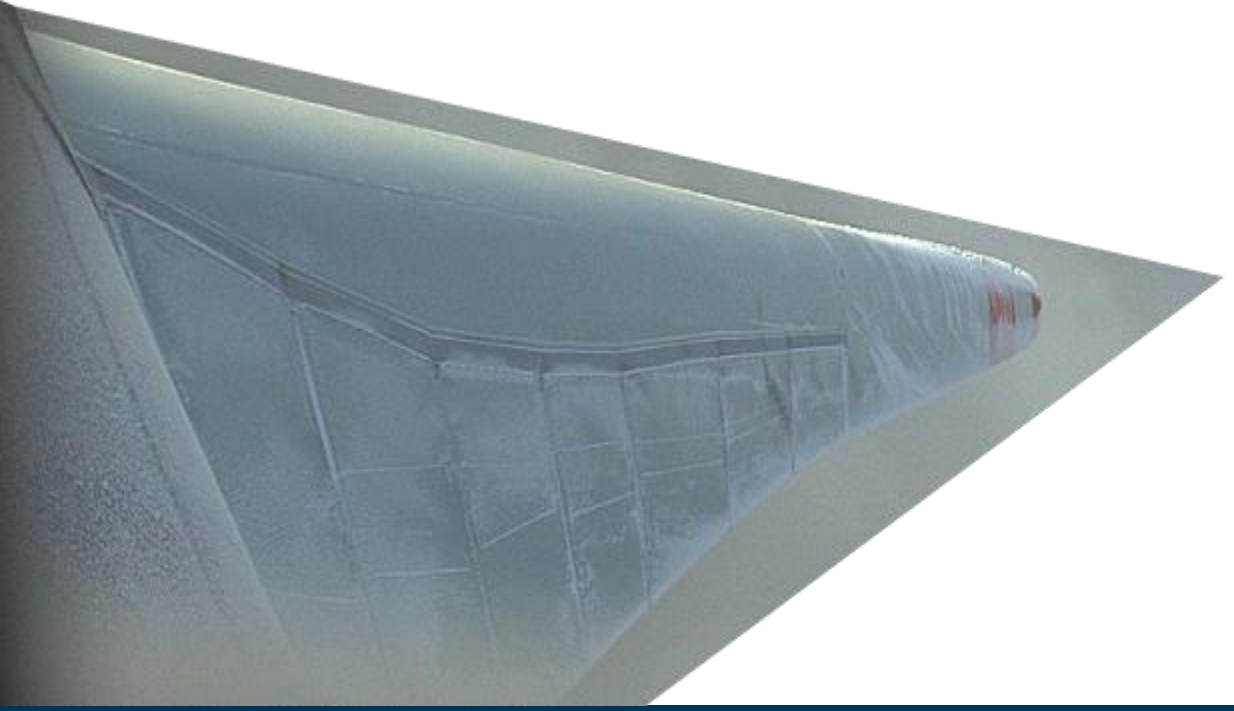


A smart algorithm for wind turbine controlling under icing conditions

Meteotest, Uni Vienna, AIT, VERBUND

20.4.2022

Franziska Gerber, Paul Froidevaux, Michael Sedlmayer, Radu Bot,
David Gruber, Tobias Glück, Thomas Burchhart, Simon Kloiber

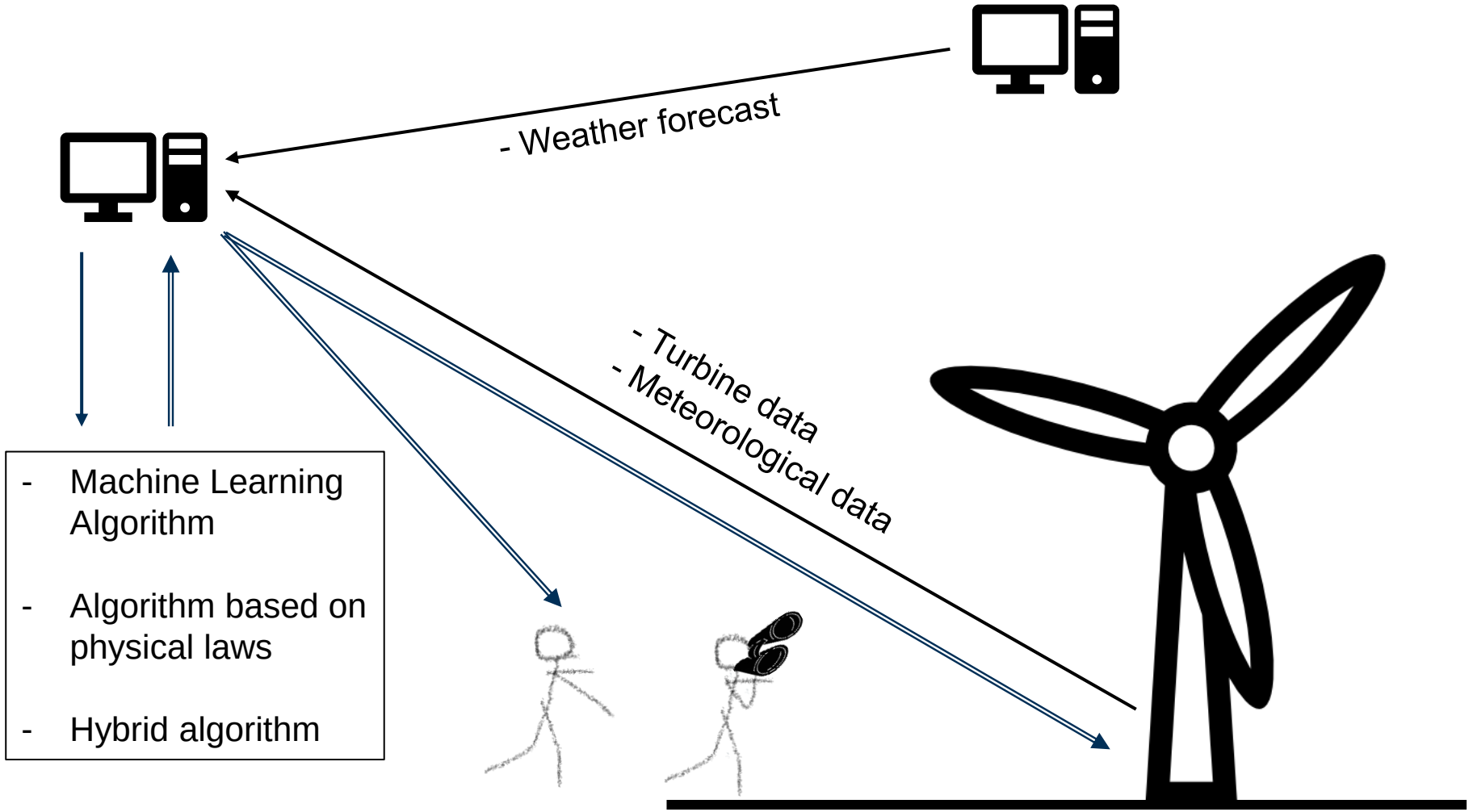
Smart Operation…
… of WIND turbines…
… under Icing Conditions

