IMPROVING THE PERFORMANCE OF WIND FARMS INSTALLED IN COLD CLIMATE – FOS4X EXPERIENCE

Winterwind Conference

Christian Lindemann, Umeå, February 2019
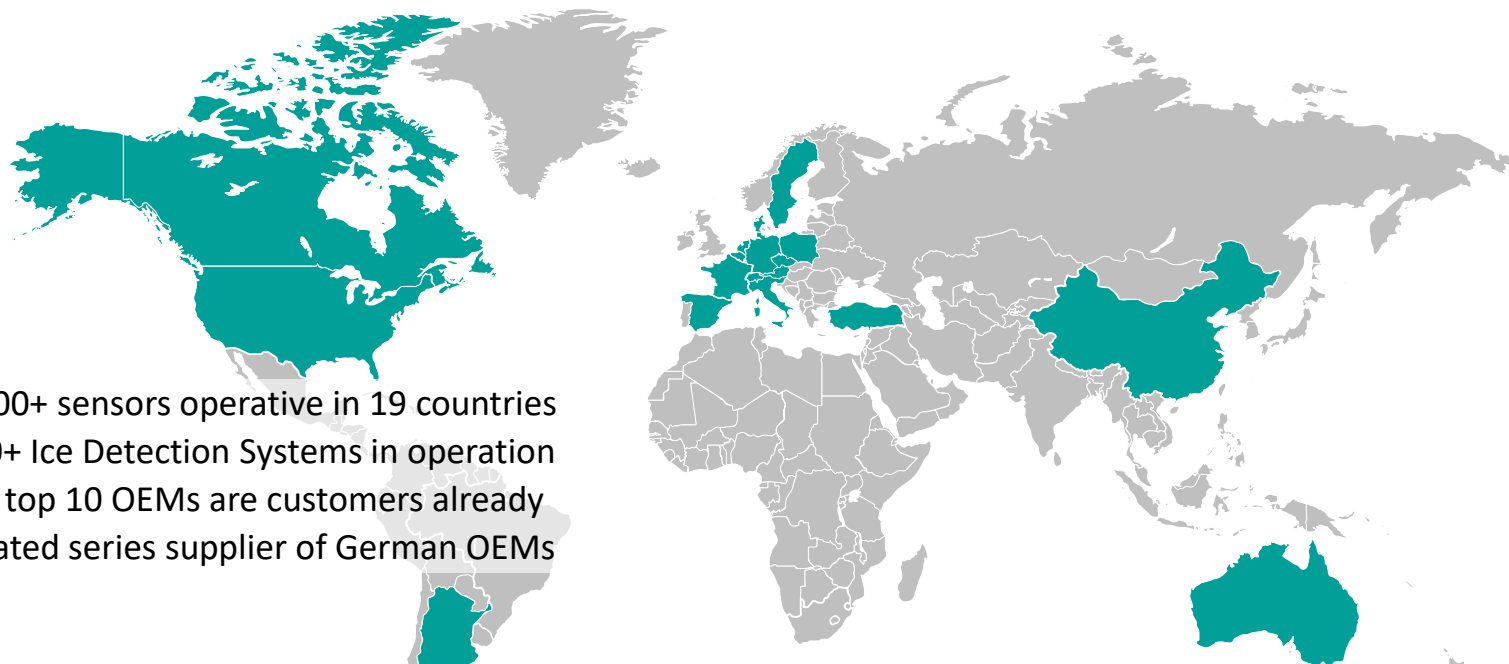
Agenda

Company overview

Unique sensor platform

Field data and applications

Installed base of 7,000+ sensors in 19 countries with the top turbine manufacturers

7,000+ sensors operative in 19 countries
300+ Ice Detection Systems in operation
All top 10 OEMs are customers already
A-rated series supplier of German OEMs

SENVION wind energy solutions

NORDEX We've got the power.

