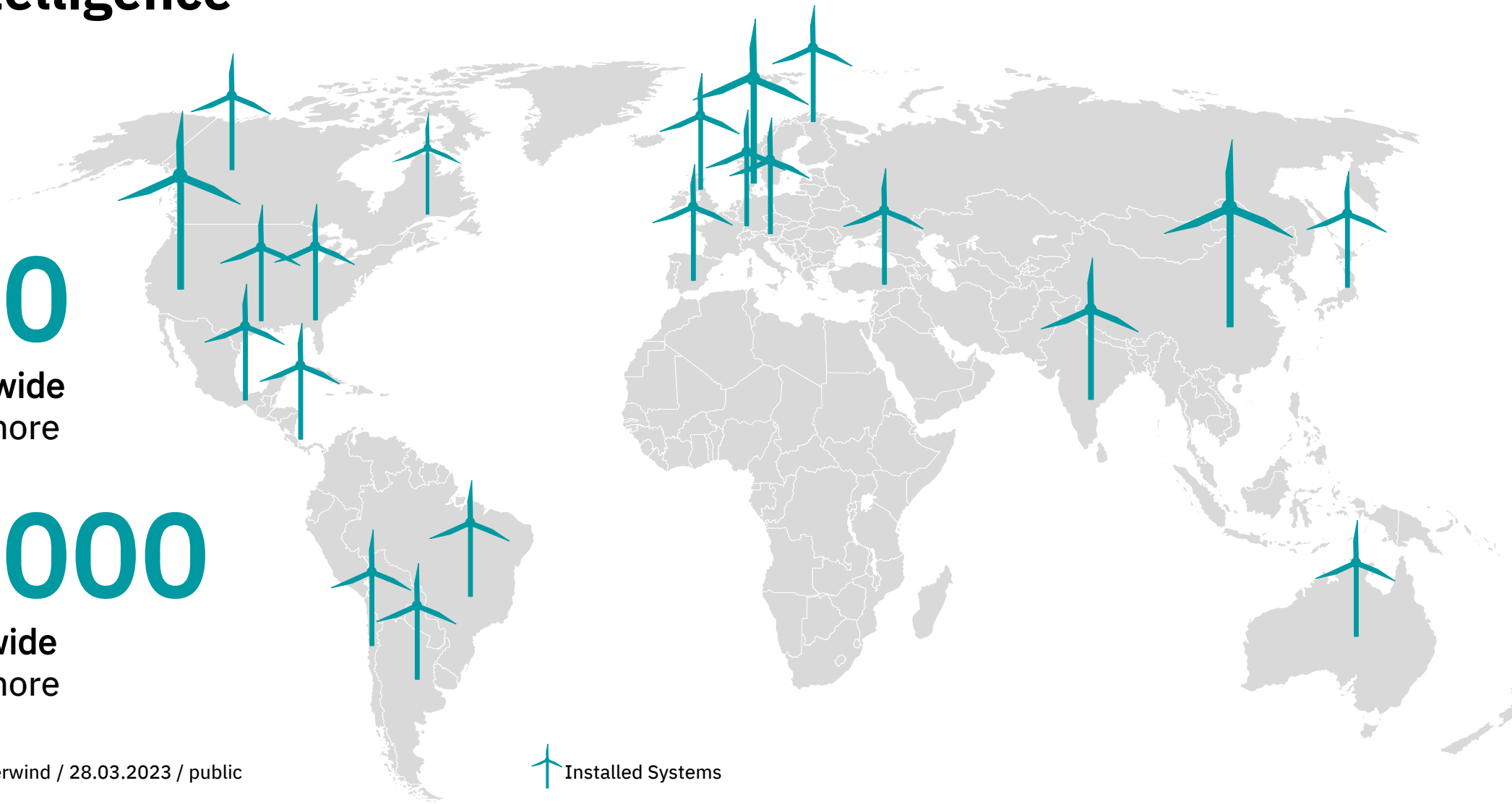
4.000

systems worldwide
onshore & offshore

More than