The project SOWINDIC …

- … is a research project by the FFG (Austrian research promotion agency)
- … gathers knowledge from technology (AIT), mathematical and environmental science (University Vienna and Meteotest) and the renewable energy industry (VERBUND)

- … aims to run rotor blade heating systems in the most efficient way
- … aims to predict best timing for blade heating cycles
- … aims to autonomously send signals to drive the blade heating system

The flow of information

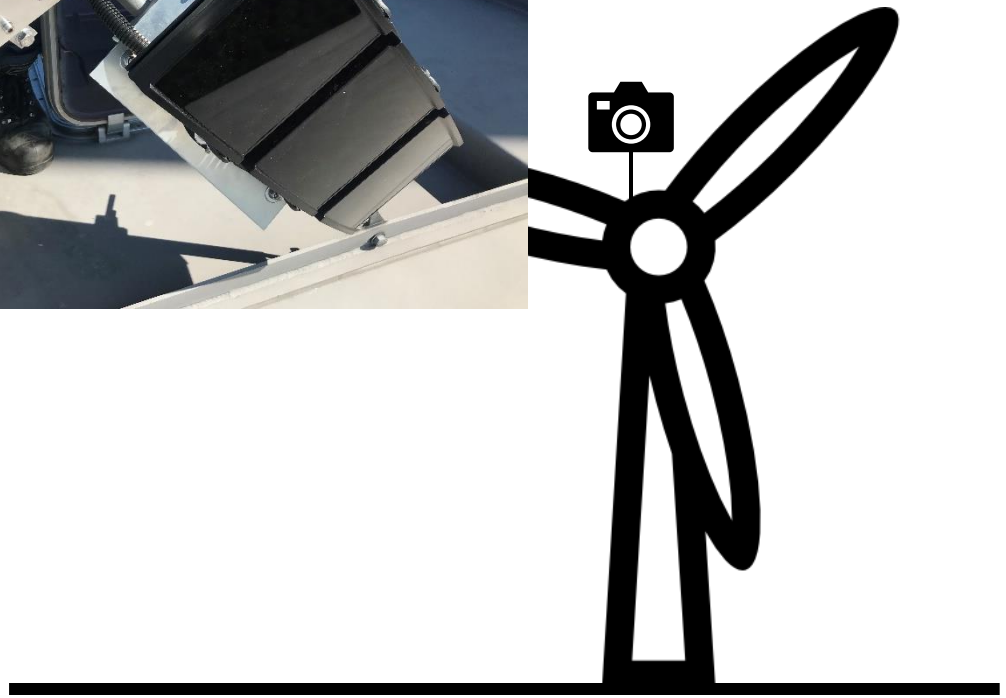


Source wind mill: http://clipart-library.com/clip-art/windmill-silhouette-clip-art-21.htm
Source binoculars: https://www.flaticon.com/free-icon/binoculars_6784073?related_id=6784073&origin=search

Additional sensors and systems

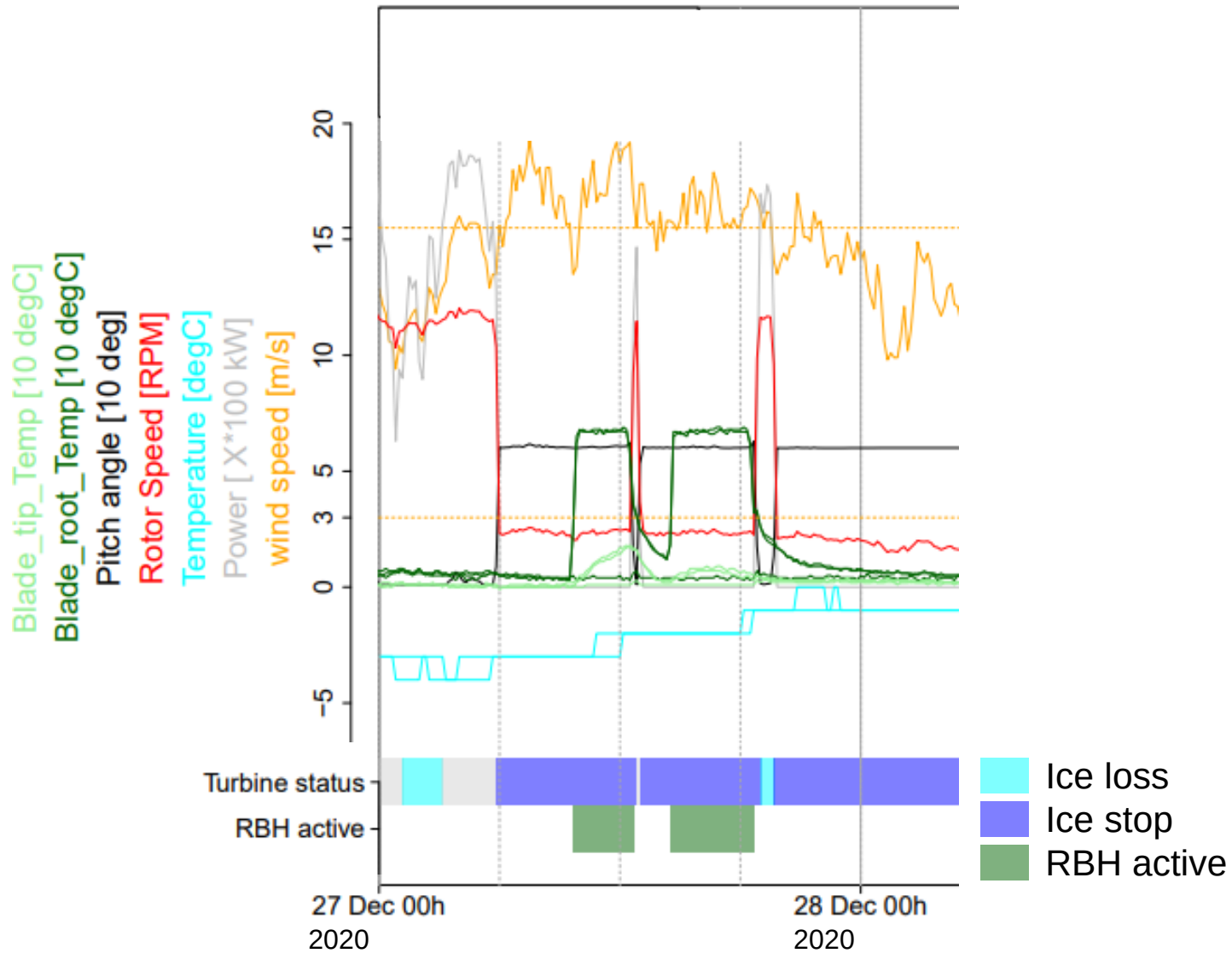
3 turbines equipped with:

- Temperature and humidity sensors
- Ice detection system
- Camera system



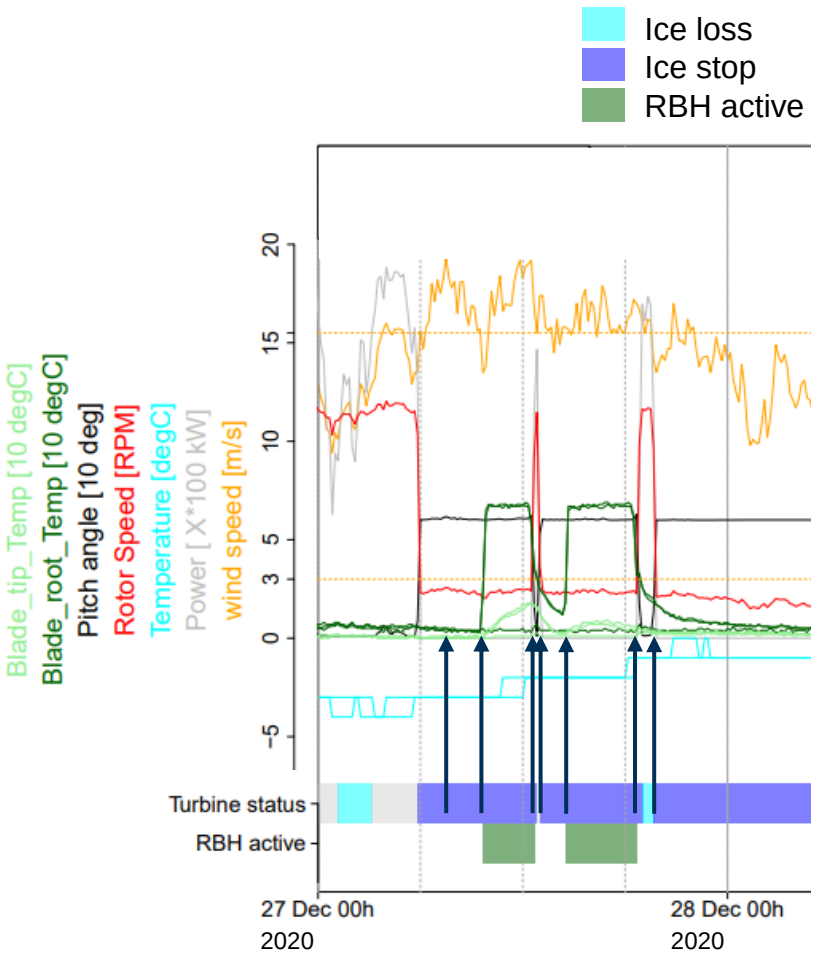
Source wind mill: http://clipart-library.com/clip-art/windmill-silhouette-clip-art-21.htm

