WINDFARM MOSCHKOGEL IN THE AUSTRIAN ALPS

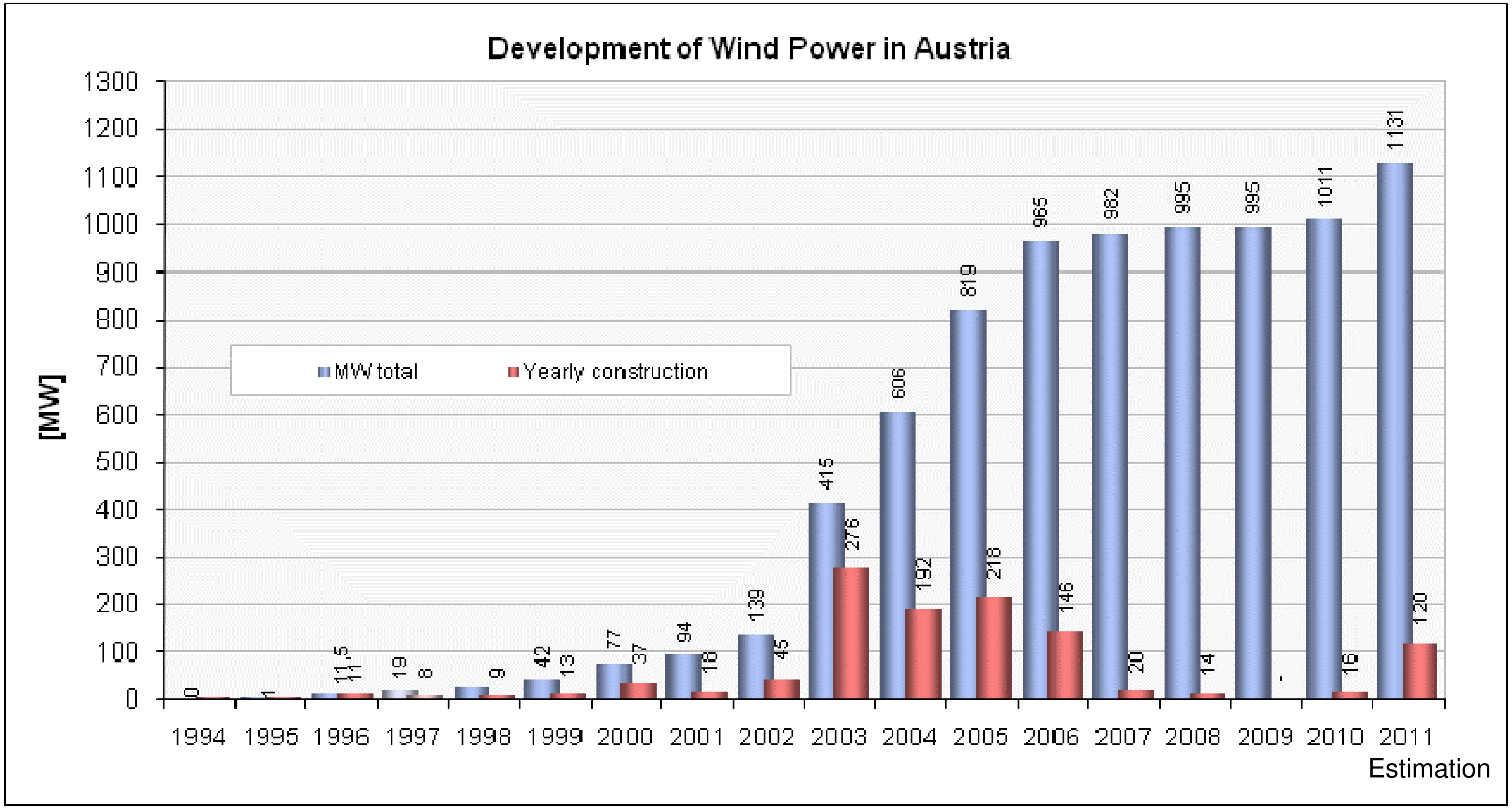
Andreas Krenn/ energiewerkstatt°

Wind Energy in Austria

State 31.12.2010

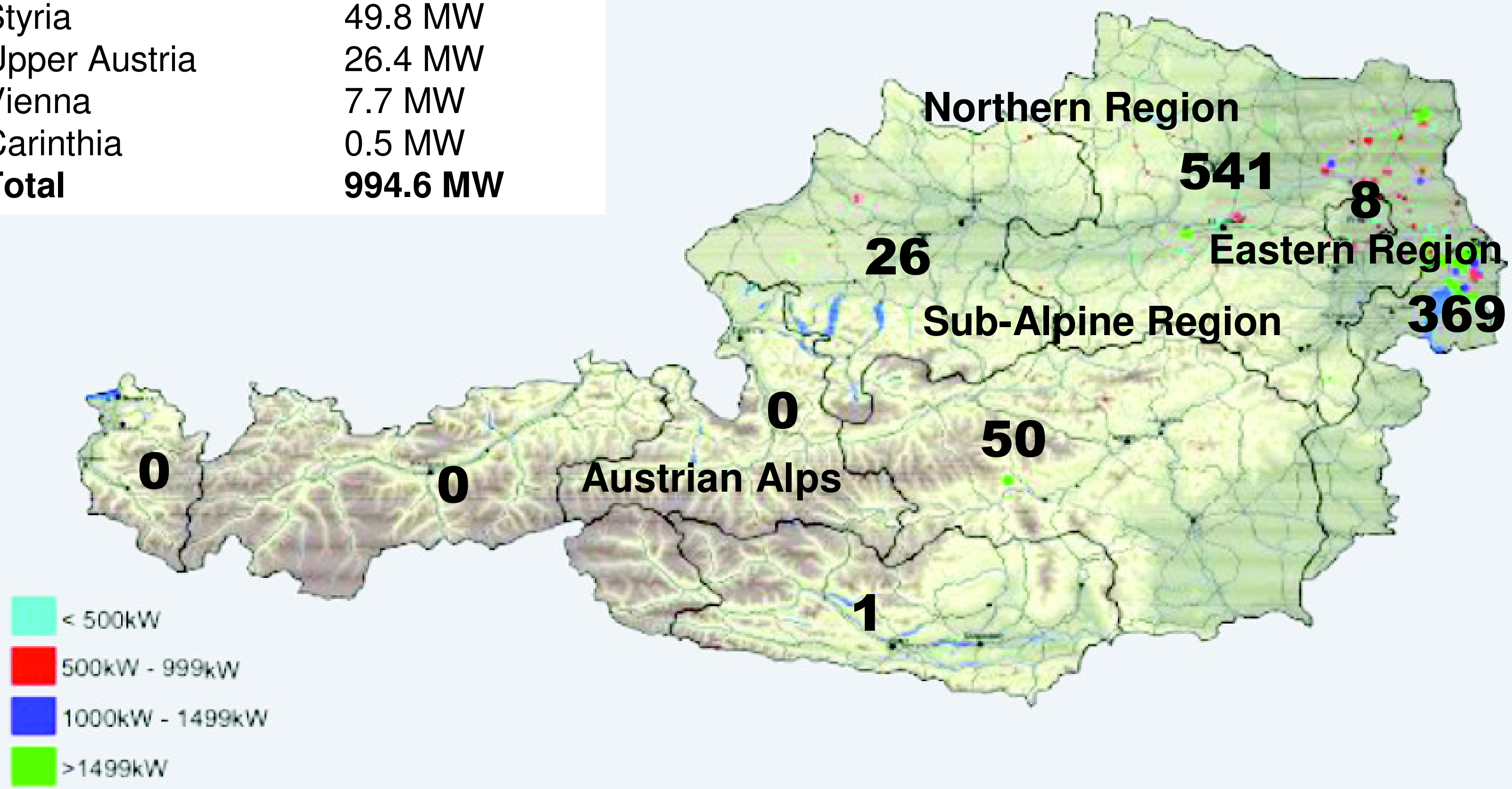
- 625 Wind turbines
- 1.011 MW installed power
- 2,34 TWh electricity generation per year
- 3 % of Austrian electricity demand