ENERCON ENERGY FOR THE WORLD

ENVISION

SIEMENS

GOLDWIND
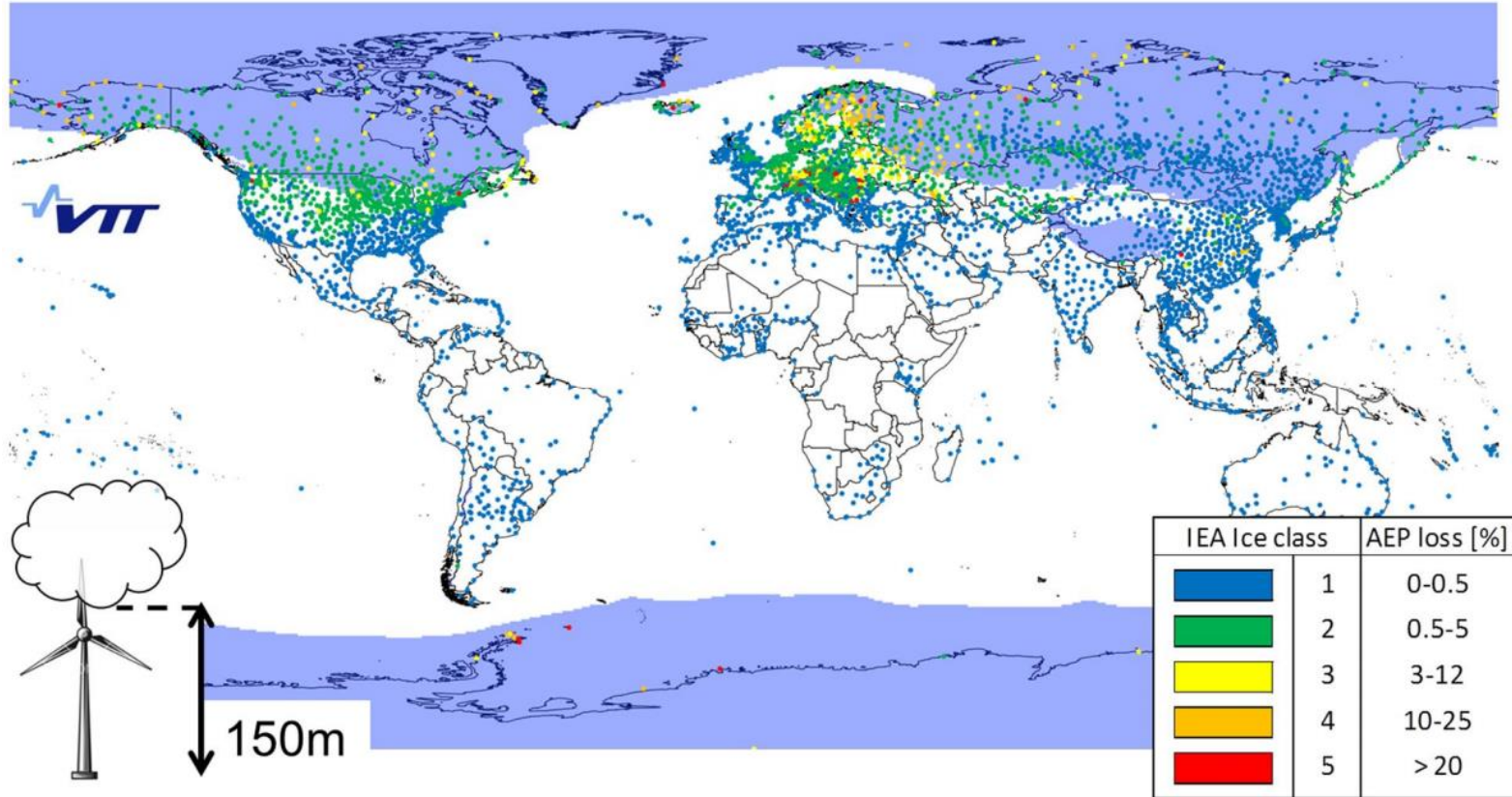
GE

MINGYANG WIND POWER PERFORMANCE BY NATURE

Vestas

上海电气 SHANGHAI ELECTRIC

| 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |

fos4X

Series delivery established for fos4Blade sensor platform

> 300 systems in operation in various IEA ice class

IEA Ice class		AEP loss [%]
	1	0-0.5
	2	0.5-5
	3	3-12
	4	10-25
	5	>20

150m

(1) AEP: Annual Energy Production

Agenda

Company overview

Unique sensor platform

Field data and applications

We provide smart turbine control solutions, enabled by our unique sensor platform
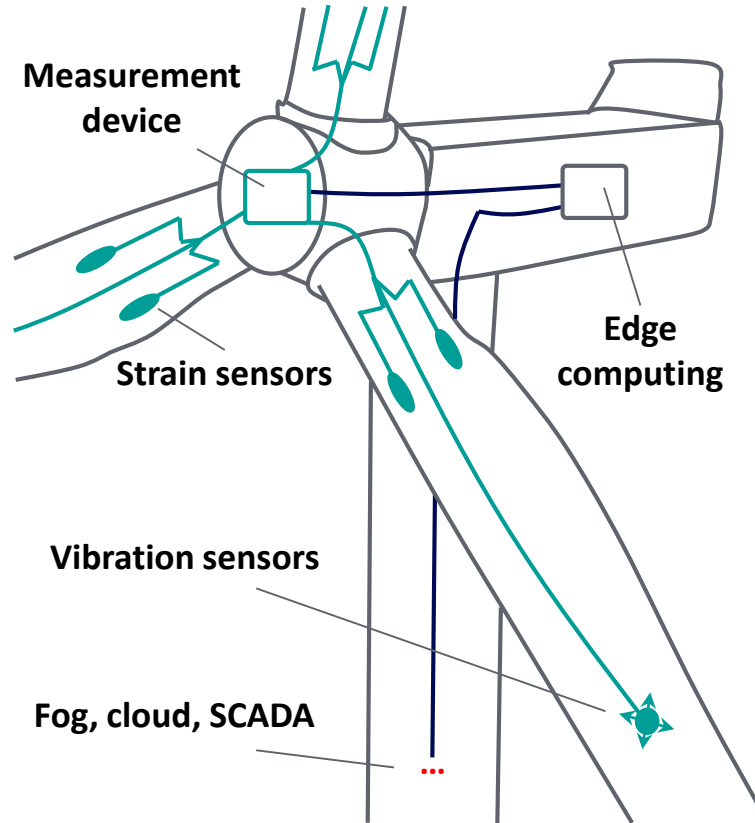
Rotor blade sensing

=

Blade sensors

+

Control applications

Measurement device

Strain sensors

Vibration sensors

Fog, cloud, SCADA

...

Edge computing

Watch our image film to experience our unique rotor blade sensing solutions

