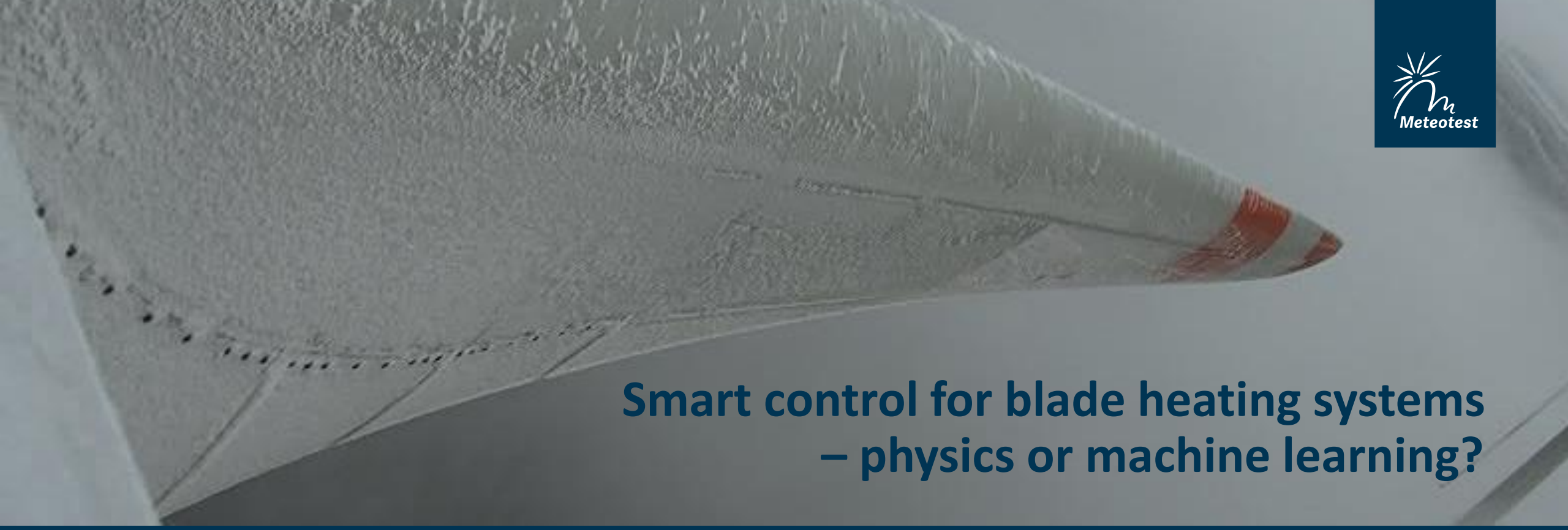


Smart control for blade heating systems – physics or machine learning?

Franziska Gerber, Paul Froidevaux, Michael Sedlmayer, Radu Bot, Martin Gruber, Simon Kloiber, David Gruber, Georg Fritze

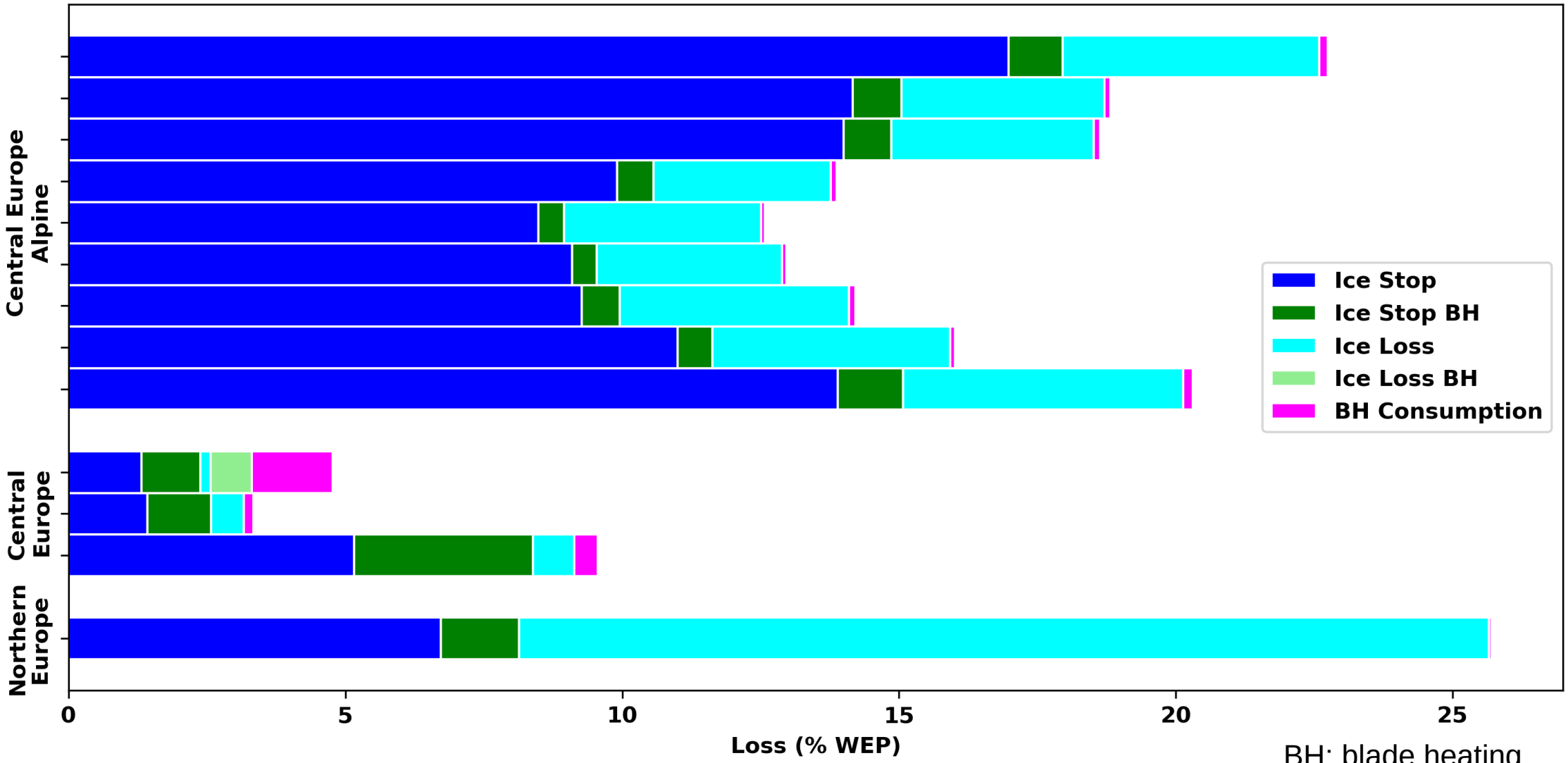
19.3.2024

Winterwind
INTERNATIONAL WIND ENERGY CONFERENCE

Smart control for blade heating systems – physics or machine learning?

