Wind Energy in Cold Climate
- experiences from Sweden
and the world!

Winterwind 2015 in Piteå

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Sales Manager
Sales Sweden

Content

1.1 ENERCON: financial stability

ENERCON
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EULER HERMES

RATING CERTIFICATE

Euler Hermes Rating GmbH
performed an extensive, neutral and independent evaluation
of the creditworthiness and sustainability of the

Enercon-Gruppe

The evaluation consisted of an analysis in all areas of the corporation including the financial situation, a market analysis, an analysis of strategy and corporate planning as well as management and organization.

In summary, Euler Hermes Rating GmbH assesses the corporate rating of Enercon-Gruppe based on information provided until June 2nd, 2014

EULER HERMES AA- RATING

The result of the rating analysis is documented in a rating report.

Hamburg, June2nd, 2014

Euler Hermes Rating GmbH

Ralf Garm
Managing Director

Aloys-Wobben-Stiftung
Energie für die Welt

1.2 ENERCON global installed capacity

- ENERCON has installed over 37 000 MW worldwide
- In Sweden: 623 turbines (975 MW)
- We are active on many markets where special technology for de-icing and cold climate is needed/required
- For instance, Scandinavia, Central Europe (Germany, Switzerland, Czech Republic), Canada, Antarctica
- We have gained lots of experience (together with Deutsche Windguard and Meteotest) from different sites with different icing conditions

1.3 ENERCON Cold Climate experience on a global level

Andermatt, Switzerland

Antarctica

2.1 ENERCON Cold Climate Package

If the wind energy converter is configured for the Cold Climate option, the parameter P2010 *Cold Climate* is set to *on* in the wind energy converter software. This changes the power curve as follows compared with normal operation:

The power curve during WEC operation is not affected at temperatures above -30 °C. Below this temperature, maximum wind energy converter power is gradually reduced to 25 % until a temperature of -40 °C is reached. At temperatures lower than -40 °C, the wind energy converter is stopped and remains ready for operation. It will be restarted as soon as the temperature has risen to -35 °C.

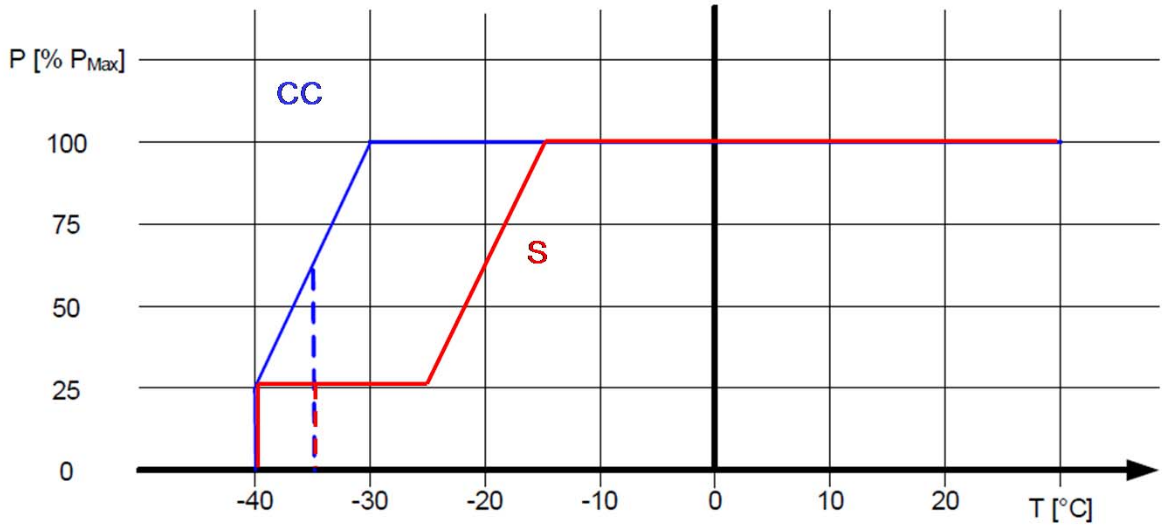
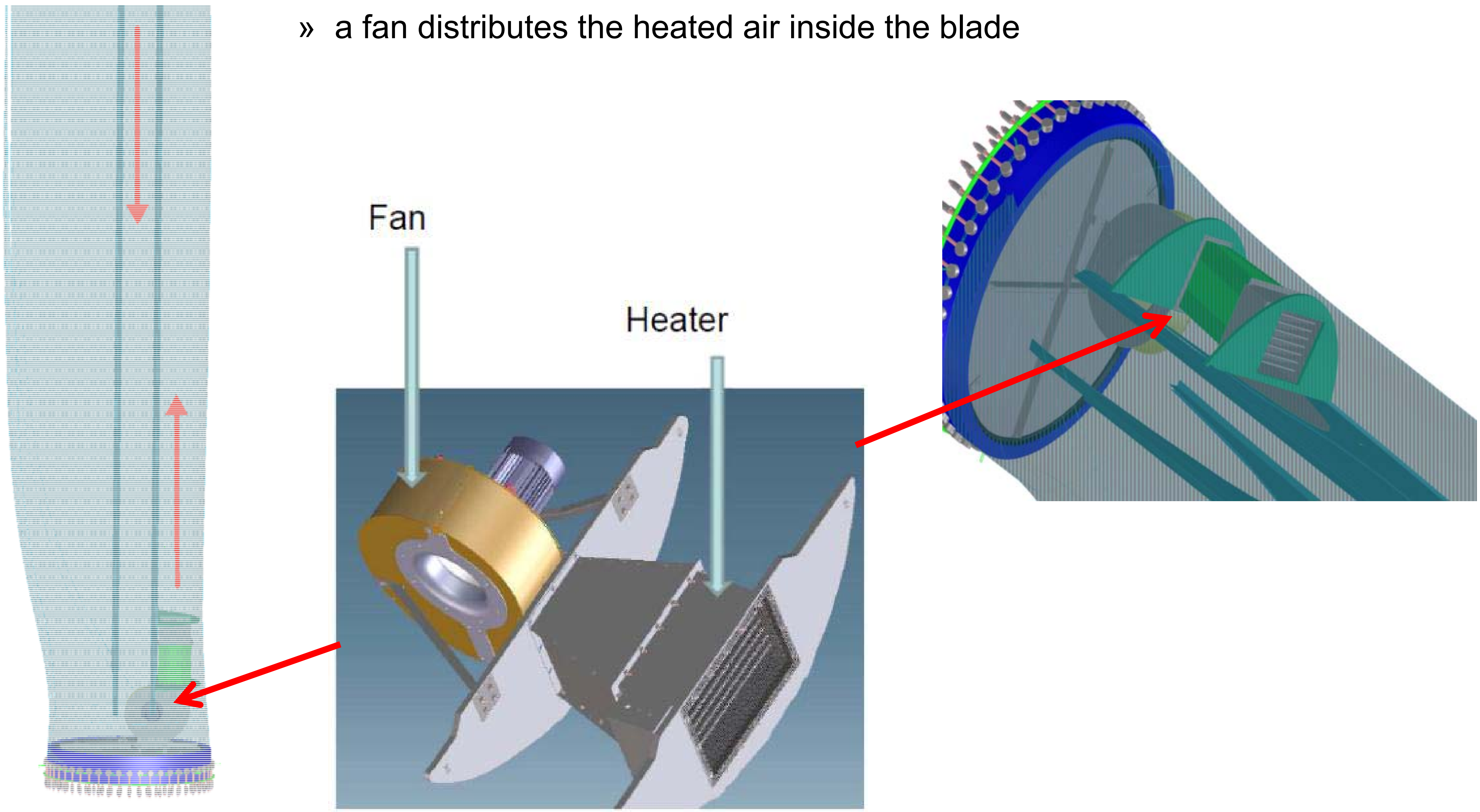


