

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



Winterwind Conference

Christian Lindemann, Umeå, February 2019

Agenda

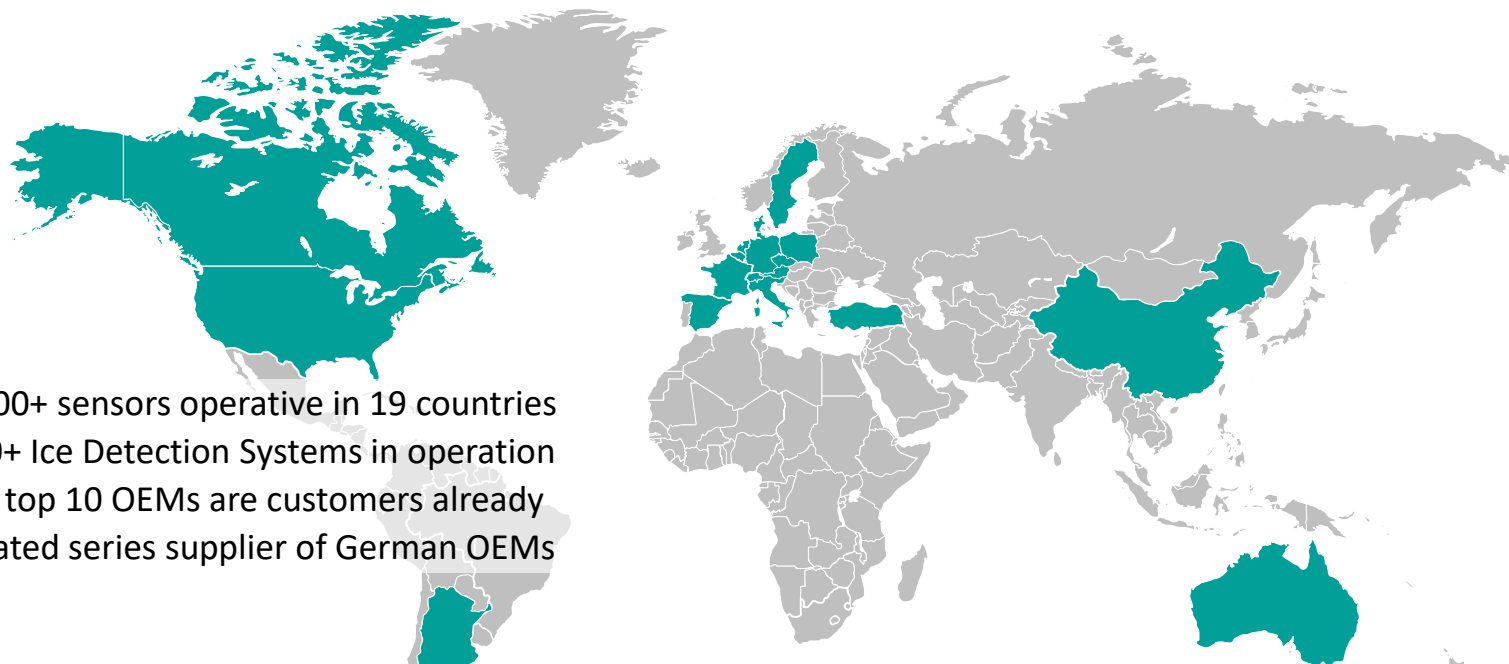
Company overview

Unique sensor platform

Field data and applications

MARKET ACCESS

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



2012

NORDEX
We've got the power.



