

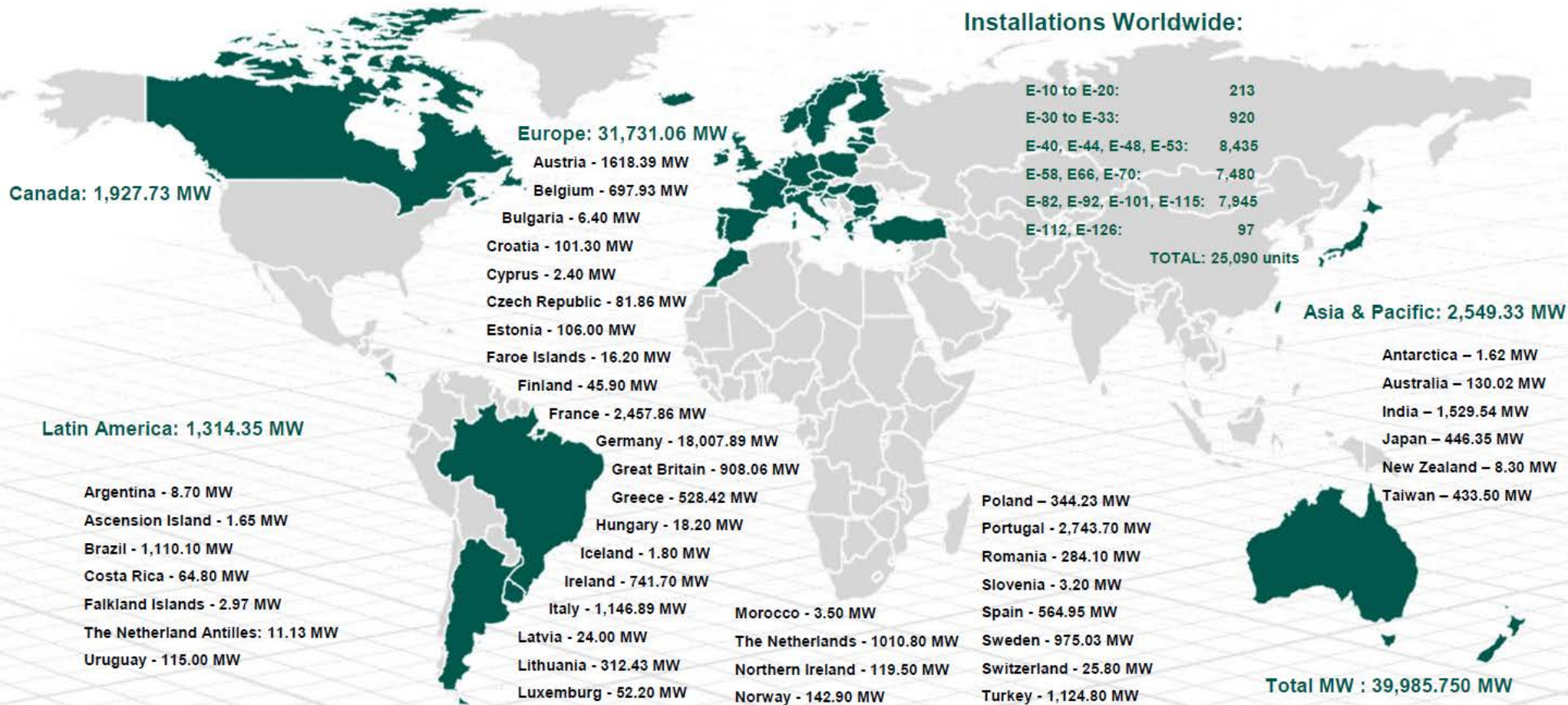
Panel discussion: Safe and reliable operation in cold climate conditions - today and in the future