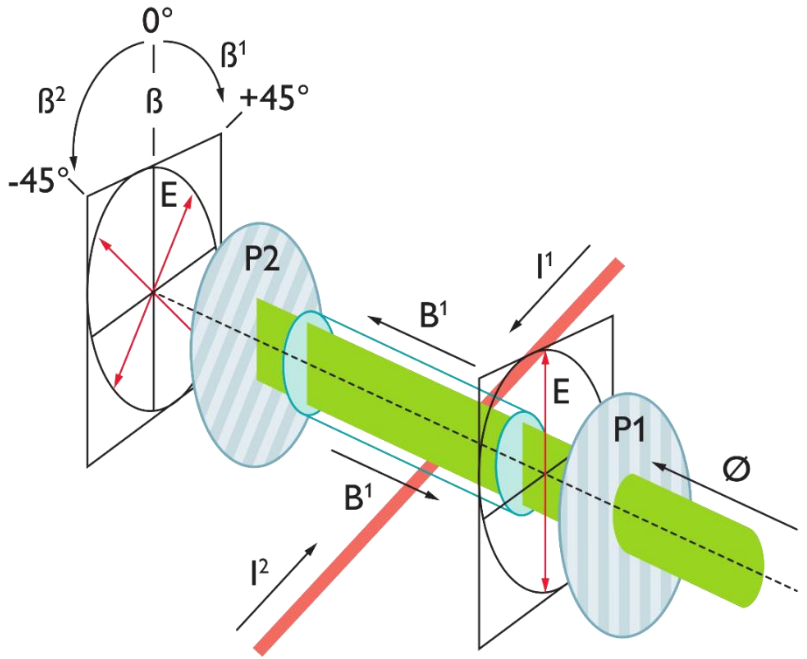
100.000

sensors worldwide
onshore & offshore



Lightning Monitoring System (LM-S)