Fig. 1: Characteristic curve Cold Climate option

2.2 Hot air system

- heating elements heats up the air to a maximum of 72°C
- a fan distributes the heated air inside the blade



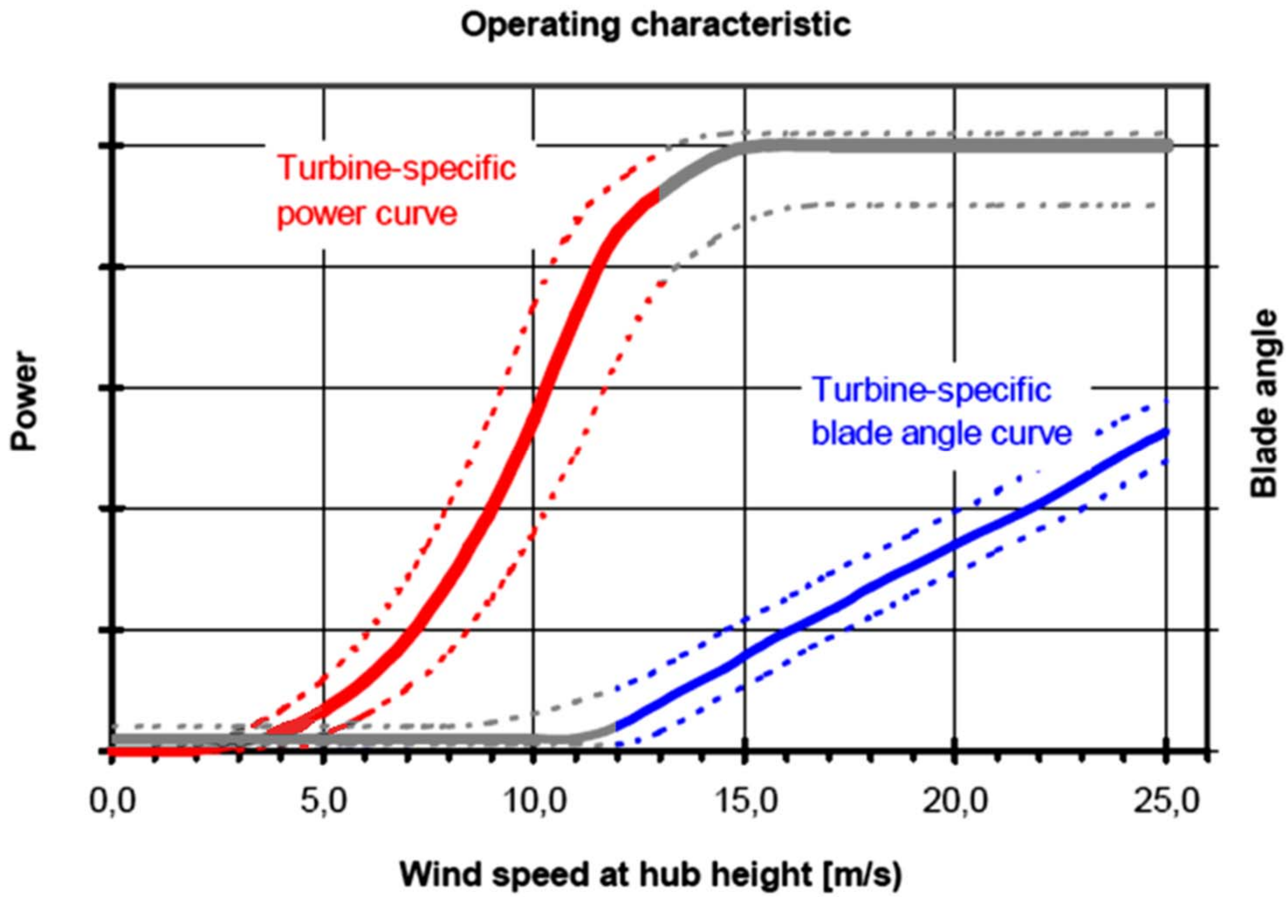
2.3 Nominal power of the RBHS

WEC type	Nominal power (per blade)	Rated power
E-44, E-48, E-53	15,2 kW	900, 800, 800 kW
E-70 E4	22,7 kW	2/2,3 MW
E-82	29 kW	2/2,3 MW
E-92	43 kW	2,3/3 MW
E-101	74,3 kW	3 MW
E-115	74,3 kW	3 MW

2.4 Ice detection system – functional principle

Red graph
- Power curve method (below rated power)
  - Deviations from the power curve detected and registered as ice on the rotor blades

Blue graph
- Blade angle method (at rated power)
  - Deviations from the blade angle compared to the wind speed detected and registered as ice



2.5 Ice detection system – proofed by TÜV Nord

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External export report from TÜV Nord available