Anne Mette Nodeland

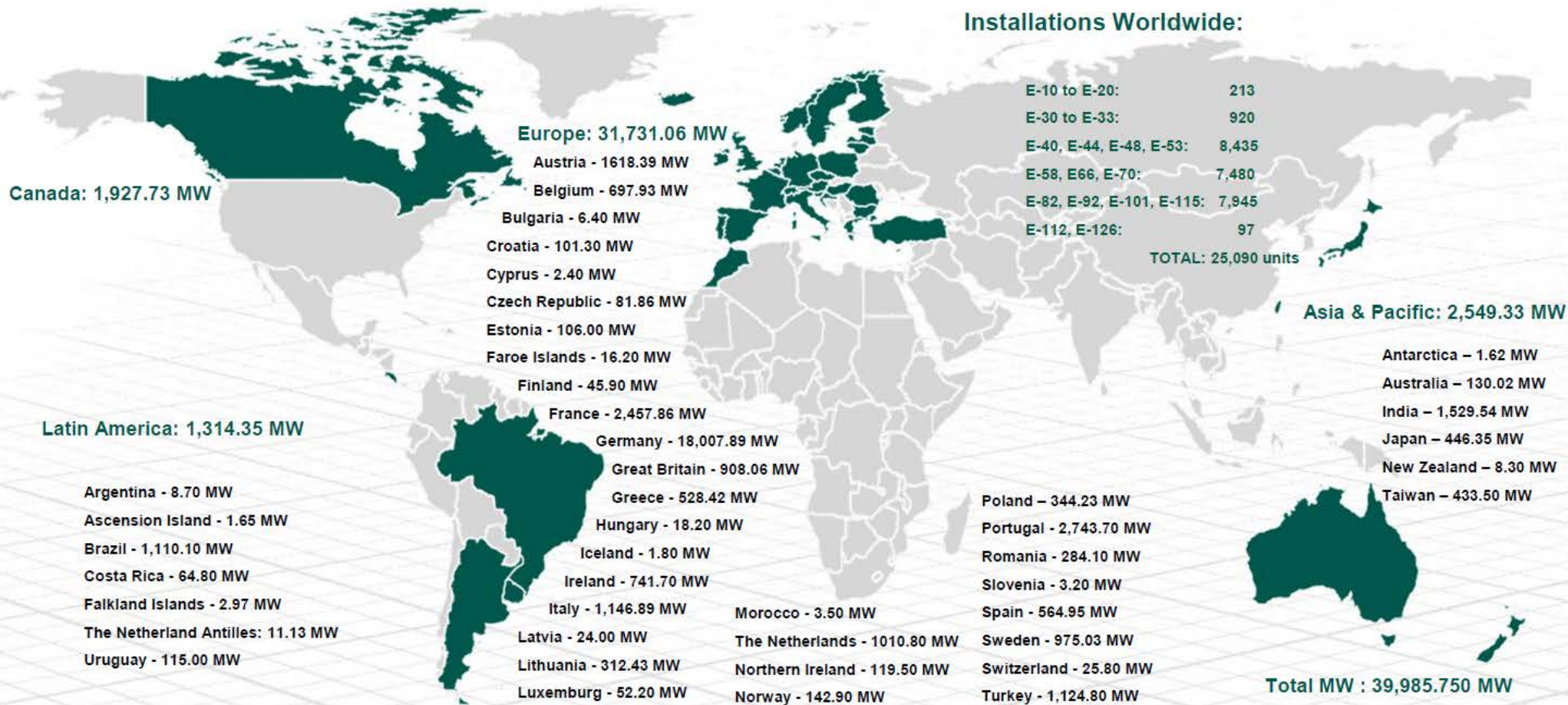
WRD Management Support GmbH

February 10th, 2016

Installed power capacity according to country



Installed power capacity according to country



Installations in countries partially affected by icing: 22,256.34 MW