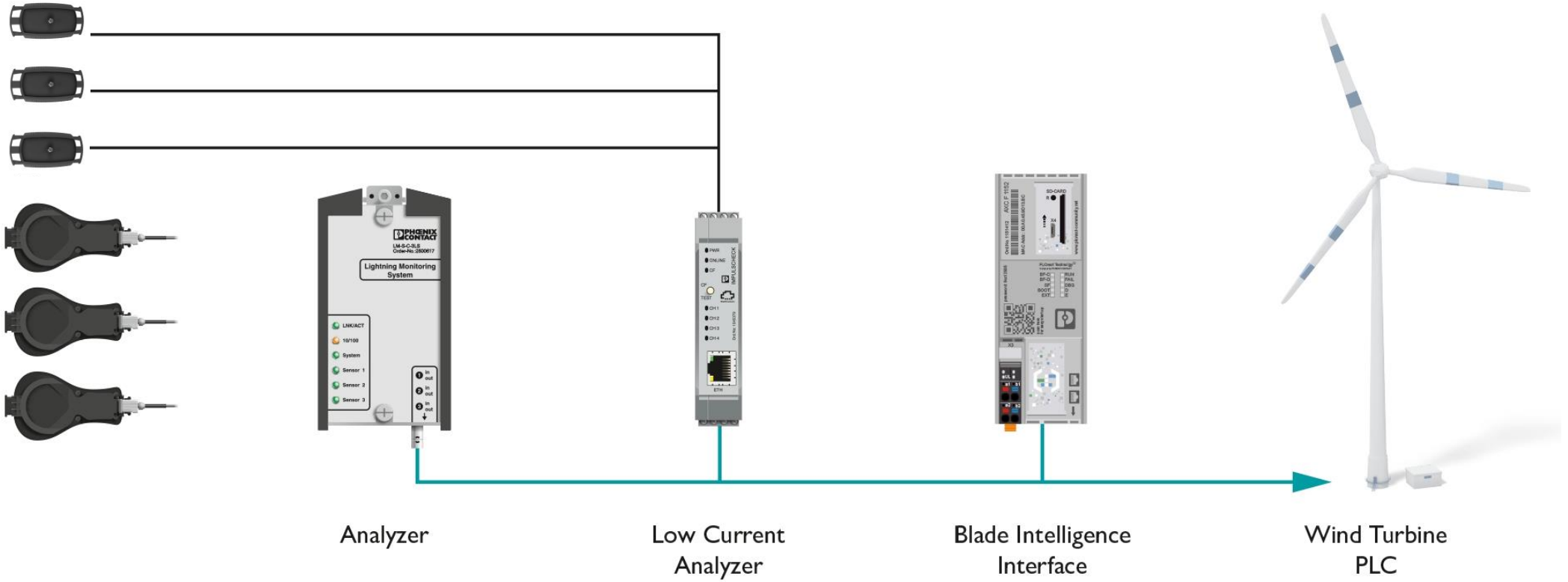
Lightning measurement by Faraday effect



Main features

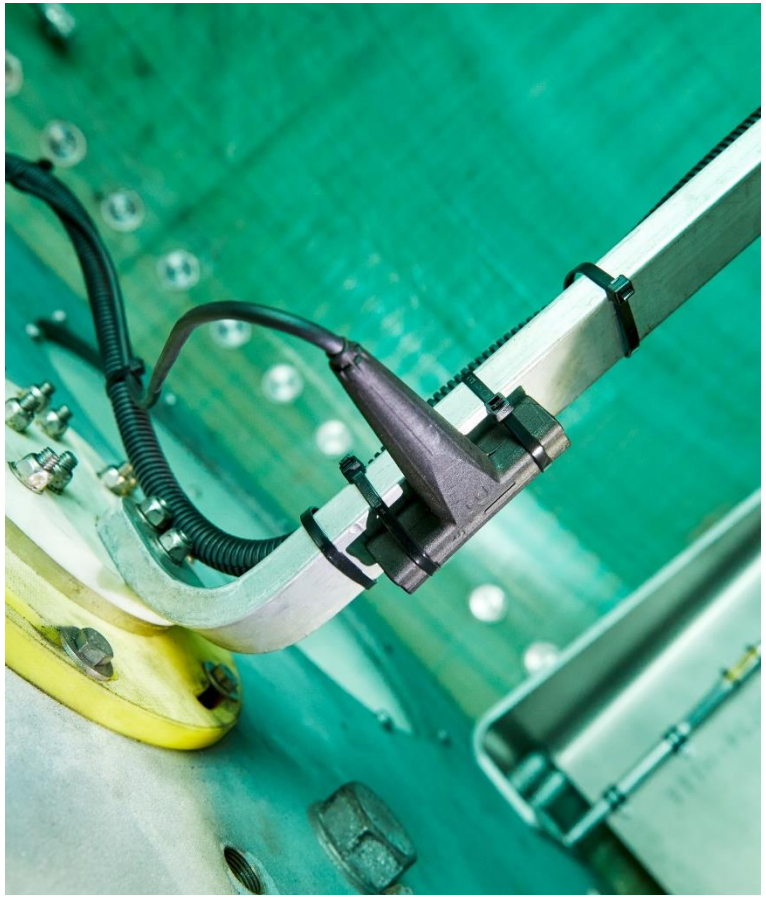
- Live monitoring system for permanent **recording** and analysis of **lightning strikes**
- Detailed **analysis** of
  - Lightning impulse current **Imax**
  - Gradient di/dt
  - Charge
  - Specific energy
- Measuring range:
  +/- 5 kA to 400 kA

