Evaluation of Vestas De-Icing System

Federal Ministry
Republic of Austria
Transport, Innovation
and Technology

IEA FORSCHUNGS KOOPERATION

energiewerkstatt
VEREIN & TECHNISCHES BÜRO FÜR ERNEUERBARE ENERGIE

- Site and turbine description
- Methodology
- Examples for icing events
- Results / Conclusions

Turbine Description

Wind turbines:

2 WT:
- Vestas V112 – 3.3 MW
- Hub height 140 m
- With blade heating
- Erected in 2016

6 WT:
- Vestas V90 – 2 MW
- Hub height 105 m
- Without blade heating
- Erected in 2005

Ice detection system
- Power curve method
- BLADEControl ice detection system (on each turbine)
- In Austria, wind turbines are not allowed to operate with iced blades!

Vestas De-Icing System

Vestas De-icing System (VDS)

- Hot Air Installation (HAI) in the root section plus air ducting in the blade.
- Power per blade: 35 kW (rated), 50 kW (max), 47 kW (actual average).
- Power transmission system to make electrical connection from the nacelle to the hub (stopped rotor).

Operational mode

- Started either automatically by the ice detection system or through manual intervention.
- A heating cycle last for two hours: 90 min heating + 30 min cool-off.
- Simultaneous for all blades.

According to wind farm operator, the blades are usually ice-free after a heating cycle.

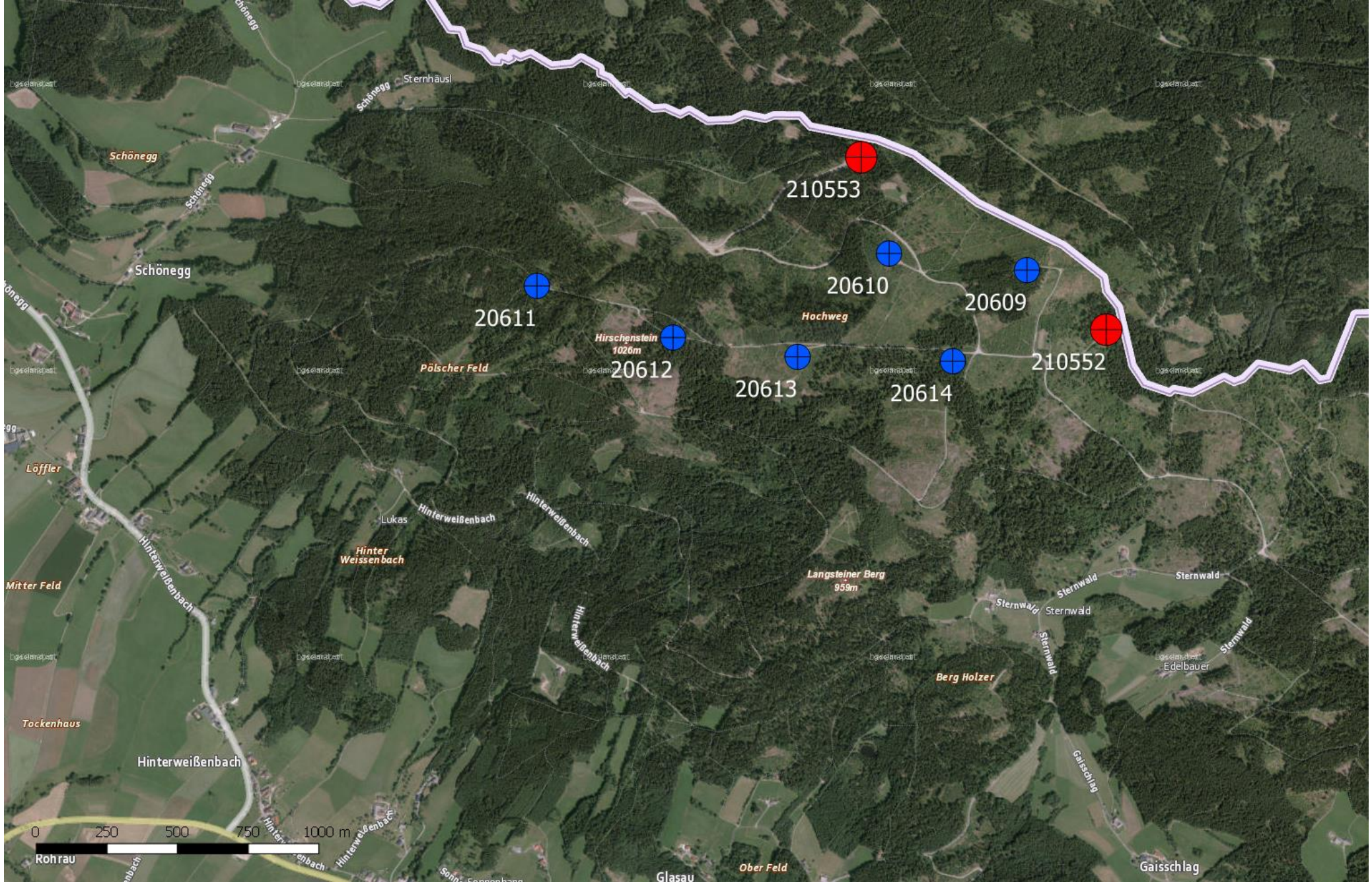
Information according to Vestas system description.