Why and how?

Production losses due to icing



BH: blade heating
WEP: Winter energy production

- Based on current conditions / no forecasts
- Heating cycles not always successful
- Loose several percent of winter production

Current versus future usage of BHSs

- Taking into account weather forecast and current icing conditions
- Specify blade heating efficiency
- Decreased winter production loss?

Smart Algorithm

Based on physical decisions (Meteotest)

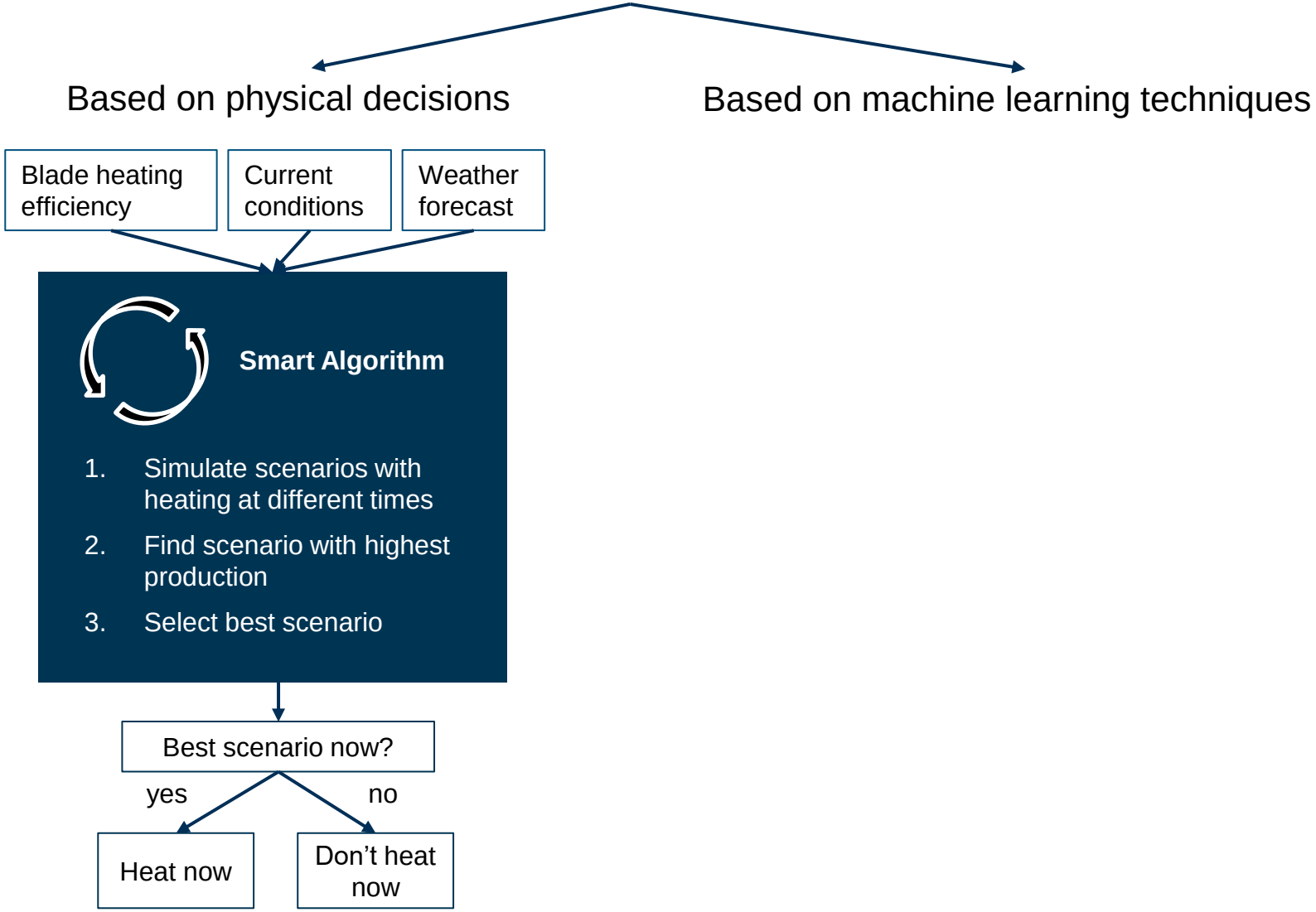
Based on machine learning techniques (University of Vienna)

