

Enhancing power production without safety concessions in cold climates

- early ice prediction by sensor fusion of surface and high-precision wind data

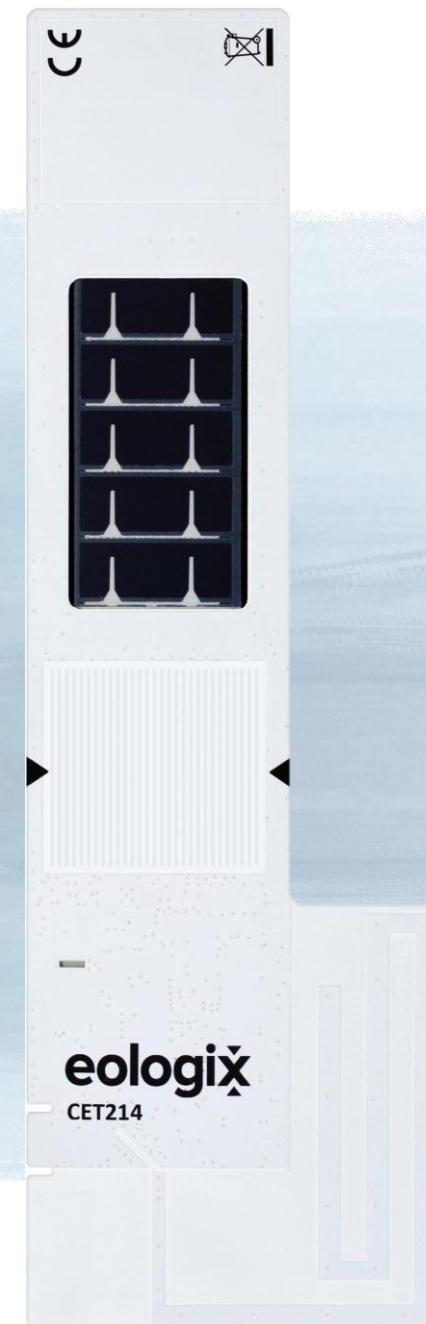
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1...eologix sensor technology gmbh

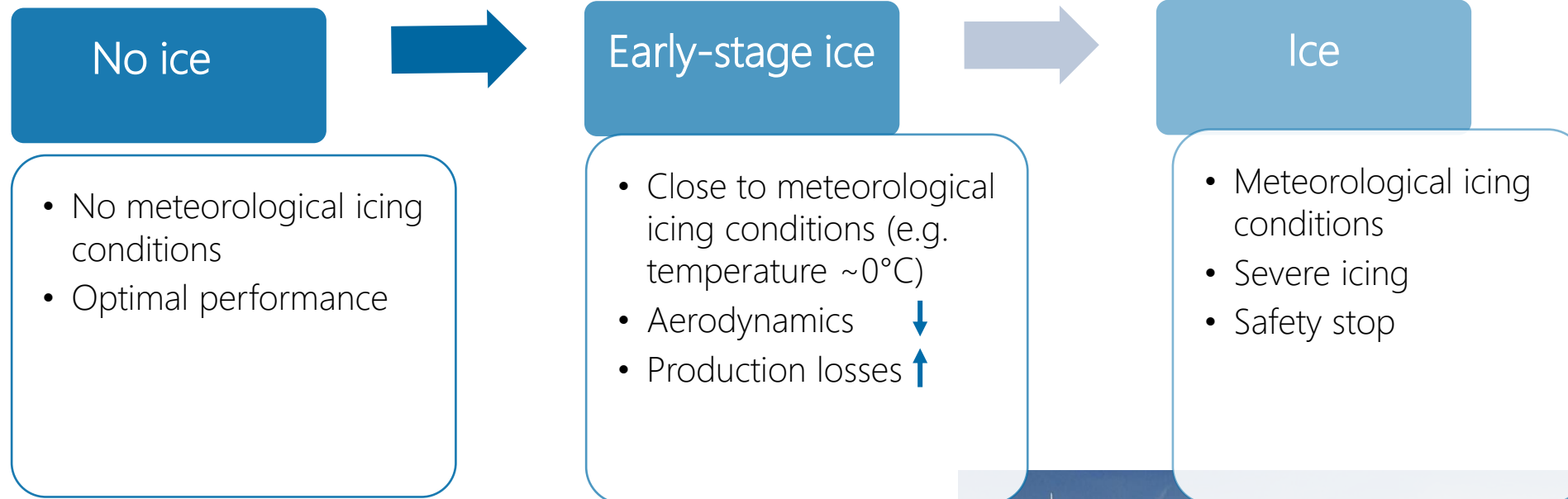
2...ROMO Wind / Nabla Wind Hub

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Problem Statement



AGENDA

1. INTRODUCTION
2. MEASUREMENT SYSTEM
3. POWER CURVE & ICING
4. MEASURE FOR EARLY-STAGE ICE
5. RESULTS

Introduction

- ▶ Thin layers of icing decrease the aerodynamic performance of the blades
 - Stall
 - Reduced output power
- ▶ A variety of approaches exists to prevent safety hazards due to icing
- ▶ But: the detection of early-stage ice events is still challenging
 - ▶ Minimum mass of ice needed for vibration-based systems