System components



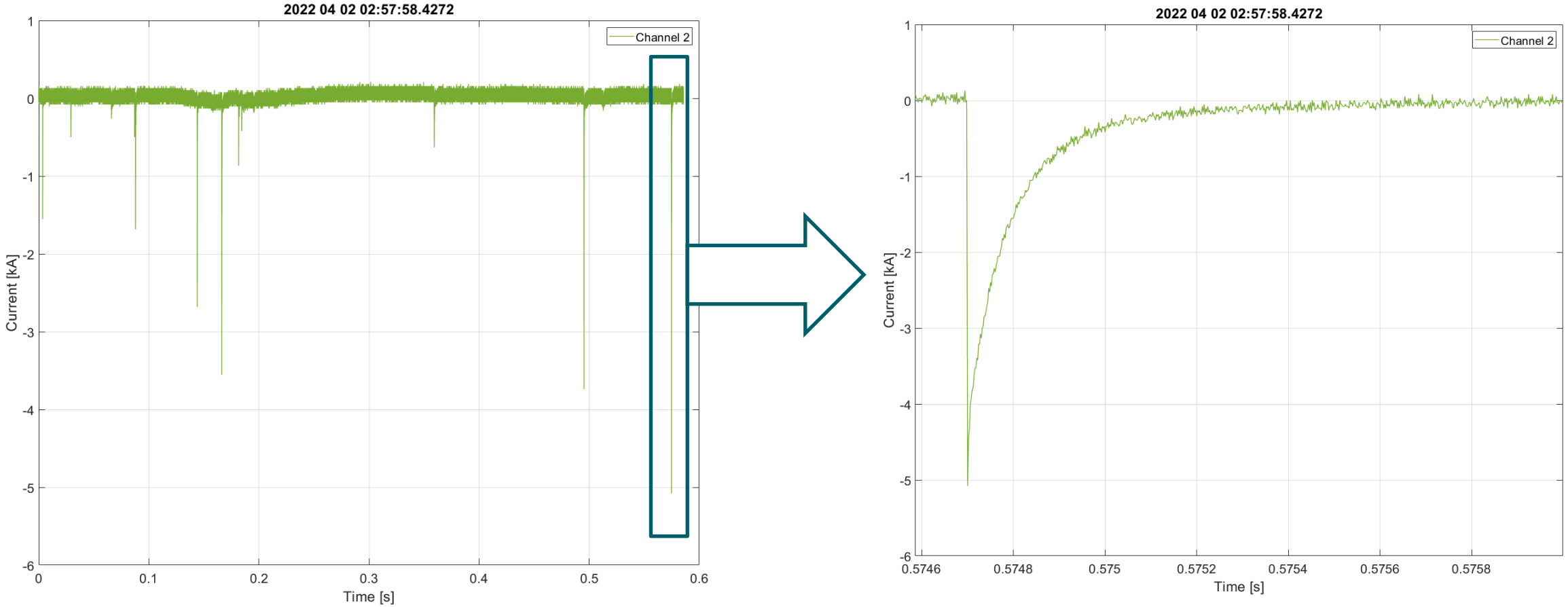
Advanced functions

- Additional function for the previous system
- Higher accuracy in the lower measuring range
- Extended measuring range from 1 kA - 400 kA
  → Recording of current curves up to 100 kA
- The PLC can request data from e.g. Vaisala or meteoarge network



Blade Intelligence | Lightning Monitoring System (LM-S)

Accurate analysis



Blade Intelligence

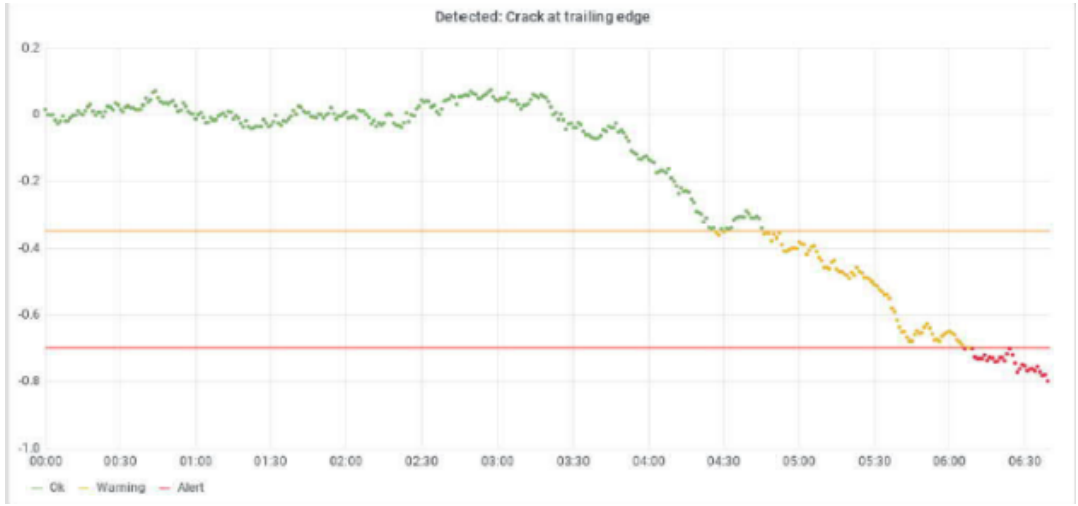
How to know before they go

Structural Health Monitoring (SH-M)