A blade heating event



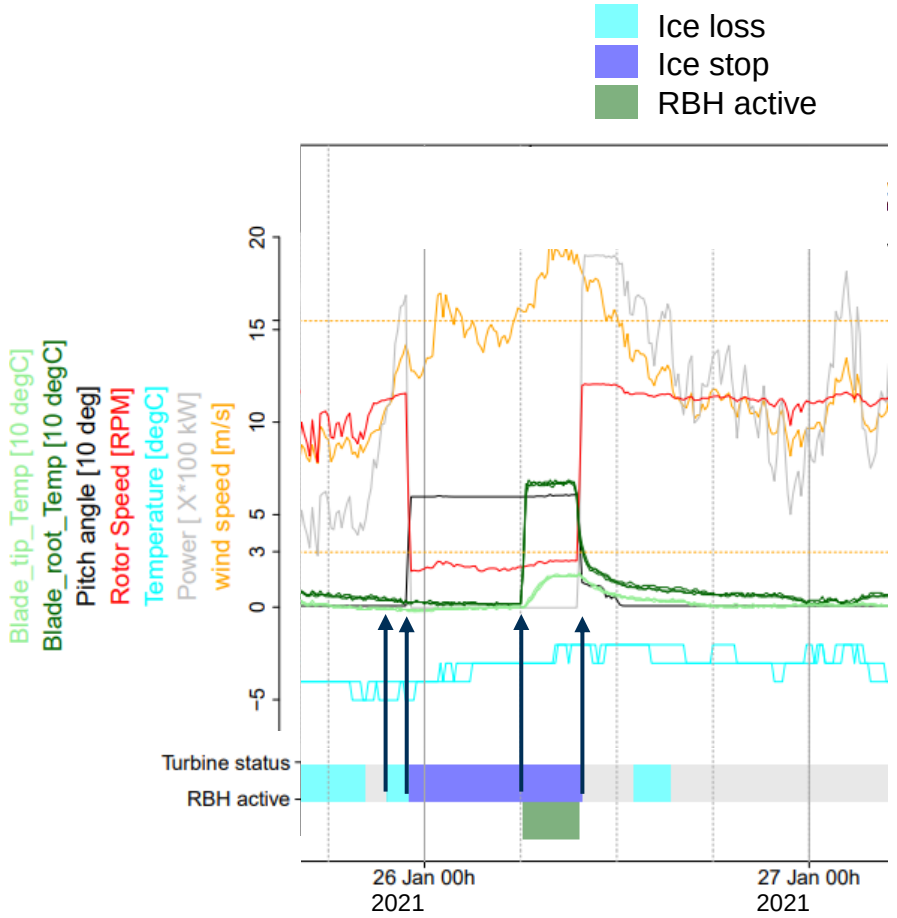
RBH: rotor blade heating

A blade heating event



RBH: rotor blade heating

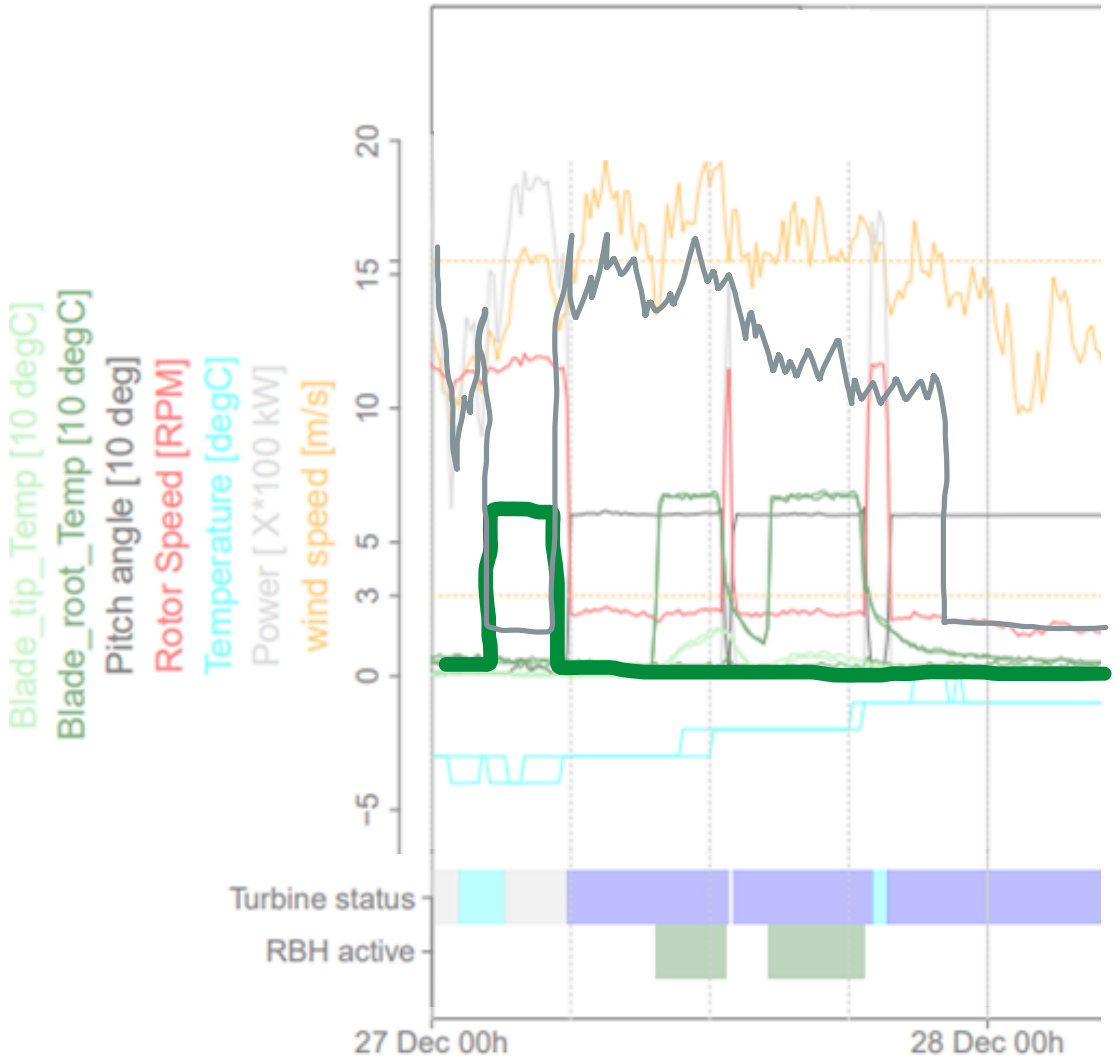