SOWINDIC – Smart Operation of Wind Turbines under Icing Conditions

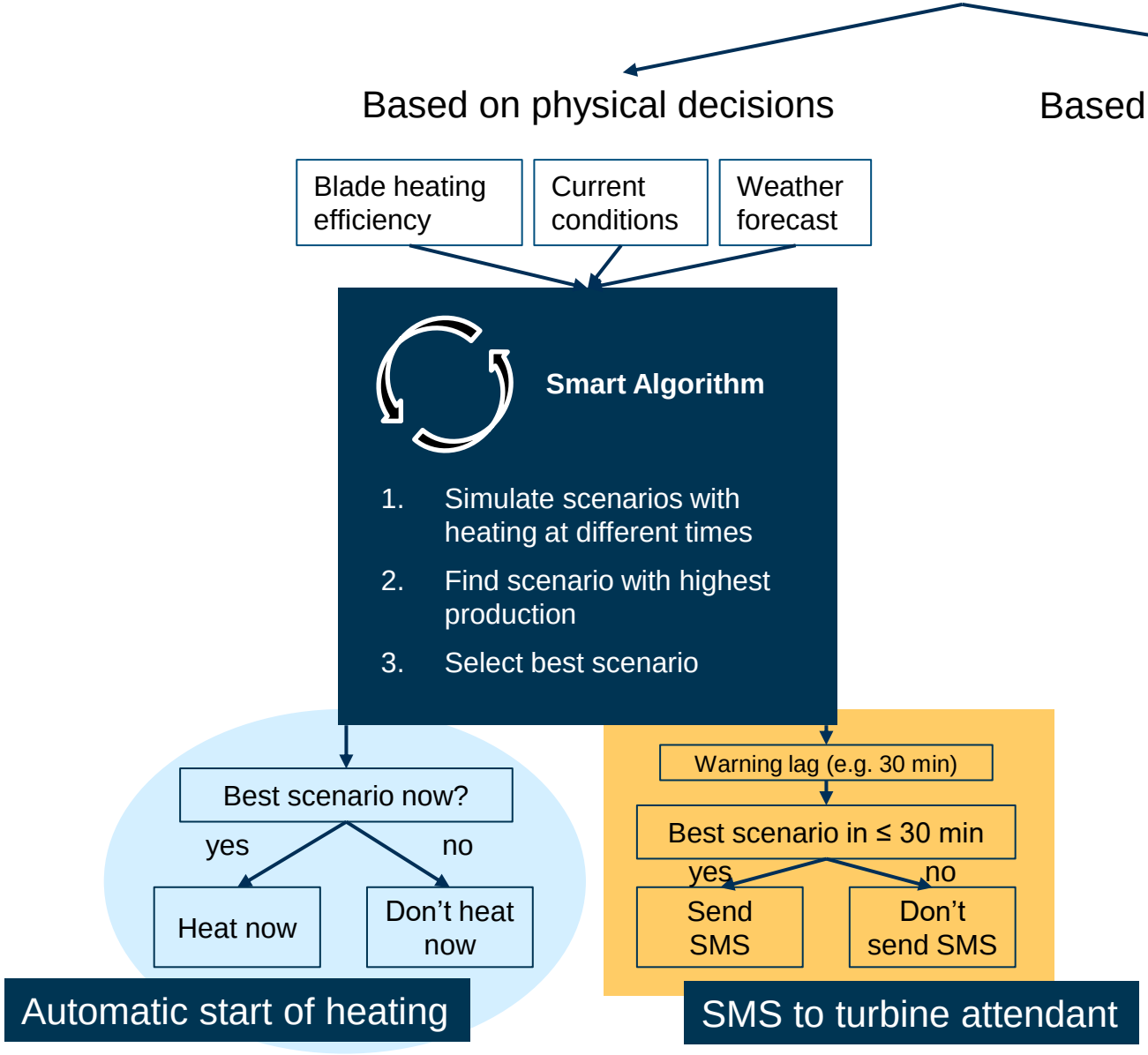
Financed: FFG (Austrian Research Promotion Agency)
Project partners:
Verbund
University of Vienna
Austrian Institute of Technology

BHS: blade heating system

Smart Algorithm



Smart Algorithm



Smart Algorithm

Based on physical decisions

Blade heating efficiency | Current conditions | Weather forecast

Smart Algorithm

1. Simulate scenarios with heating at different times
2. Find scenario with highest production
3. Select best scenario

Best scenario now?
- yes → Heat now
- no → Don't heat now

Automatic start of heating

Warning lag (e.g. 30 min)

Best scenario in ≤ 30 min
- yes → Send SMS
- no → Don't send SMS

SMS to turbine attendant

Based on machine learning techniques

SCADA data | Meteo data | Icing sensors | Weather forecast

Smart Algorithm: Learn from historical events → ML models

Normal operation

Prediction whether
- Turbine stop due to icing is imminent

yes → Turbine stop

Prediction whether
- Heating will be successful

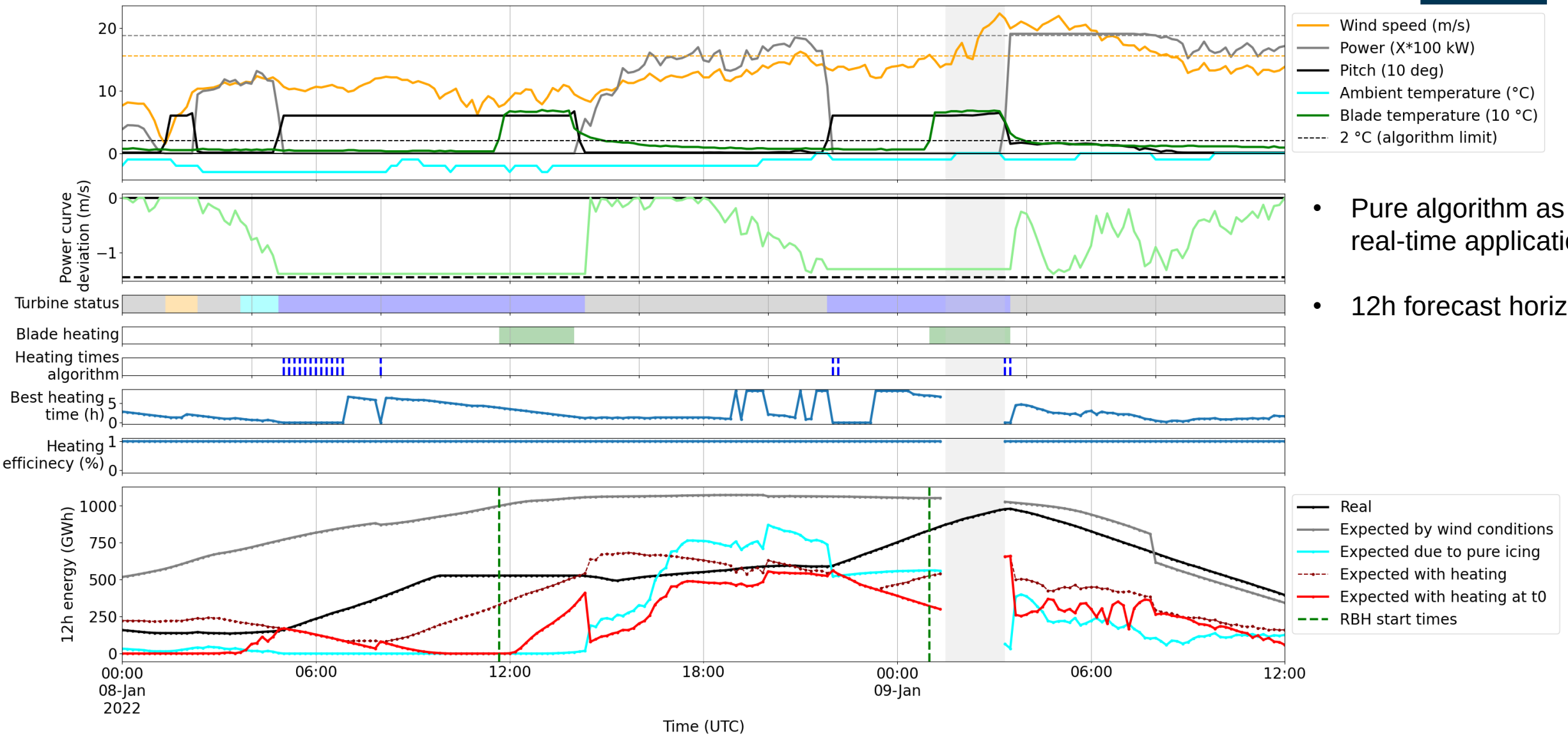
- yes → Heat in 30 min
- no → Don't heat

ML: machine learning

Smart control for blade heating systems – physics or machine learning?

