IMPACT OF LIGHT ICE MASSES ON EXPECTED WIND POWER PRODUCTION

fos4X
rotor blade sensing

Winterwind 2020

Are, February 3rd, 20

Florian Rieger

Agenda

fos4X Introduction

Motivation

Functionality

Methodology

Results

Summary

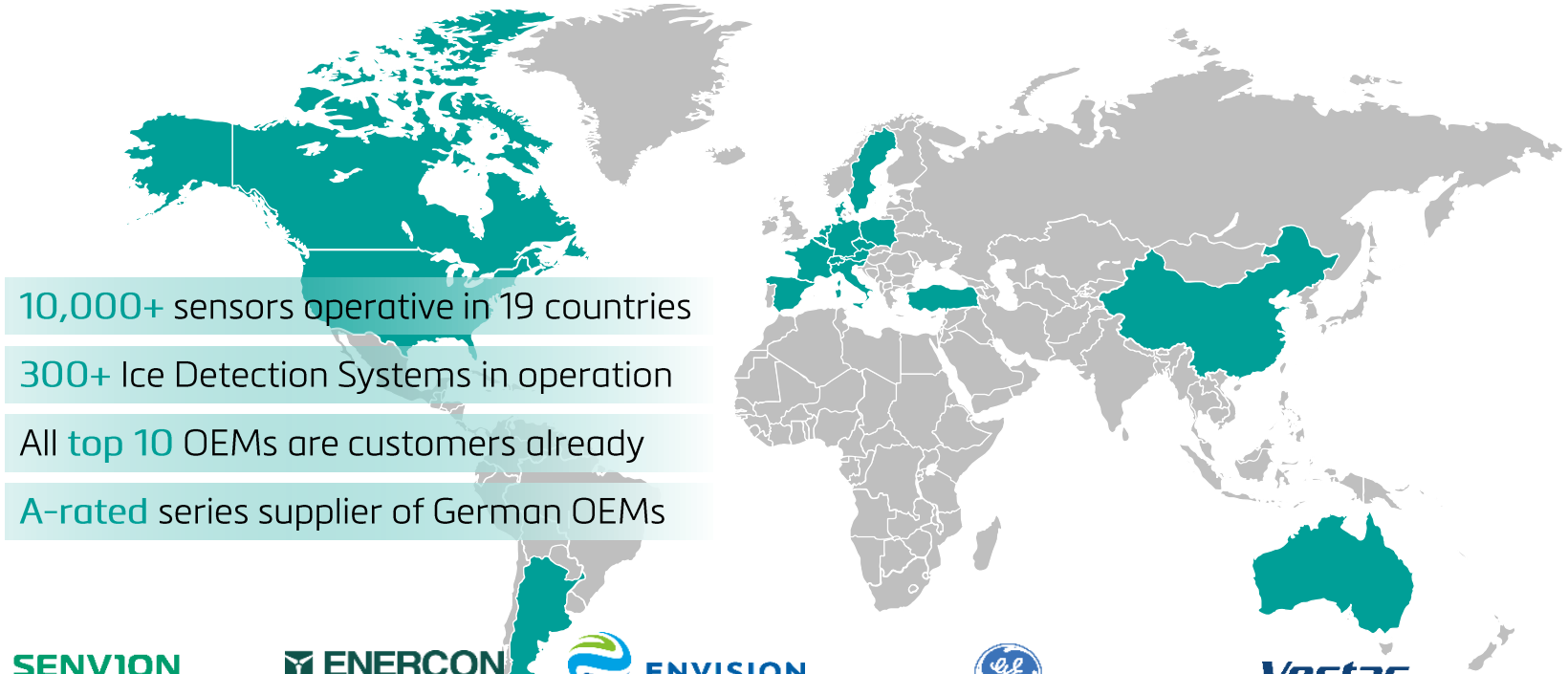
fos4X has a 8-year history with strong growth, series integrations with several wind turbine manufacturers, a strong patent base, and a passionate team of industry experts

- Founded in 2010
- Spin-off of Technical University Munich
- 80 full-time employees
- 2 offices (Munich & Beijing)
- Deloitte Technology Fast 50 Award 2018 (14th cross-industry, 1st cleantech)
- 31 patents granted, 101 pending

We even have a movie about our digital vision... (1)

(1) Video: https://www.youtube.com/watch?v=Er4WooWezfc&t=3s

Installed base of 10,000+ sensors in 19 countries with the top turbine manufacturers



- 10,000+ 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. — 2012
ENERCON ENERGY FOR THE WORLD — 2013
SIEMENS — 2014
ENVISION — 2014
GOLDWIND — 2015
GE — 2016
MINGYANG WIND POWER PERFORMANCE BY NATURE — 2017
Vestas — 2018
上海电气 SHANGHAI ELECTRIC — 2019

Series delivery established for fos4Blade sensor platform

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What is the impact of light icing on wind turbine power output?