Another blade heating event



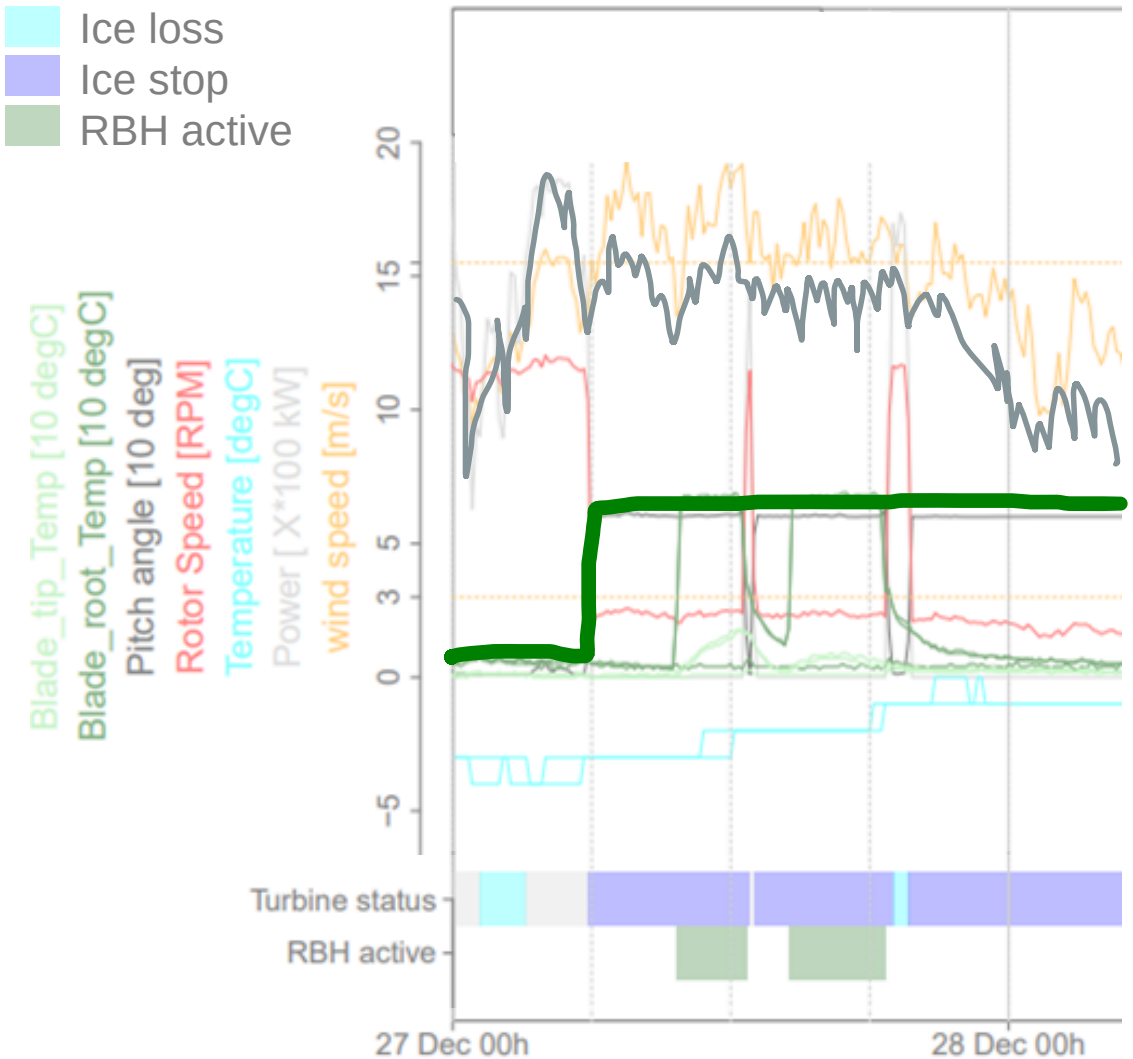
RBH: rotor blade heating

A blade heating event – how to improve?

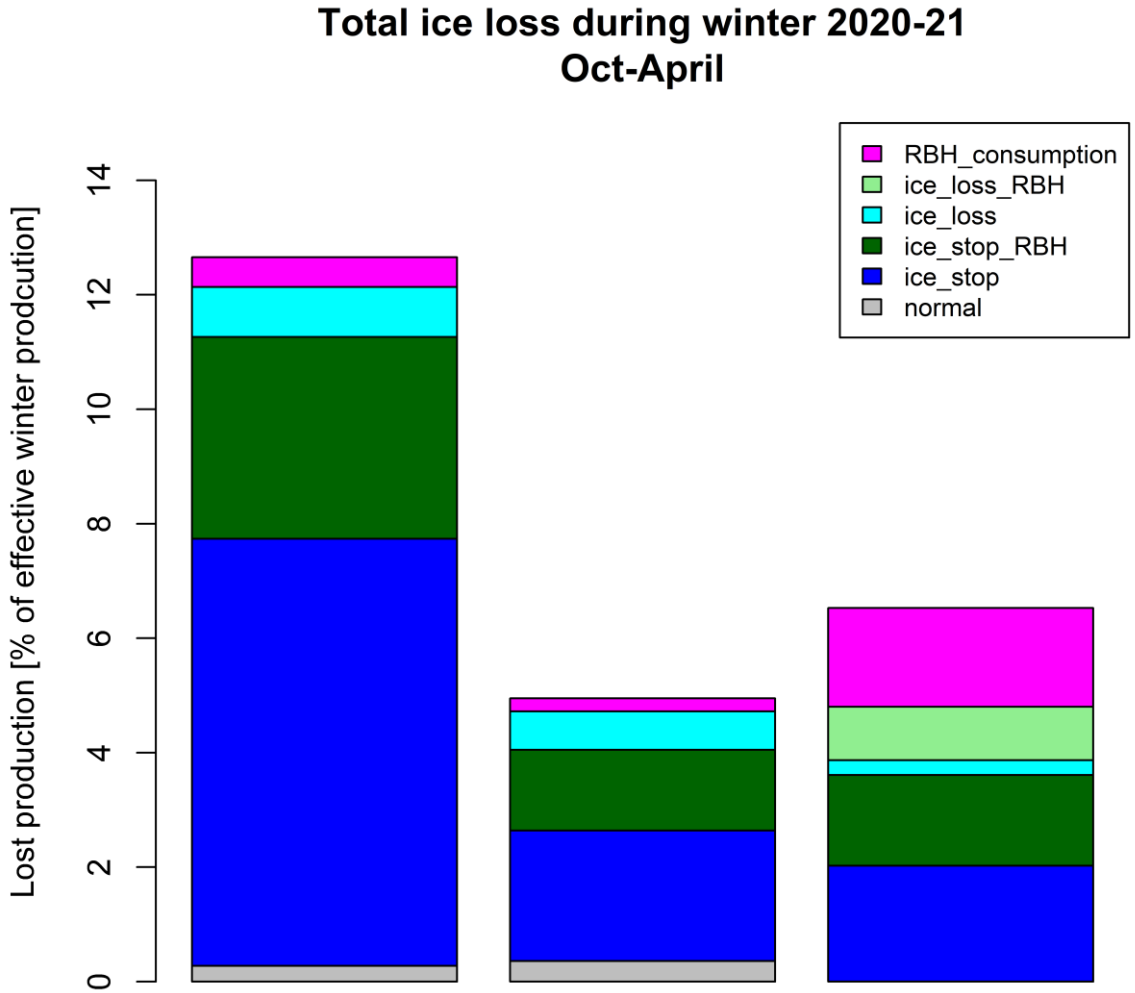
Proactive heating?