Wind Energy in Austria

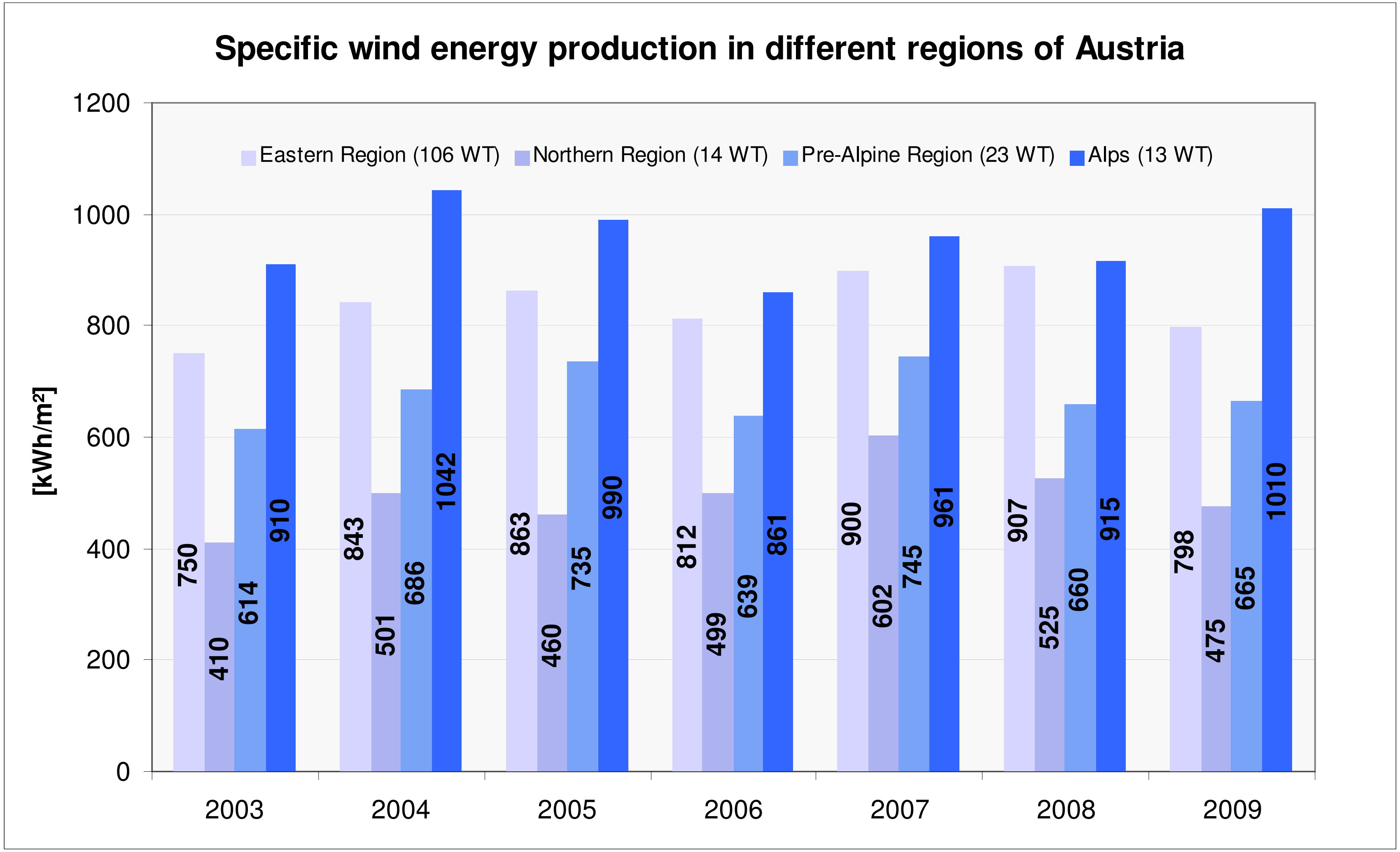


Regional shares of wind energy in Austria (end of 2009)

Lower Austria	541.3 MW
Burgenland	369.2 MW
Styria	49.8 MW
Upper Austria	26.4 MW
Vienna	7.7 MW
Carinthia	0.5 MW
Total	**994.6 MW**