2013

ENERCON
ENERGY FOR THE WORLD



2014

ENVISSION
SIEMENS

2015

GOLDWIND

2016



MINGYANG WIND POWER
PERFORMANCE BY NATURE

2017

Vestas

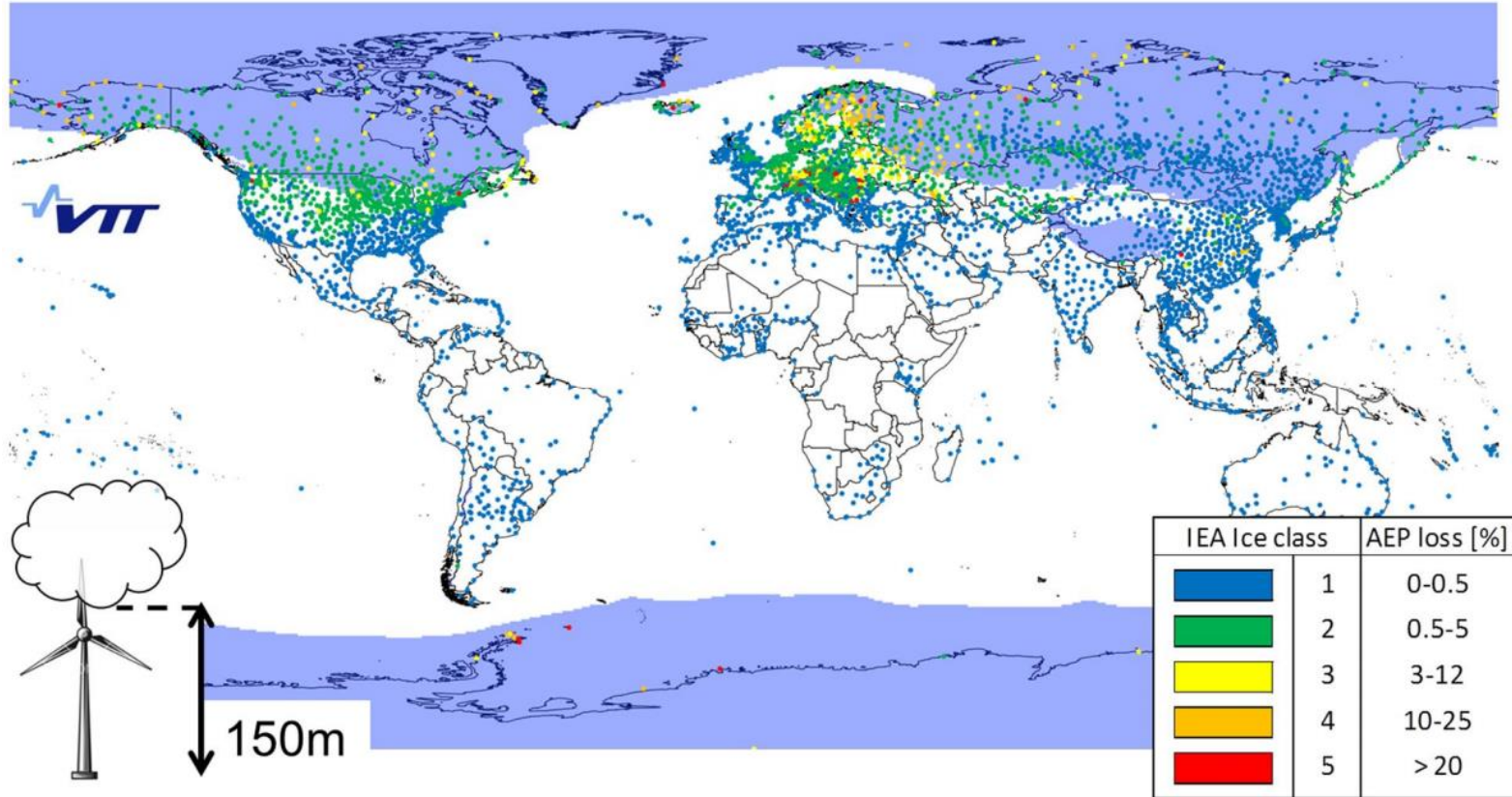
上海电气
SHANGHAI ELECTRIC

2018



IEA CLASS MAP

> 300 systems in operation in various IEA ice class



(1) AEP: Annual Energy Production

Agenda

Company overview

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Field data and applications

SOLUTION

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

Rotor blade sensing

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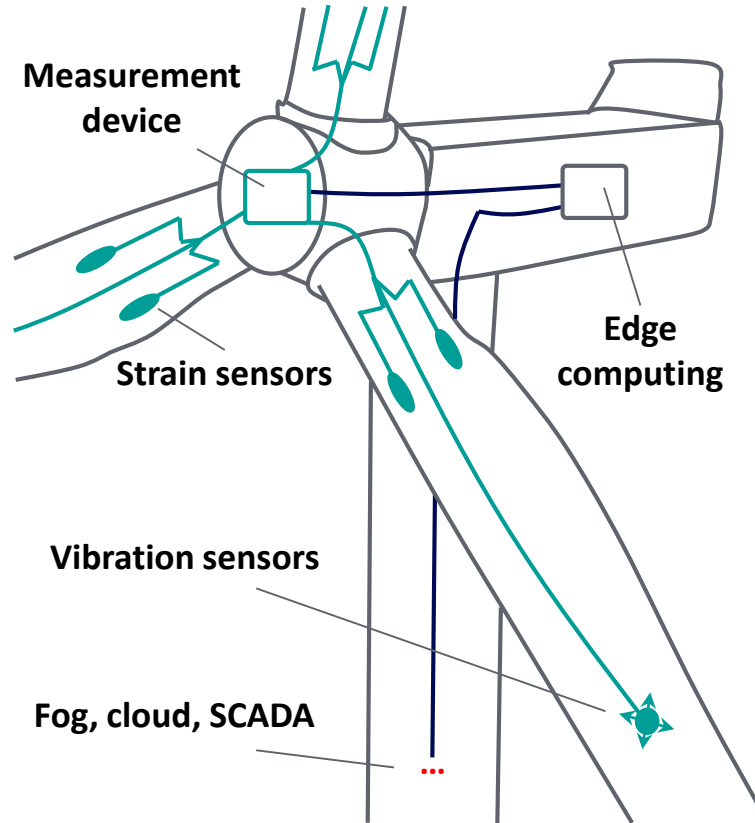


Blade sensors

+



Control applications