Heating during operation?



Heating options – a case study



Preliminary results

- Significant differences with same heating strategy possible
- In this particular case, heating during operation was associated with increased energy consumption (~1.5% of winter production) without reduction of ice stops.

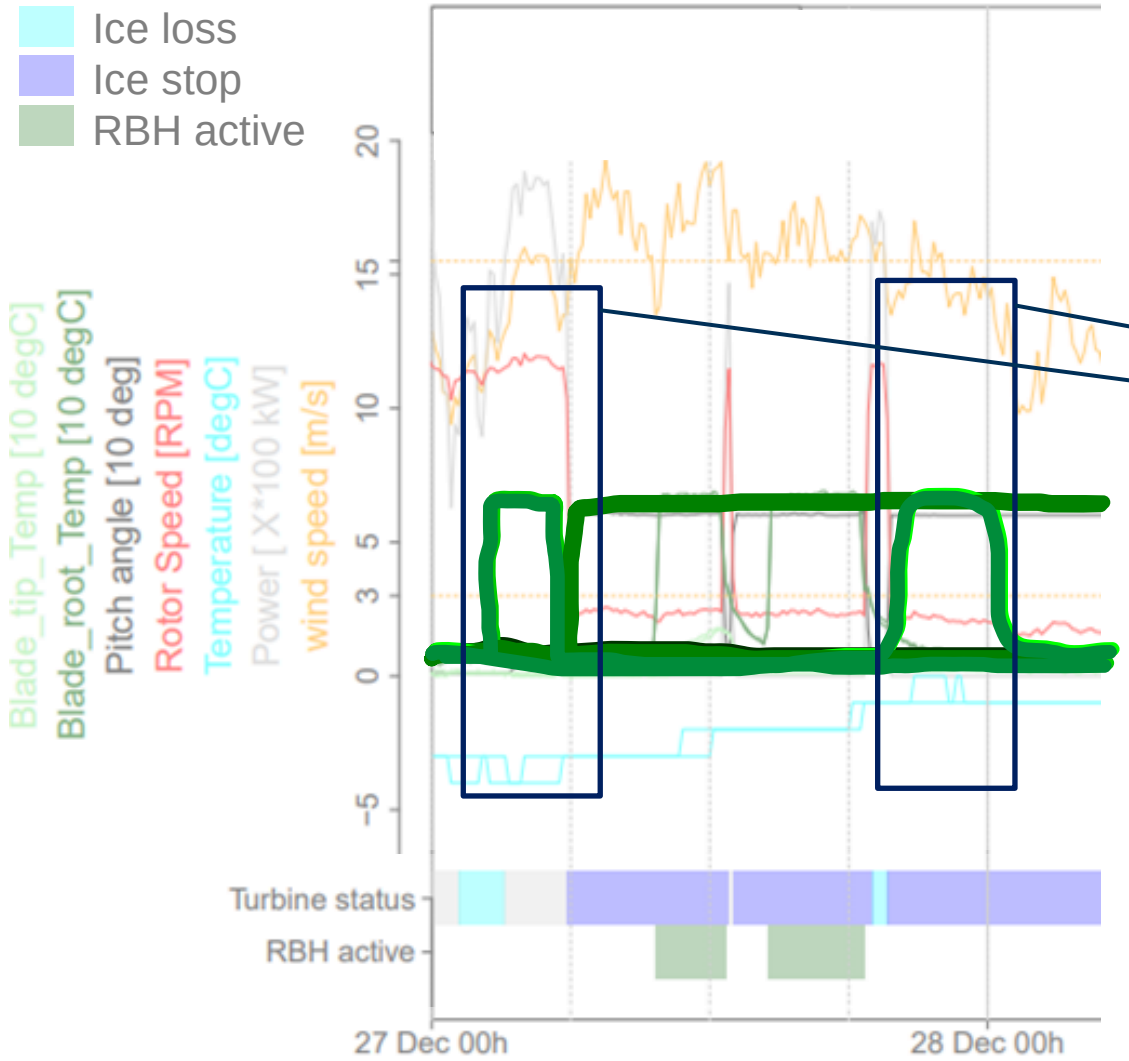
Caveats

- *Different turbine types*
- *Different exposition of the turbines to icing (altitude, location)*