Success Stories: Cracks get your attention in an early phase

Detected: Crack at trailing edge

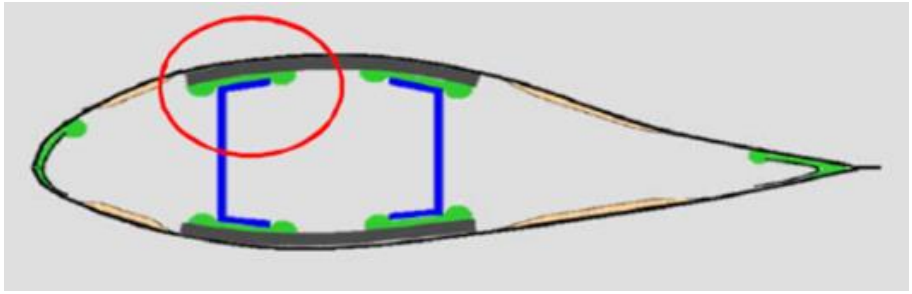
- Length about 35 cm orthogonal to trailing edge at 12 m radius
- Rope access repair was possible



Success Stories: Cracks get your attention in an early phase

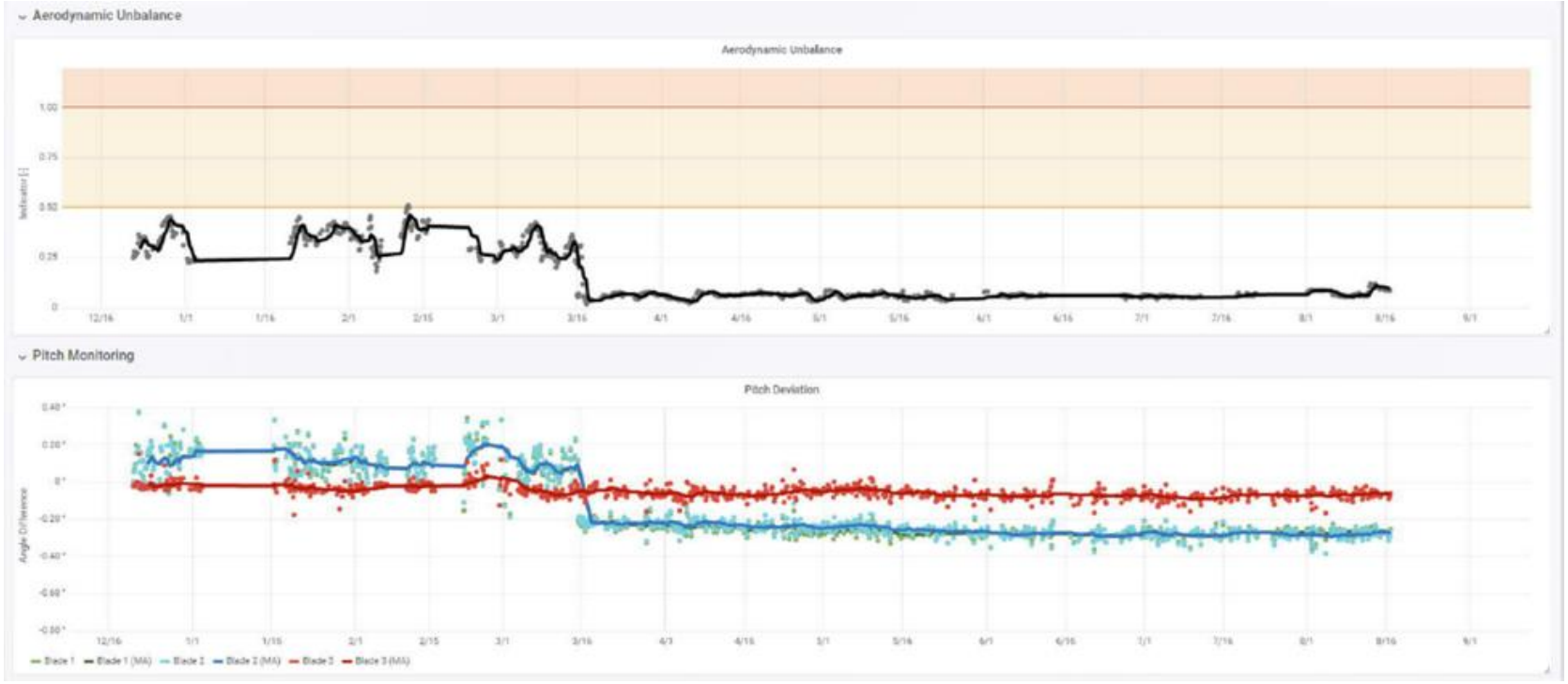