Specific wind energy production in Austria



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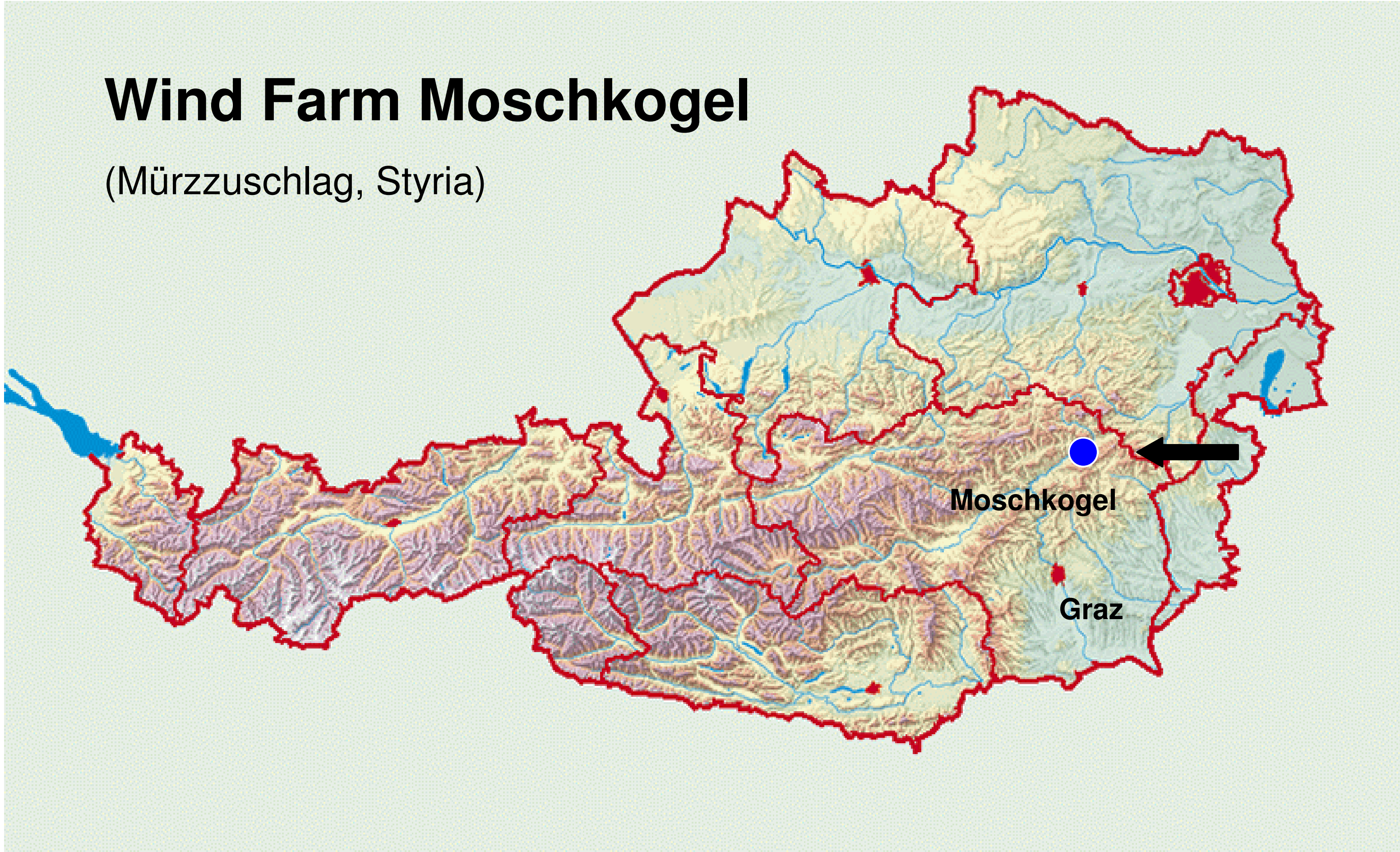
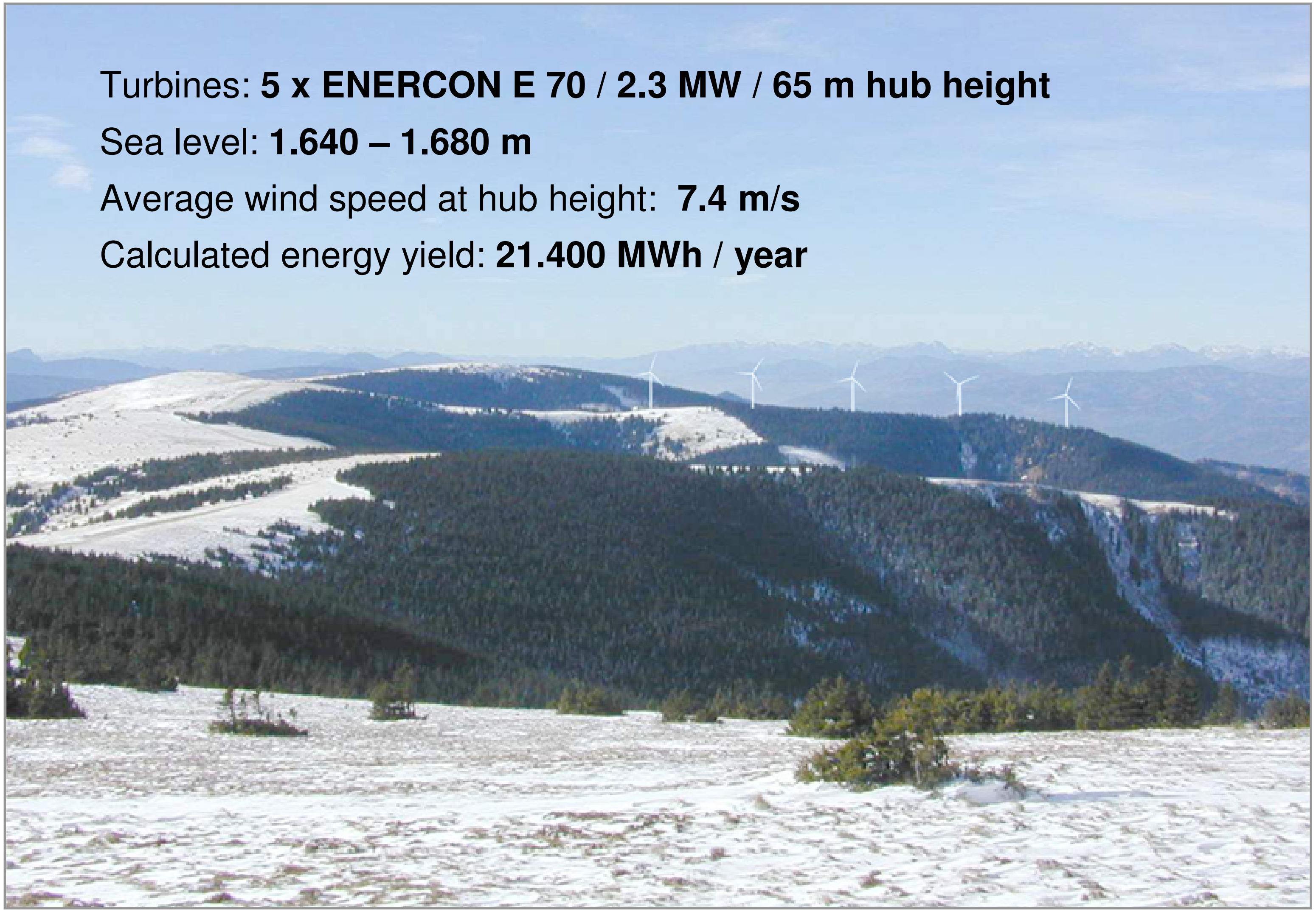