Functionality valuation of ice detection system to prevent ice throw

TÜV NORD SysTec GmbH & Co. KG
Energie- und Systemtechnik
Zertifizierungsstelle für Windenergieanlagen

TÜV NORD

Hamburg, 31.10.2014

Gutachten

Zur Bewertung der Funktionalität von Eiserkennungssystemen zur Verhinderung von Eisabwurf an ENERCON Windenergieanlagen:

Eisansatzerkennung nach dem ENERCON-Kennlinienverfahren

TÜV NORD Bericht Nr.: 8111 084 844-2 De Rev.2

Gegenstand der Prüfung: Eiserkennung durch das ENERCON Kennlinienverfahren

Anlagenhersteller: ENERCON
Dreekamp 5 F&E
26605 Aurich
Germany

Aufsteller der Nachweise: TÜV-Nord Systec
Große Bahnstraße 31
22525 Hamburg
Germany

Dieser Prüfbericht umfasst 43 Seiten.

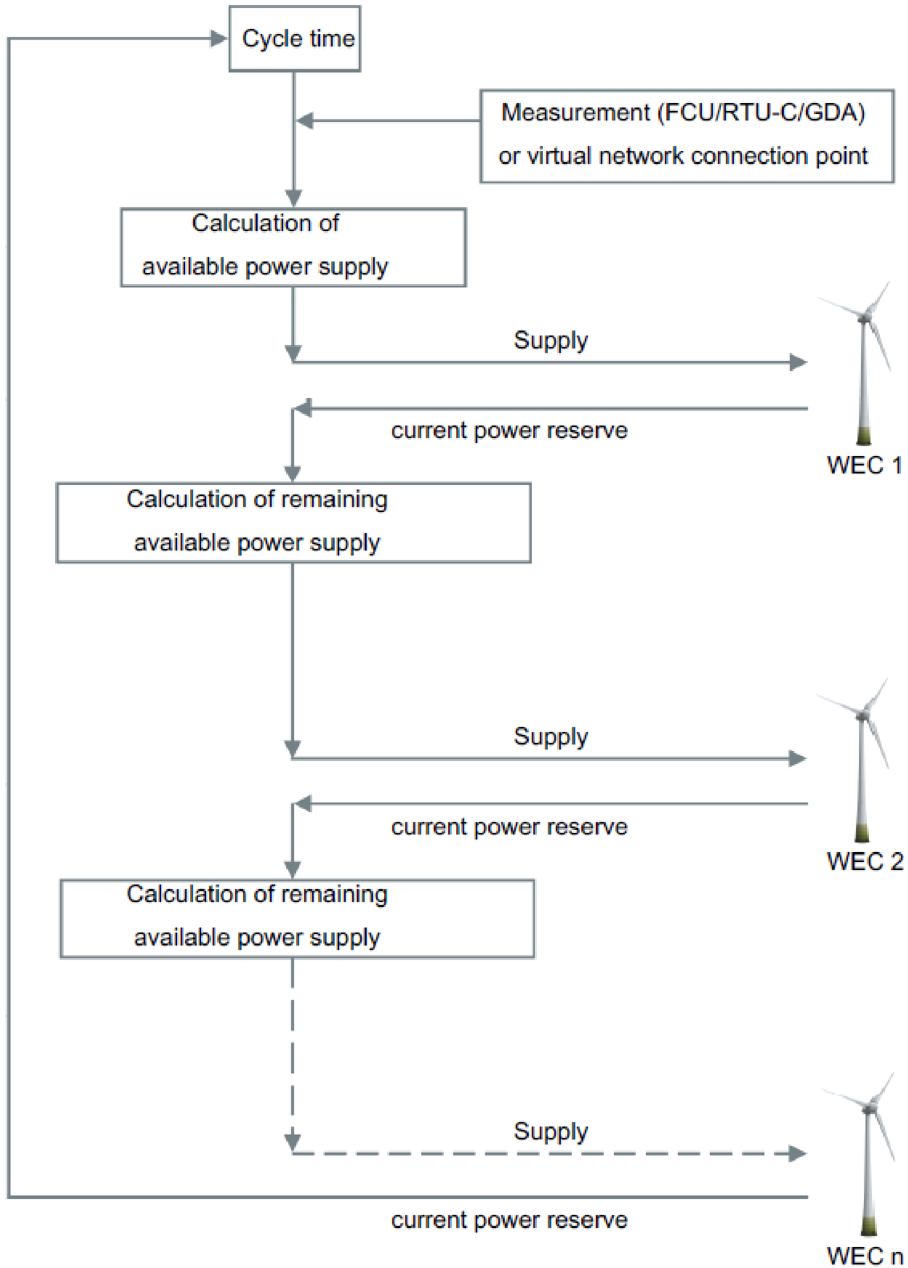
Rev.	Datum	Änderungen
0	29.10.2014	Erste Fassung
1	30.10.2014	Korrekturen
2	31.10.2014	Korrekturen