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

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

UNIQUE TECHNOLOGY

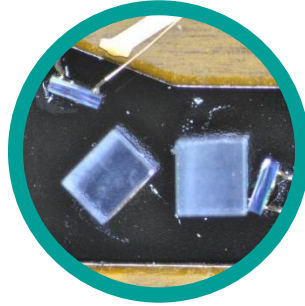
Our fiber optic sensor technology is ideally suited for rotor blade sensing

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

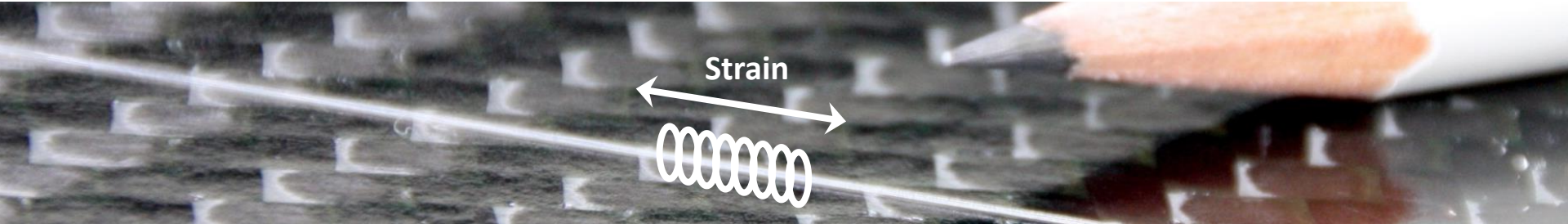
Many centuries of cumulated operating lifetime on wind turbines all over the world prove the reliability of our fiber optic sensors for rotor blades

FIBER-BRAGG GRATING

We use fiber-optic strain gauges to measure blade loads

Sensor principle

Wavelength shift in reflected light is proportional to strain and temperature at FBG