Site Description I

- Elevation of about 1000 m.
- 35 to 45 icing events per year.
- Instrumental icing of 9% to 12% of the year.

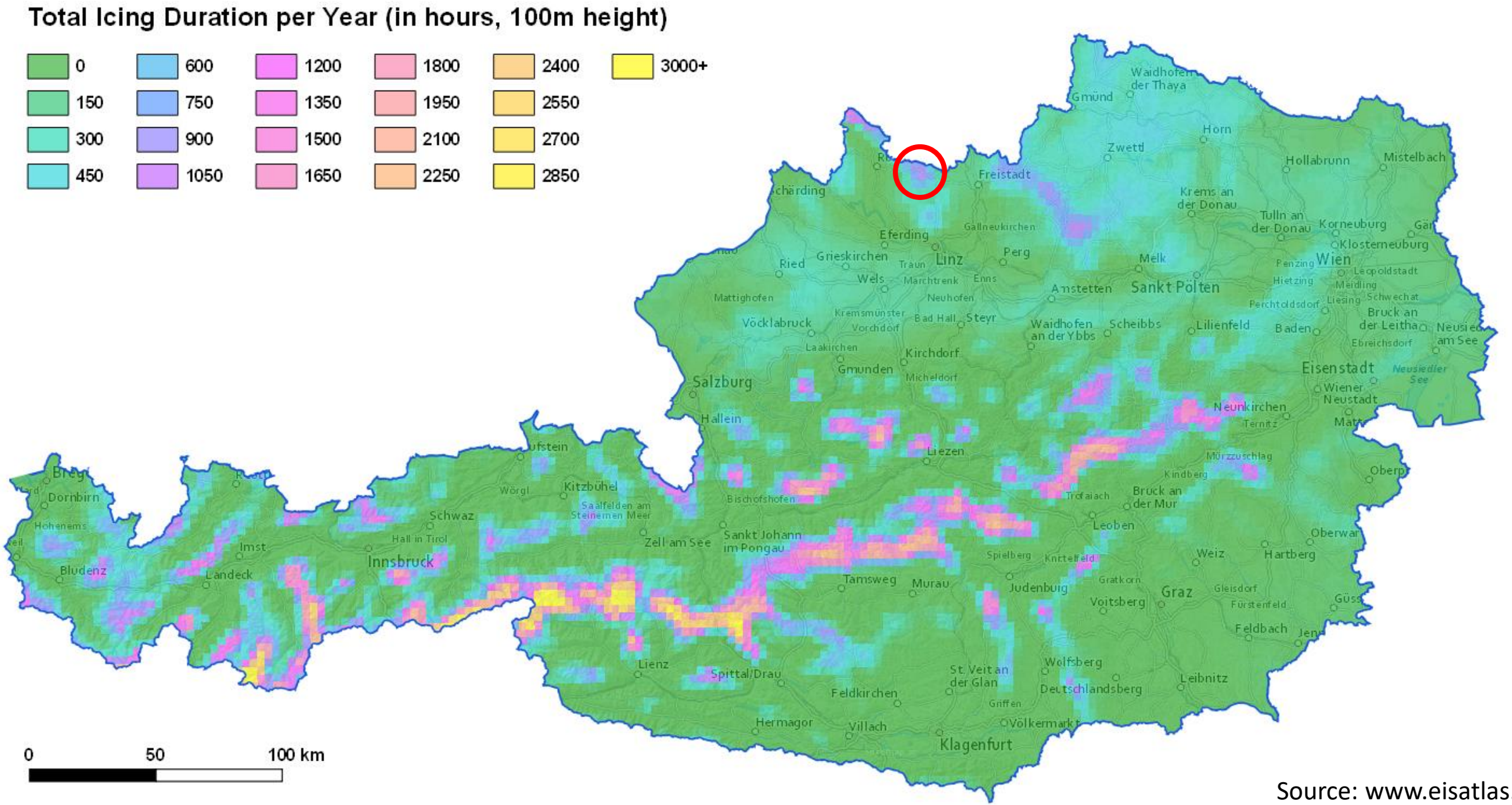
  => **IEA icing class 3**

- Well-suited for the evaluation:
  -> (comparatively) severe icing.
  -> High demands on the blade heating system.
  -> Turbines w/ and w/o blade heating in immediate vicinity.