TÜV NORD CERT GmbH · Zertifizierungsstelle für Windenergieanlagen · Langemarckstr. 20 · 45141 Essen · windenergy@tuev-nord.de

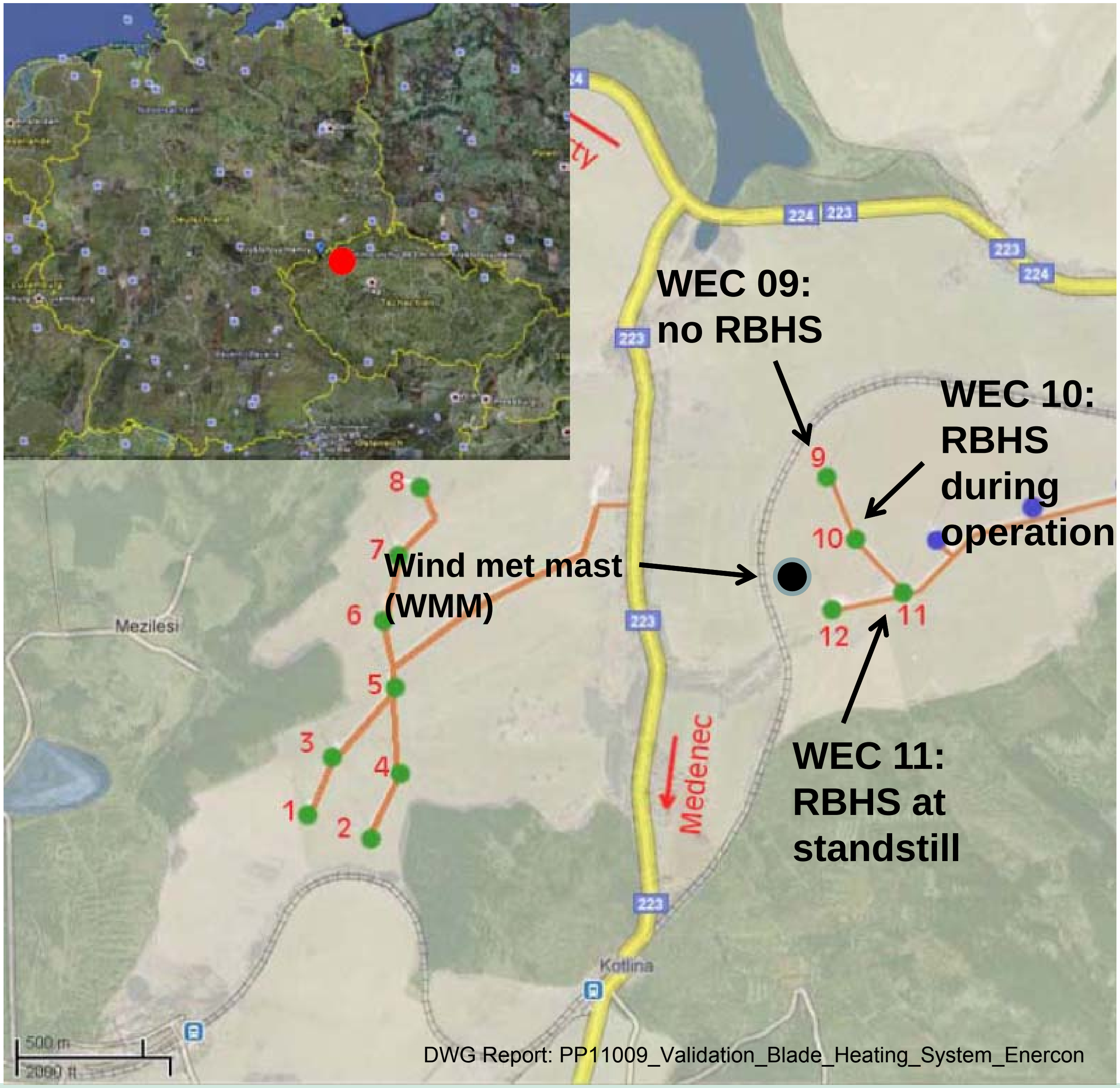
2.6 Power consumption management

- SCADA software limiting maximum power consumption RBHS in wind farm
- Target:
  prevent RBHS consumption out of electrical grid (expensive)
- Advantages:
  - Control and limit peak power consumption
  - Avoid associated penalties from grid operator