Installations in countries in large part affected by icing: 4,739.17 MW

1: Ice detection system

2: Hot air blade heating system

3: Extended IEA Table

4: Cold climate package

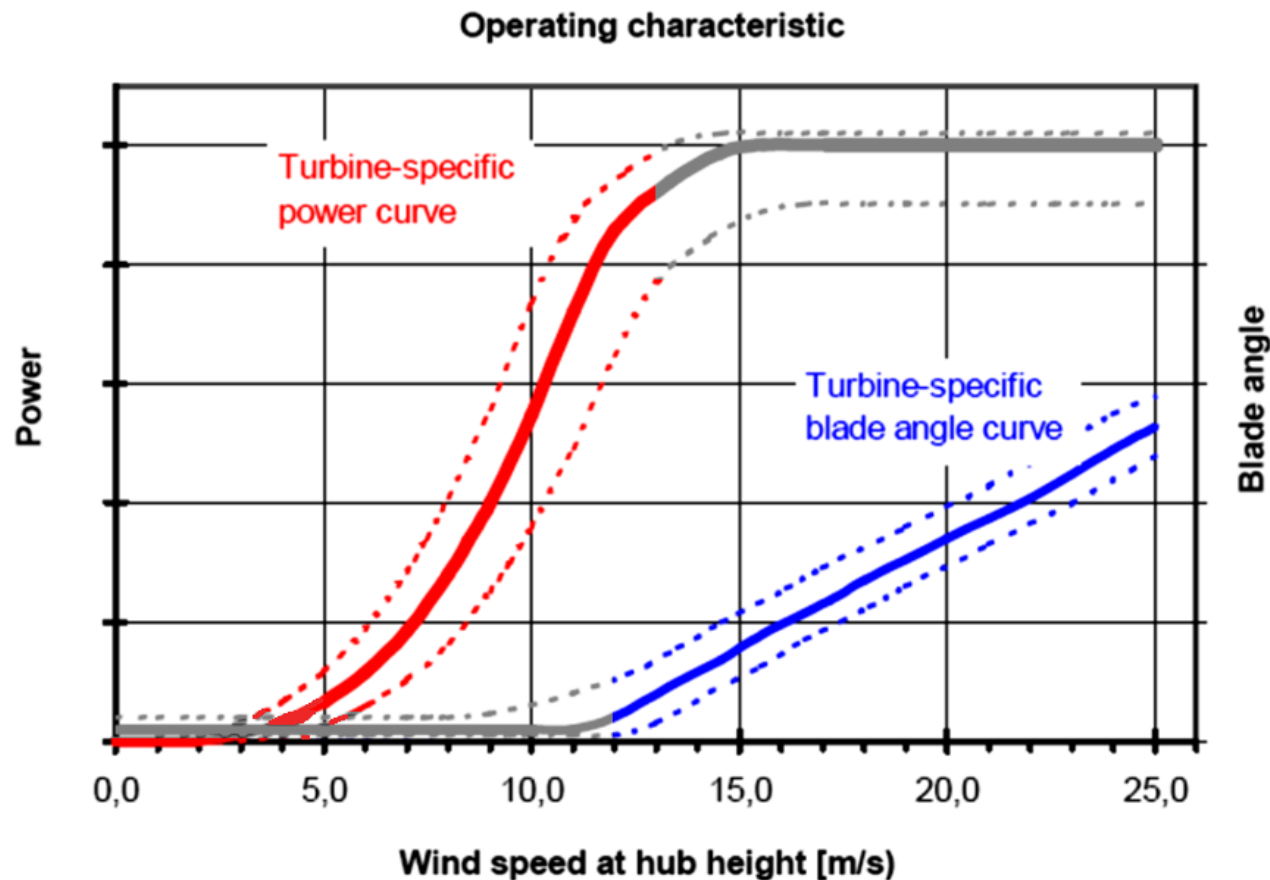
1 Ice detection system – functional principle