https://www.fos4x.de/x4edge/en/x4edge-video/

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UNIQUE TECHNOLOGY

Our fiber optic sensor technology is ideally suited for rotor blade sensing

We filed **more than 100 patents** in the field of
industrial fiber optic measurement

Fiber optic sensing technology
No electro magnetic interference
Intrinsic lightning protection
High load cycle capacity
Wide measurement ranges
Long transmission lengths
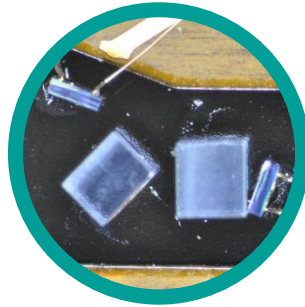
Proprietary demodulation
We revolutionized fiber optic
measurement thanks to an
innovative signal demodulation
technology, enabling life-long
measurement in industrial
environments

Proven reliability
Many centuries of cumulated
operating lifetime on wind turbines
all over the world prove the
reliability of our fiber optic sensors
for rotor blades
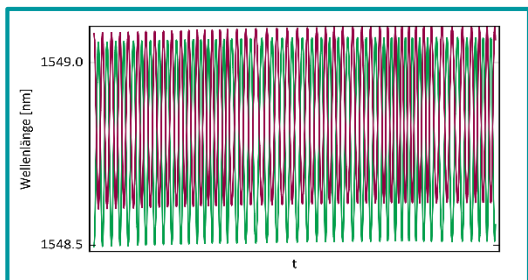
Agenda