Nergica Report[1]

- Performance assessment of rotor-mounted ice detectors
- Comparison of three different ice detection systems
- Two hub-mounted cameras have been used as reference
- The evaluation has shown that vibration-based systems function reliably and detect moderate and severe icing correctly
- The only criticism was the lack of an indicator for light icing

(1) Rotor-Mounted Ice Detectors – Performance Assessment, Nergica, 2019

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Technical Solution

Turn-key solution

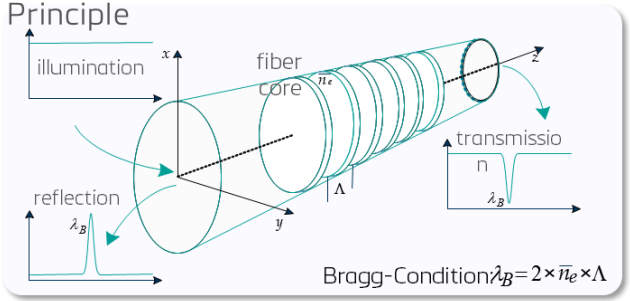
- Available as retro-fit solution or installation ex factory
- Robust series hardware
- Precise vibration data from fiber optic sensor

fos4Acc 2D Acceleration Sensor

fos4Test Measurement Unit

Hub Control Cabinet

Principle



This certified configuration allows

- Blade ice detection
- Blade condition monitoring

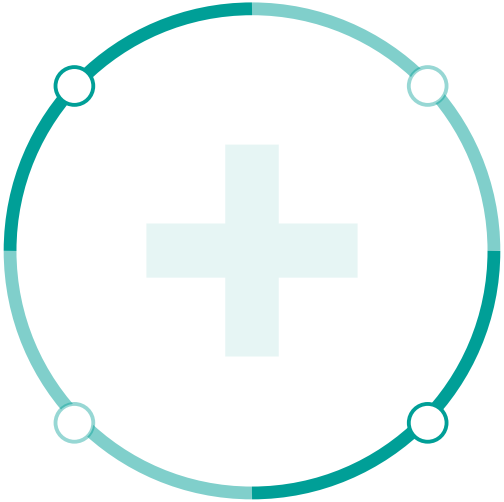
Fiber-optic sensors have advantages over conventional sensors