Red graph

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

Blue graph

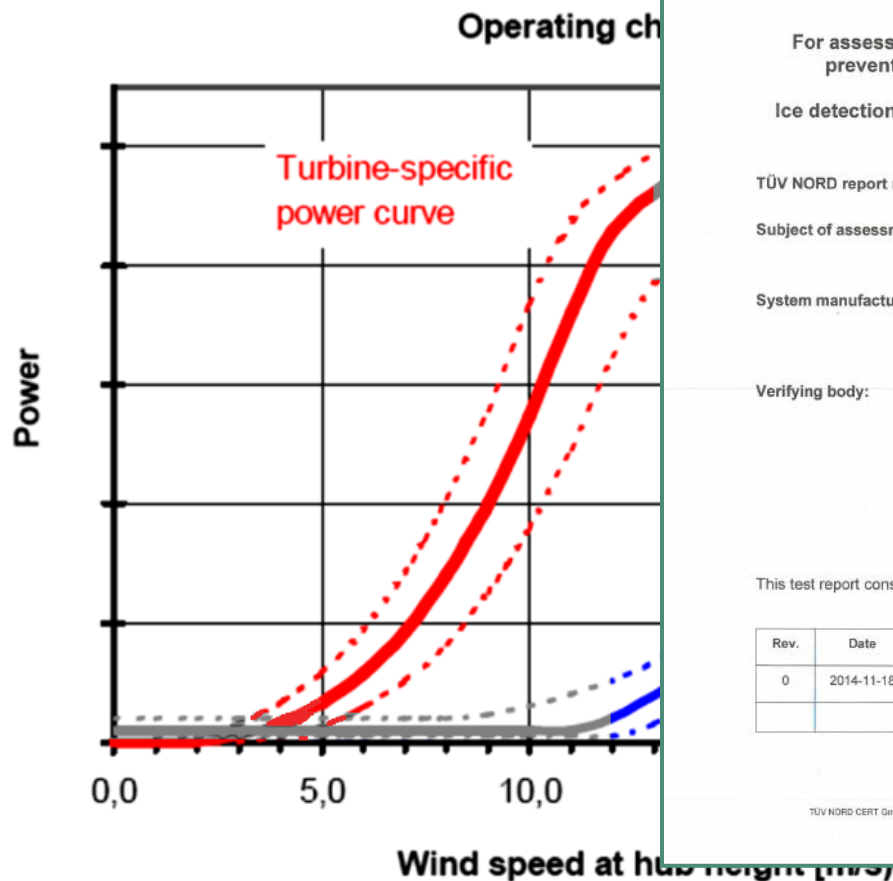
- Blade angle method (at rated power)
 - Deviations from the blade angle compared to the wind speed are detected and registered as ice



1 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



TÜV NORD SysTec GmbH & Co. KG
Energie- und Systemtechnik (Energy management and system engineering)
Zertifizierungsstelle für Windenergieanlagen (Certification body for wind turbines)



Hamburg, 2014-11-18

Expert report

For assessment of the functionality of ice detection systems to prevent ice throw at ENERCON wind energy converters:

Ice detection system based on the ENERCON power curve method

TÜV NORD report no.: 8111 881 239-2 E Rev.0
Subject of assessment: Ice detection system based on the ENERCON power curve method
System manufacturer: ENERCON
Dreerkamp 5 F&E
26605 Aurich, Germany
Germany
Verifying body: TÜV NORD SysTec GmbH & Co. KG
Große Bahnstraße 31
22525 Hamburg
Germany

Reviewed
Hamburg, 25. JUNI 2015
Expert of
TÜV NORD SysTec GmbH & Co.KG
L. Kluge
8111881239-2 E