→ *More side-by-side comparison tests required*

→ *No smart algorithm yet*

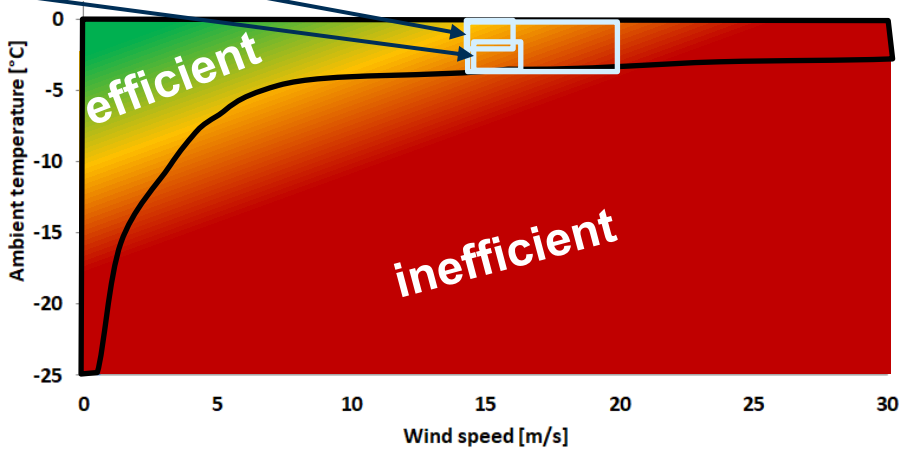
Smart Algorithm – Heating options



Weather Forecast

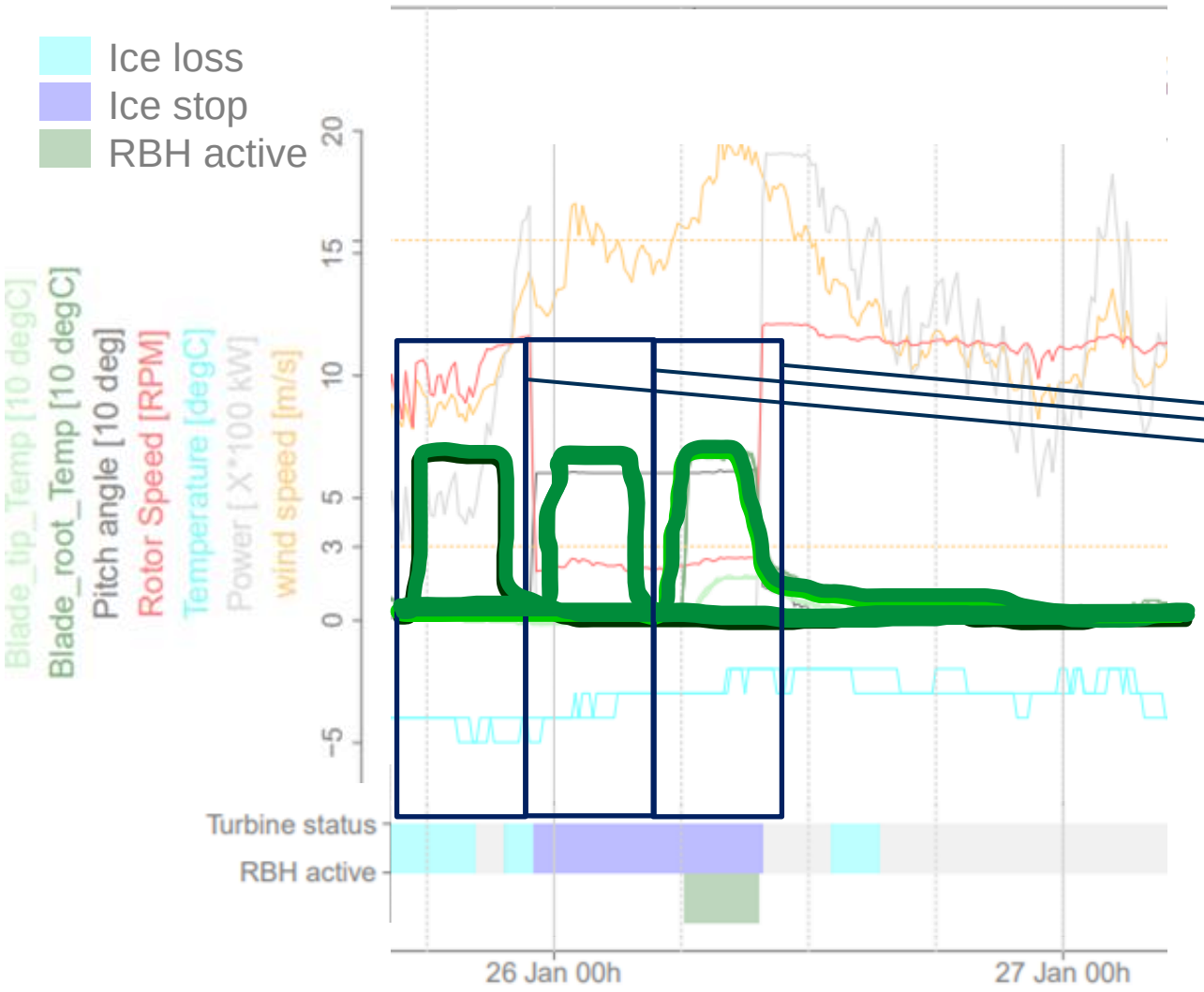
- High wind speed
- Low temperatures
- High concentration of supercooled cloud droplets (LWC)
- Low incoming shortwave radiation

→ At the edge of the **<u>schematic</u> blade heating envelope**
+ high supercooled LWC
+ low incoming shortwave radiation



→ best scenario <u>depends on</u>:
- heating strategy
- predicted atmospheric conditions

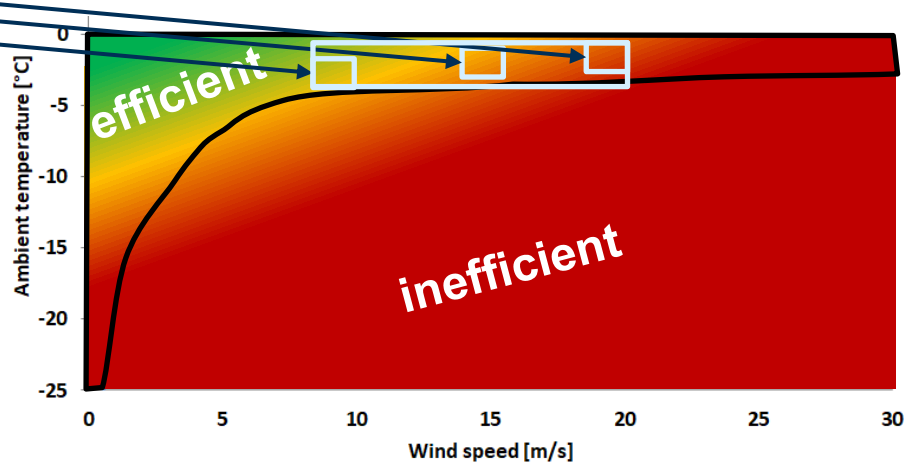
Smart Algorithm – Choice of scenario



Weather Forecast

- Varying but high wind speed
- Low temperatures
- Moderate supercooled cloud droplets (LWC)
- Increasing incoming shortwave radiation

→ Wide range of **<u>schematic</u> blade heating envelope**
+ some supercooled LWC
+ some shortwave radiation