No electrical power at sensor position

Passive working principle

No EMI(1) and no lightning issues

Optical information transmission



Lower cabling and application cost

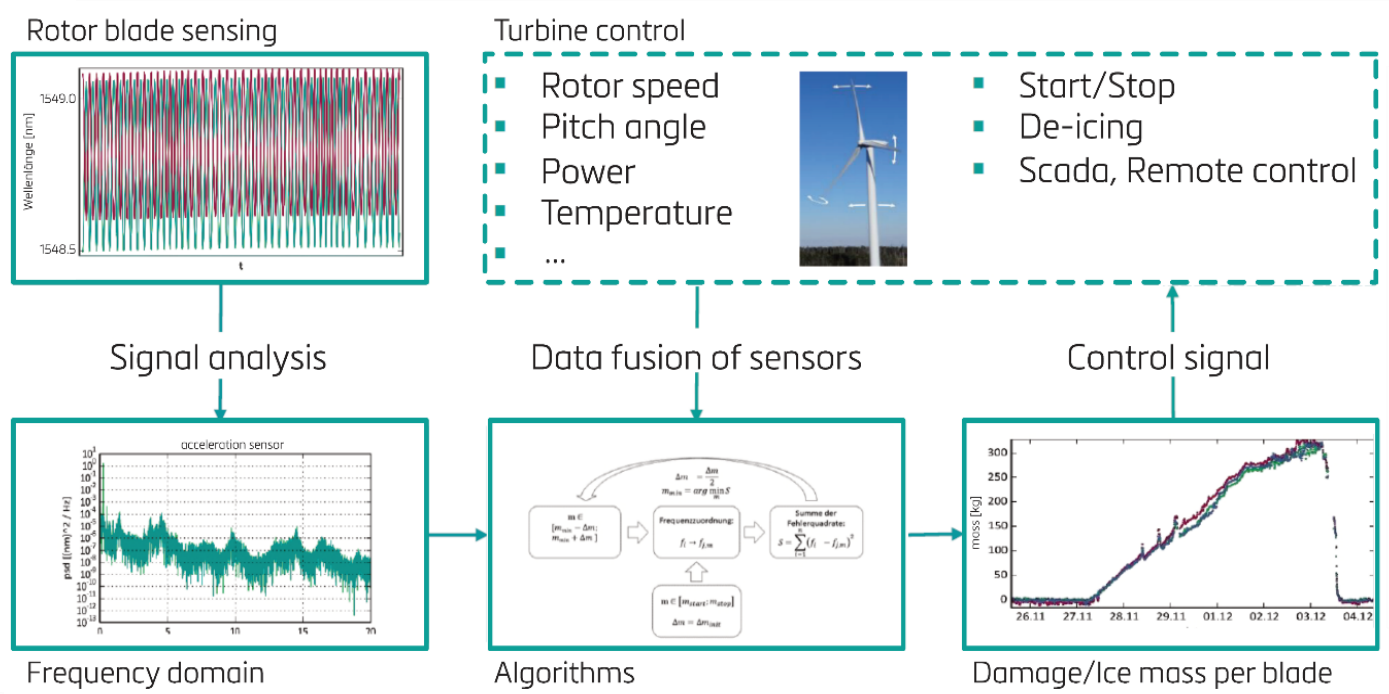
Mass product telecom fibers

Fit and forget: Long life, no maintenance

Robust sensors for FRP(2) structures

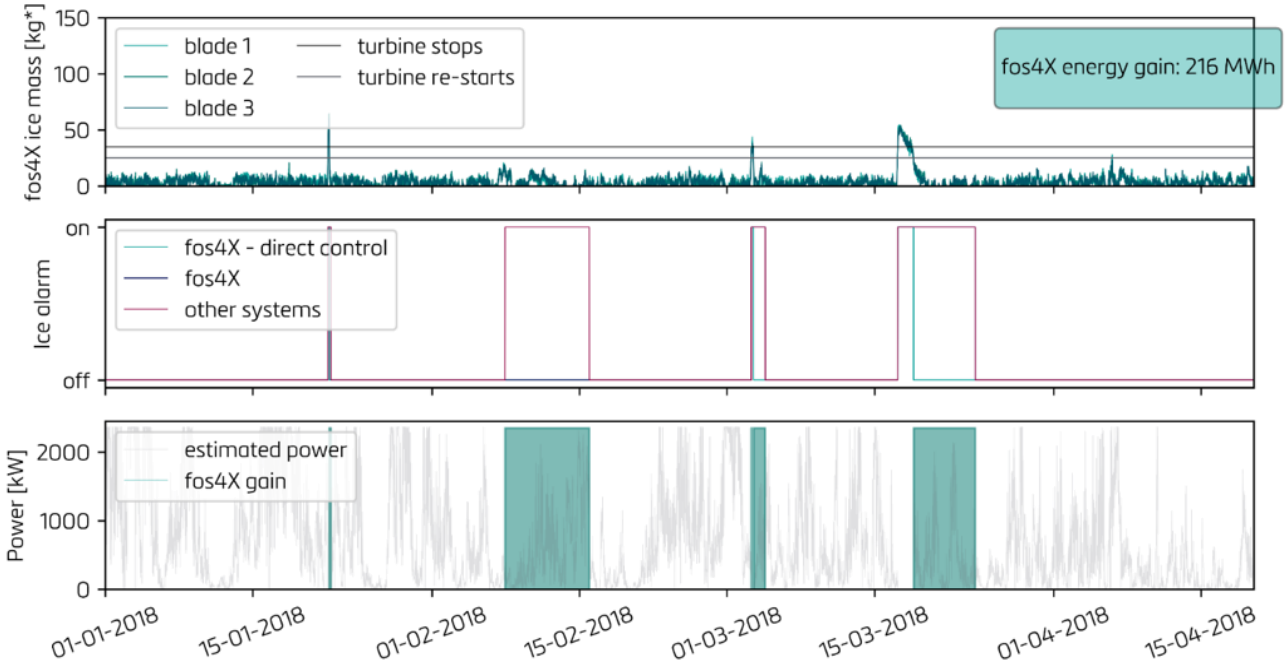
(1) EMI: electromagnetic interference
(2) FRP: fiber reinforced plastic

Wavelengths are converted into frequency, which relates to blade properties under excitation



HOW ARE MEASURED ICE MASSES USED BY CUSTOMERS?

Ice mass thresholds mark the beginning and end of ice events for customers to stop/start turbine