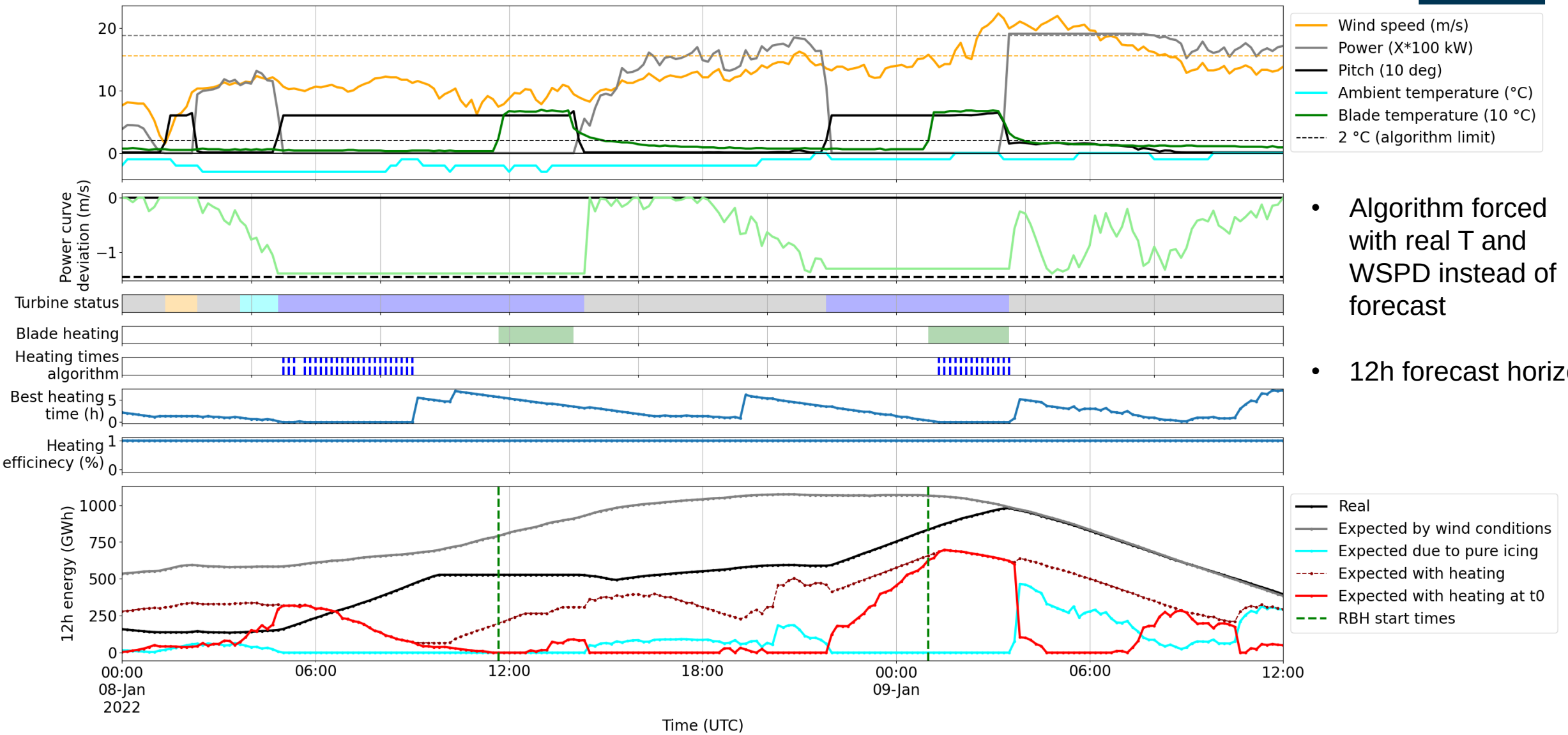
Physics – example events

An icing event and its results



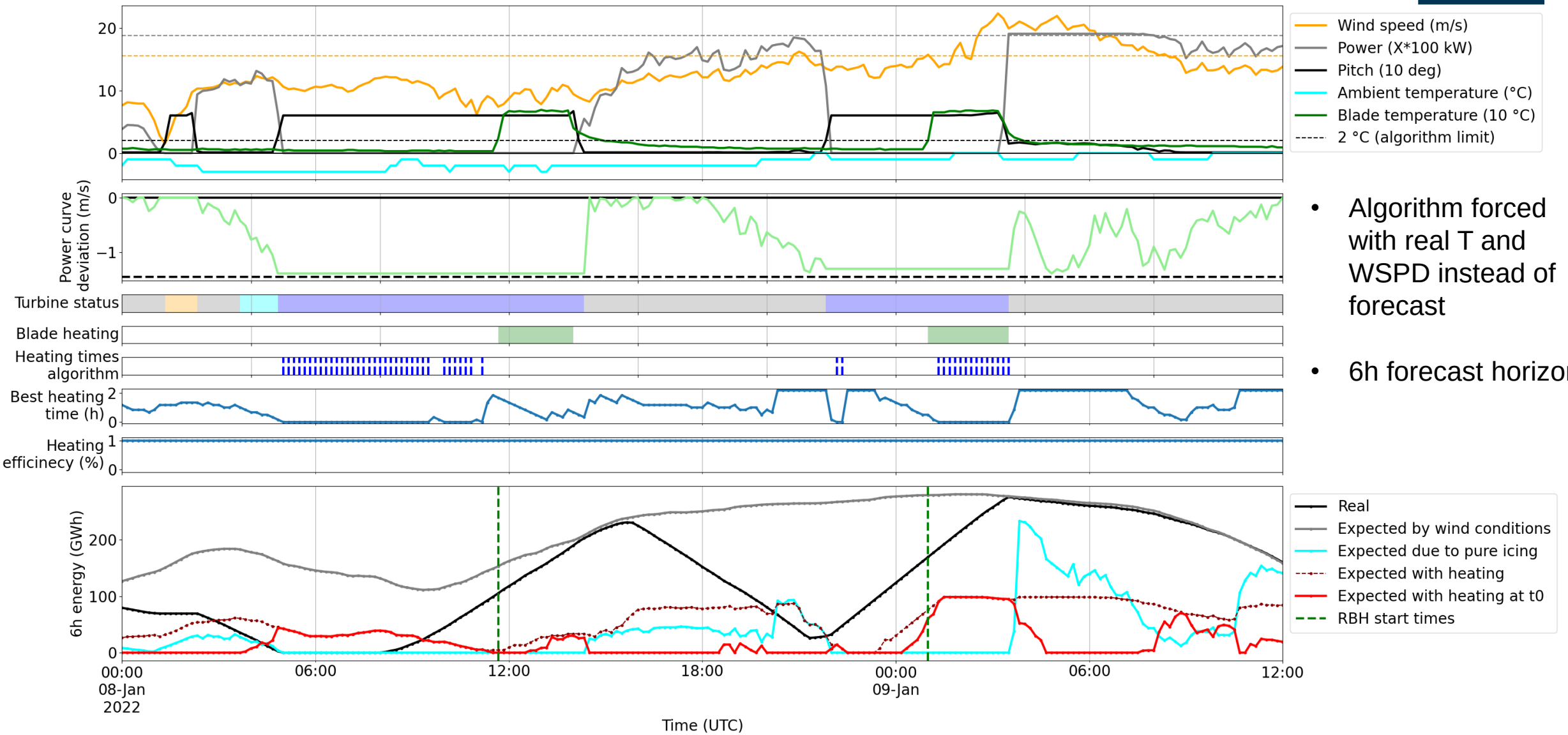
- Pure algorithm as in real-time application
- 12h forecast horizon