Wind Farm Moschkogel
(Mürzzuschlag, Styria)
Moschkogel
Graz

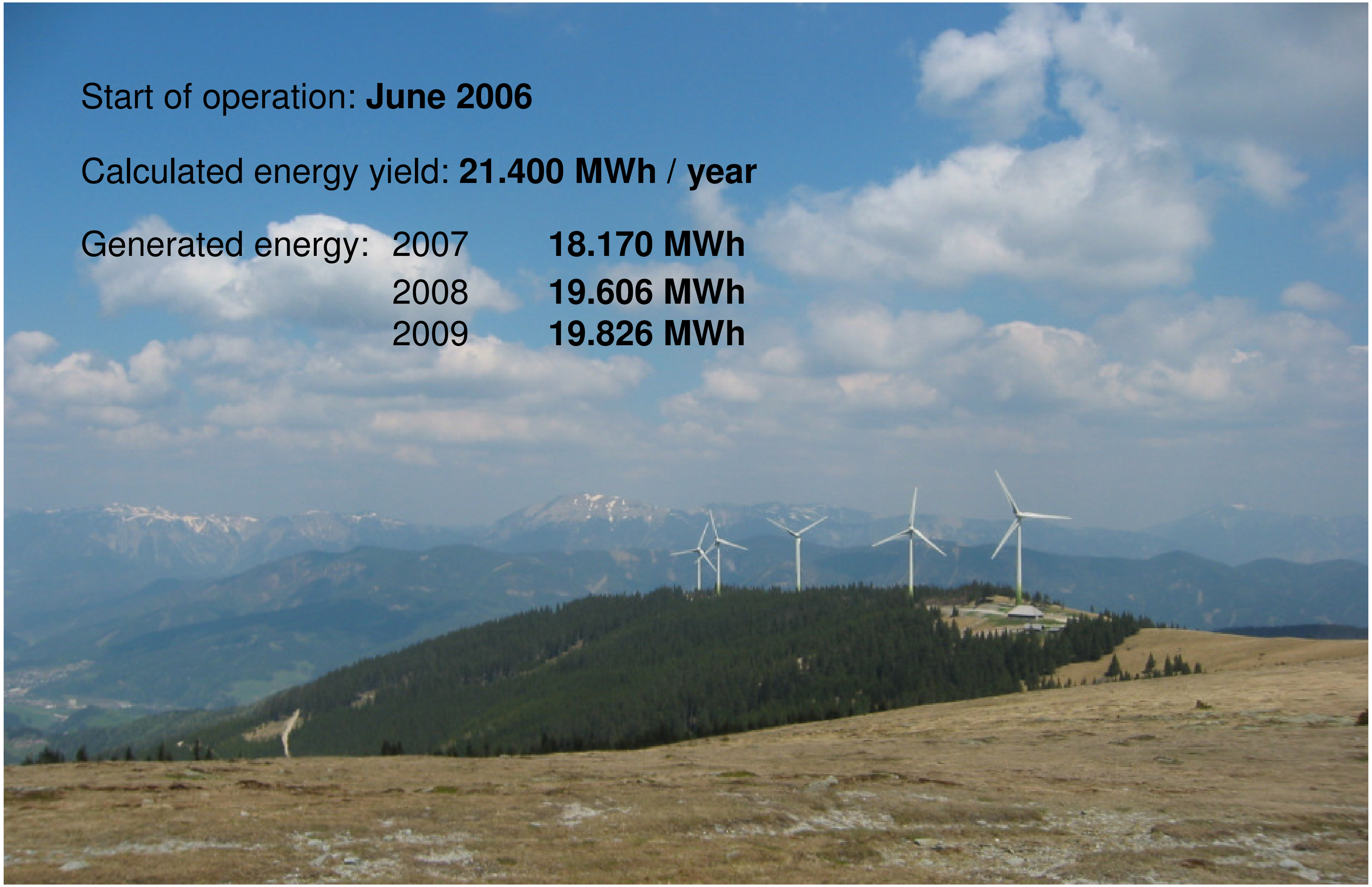


Technical Data of Wind Farm Moschkogel

Construction of Wind Farm Moschkogel

Construction of Wind Farm Moschkogel

Construction of Wind Farm Moschkogel



Information: www.viktorkaplanakademie.at

Wind Farm Moschkogel

Requirements of authorities concerning construction

- **Warning signs which indicate danger of ice throw** have to be be placed on each entrance point to the wind farm area with a minimum distance of 250 m to the turbines.
- One single wind turbine has to be **equiped with an ice detector** for automatic stop of all turbines if danger of icing occurs.
- **Operation of wind turbines during ice accretion is not allowed** – turbines have to be stopped automatically.
- **Automatical Re-start** of the turbines during danger of icing is **not allowed**.
- **Manual Re-start** of wind turbines after automatical stop due to icing is only allowed under on-site attendance of operational staff.

Conditions for accretion of ice, rime or snow

- Temperatures around **0°Celsius** and **high humidity**

  No Ice accretion above +1°Cesius because of high temperature

  No ice accretion below -7° Celsius because of low humidity

Effects of ice accretion on rotor blades

- Reduction of WEC efficiency

  Losses of energy

  Strain on materials

  Increased noise emissions

  Danger for persons and objects

Ice or no Ice?

Enercon Ice Detection System

Power Curve Method

Based on the sensitivity of rotor blade profiles against change in contour and roughness.

The resulting significant change in a WEC´s operating performance is used to detect ice build-up (interrelation of wind / rotational speed / power / blade angle).

Advantage: The power curve method is able to detect ice formation even in a situation when ice detectors on the nacelle are not detecting ice because WEC´s with large rotor blades may dip into clouds and thus be affected by icing conditions

Disadvantage: PCM is not able to detect ice during standstill of the rotor

Enercon Ice detector

Enercon uses LABKO Ice detector on the nacelle – no experience available

A reliable ice detection is precondition to any subsequent activity

ENERCON Blade Heating

De-Icing or Anti-Icing?

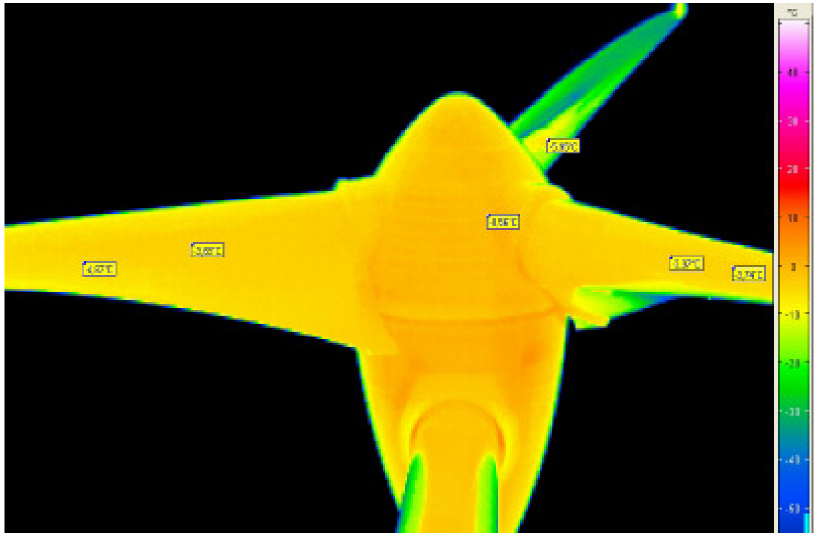
Testing two different systems

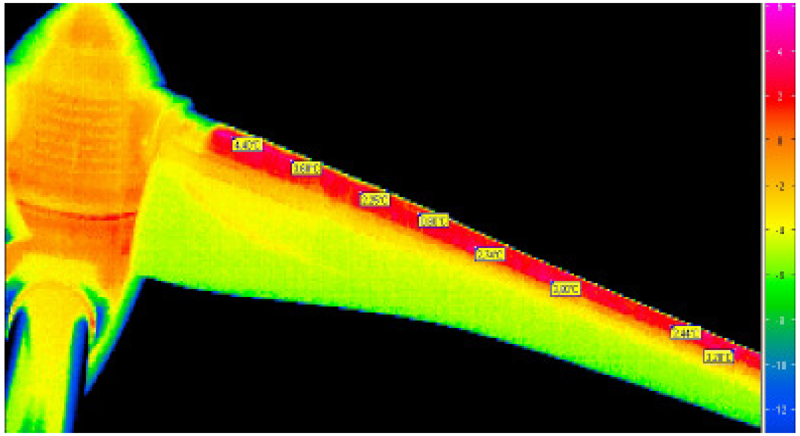
Electrical heating elements inside the blade

Use of electrical heating resitsors inside the rotor blade and inside the leading edge of the blade. For safety reasons a low voltage supply has been choosen.

Heating by circulation of warm air inside the blade:

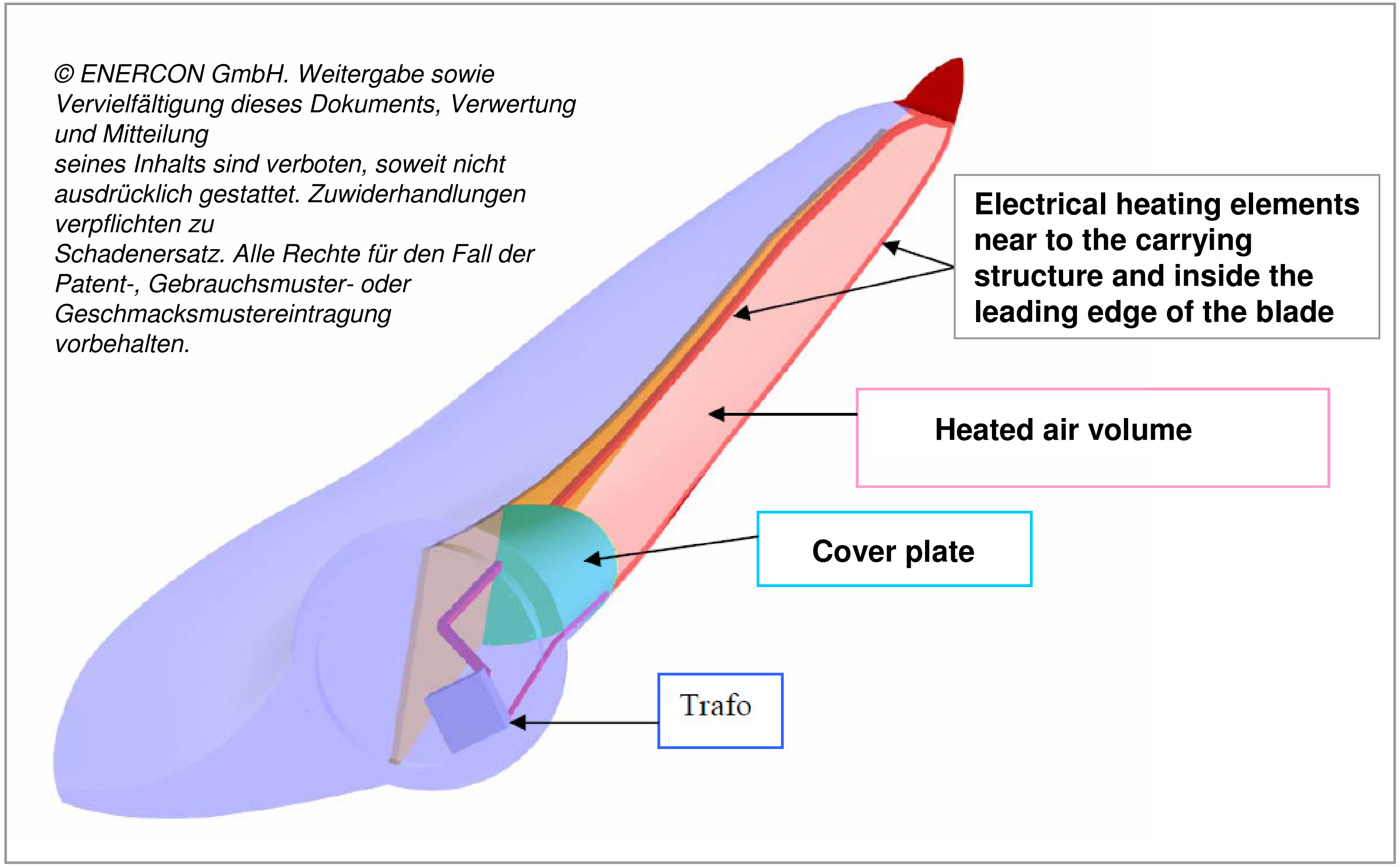
Warm air is generated by a heating register closed to the blade root and dispensed by circulation channels to the leading edge of the blade.



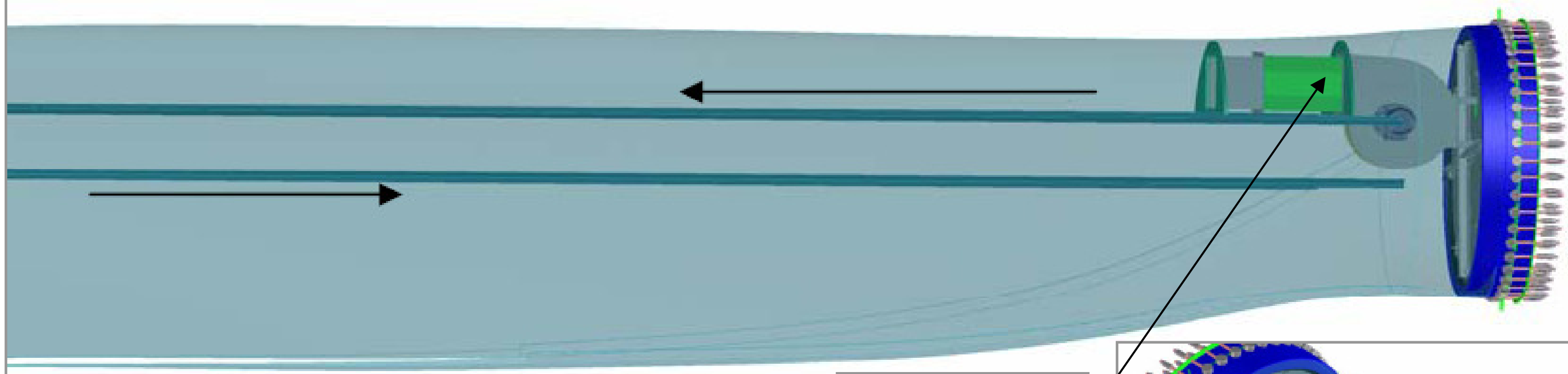


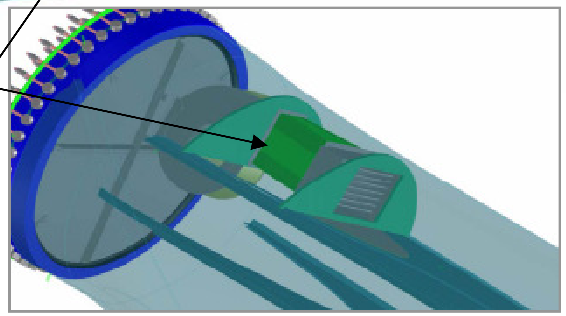
Pictures above: Thermography of the rotor blade before and after switching on the blade heating

De-Icing by electrical heating elements inside the blade



De-Icing by circulation of warm air inside the blade





Heating power

Electrical heating register:	2 x 10 kW per blade
Radial ventilator:	3 kW per blade
Total heating power:	Max. 70 kW

Operational experience during winter at WF Moschkogel

- Contrary to the requirements of approval documents **no ice detector** has been installed, because authorities accepted the ENERCON Ice detection system by power curve verification.
- ENERCON has tested two different blade heating systems

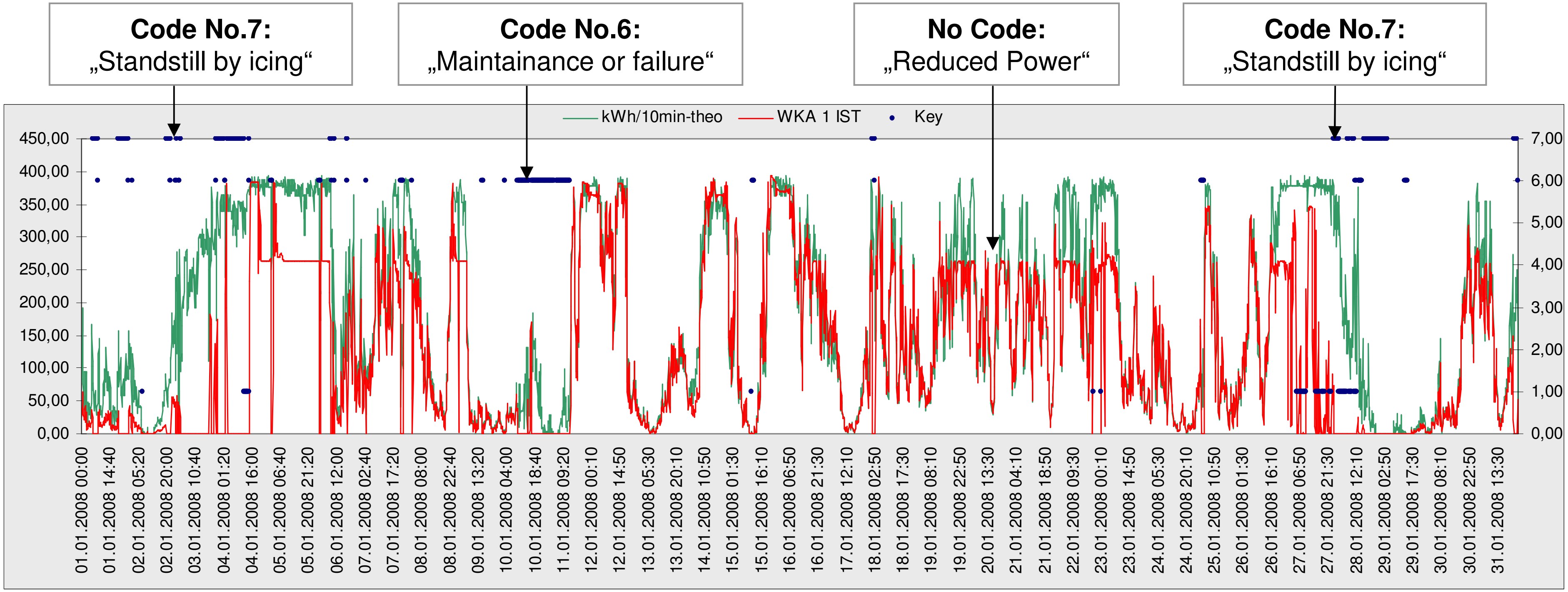
2006	2007	2008	2009	2010
07 08 09 10 11 12	01 02 03 04 05 06 07 08 09 10 11 12	01 02 03 04 05 06 ★ 07 08 09 10 11 12	01 02 03 04 05 06 07 08 09 10 11 12	01 02 03 04