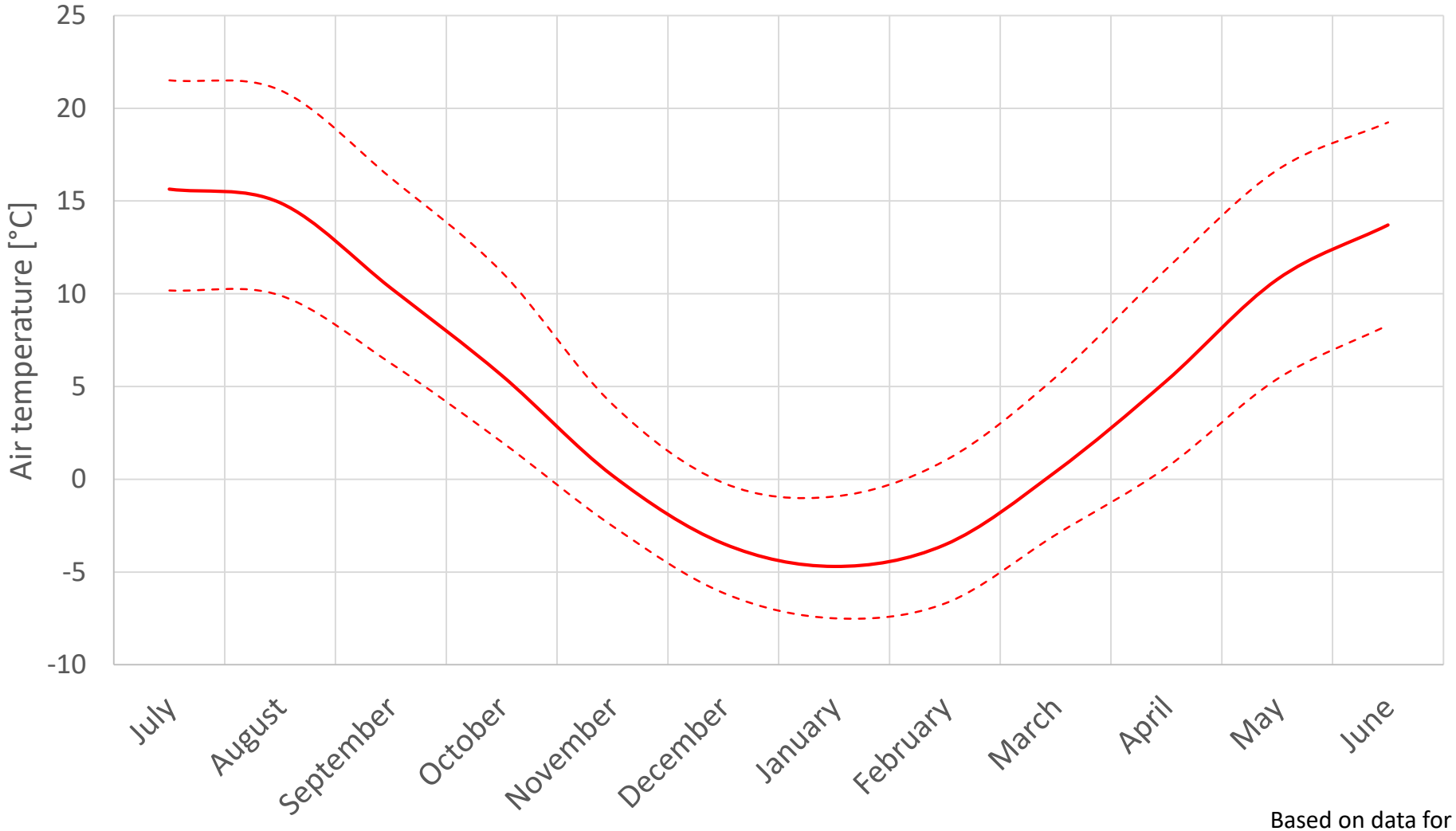
Red: V112 w/ blade heating

Blue: V90 w/o blade heating



Source: www.eisatlas.at

Site Description II



Based on data for 1981 – 2010.
Monthly means of daily highs, lows and averages, extrapolated for 1000 m elevation.

Methodology I

Data basis

- Observation period: 2017-01-01 to 2017-05-01 and
  2017-10-01 to 2018-05-01