    (e. g. consumption for RBHS during icing period and lack of wind)
- Procedure:
  cascaded switch on of single turbines according to available wind farm internal power production



3.1 Krystofovy Hamry – E-82 with 78m HH



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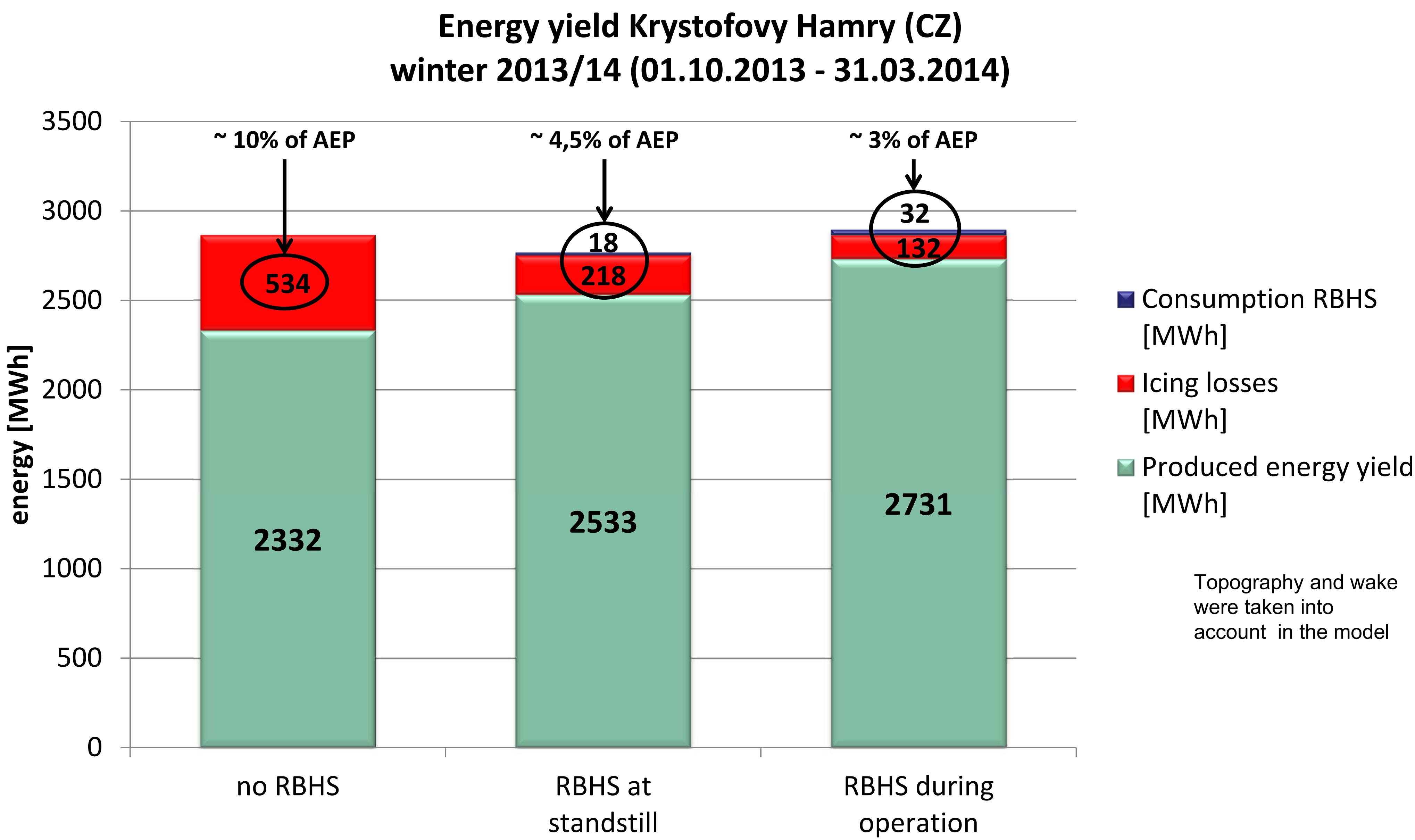
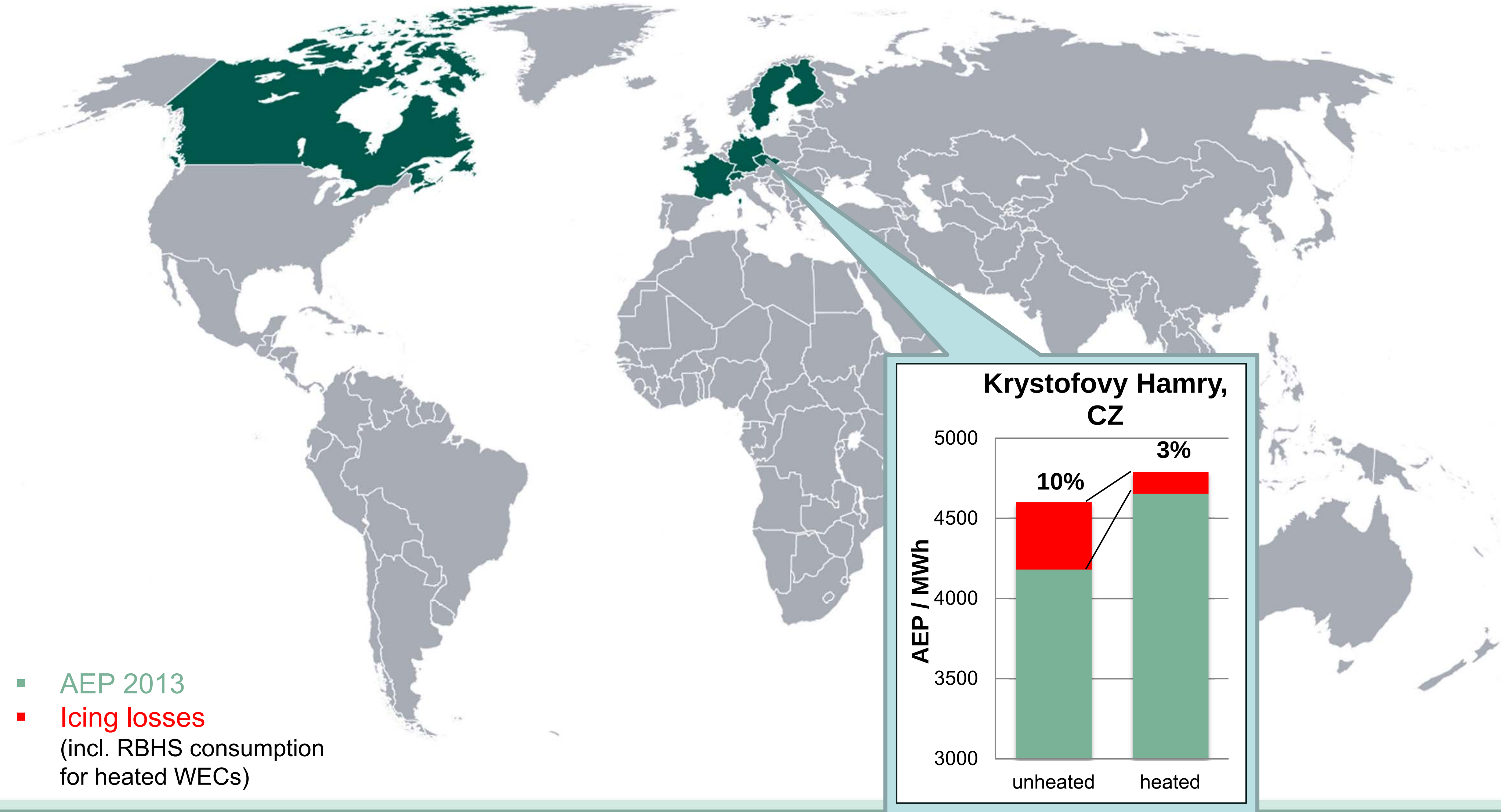