An icing event and its results



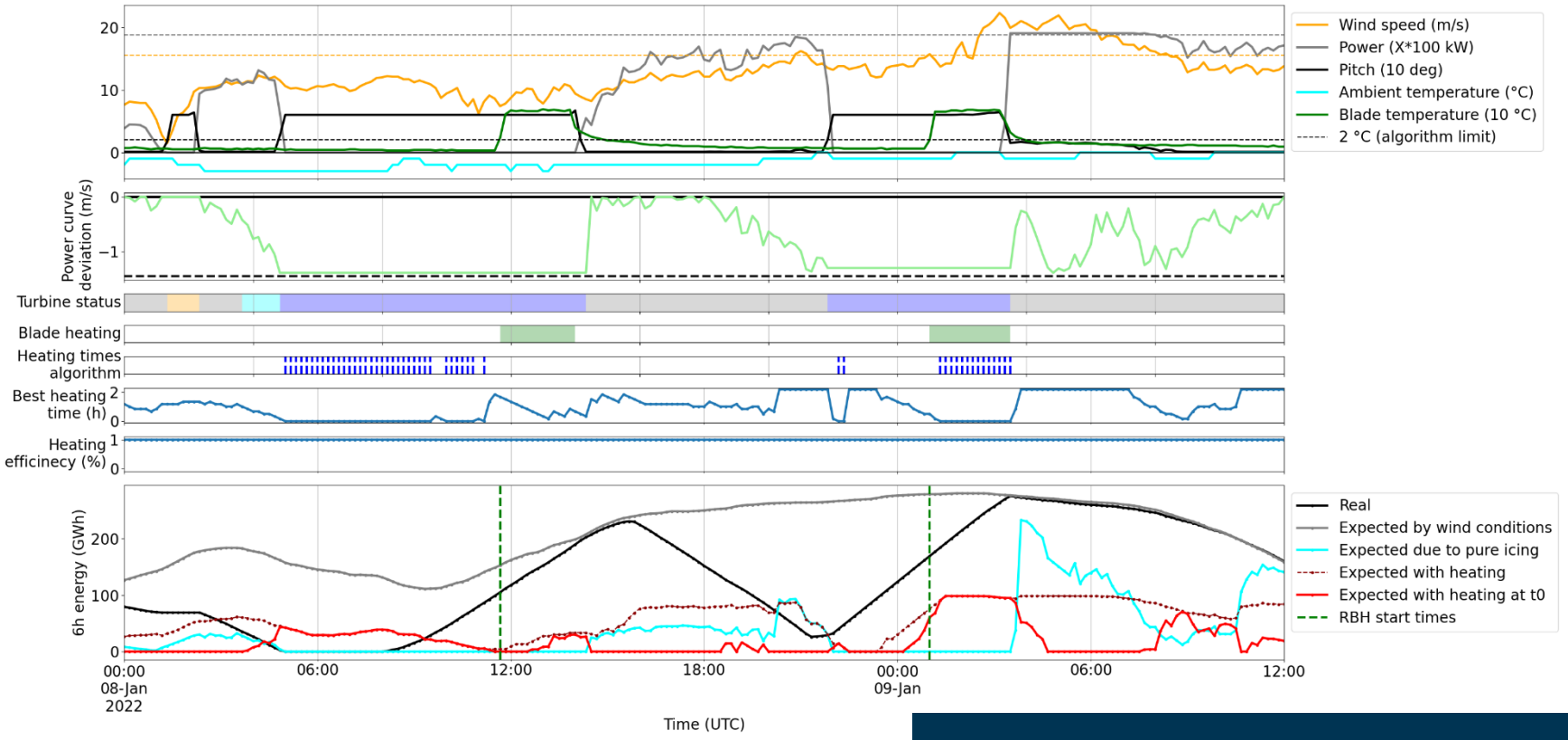
- Algorithm forced with real T and WSPD instead of forecast
- 12h forecast horizon

An icing event and its results



- Algorithm forced with real T and WSPD instead of forecast
- 6h forecast horizon