NEW APPROACH:

Measurement of early-stage icing (MESI)
= intermittent stage between pre-icing and operational icing

→ Close the gap between meteorological methods and commercial ice detection methods

Introduction

Advantages of MESI:

Optimise the activation of the anti-icing system:

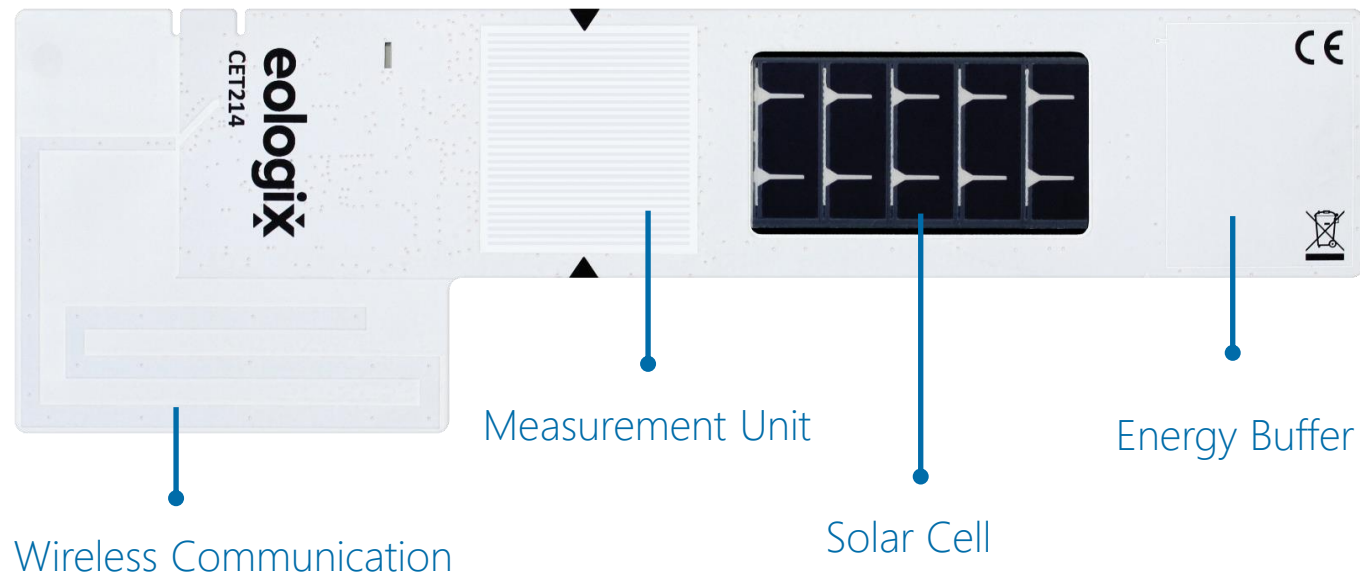
- increase power production
- prevent safety-stops

Separate power losses due to early-stage icing from other deviations (e.g. mechanical faults).

Measurement System

Eologix ice detection + ROMO Wind measurements + SCADA power output

1 Eologix ice detection



Eologix & iSpin - Introduction

2 ROMO Wind /Nabla Wind Hub iSpin Technology

- Ultrasonic anemometer
- Installation at the hub
- Measurements taken in front of the rotor
- Measurement of wind speed, yaw errors and wind inclination angles
- 10 Hz data