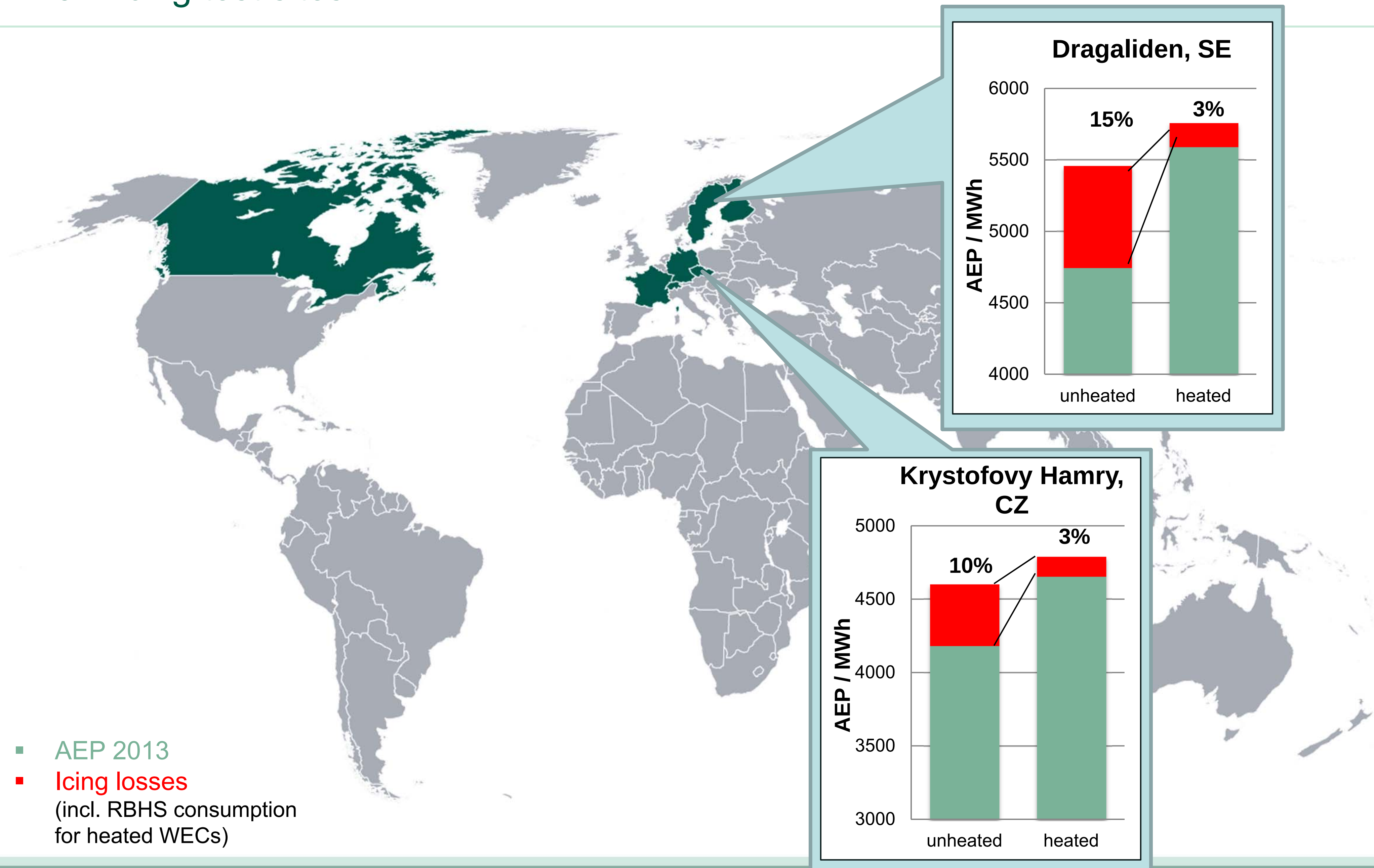
Topography and wake were taken into account in the model