- 10-min averaged time series for wind speed & direction (nacelle anemometer), power, nacelle position.
- Turbine and blade heating logs.
- Operational experience through private communication.

Procedure

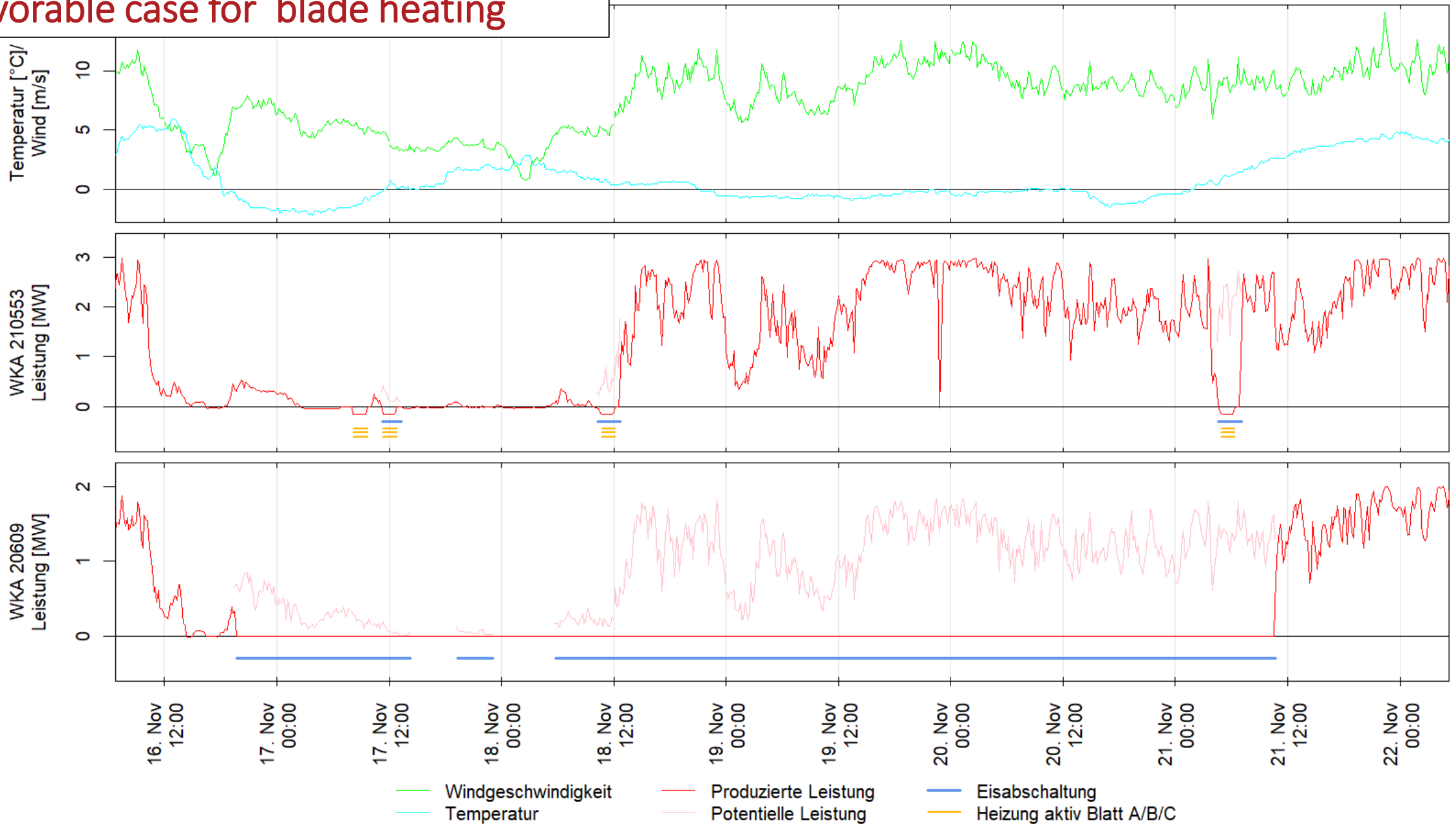
- Expected power from power curves and wind speeds.
- Clean power curves for V90 and V112 (individual, unidirectional).