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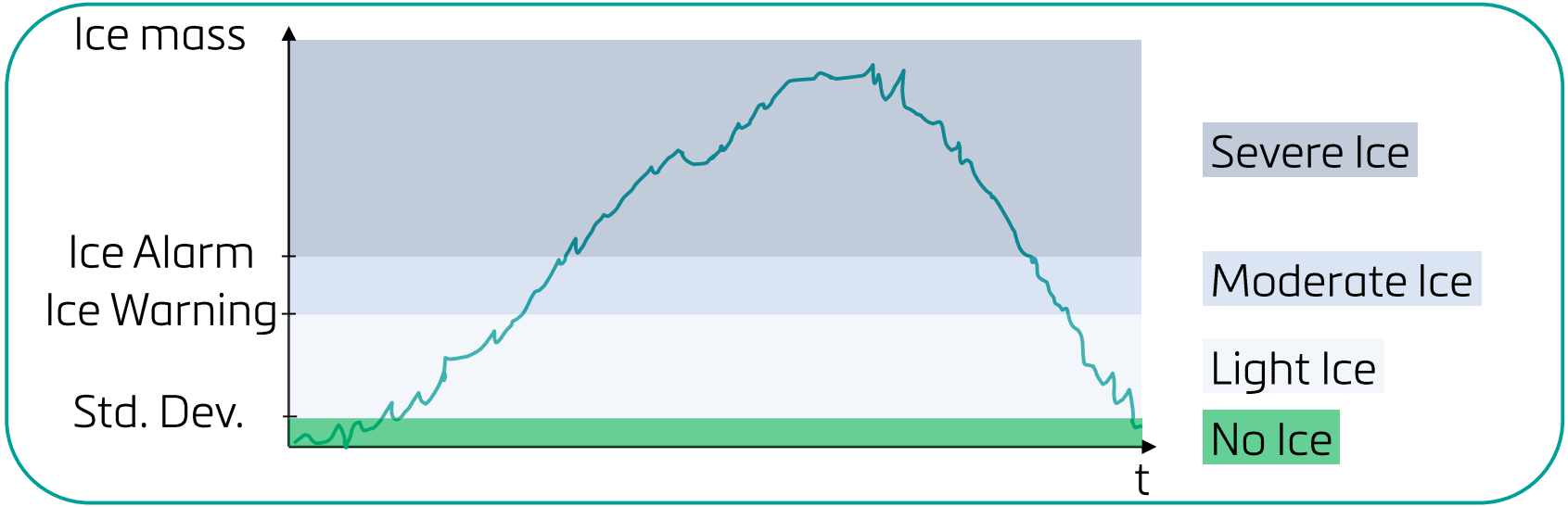
How the analysis has been done?

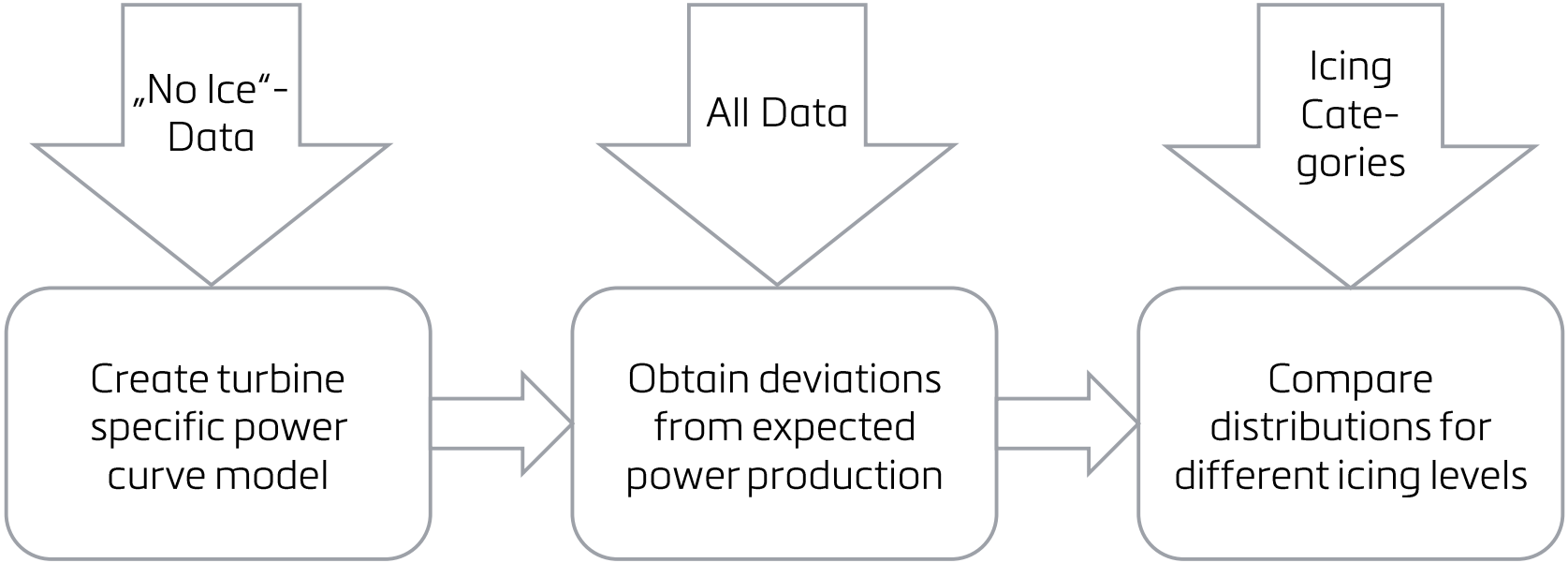
Data

- For the analysis, the data of 6 turbines within one wind farm has been used
- The data has been labeled according to 4 different icing levels:
  „No Ice“, „Light Icing“, „Ice Warning“ and „Ice Alarm“



How has the analysis been done?