1. Send light



2. FBG reflects light



3. Detect Signal

TECHNOLOGICAL ADVANTAGE

Fiber-optic sensors have advantages over conventional sensors



**No electrical power at
sensor position**

Passive working principle



**Lower cabling and
application cost**

Mass product telecom
fibers



**No EMI⁽¹⁾ and no
lightning issues**

Optical information
transmission



**Fit and forget: Long life,
no maintenance**

Robust sensors for FRP⁽¹⁾
structures

Agenda

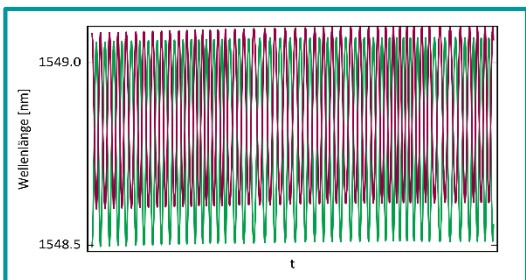
Company overview

Unique sensor platform

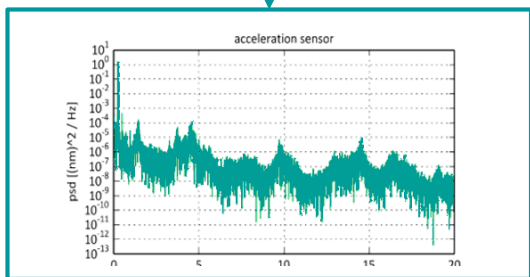
Field data and applications

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

Rotor blade sensing



Signal analysis



Frequency domain

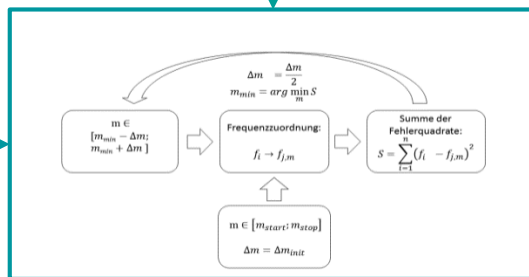
Turbine control

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



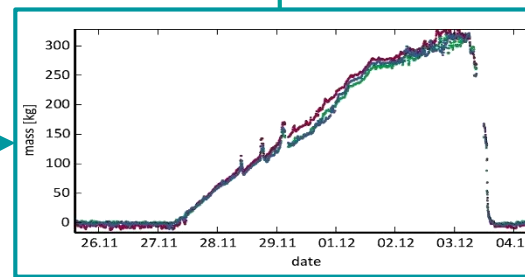
- Start/Stop
- De-icing
- Scada, Remote control

Data fusion of sensors



Algorithms

Control signal



Damage/Ice mass per blade

OPTIMIZATION OF WIND FARMS

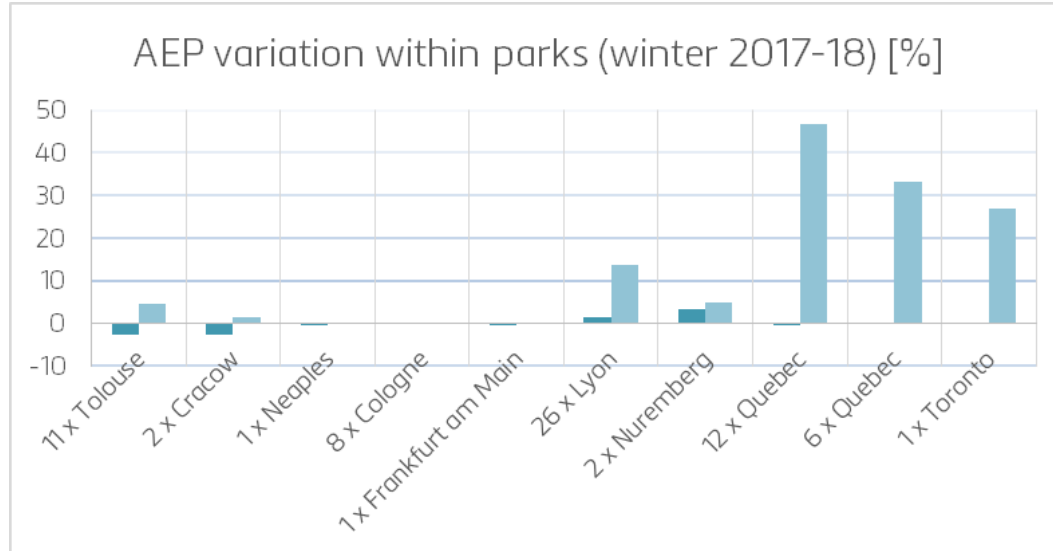
Rotor Ice Control - Experience

Close to (Country)	Number	Hub height (m)	Relative gain in farm [%]
Toulouse (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