An icing event and its results

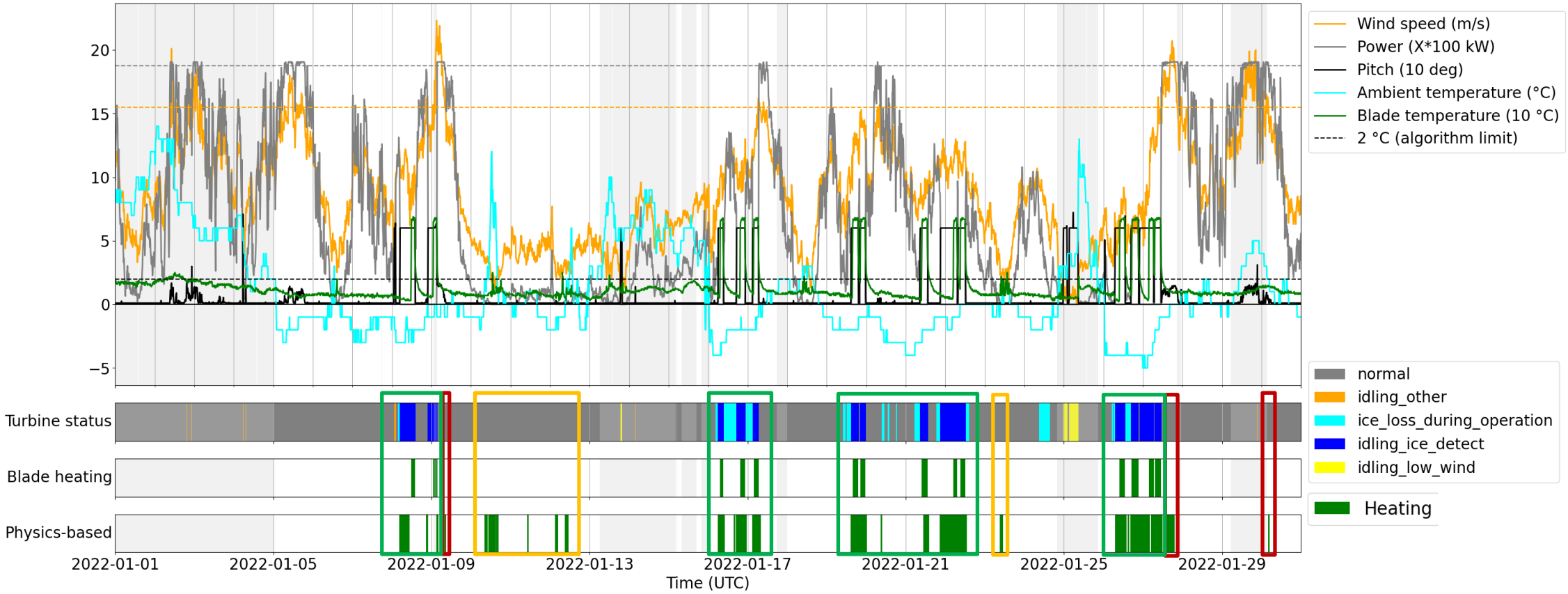


- Can predict reasonable heating times
- Quality of weather forecast has a strong influence
- More frequent heating predicted with shorter evaluation horizon
- Sometimes too strong icing effect in model

Smart control for blade heating systems – physics or machine learning?