Methods



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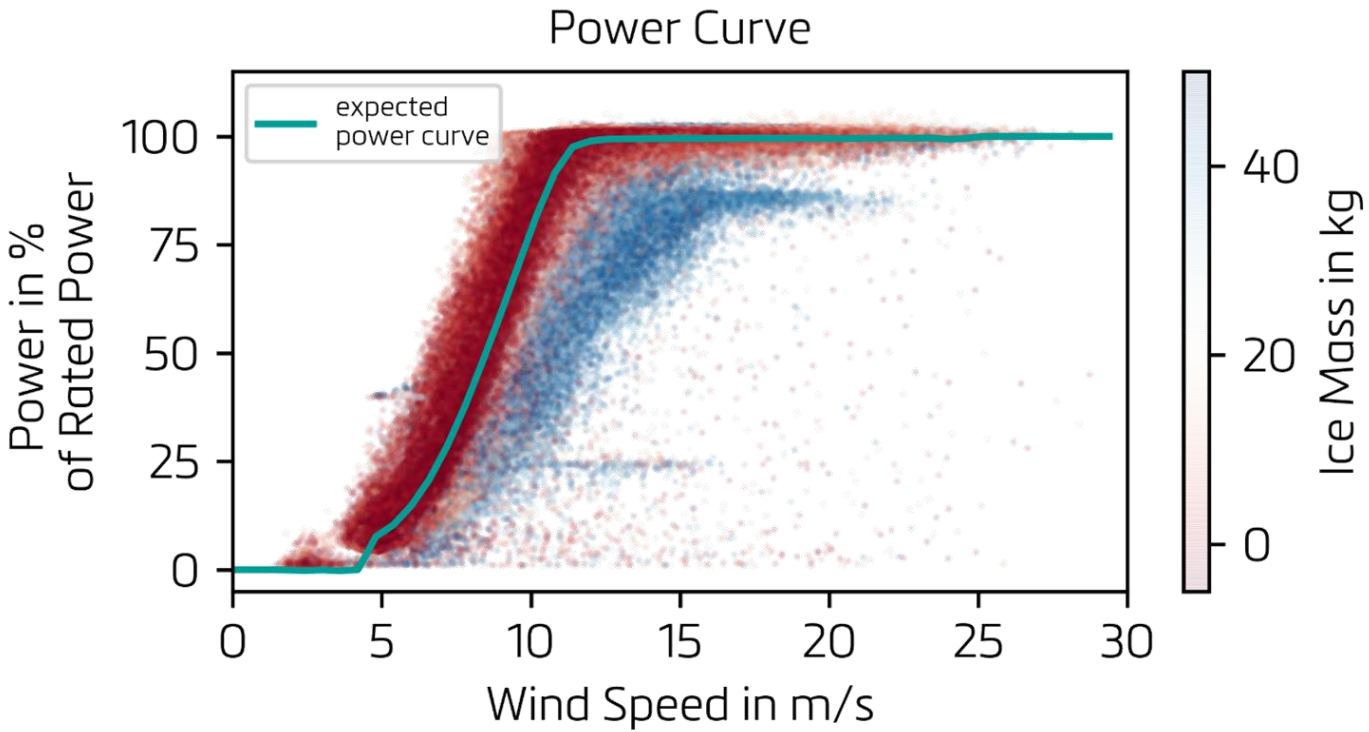
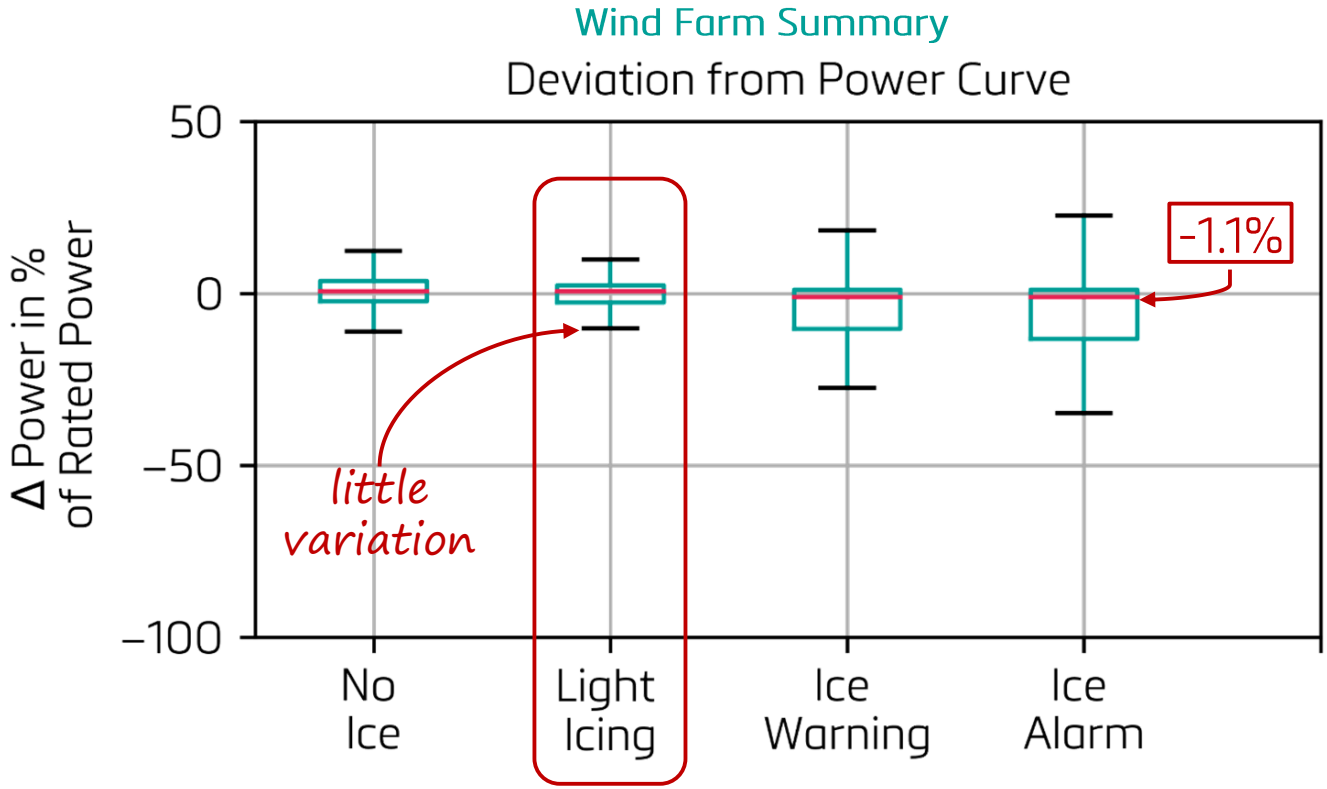
Deviations from power curve only due to high ice masses