Company overview
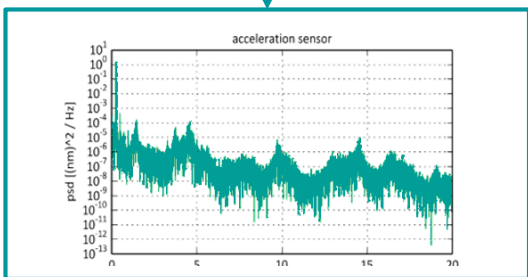
Unique sensor platform

Field data and applications

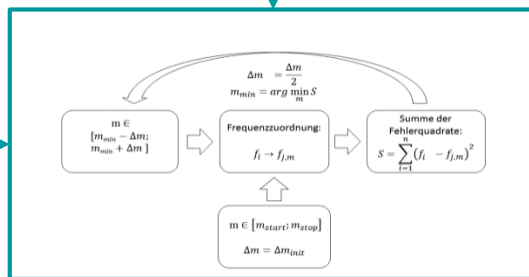# Optimization of turbine down-time during winter via Rotor Ice Control

Rotor blade sensing

Turbine control
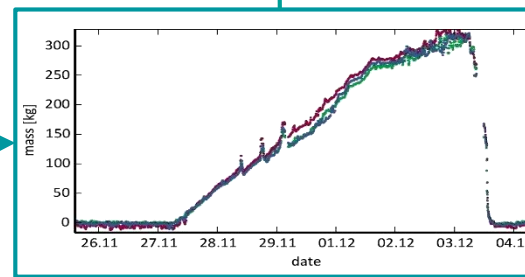
- Rotor speed
- Pitch angle
- Power
- Temperature
- ...

- Start/Stop
- De-icing
- Scada, Remote control

Signal analysis

Data fusion of sensors

Control signal

Frequency domain

Algorithms

Damage/Ice mass per blade

Rotor Ice Control - Experience

Close to (Country)	Number	Hub height (m)	Relative gain in farm [%]
Tolouse (France)	11	88	2.5
Cracow (Poland)	2	88	-2.1
Neaples (Italy)	1	100	-0.2
Cologne (Germany)	8	100	0.0
Frankfurt am Main (Germany)	1	100	-0.1
Lyon (France)	26	88	6.0
Nuremberg (Germany)	2	100	4.2
Quebec (Canada)	12	88-100	7.7
Quebec (Canada)	6	88-100	10.3
Toronto (Canada)	1	100	27.0

- 70 wind turbines in the range of 2-3 MW

- Hub heights between 88-100m

- Sites up to 1000 MASL

- 5 countries in the Northern Hemisphere

- Data evaluated during winter 2017-18

(1) MASL: meters above sea level

fos4X

Rotor Ice Control - Experience

AEP variation within parks (winter 2017-18) [%]
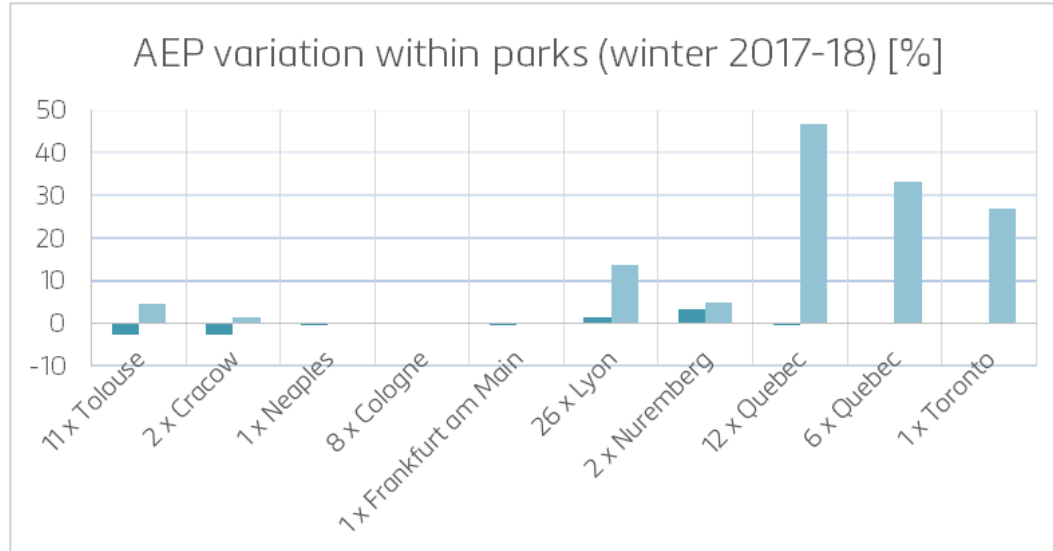
- Differences in AEP gained within wind farm requires to assess the impact of layout and terrain elevation on expected turbine icing