3 SCADA data

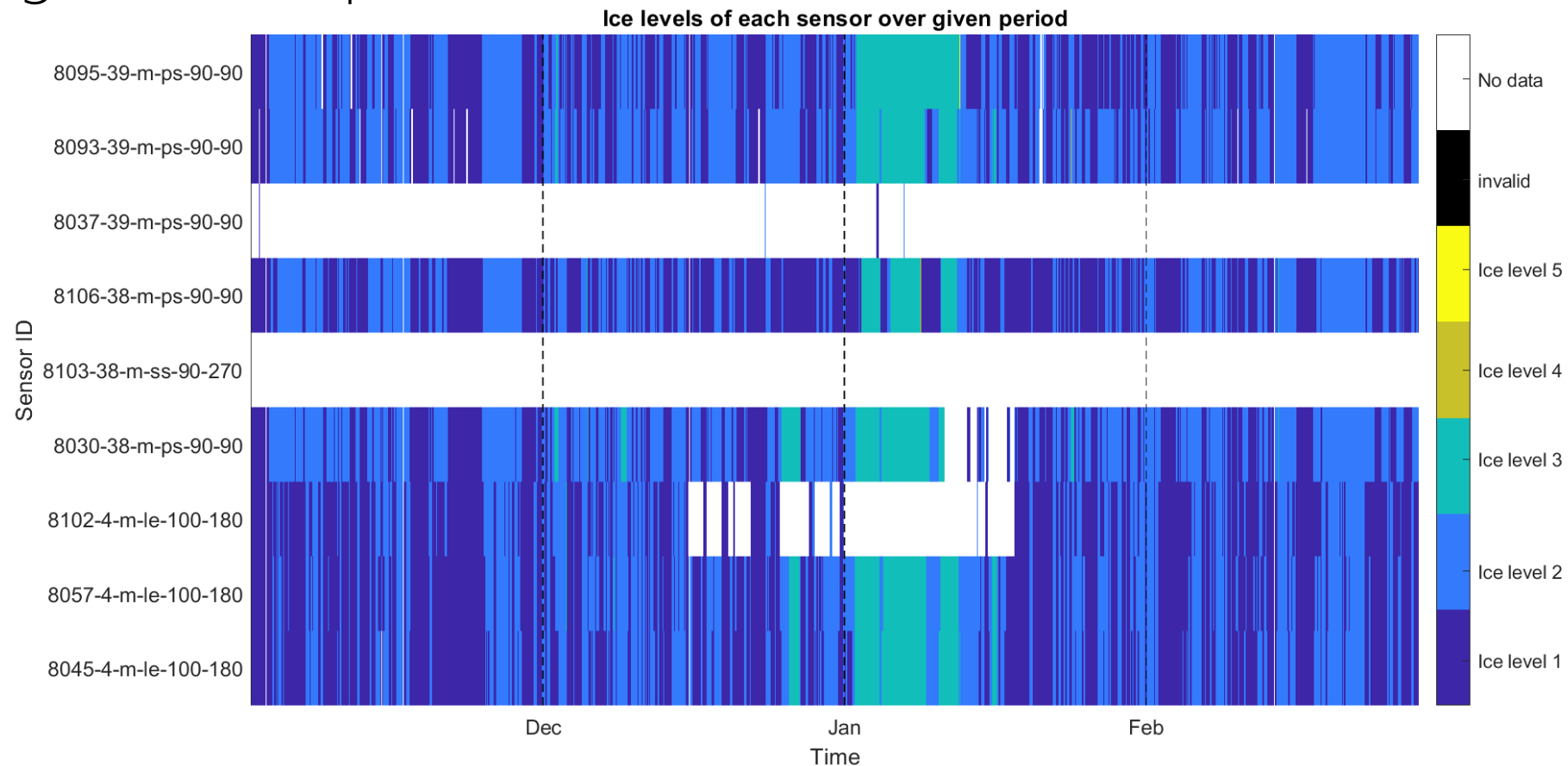
- Turbine power output



iSpin sensor mounted at the hub
(Picture courtesy of ROMO Wind).