Detected: Crack at trailing edge

- Length about 35 cm orthogonal to trailing edge at 12 m radius
- Uptower repair was possible



Structural Health Monitoring (SH-M)

Success Stories: Detection of AU by pitch angle misalignment



Structural Health Monitoring (SH-M)

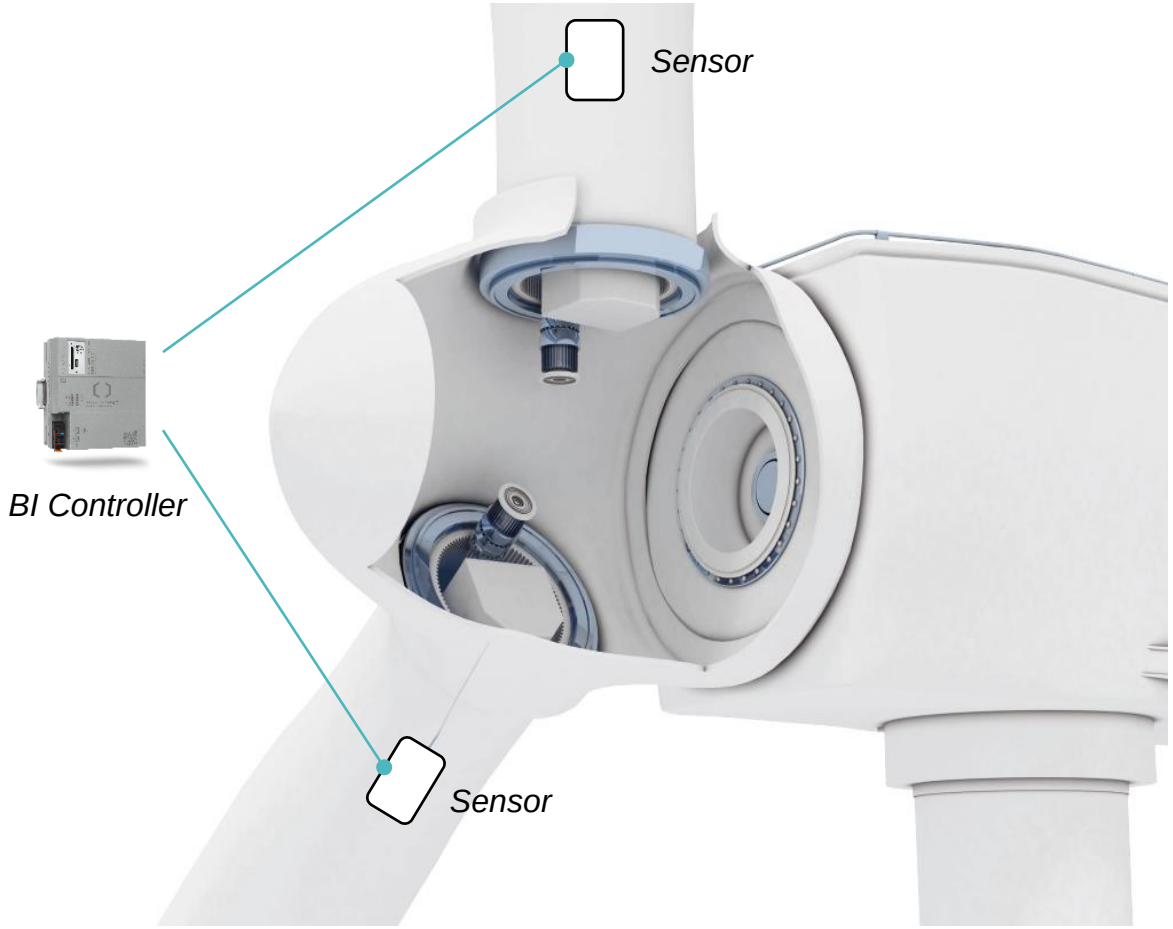
Gaining Insights from the Blade Structure