Wind Farm Summary

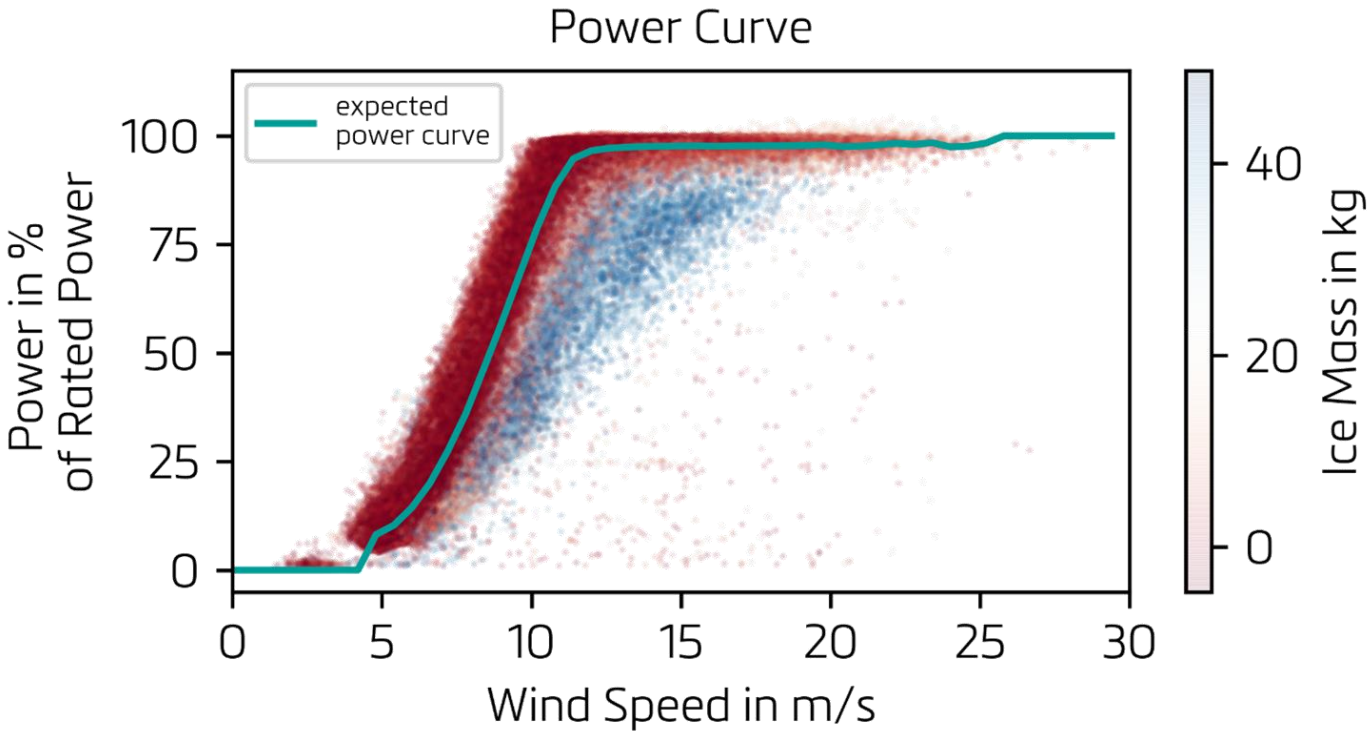


Light icing seems to have no impact on power production

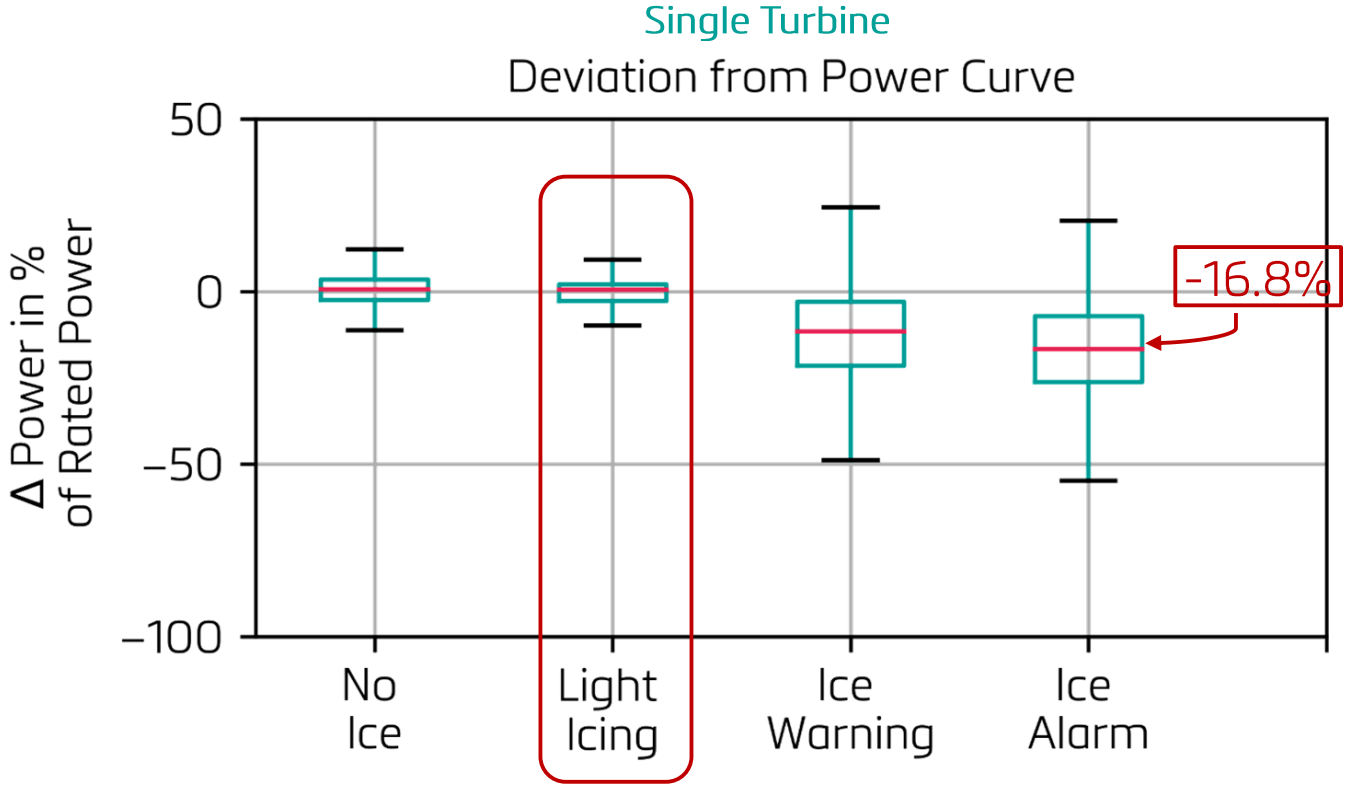


Deviations from power curve only due to high ice masses

Single Turbine



Light icing seems to have no impact on power production



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What is the impact of light icing on wind power production?