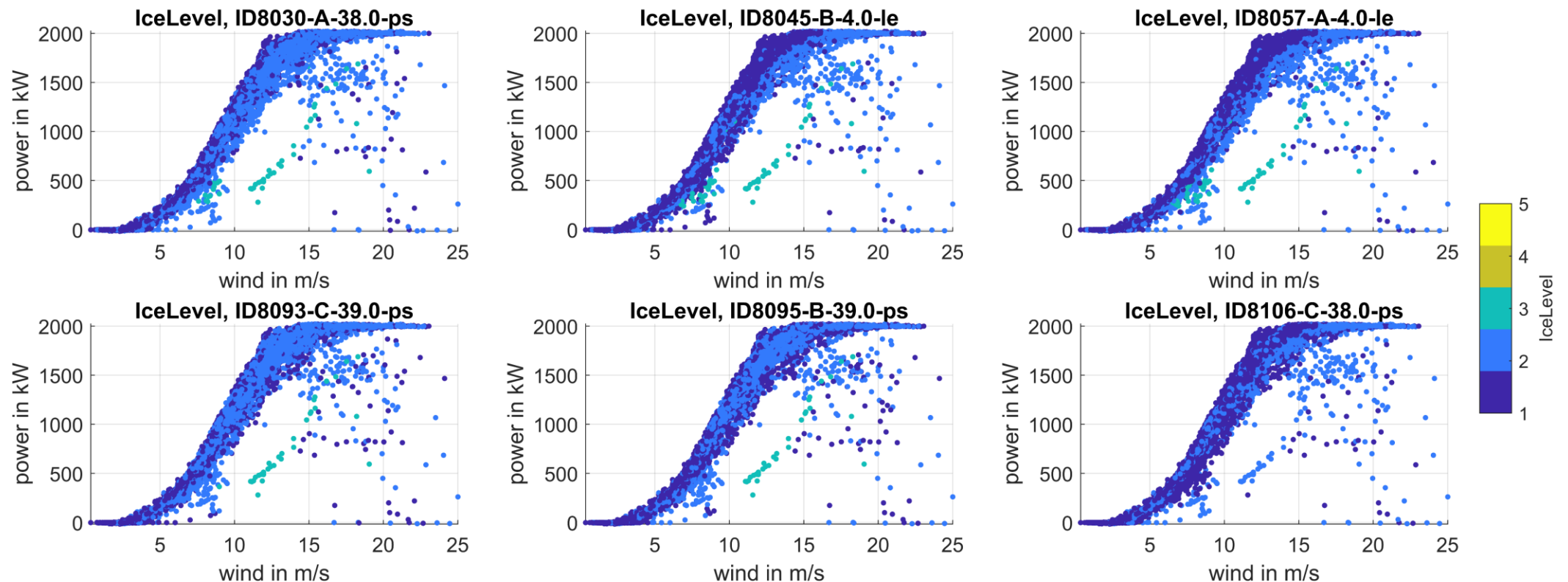
Power Curve & Icing

► Eologix ice level per sensor



Power Curve & Icing

- Power curve and correspondence to eologix ice levels

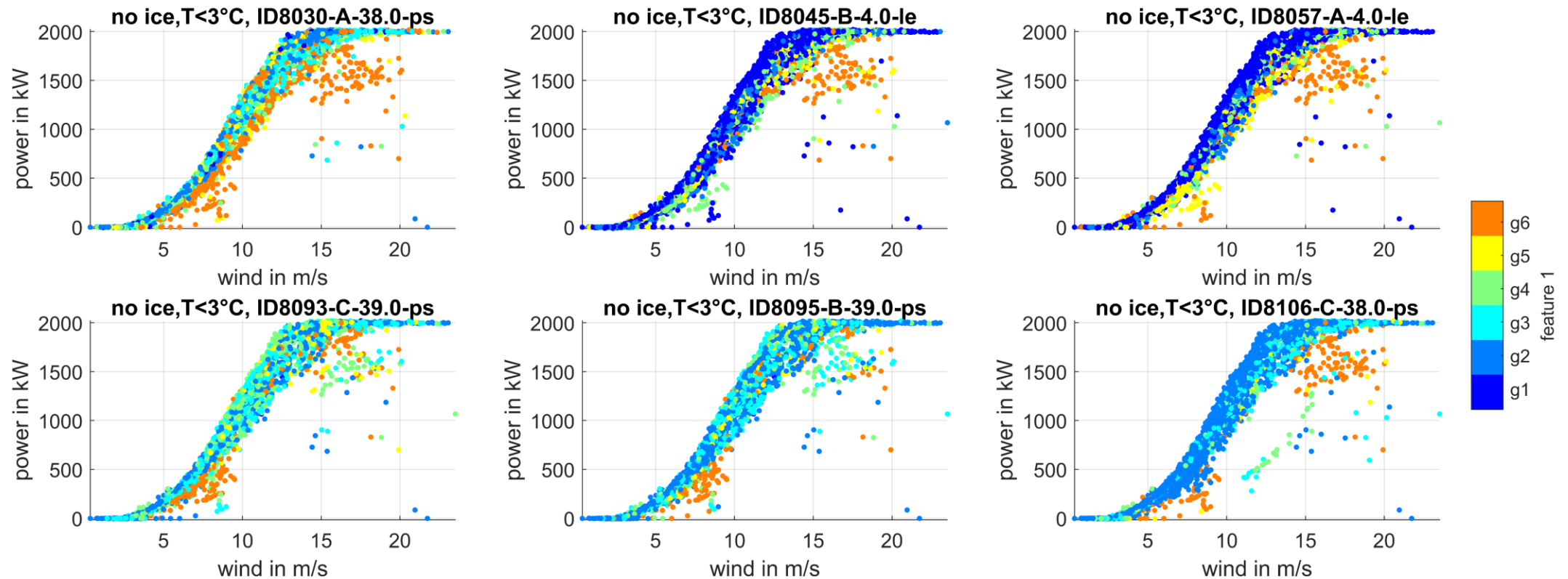


Measure for early-stage ice (MESI)

- Combination of several features per sensor
 - Temperature
 - Feature 1: "Activity Feature", 6 different levels
 - Feature 2: "Icing Feature", 4 different levels
- MESI (per sensor):
 - Temperature below 3°C
 - Feature 1: member of levels ≥ 4
 - Feature 2: member of levels 1,3,4
- MESI (combined for all sensors):
 - Early-stage ice detected for more than 50% of sensors