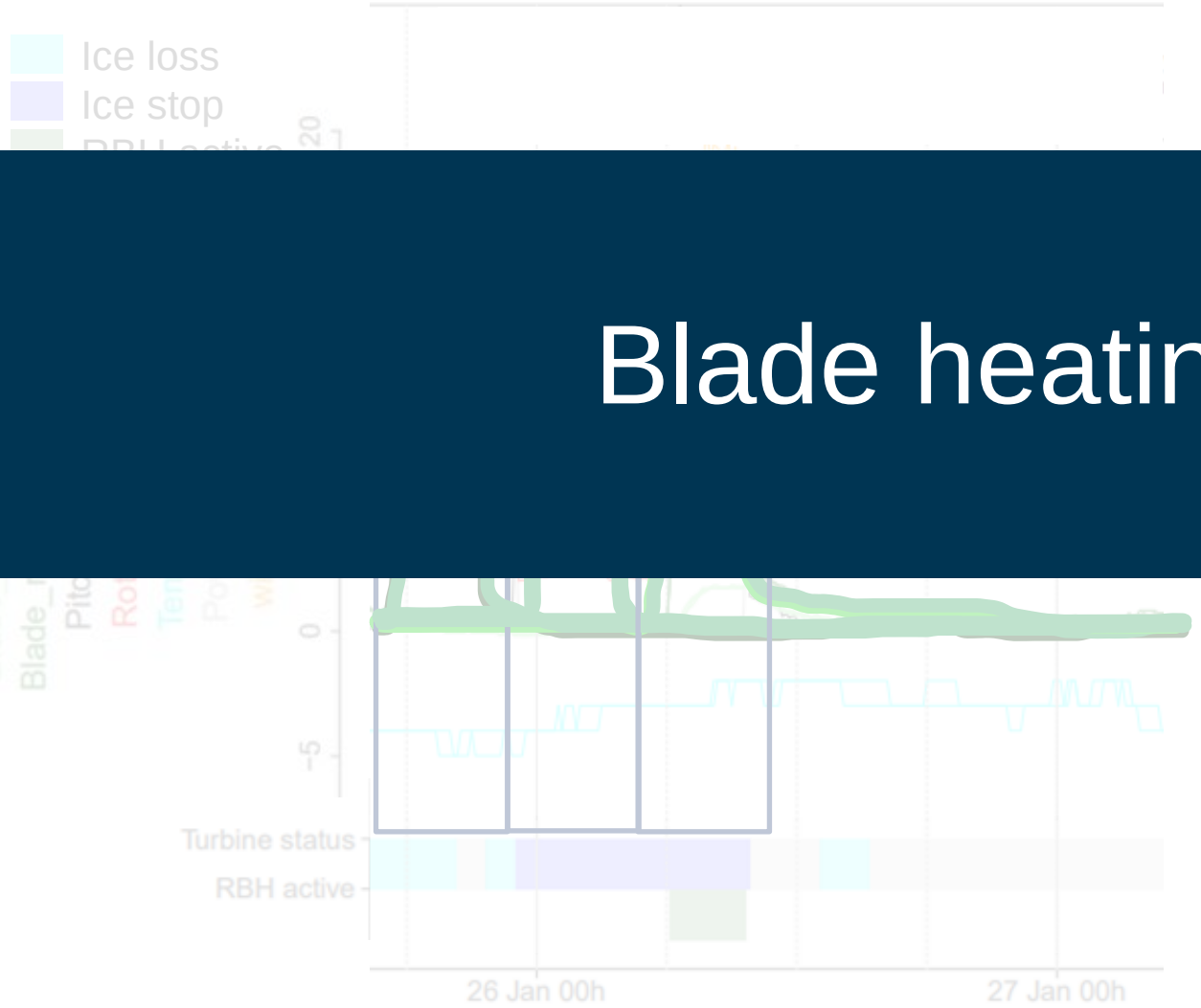


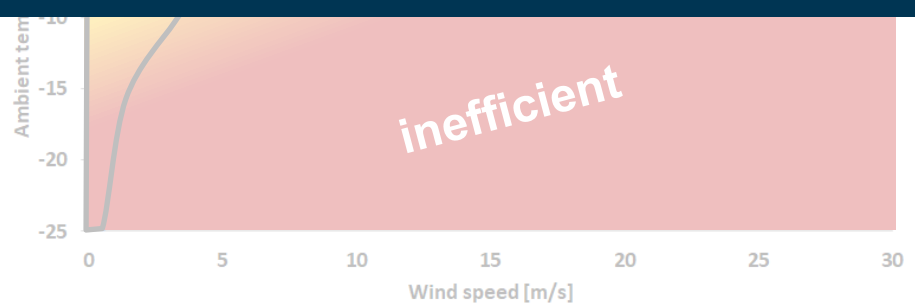
→ best scenario <u>chosen</u> based on:
- predicted energy production

Smart Algorithm – Choice of scenario

Weather Forecast
- Varying but high wind speed
- Low temperatures
- Moderate supercooled cloud droplets (LWC)

Blade heating envelope





→ best scenario chosen based on:
- predicted energy production

The planned algorithms

Based on physical laws

Algorithm based on physical laws using turbine data, local measurements and weather forecasts

E.g.

- Is icing prevention necessary?

- Are wind speed, temperature and icing conditions favorable for prevention?

Machine Learning

Train algorithm by Machine Learning techniques based on turbine data, local measurements and weather forecasts

→ stay tuned for results by the University of Vienna

Hybrid algorithm

A combination of the algorithm based on physical laws and the machine learning algorithm

Take home …

- … that the **efficiency of blade heating systems** is limited by the **external conditions** (blade heating envelope: wind speed, temperature, supercooled droplets, radiation)
- … that Meteotest, University of Vienna, AIT and VERBUND are developing an algorithm to **run the rotor blade heating system when conditions are most favorable**
- … the system is planned to **allow real-time turbine control** or run with an SMS system

SOWINDIC Smart Operation… … of WIND turbines… … under Icing Conditions

by Meteotest, University of Vienna, AIT and VERBUND

Take home …

- … that the **efficiency of blade heating systems** is limited by the **external conditions** (blade heating envelope: wind speed, temperature, supercooled droplets, radiation)
- … that Meteotest, University of Vienna, AIT and VERBUND are developing an algorithm to **run the rotor blade heating system when conditions are most favorable**
- … the system is planned to **allow real-time turbine control** or run with an SMS system

Questions & Feedback?

Meteotest

www.meteotest.ch