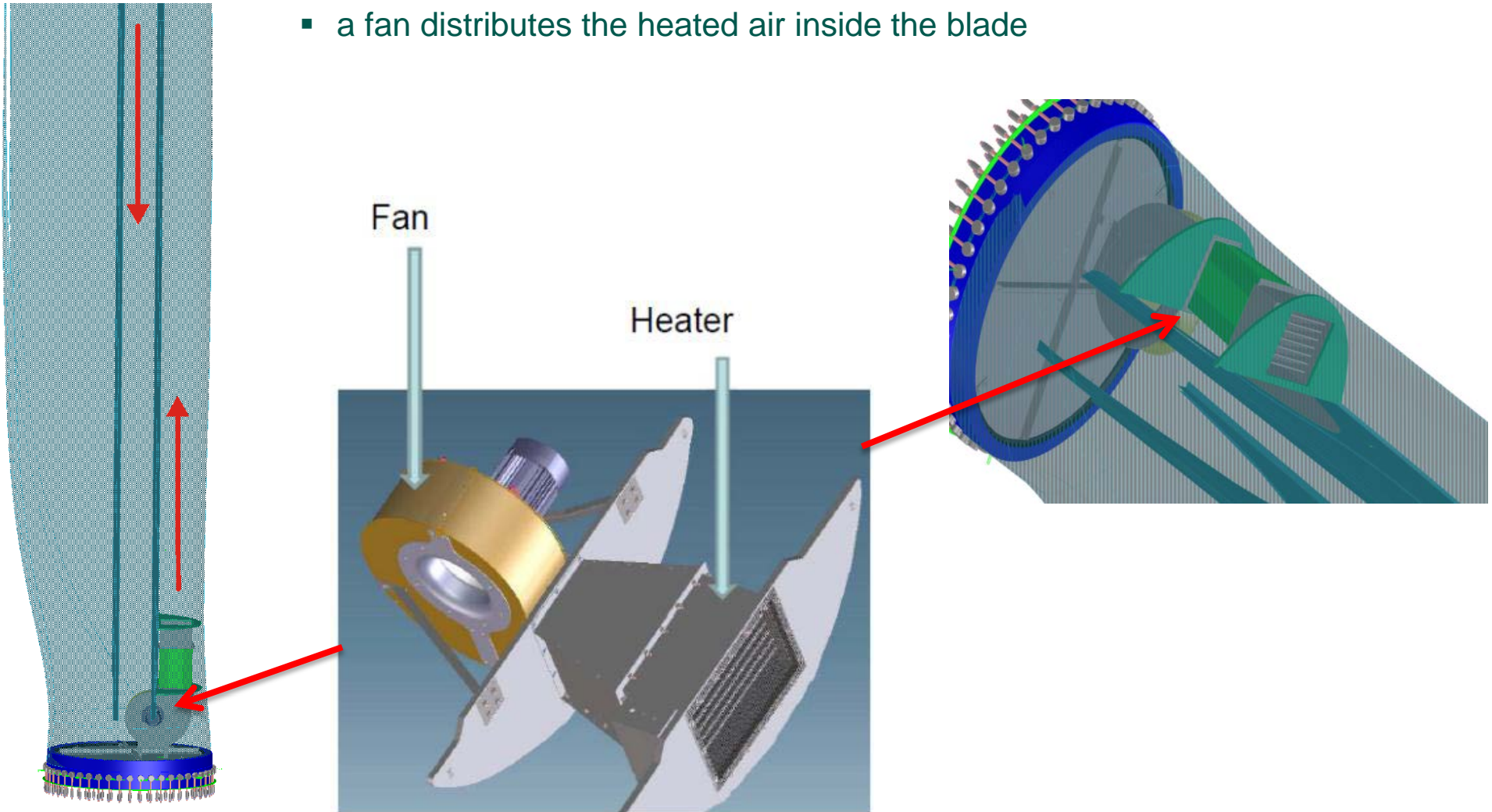
This test report consists of 40 pages.

Rev.	Date	Changes
0	2014-11-18	First Draft

TÜV NORD CERT GmbH - Certification Center for Wind Energy Systems - Langemarkstr. 20 - 45141 Essen, Germany - windenergy@tuv-nord.de

2 Hot air blade heating system

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



3 Extended IEA Table

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 Extended IEA Table

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

4 Cold climate package

- In standard conditions, the maximum power decreases for temperatures below -15°C
- With cold climate adjustments, the maximum power can be reached until -30°C.