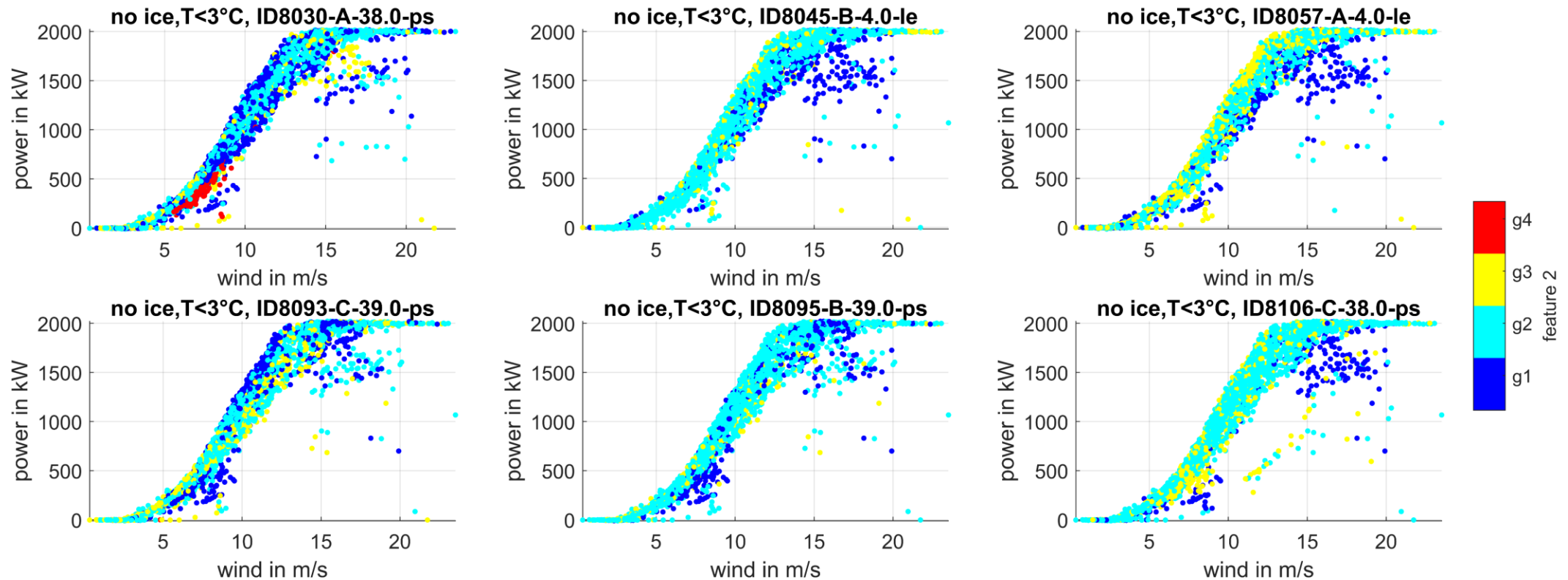
Measure for early-stage ice (MESI)

► Feature 1



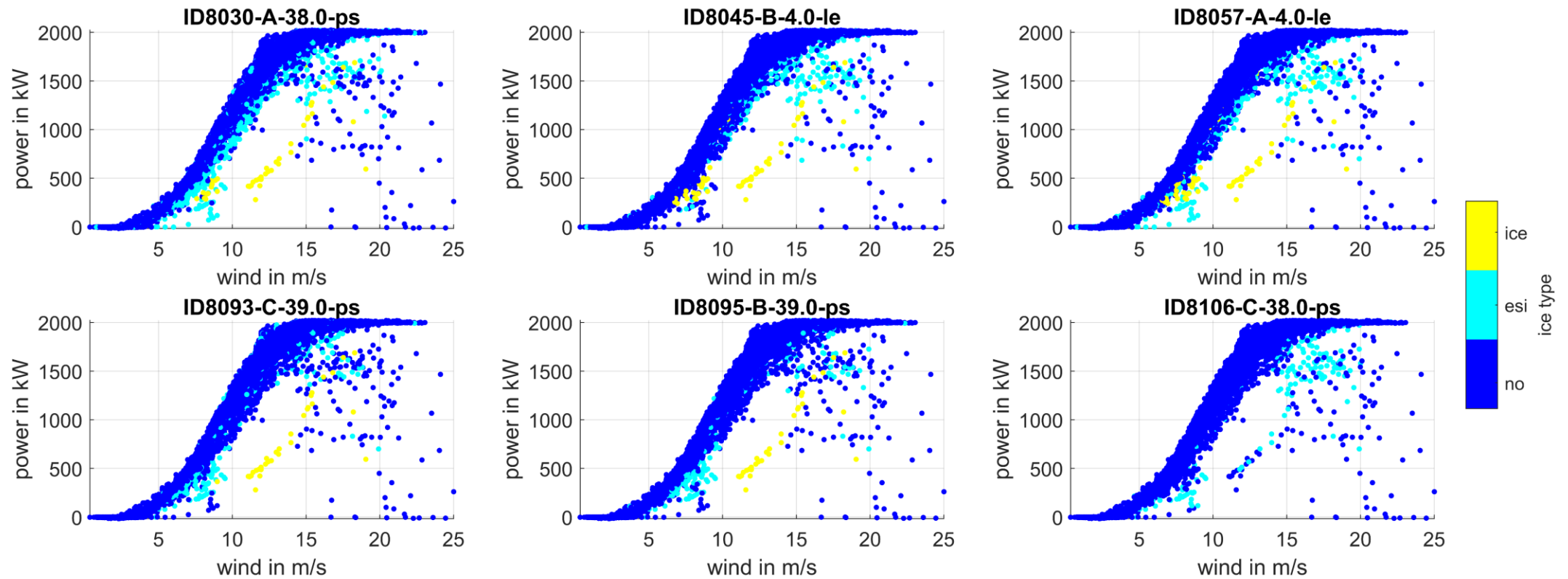
Measure for early-stage ice (MESI)