OPTIMIZATION OF WIND FARMS

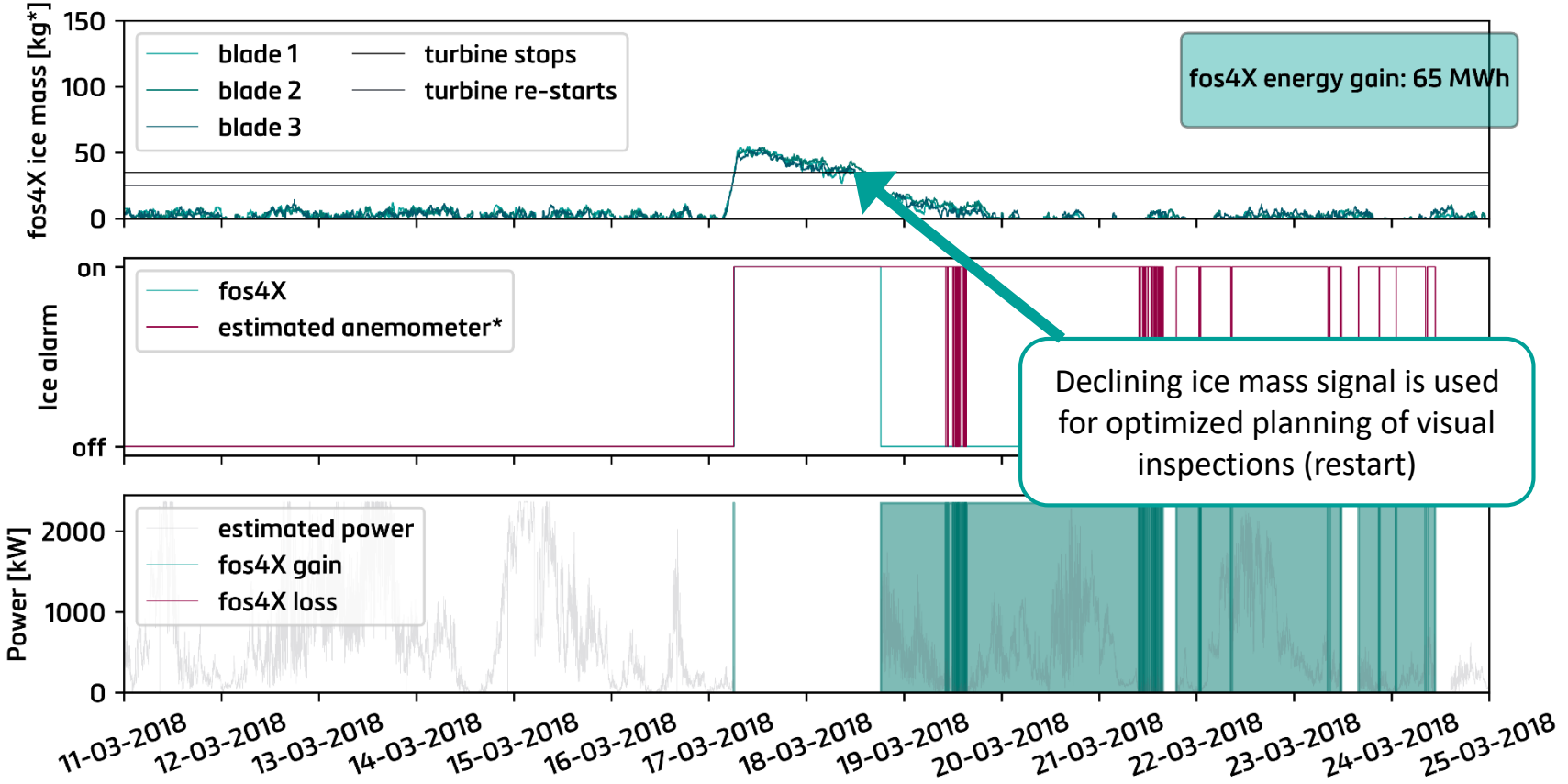
Rotor Ice Control - Experience



- 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