- Inter annual variation requires a long-term assessment

- Correlation to IEA class require a risk-adjusted cash flow return estimation
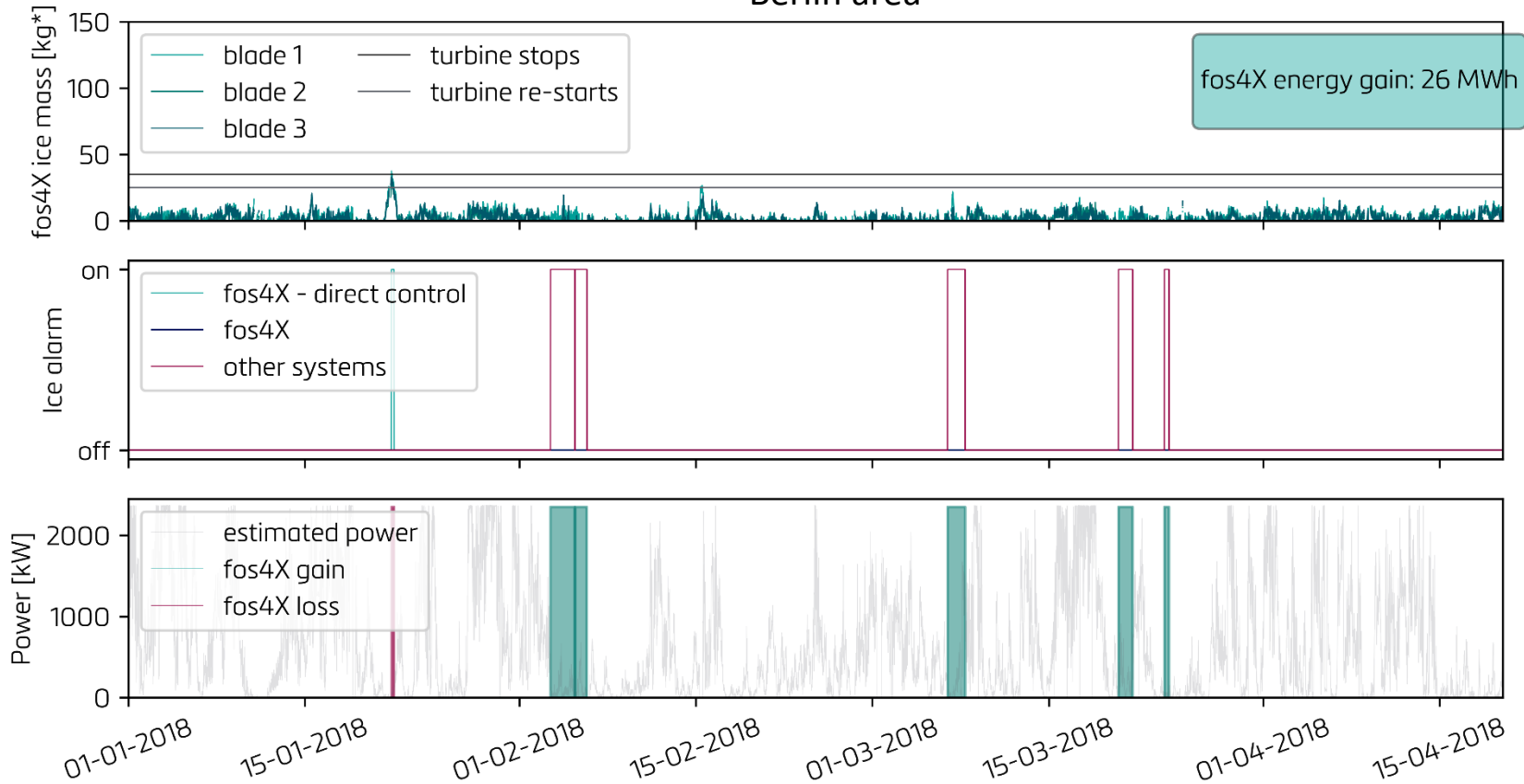