Methodology II

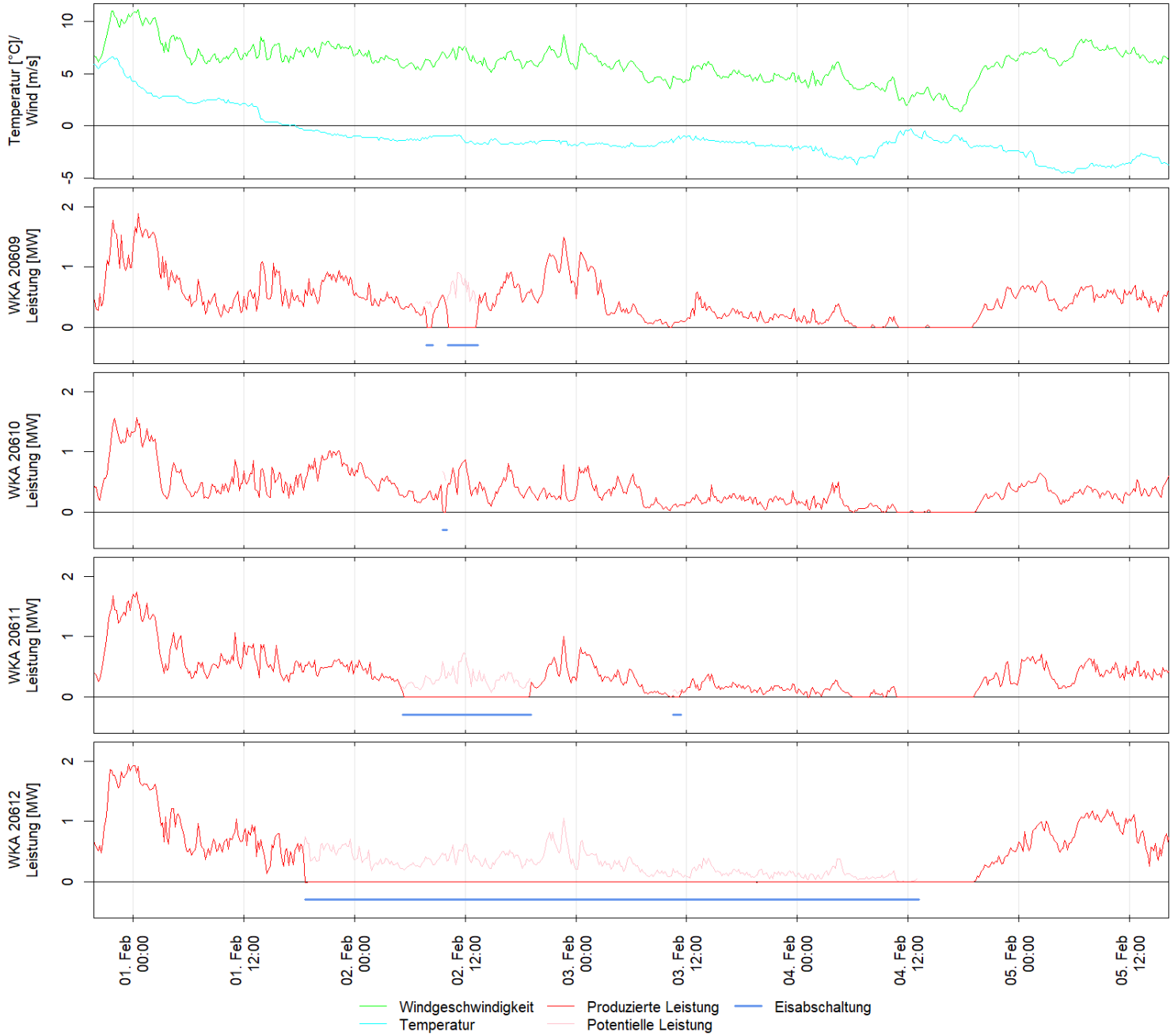
Errors from nacelle anemometry

- Calculation of icing losses is based on nacelle anemometers.
- Errors in the transfer function to the free wind (and other anemometer errors) cancel-out to a some degree.
- To compute icing losses one compares wind speeds from operating WT (power curve) and stopped WT.
- Careful comparison of pairs of WT, one operational, one stopped due to icing, revealed on average a -0,4 m/s deviation in measured wind speed. (only for V90!)