► Feature 2



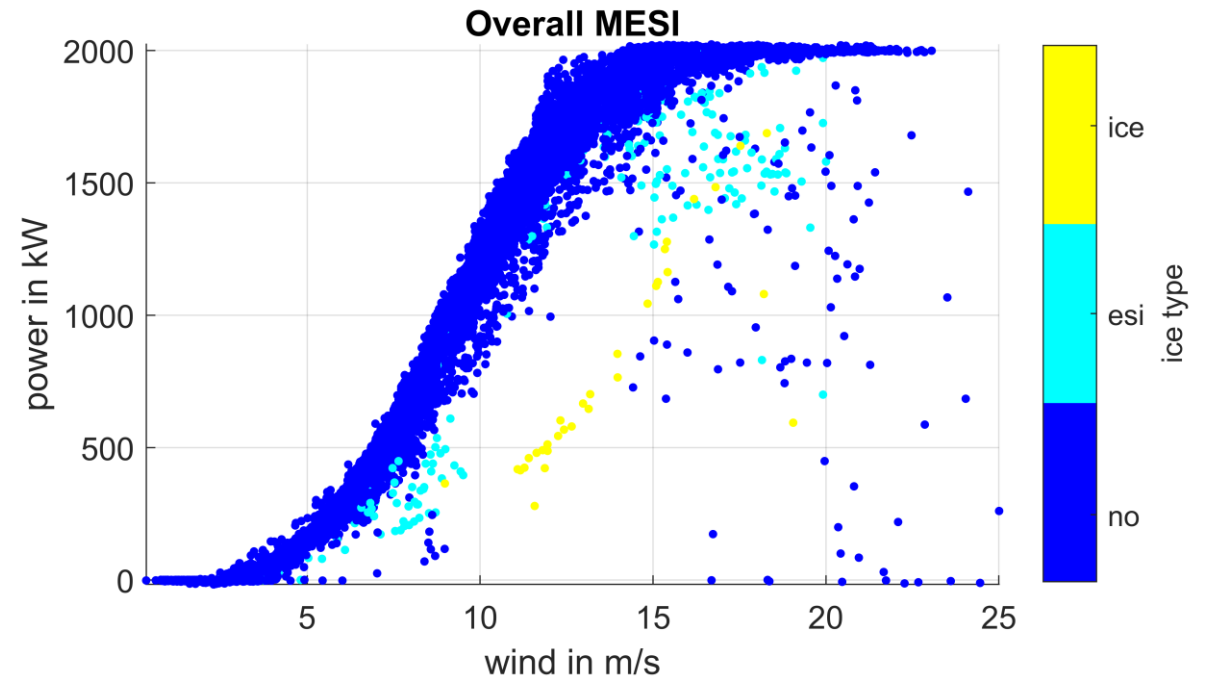
Results

► MESI per sensor



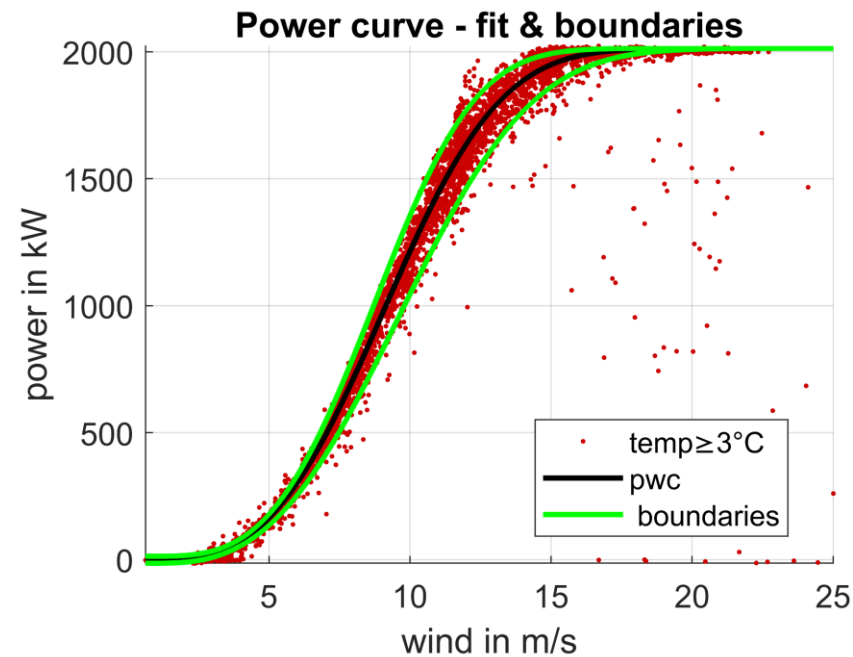
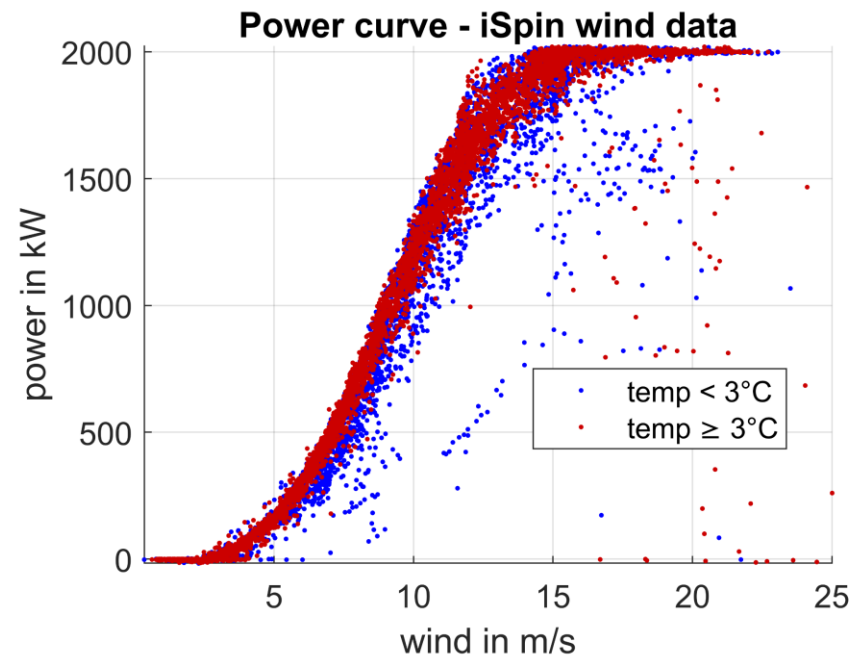
Results