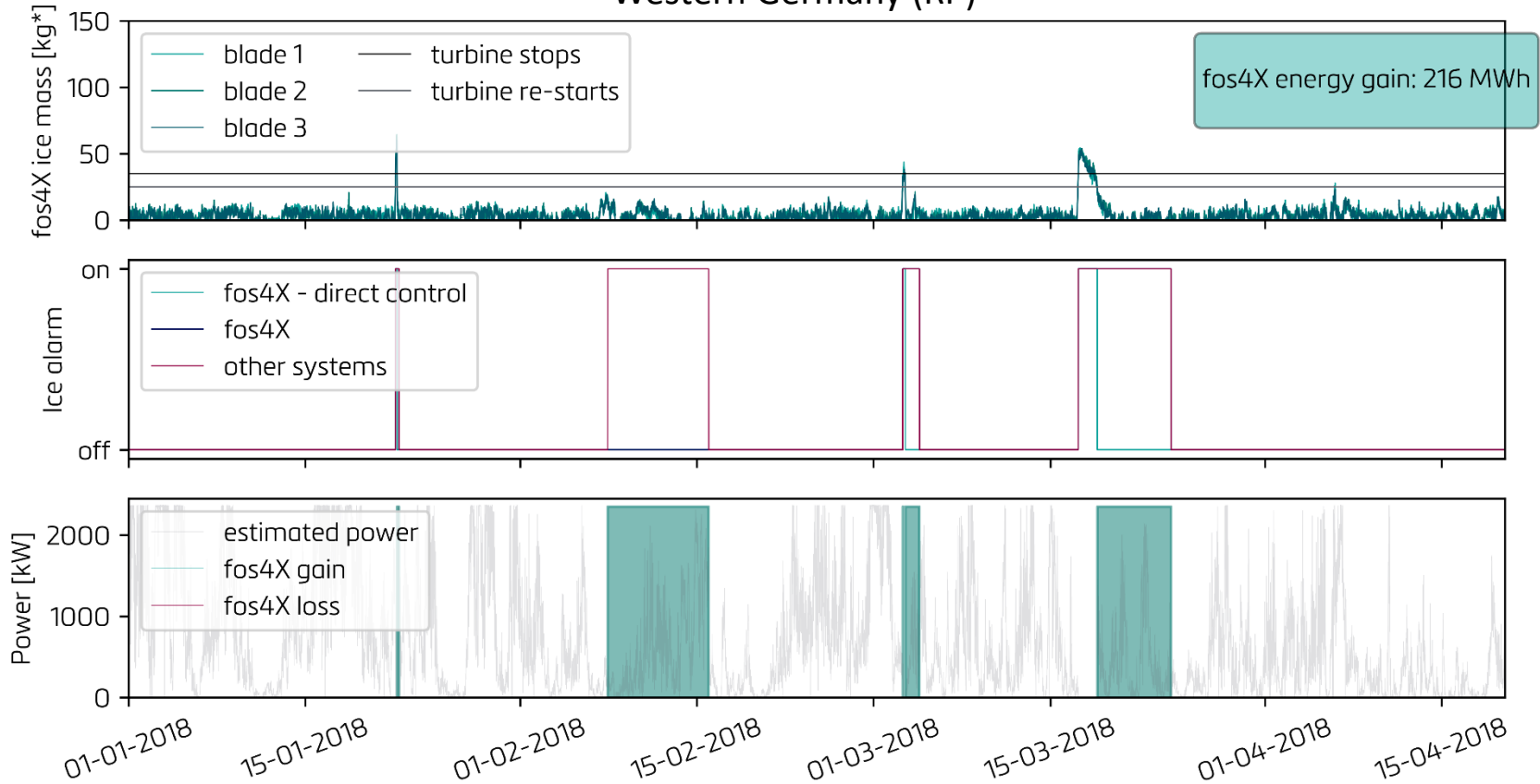
Automatic restart
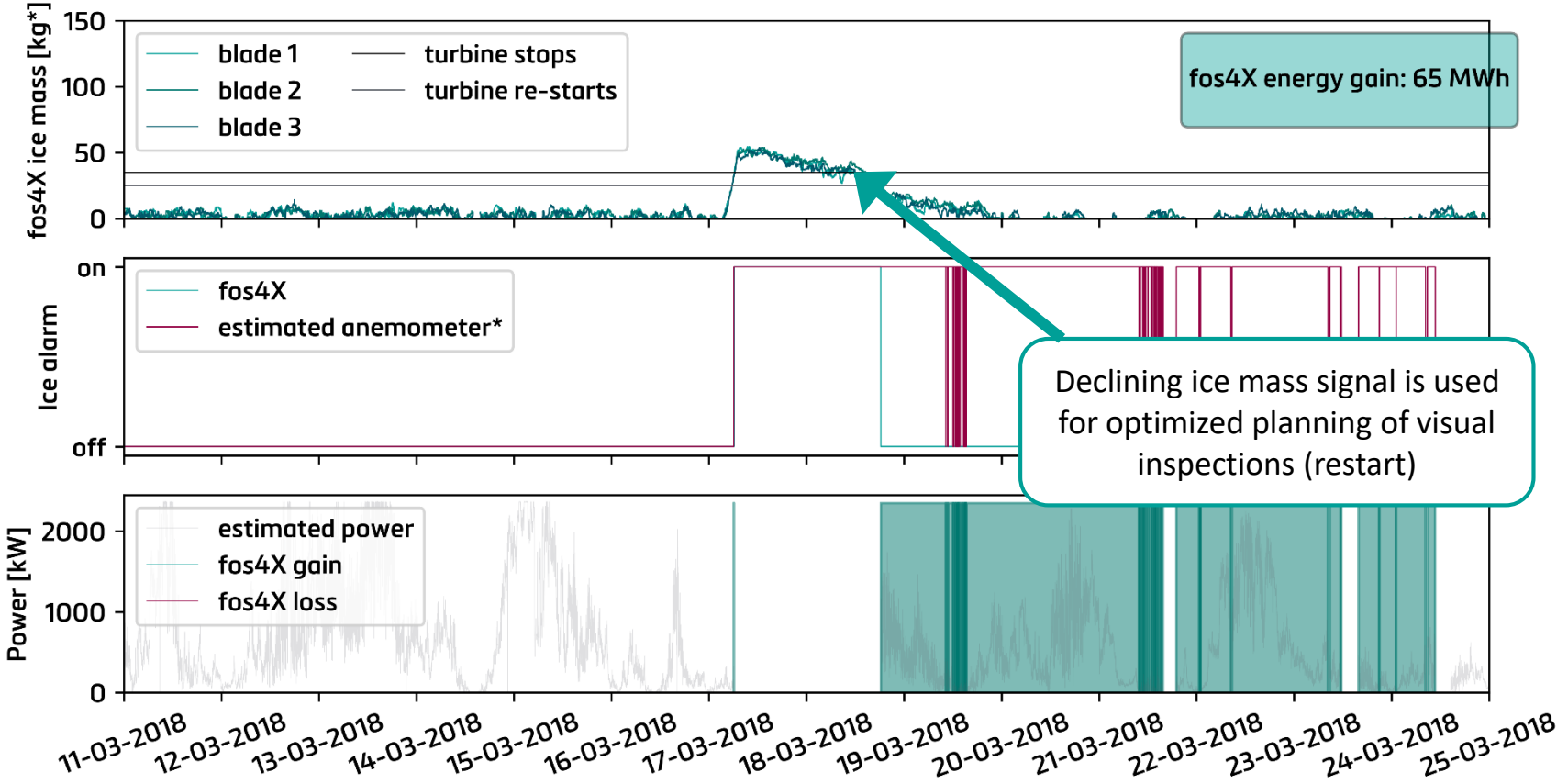
Berlin area

fos4X energy gain: 26 MWh

Nacelle-based system

15

Western Germany (RP)

fos4X energy gain: 216 MWh

Power curve

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Get in touch with fos4X!

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