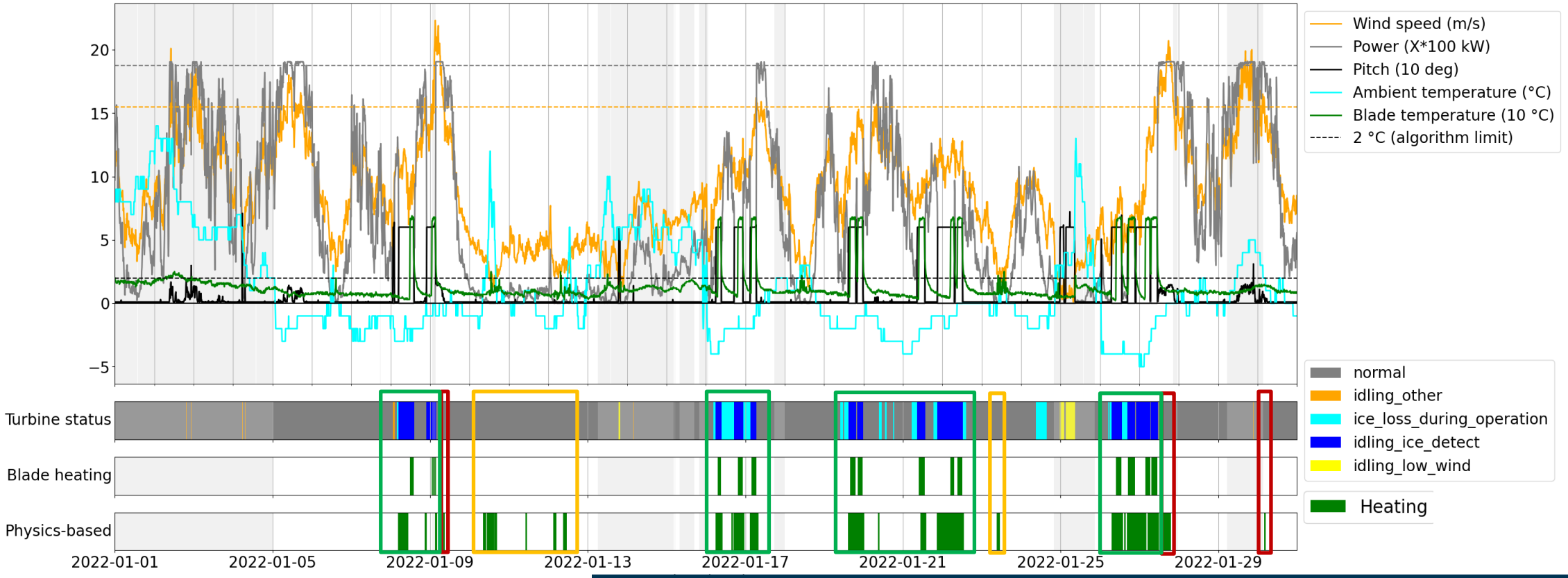
Physics – an entire month

Physics vs. machine learning



High wind speeds | Low wind speeds | Well represented

Physics vs. machine learning

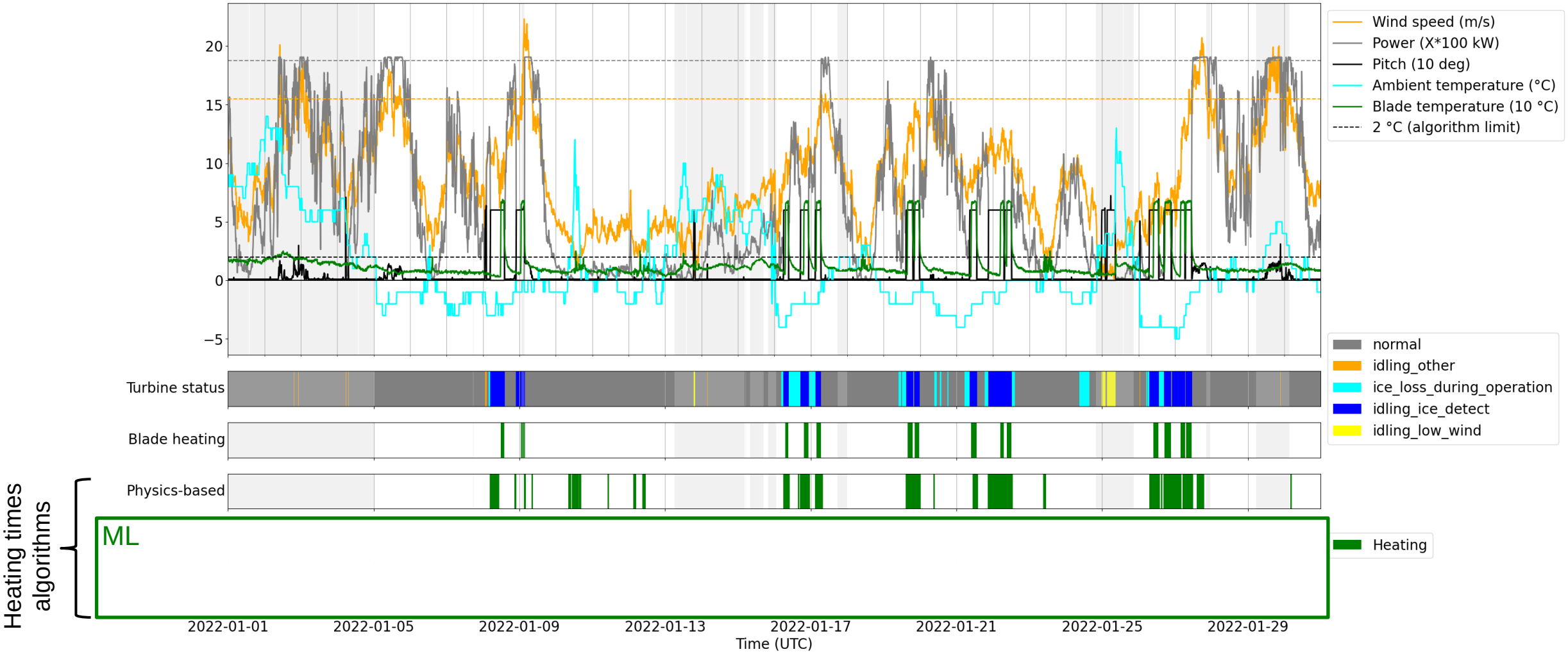


- Production losses due to false alarms during high wind speeds
- Potential production gain due to well chosen heating during icing
- No missed period during which heating was active

Smart control for blade heating systems – physics or machine learning?