- Light icing seems to have almost no effect on the turbine power output
- Depending on the application, it is still possible to lower alarm thresholds
- A larger analysis is ongoing with
  - narrowed down data like e.g. normal operation, free stream etc.
  - different turbine types and sites
  - other variables that might have impact other than icing

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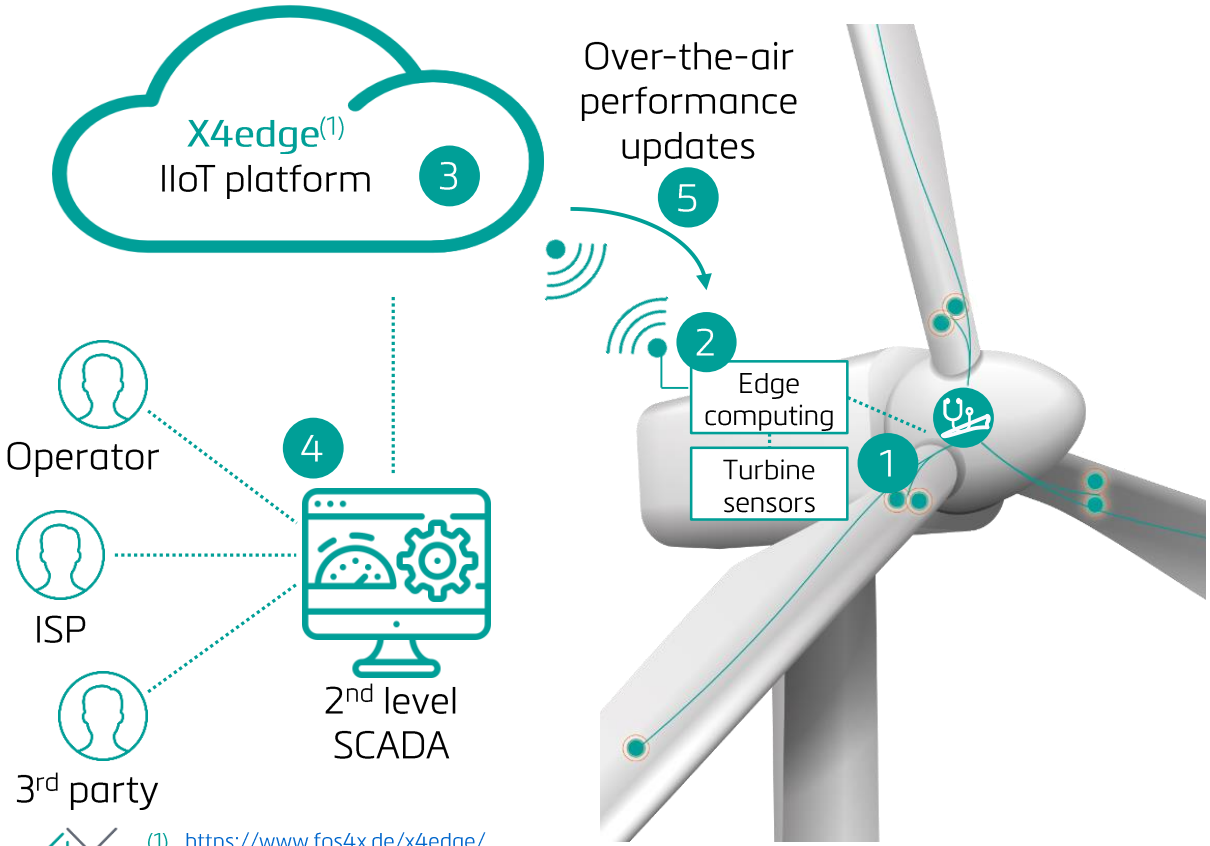
L. Vera-Tudela, F. Rieger*

Update your turbines with smart sensors and edge analytics that connect to your established operating and monitoring systems



Description

1. Acquire more and smarter data with retrofit solution
2. Analyze data in real-time and transfer to cloud
3. Automate analyses and connect to other systems
4. Access smarter turbine data through established channels
5. Improve performance with over-the-air updates

(1) https://www.fos4x.de/x4edge/

Park Overview

Deviation from expected power production in %

Turbine	No Ice	Light Ice	Moderate Ice	Severe Ice
A	0.86 +/- 5.93	0.38 +/- 7.90	-4.66 +/- 11.44	-8.29 +/- 13.65
B	0.68 +/- 6.39	0.37 +/- 7.44	0.19 +/- 9.13	0.54 +/- 9.68
C	0.61 +/- 5.37	0.79 +/- 6.81	-0.05 +/- 9.76	-1.18 +/- 11.52
D	0.55 +/- 6.7	0.52 +/- 7.7	-11.63 +/- 13.26	-16.81 +/- 13.30
Park	**0.65 +/- 6.24**	**0.58 +/- 7.55**	**-1.05 +/- 10.98**	**-1.10 +/- 12.50**