- Overall MESI
 - Early-stage ice detected for more than 50% of sensors



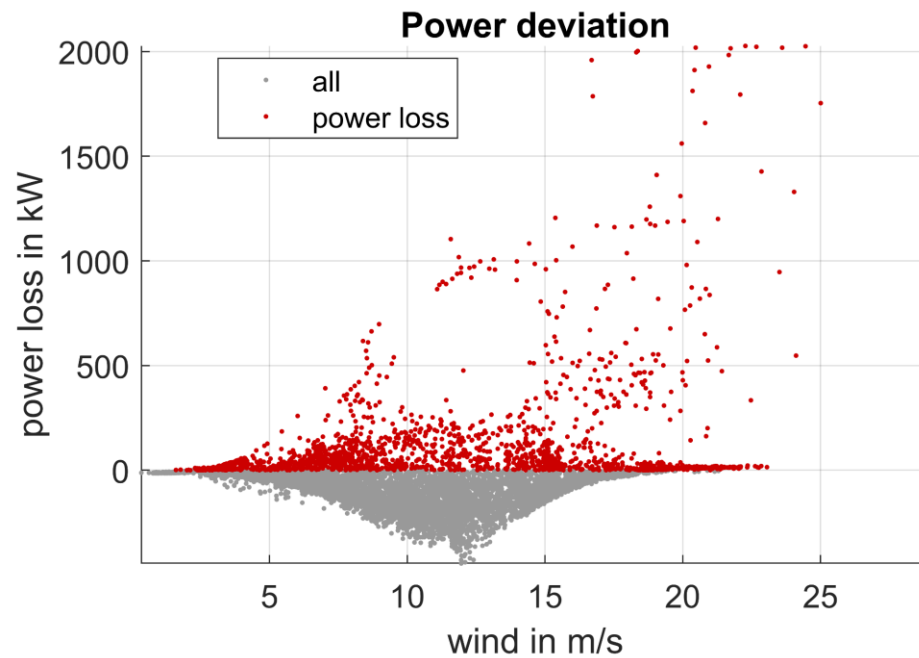
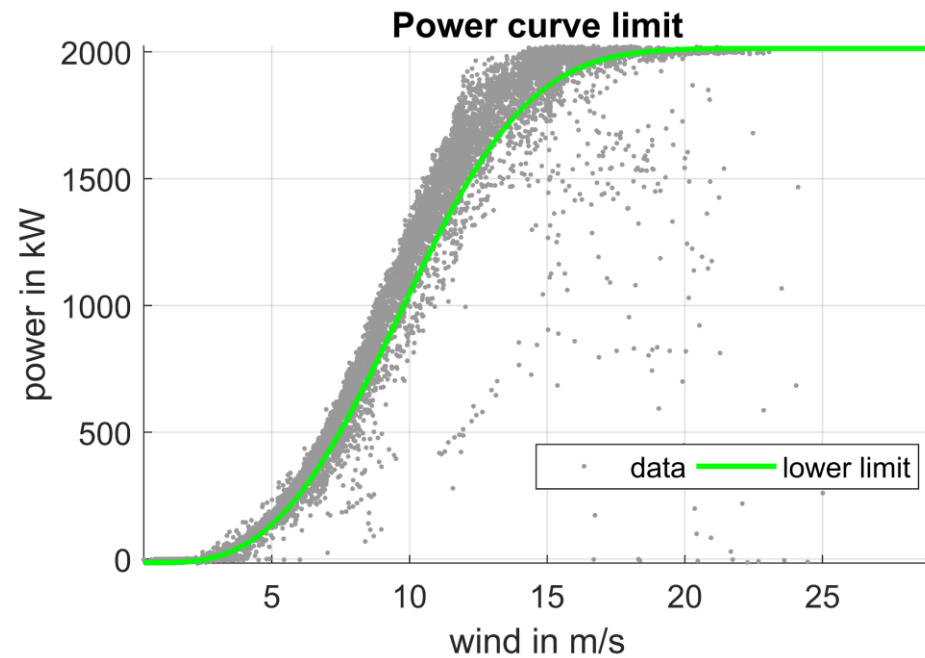
Power Curve & Icing