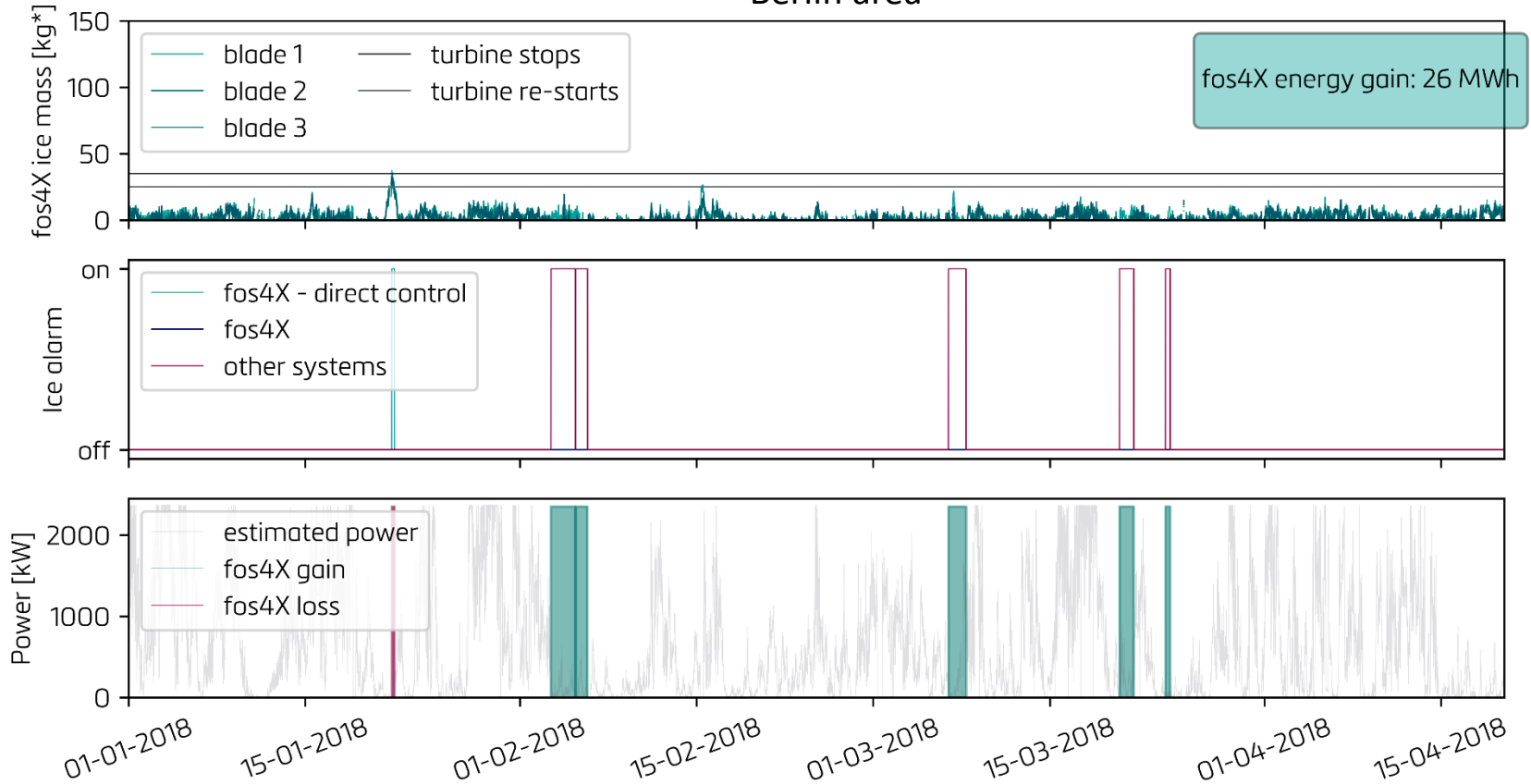
ICE EVENT DETAILS

Automatic restart



ICE EVENT DETAILS

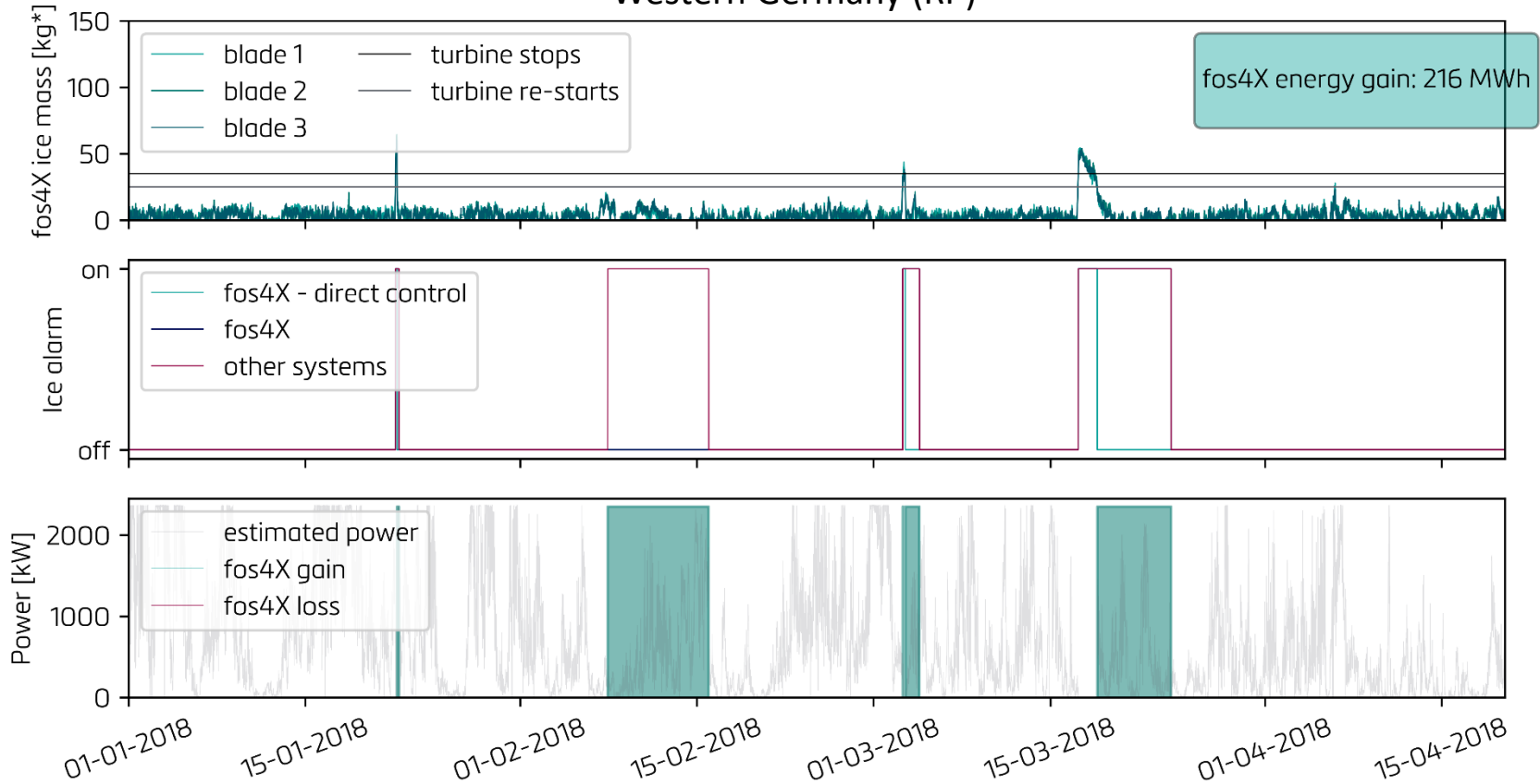
Berlin area



fos4X energy gain: 26 MWh

ICE EVENT DETAILS

Western Germany (RP)



fos4X energy gain: 216 MWh

Get in touch with fos4X!

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