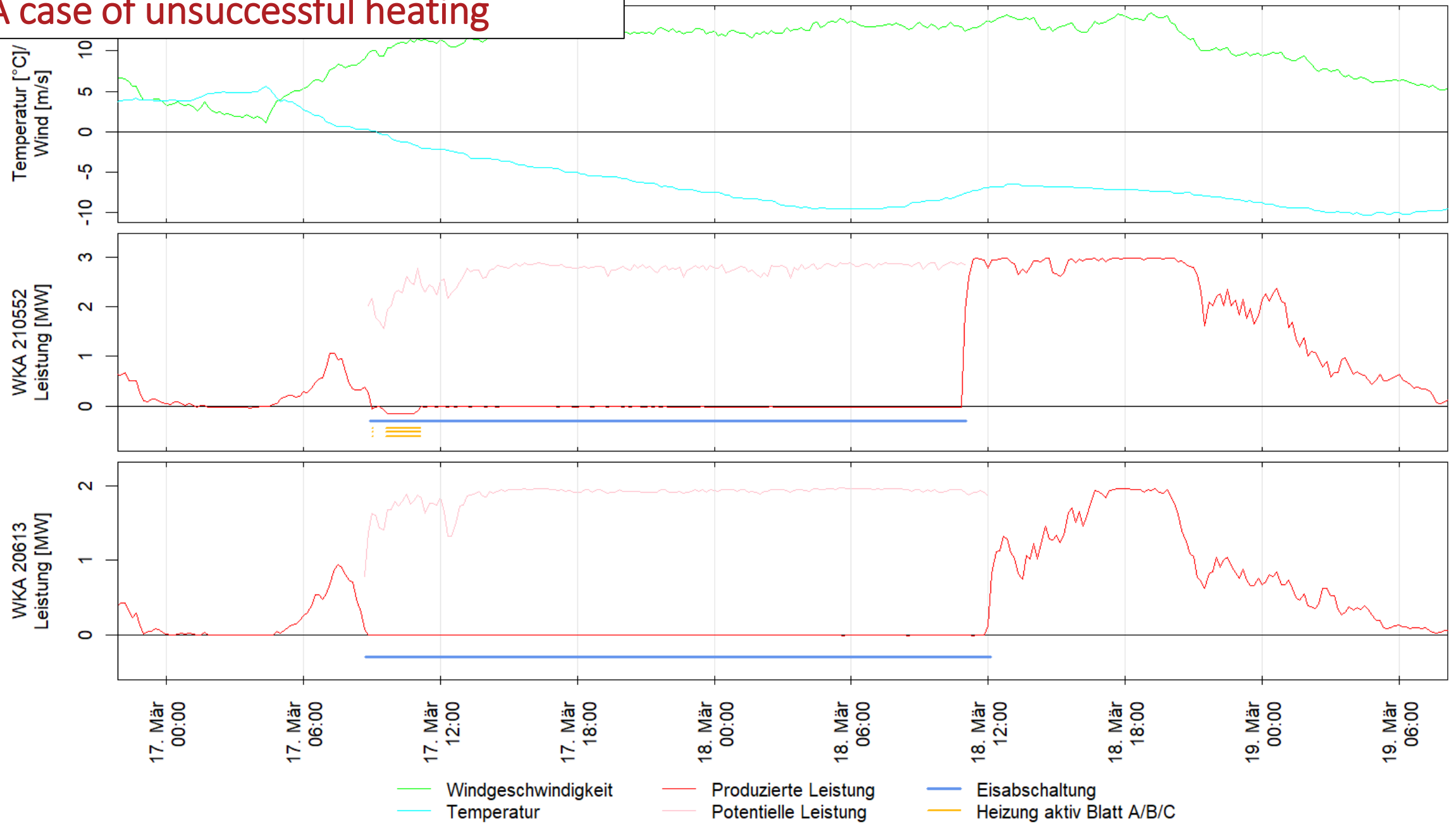
A favorable case for blade heating



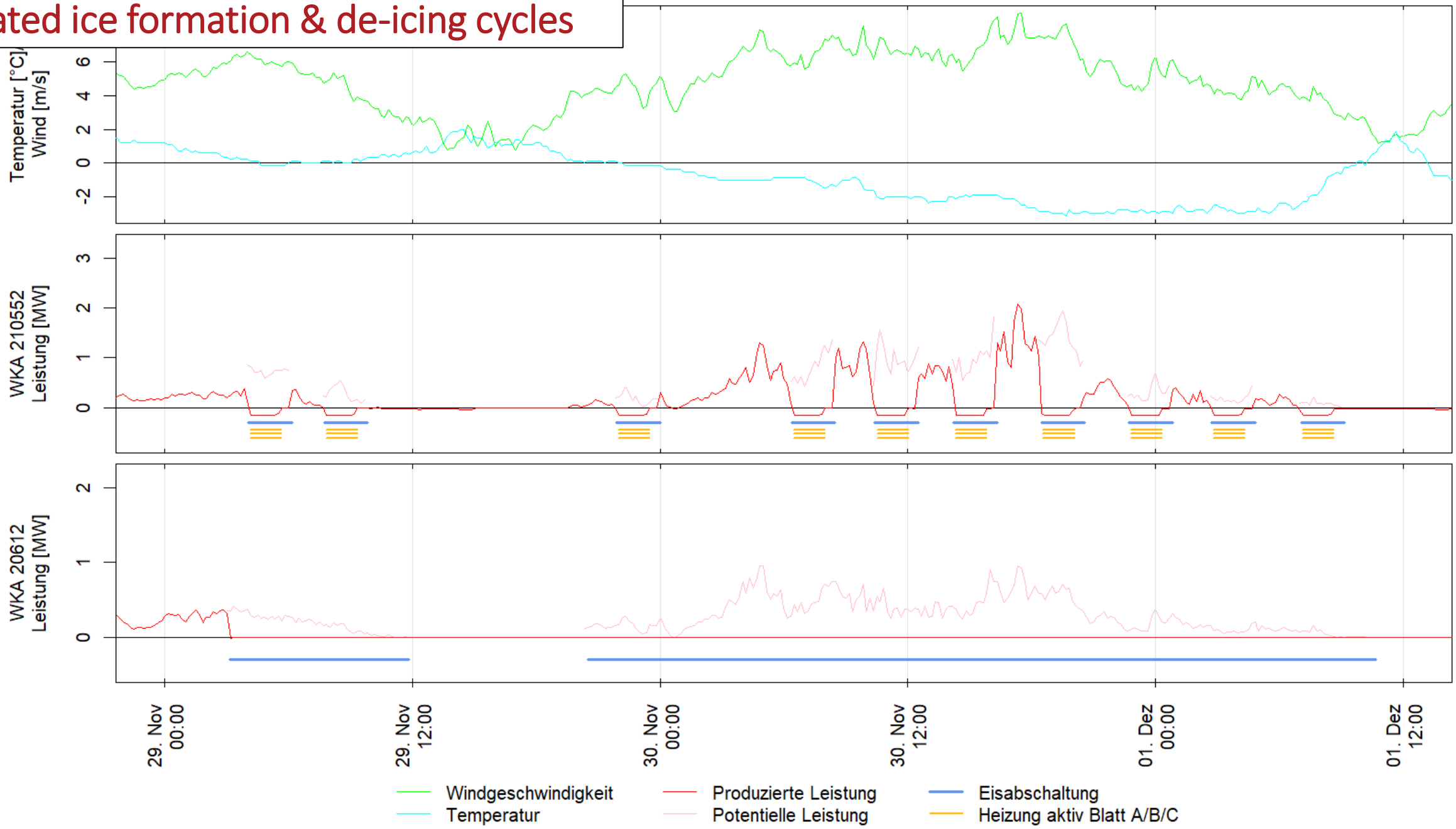
Different Icing on individual turbines



A case of unsuccessful heating



Repeated ice formation & de-icing cycles



Results

Turbine ID	Number of icing events total	Number of icing events per winter	Icing duration total [h]	Icing duration per winter [h]	Icing losses total [MWh]	Icing losses per winter [MWh]	Icing losses per winter and MW installed power [MWh]
20609	69	44	1343	855	1020	649	325
20610	57	36	1226	780	792	504	252
20611	64	41	1479	941	892	568	284
20612	70	45	1625	1034	1111	707	353
20613	41	26	1335	849	847	539	270
20614	55	35	1550	986	966	615	307
210552	171	109	570	363	611 (631)	389 (405)	130 (135)
210553	163	104	647	412	730 (749)	465 (479)	155 (160)