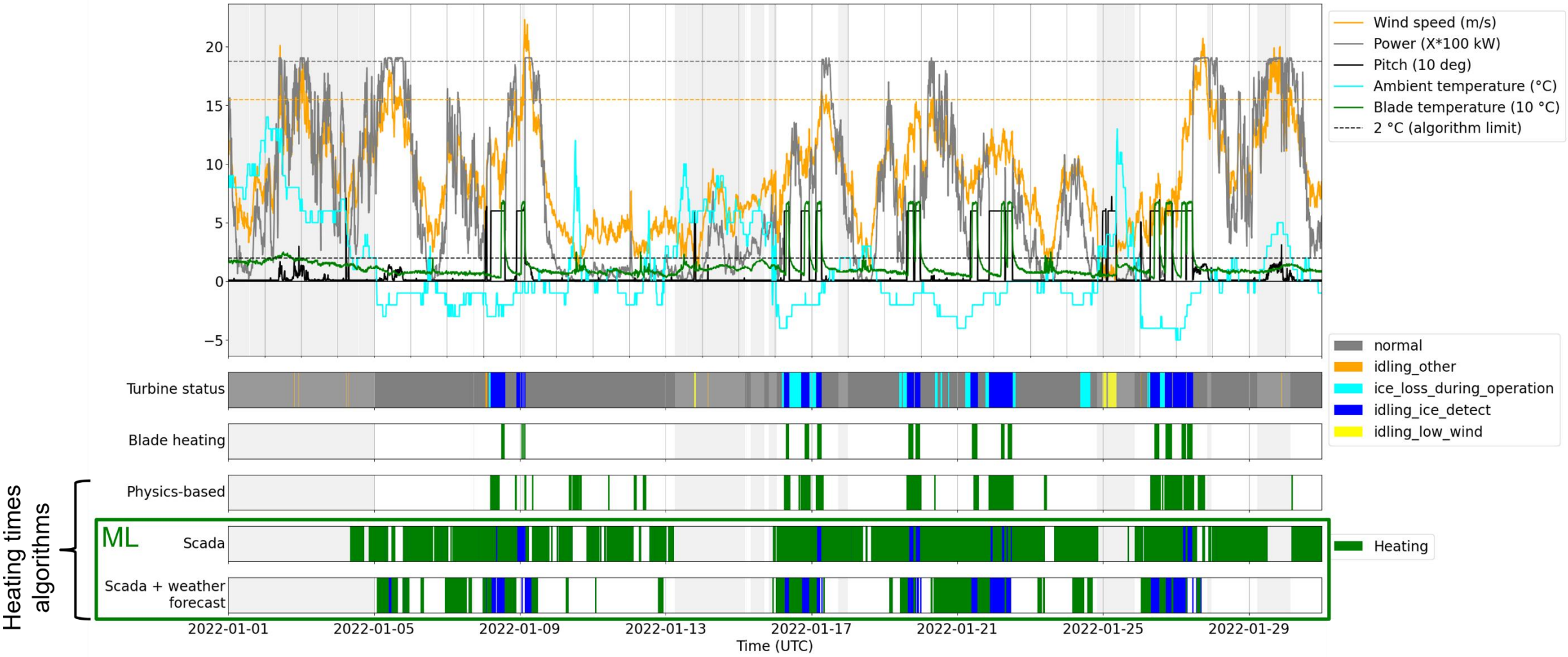
Physics vs. machine learning

Physics vs. machine learning



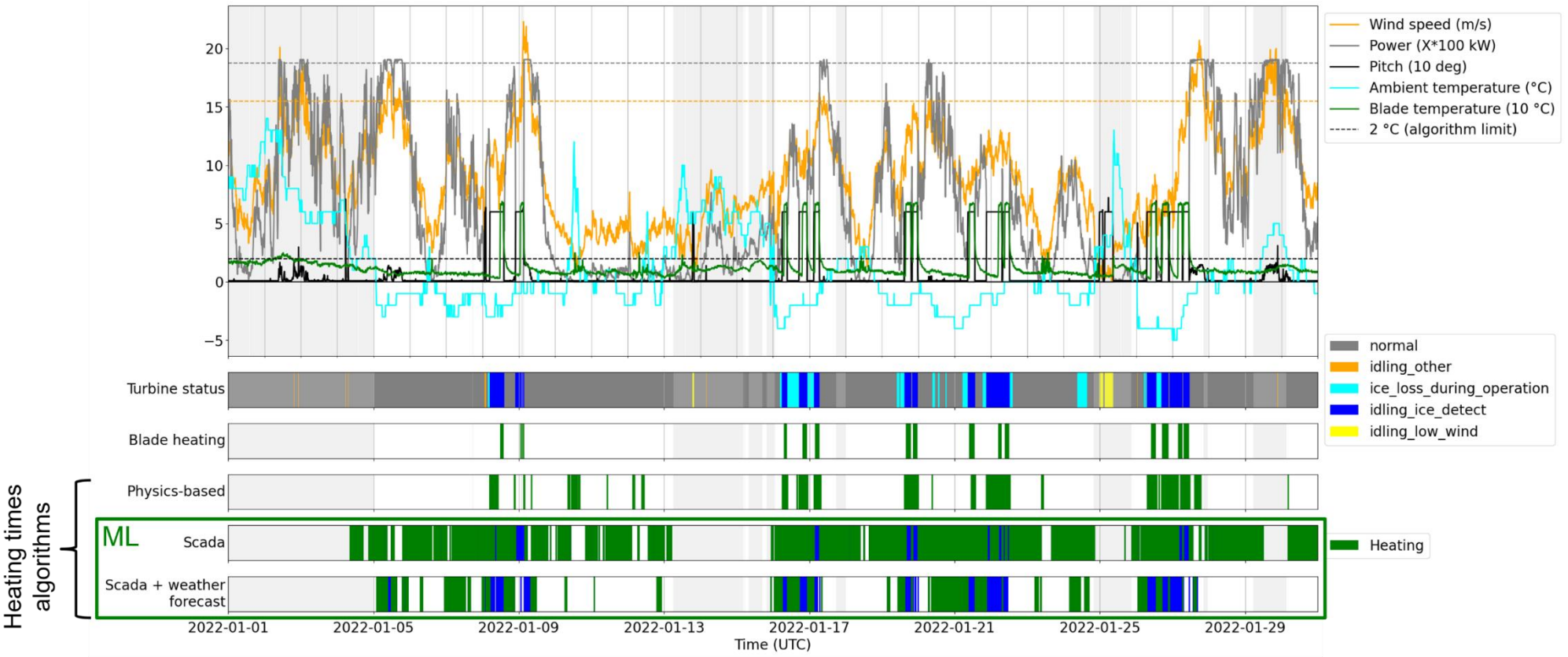
ML: machine learning

Physics vs. machine learning



ML: machine learning

Physics vs. machine learning



- More frequent icing predicted in ML vs. measurements
- Reduced icing prediction with forecast
- More heating times in ML algorithm vs. physically-based algorithm

ML: machine learning

Smart control of BHS – Physics or machine learning?

- Historic and real-time prediction of best heating periods
- Reasonable results with respect to default heating / icing periods
- More frequent icing/heating in ML vs. physically-based algorithm

Outlook: - Validate results and refine parameter settings
- Test and adapt algorithm for other wind parks (SOPWICO)

Thanks to:

SOWINDIC – Smart Operation of Wind Turbines under Icing Conditions

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Verbund
University of Vienna
Austrian Institute of Technology

SOPWICO – Smart Operation of Wind Power Plant in Cold Climate

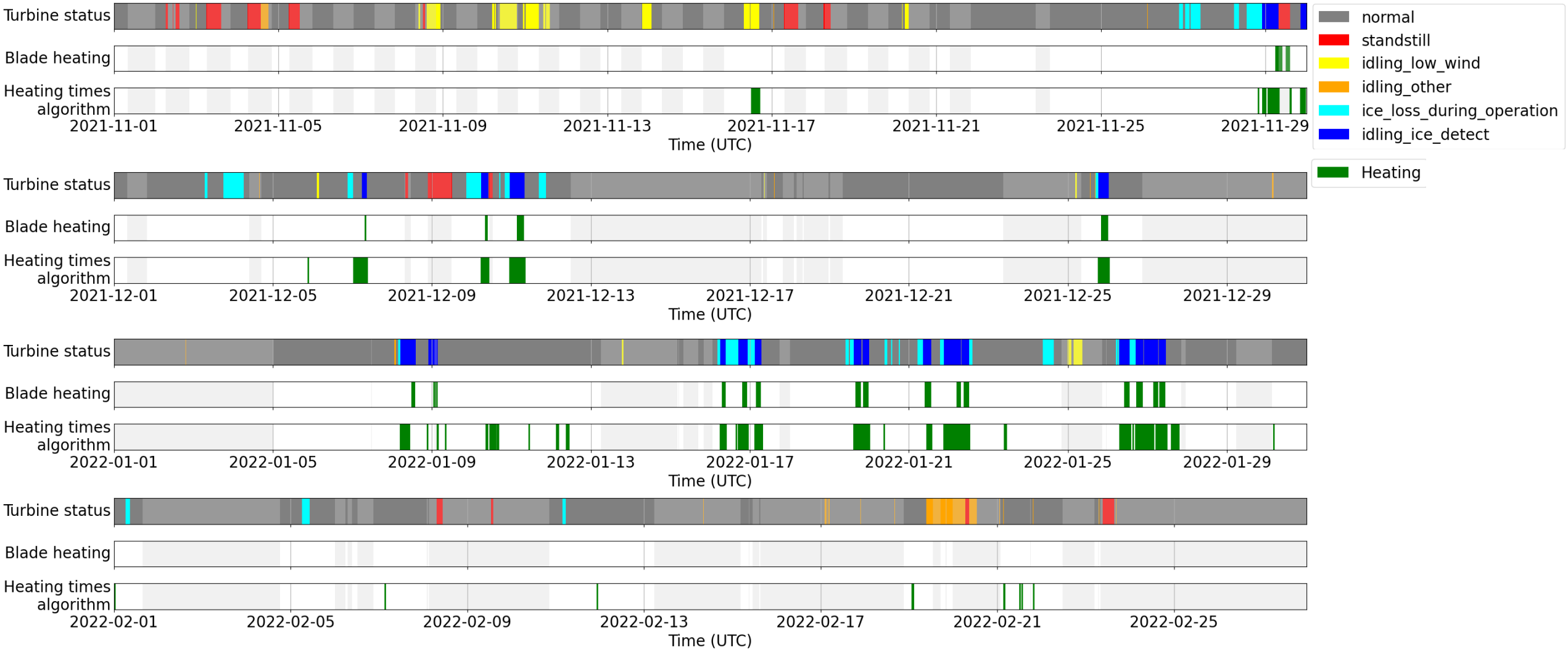
Financed: VGBE partners
Data sharing and financing partners:
BKW, CGNEE, Vattenfall, Verbund
Financing partners:
EVN, fortum, SWM, steag
Weblink: https://www.vgbe.energy/en/news/sopwico-wpp-cold-climate/

Questions?

Meteotest

www.meteotest.ch

Heating predictions for the November 2021-February 2022



Heating predictions for the November 2021-February 2022