- Power curve with SCADA data and iSpin wind measurements



Results

- Detect deviations from the power curve



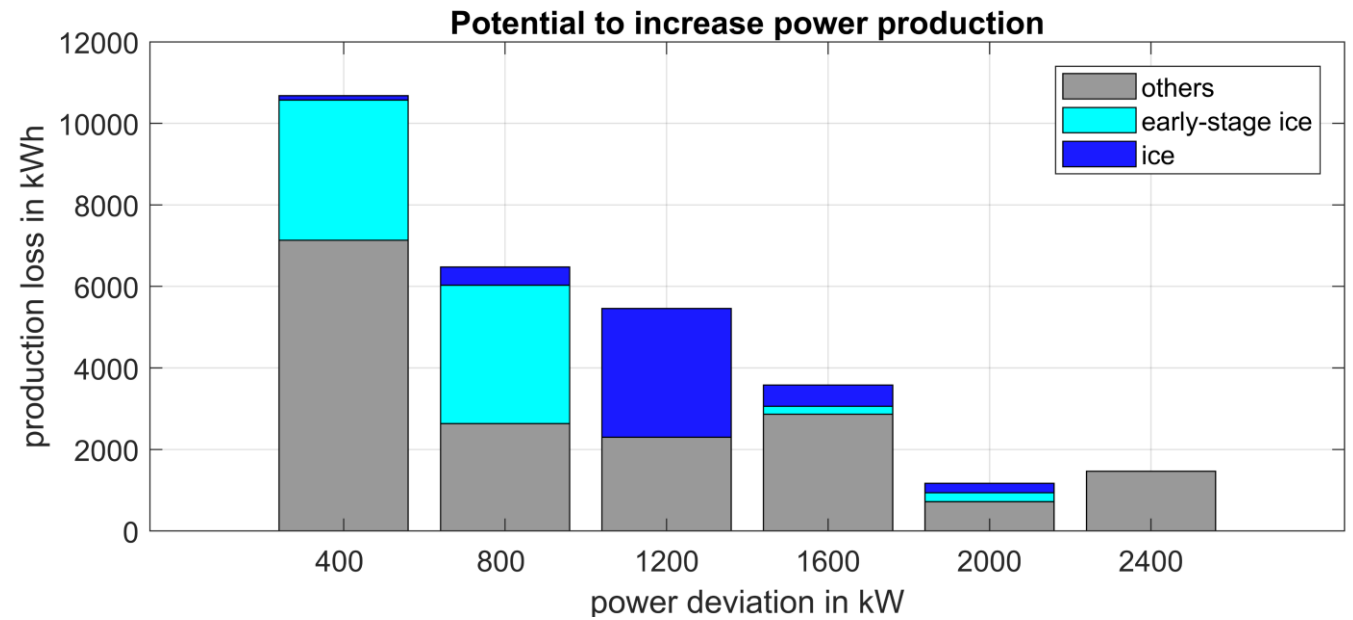
Results

Production losses for a test turbine in France:

- 3 months (01/12/2020 – 28/02/2021)
- location in southern France

Production losses due to ...

- Ice: 4.5 MWh
- Early-stage ice: 7.2 MWh
- Other reasons: 17.1 MWh



Summary

- Combination of eologix ice measurements, iSpin wind measurements and SCADA power data
- MESI developed based on eologix ice and temperature measurements on the blades
- Analysis of power curves under icing conditions
- Production losses due to early-stage ice detected on an operational turbine

Benefits of MESI:

- + Detect early-stage ice
- + Optimise blade heating
- + Prevent production loss
- + Prevent foreseeable standstills
- + Distinguish between icing and other causes (e.g. blade damage, mismatch of turbine settings etc.)



ANY QUESTIONS?

Get in touch with us.
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