3.3 Icing test sites



- AEP 2013
- Icing losses
  (incl. RBHS consumption
  for heated WECs)

3.4 Icing test sites



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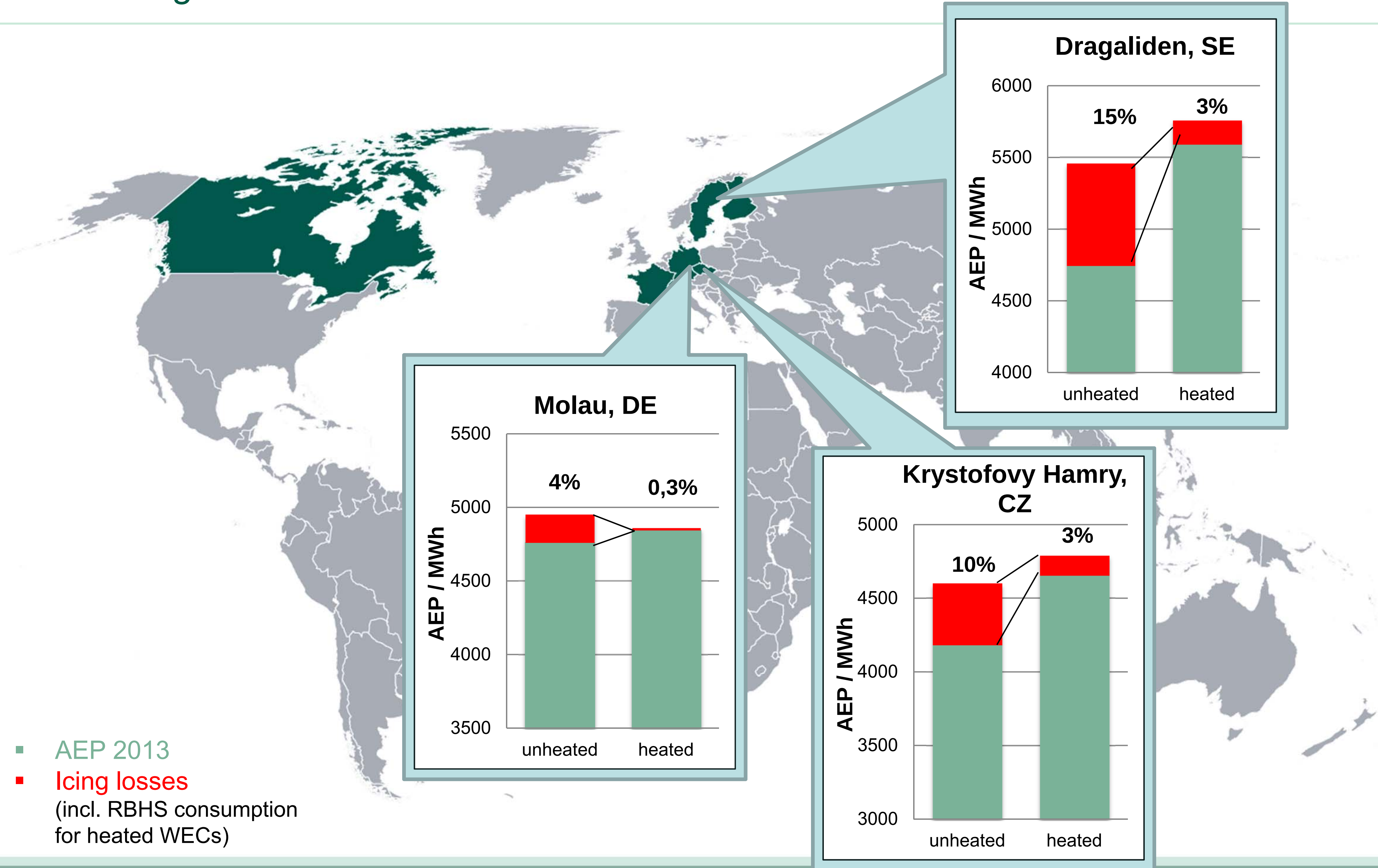