De-icing by electric heating elements	**De icing by warm-air circulation**	**Anti-icing by warm-air circulation**
Operation mode: Ice detection by Power Curve verification Automatic turbine cut-off Manual switch on of blde heating Manual turbine start ★) Exchange of all rotor blades	**Operation mode:** Ice detection by power curve verification Automatical turbine cut-off Manual heating switch-on Manual turbine start	**Operation mode:** Ice detection by power curve verification Heating and anti-icing during operation

Monitoring of blade heating at wind Farm Moschkogel

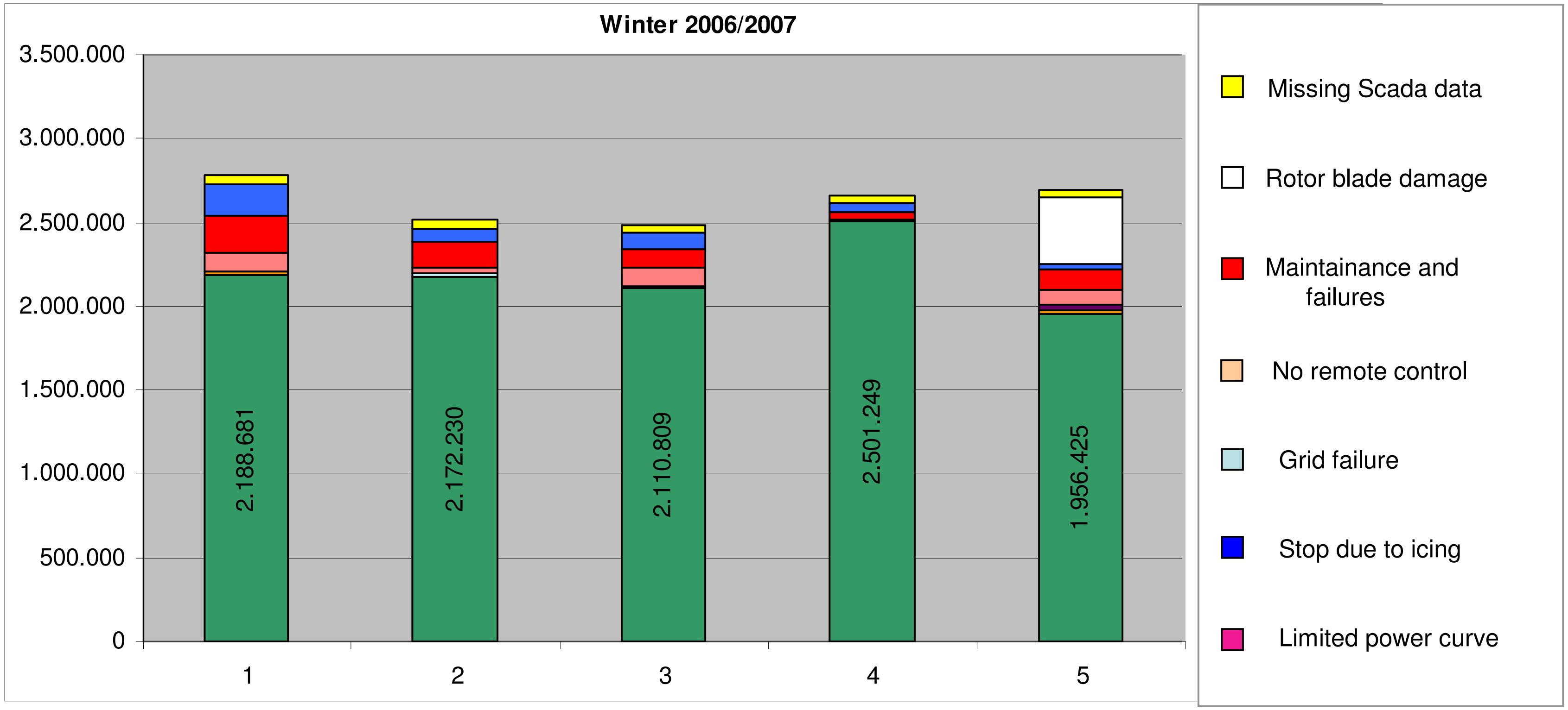
- Monitoring of blade heating is based on 10 min time series data which were recorded by the wind turbines (wind speed, temperature, power and status data).
- No additional measurements of pressure, humidity or ice-detection have been performed.
- Calculation of production losses by icing (and other turbine errors) is based on comparison of actual 10-minute energy production against theoretical energy production which has been calculated by using the recorded wind speed data and power curve of the turbine.

Operational data (example)
January 2008



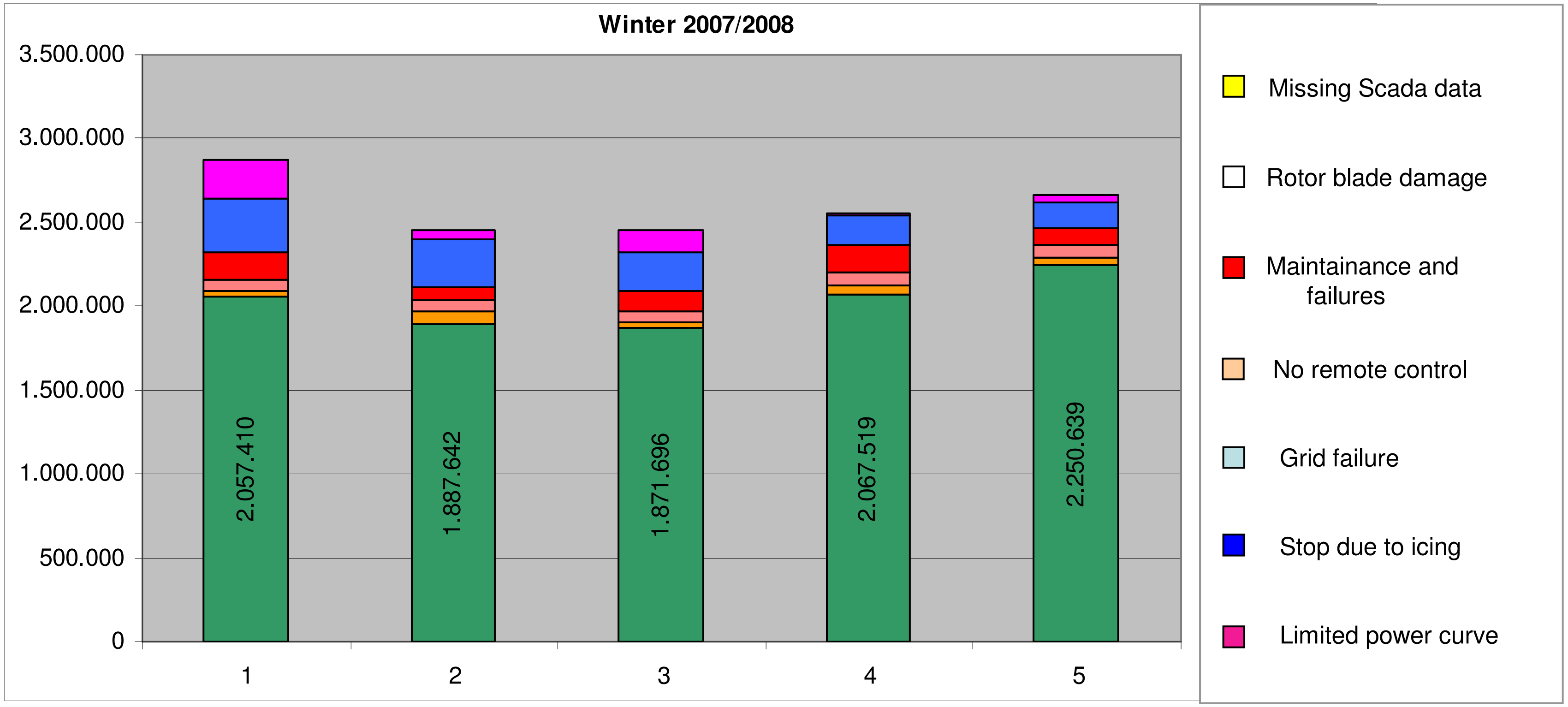
Production and calculated losses during winter 2006/2007