Average V90	**59**	**38**	**1426**	**908**	**938**	**597**	**298**
Average V112	**167**	**106**	**609**	**387**	**670 (690)**	**427 (442)**	**142 (147)**

Numbers in brackets include energy expended in blade heating

Results & Conclusions I

- Reduced icing duration (=downtime) by 57%
  (from 908 h to 387 h per year).
- More than twice as much ice detections and turbine stops
  (106 vs. 38 per year).
- Serval cycles of blade icing and de-icing under persistent icing conditions.
- For turbines with blade heating, the average icing (shutdown) duration is 3.6 hours (of which de-icing procedure takes 2 hours).
- For the turbines without blade de-icing, the average duration of icing-shutdowns is about 24 hours.

Results & Conclusions II

- Reduction of the production losses due to icing 51%.
- Increases of the annual energy yield equivalent to 151 full load hours.
  (These numbers already include the energy consumption of the heating system)
- Operation of the heating system usually leads to ice-free rotor blades.
- The maximum heating capacity of the de-icing system was no serious limitation. 87% of the time when icing occurred, wind and temperature conditions were within the specified operational limits.
- The balance of produced energy and energy used for blade heating is generally clearly positive, also for phases with repeated icing and de-icing and at moderate wind speeds.

Thank You!

Link to public report in German and English:
nachhaltigwirtschaften.at/de/iea/publikationen/iea-wind-task-19-summary-evaluation-vestas-deicing-system.php