- Impact Indicator
  - → Moving parts in the blade
- Blade Vibration Indicator
  - → Comparison on all three blades vibration behavior
- Frequency Anomaly Indicator
  - → Eigenfrequency analyses on each blade
- Aerodynamic Imbalance Indicator
  - → Identification of aerodynamic imbalance in the rotor
- Option: Ice Detection with Auto Restart

Structural Health Monitoring (SH-M)

System Set Up

- 1 Accelrometer per blade
  - 3 Axis Measurement
  - 1 Temperature Signal
- Sensor glued at 1/3 blade length
- Blade Intelligence PLC for calculating in the hub



Structural Health Monitoring (SH-M)

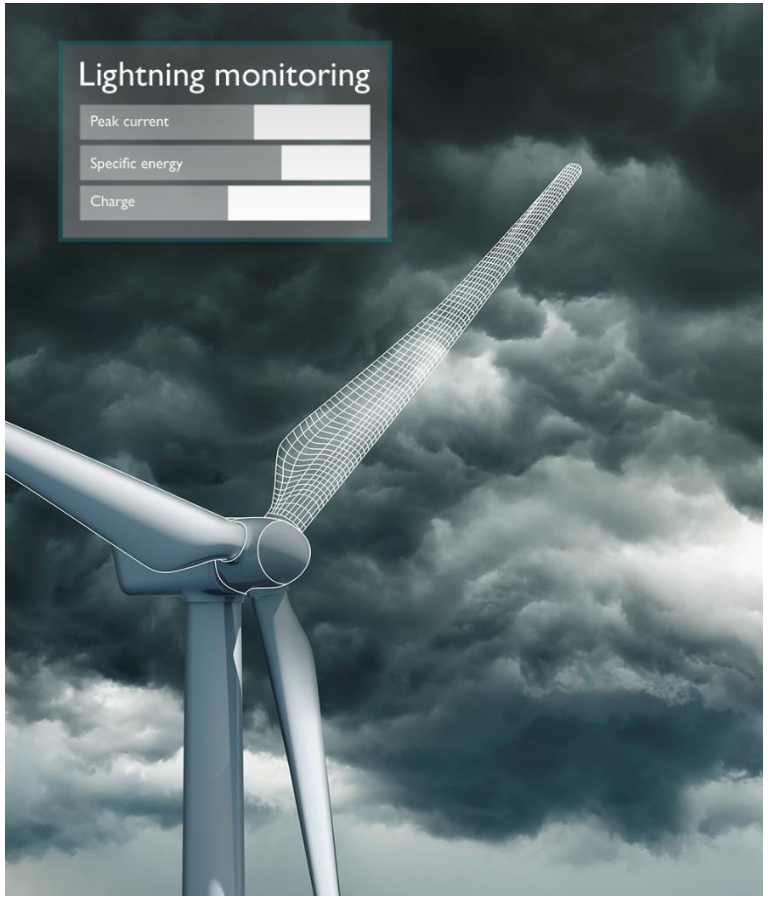
What about Lightning?

- Sensors tested up to
  - 200 kA 8/20
  - 100 kA 10/350
- Lightning Impulses

Blade Intelligence

Conclusion

- Gain detailed information about lightning strikes
- Monitoring of the rotor blade through structural monitoring
  - → Constant monitoring of the condition
  - → Detect non-visible/non-hearable structural damages



Empowering the All Electric Society

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Thank you

more information on our **website**