- During winter 2006/2007 all 5 turbines were equipped with an ENERCON de-icing system using electric heating elements.
- Although this winter was a „gentle“ one, the losses caused by icing have been quite high. The main reason for the losses was the damage of one blade heating element at turbine No. 05.
- Another reason for losses was the long standstill time beween automatic turbine stop and manual start of the heating
- Total availability of the windfarm including standstills by icing during winter 2006/07: 88.0%



Production and calculated losses during winter 2007/2008

- Winter 2007/2008 was the second year of operating the electric heating elements.
- Main reason for losses was again the long standstill time between automatic turbine stop and manual start of the heating (1-3 hours, heating time is included in „T6-maintainance“). The wind farm attendant had to spend much time at the site, because each single turbine had to be supervised and re-started manually.
- Also the blade heating has been affected by lighning during summer time.
- Total availability of the windfarm including standstills by icing during Winter 2007/08: **86.8%**



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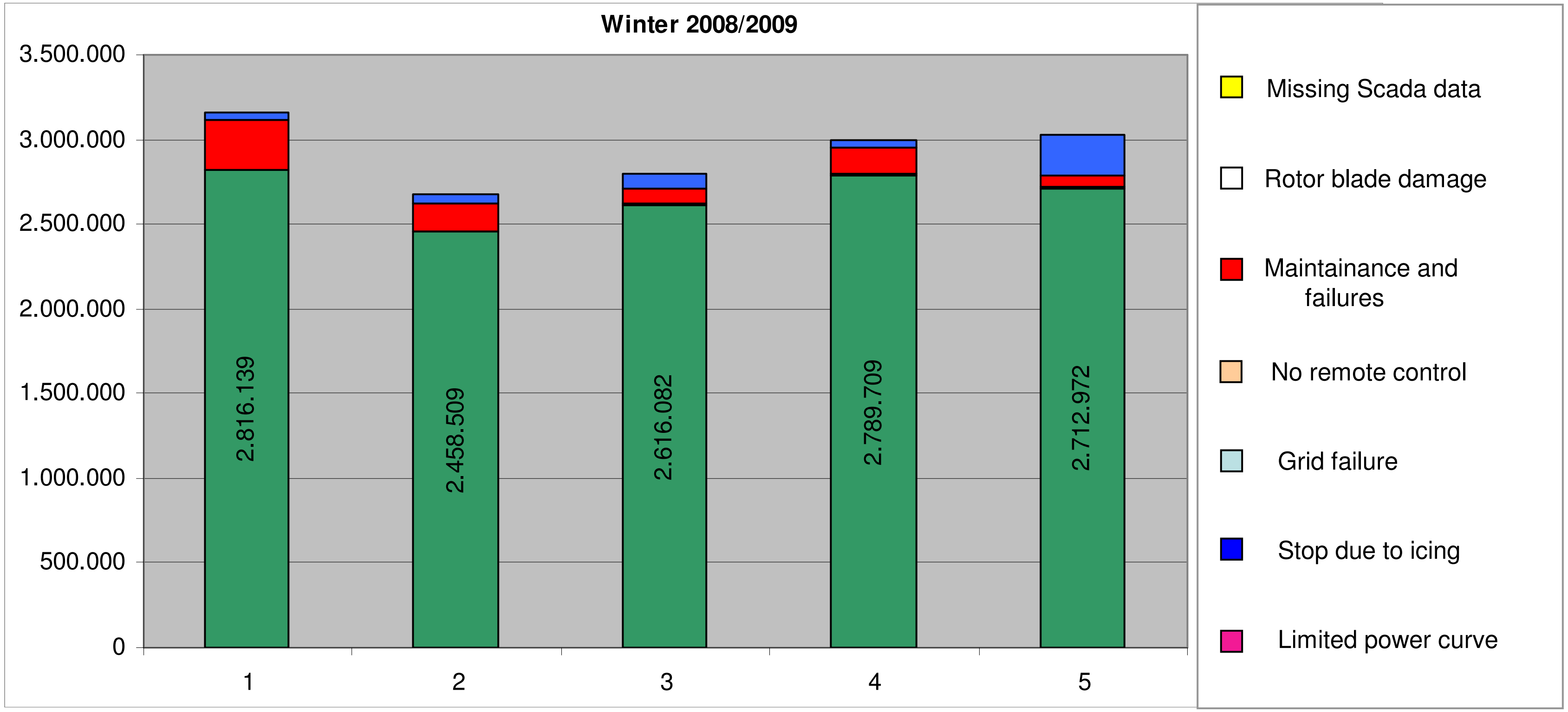
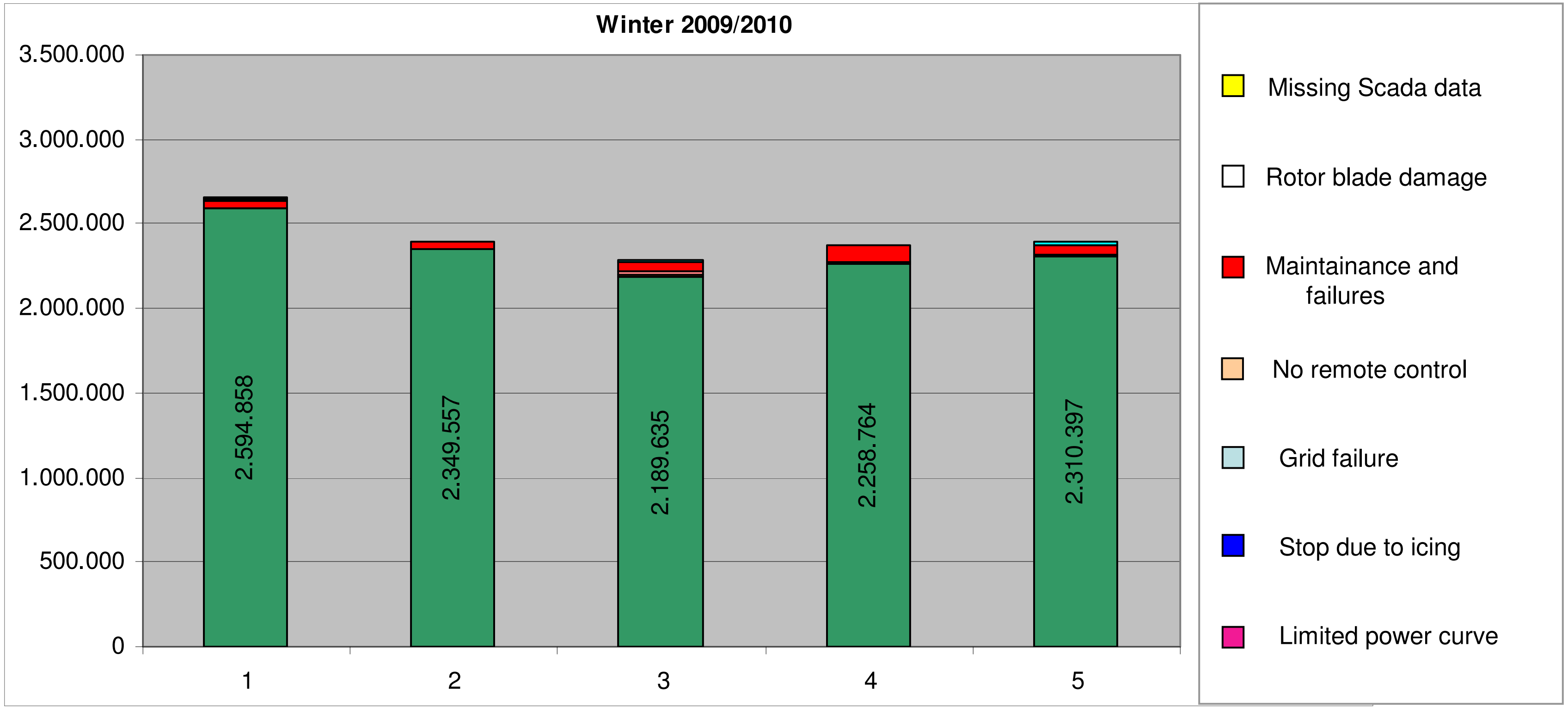
Production and calculated losses during winter 2008/2009