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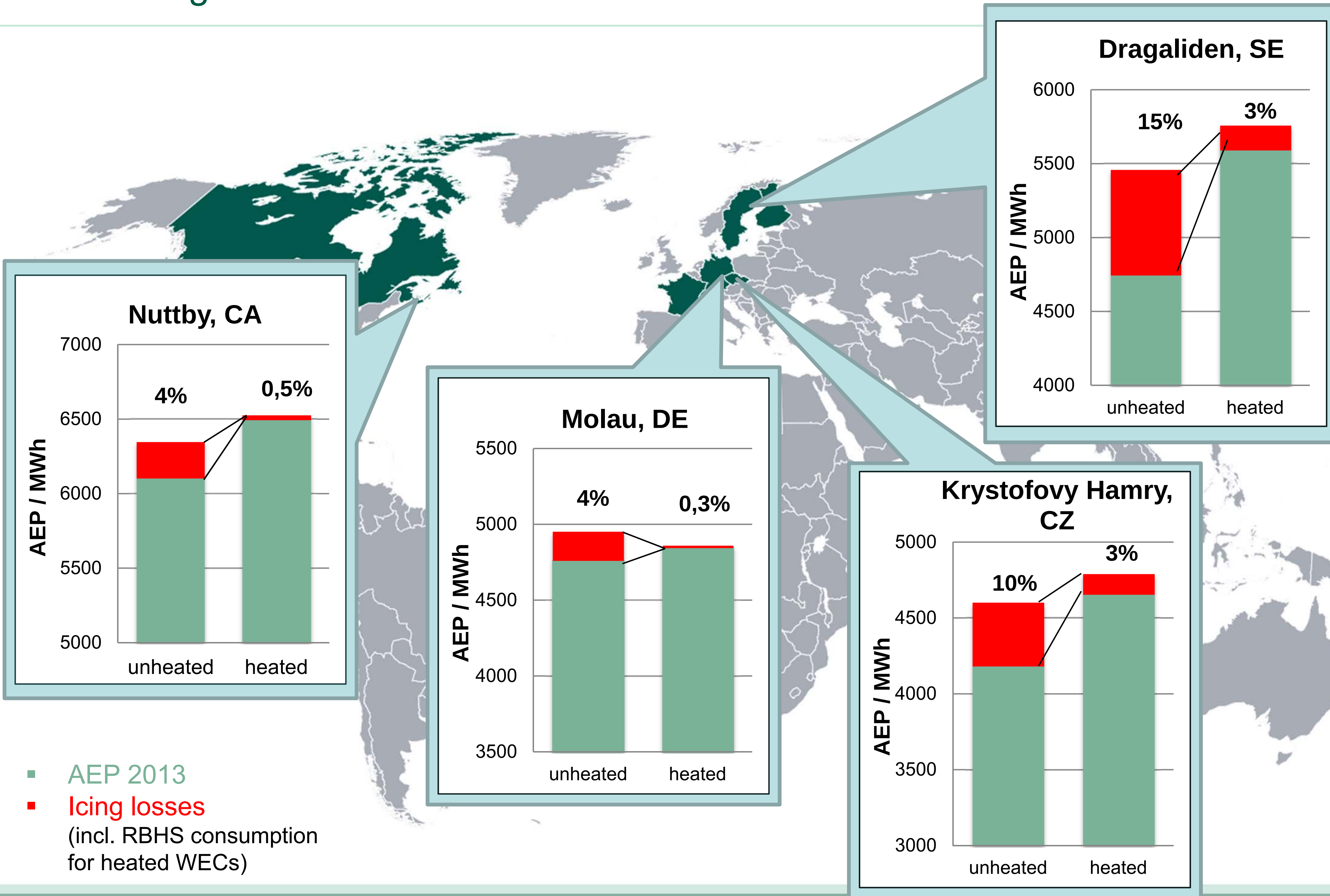

- AEP 2013
- Icing losses
  (incl. RBHS consumption for heated WECs)

3.7 Icing classifications from IEA with influence of EC RBHS

IEA ice class	Meteorological icing	Instrumental icing	Production loss (WEC without RBHS)
no.	% of year	% of year	% of AEP
5	>10	>20	>20
4	5-10	10-30	10-25
3	3-5	6-15	3-12
2	0,5-3	1-9	0,5-5
1	0-0,5	<1,5	0-0,5

iea wind: expert group study

13. wind energy projects in cold climate – 1. edition 2011

3.8 Icing classifications from IEA with influence of EC RBHS

IEA ice class	Meteorological icing	Instrumental icing	Production loss (WEC without RBHS)	**Production loss (WEC with RBHS, consumption incl.)**	**Validation**
no.	% of year	% of year	% of AEP	**% of AEP**	**Site**
5	>10	>20	>20	**>4**	**-**
4	5-10	10-30	10-25	**1,5-5**	**Krystofovy Hamry (CZ)* Dragaliden (SE)* Gabrielsberget (SE)**
3	3-5	6-15	3-12	**0,5-3**	**St. Brais (CH) Nuttby (CA)**
2	0,5-3	1-9	0,5-5	**0-1,5**	**Molau (DE)***
1	0-0,5	<1,5	0-0,5	**<0,5**	**-**

iea wind: expert group study
13. wind energy projects in cold climate – 1. edition 2011

Performance of ENERCON WECs

*Proved by Meteotest

Summary

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- More than 15 years experience of the RBHS!
- Well-proven ice detection system using the power curve. The Enercon RBHS uses a hot air system, heating the turbine blades from the inside.
- A newly developed „Power consumption management“ limits the power consumption of the wind park, in order to ensure net stability and avoid unnecessary fees.
- With the Cold Climate Package, the technology of the turbines are adjusted to survive harsher weather.
- The production gain due to the Enercon RBHS has been calculated using several sites, with different intensities of ice, leading to the extension of the IEA icing table with production losses using Enercon turbines with RBHS installed.

Picture: Jonas Lundmark

Thanks a lot for your attention!

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