- In summer 2008 the rotorblades of all 5 turbines have been changed and equipped with the new ENERCON blade heating system which heats by warm-air circulation
- The new blade heating system was operated manually during its first winter.
- „De-icing“ showed good results.
- Total availability of the windfarm including standstills by icing during Winter 2007/08: **93.7%**

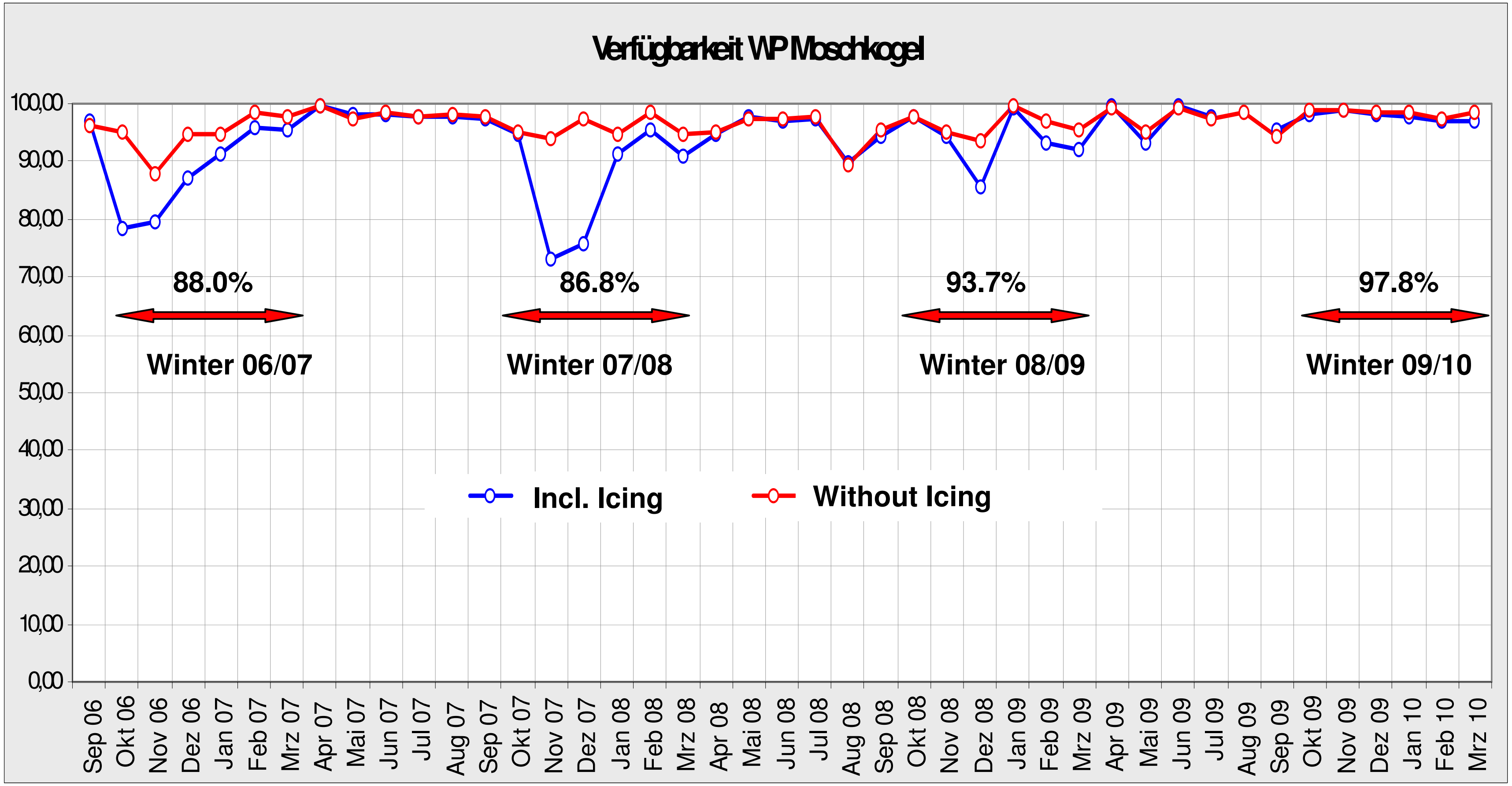


Production and calculated losses during winter 2009/2010

- Winter 2009/2010 was the second winter of operating warm-air circulation heating.
- The system has been operated automatically and during operation of the turbine (Anti-Icing).
- A special „counter“ checks if „Aniti-icing“ during operation works efficiently. If anti-icing is not able to keep the rotor blades free of ice, the turbine is stopped and „De-icing“ is started automatically.
- The results of „Anti-icing“ has been excellent and it seems, there is no danger of falling down of bigger pieces of ice during heating time.
- Total availability of the windfarm including standstills due to icing in Winter 2009/10: 9**7.8%**



Technical availability with and without ice



Performance of ENERCON blade heating by „warm-air-circulation“

- „De-Icing“ and automatic re-start works in priciple, but no technical verification is available
- „Anti-Icing“ during operation is possible, but no technical verification is available
- Detection of ice on rotor blades during stand still is not possible
- Operator has to carry the risk for automatically operating and „Anti-Icing“ during operation.
- ENERCON heating system has to been accredited by the authorities.

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