TECHNICAL ASSESSMENT OF ROTOR BLADE HEATING SYSTEMS IN THE AUSTRIAN ALPS

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INTRODUCTION

The demand for wind turbines with an appropriate cold climate technology is steadily increasing. One possibility for keeping the rotor blades ice-free or de-ice them, respectively, is to heat them. The thermal energy for melting the ice can either be provided directly on the surface or the air inside the rotor blades is heated. A very limited number of manufacturers offer anti- and de-icing solutions.

Fig. 1: Wind farm Moschkogel in the Austrian Alps

In the Wind Farm Moschkogel (Figure 1) located at 1.600 m.a.s.l. in the Austrian Alps, five ENERCON E70 wind turbines have been equipped with such rotor blade heating systems. During the first two years of operation a heating system was used that provided warm air from electrical heating transistors placed along the inner side of the leading edge (Figure 2). Due to disappointment with this initially used heating system, all blades of the 5x 2,3 MW turbines were exchanged in summer 2008 and equipped with an amended heating system based on warm air circulation inside the blade. The total heating power of that new system is 70 kW per turbine.

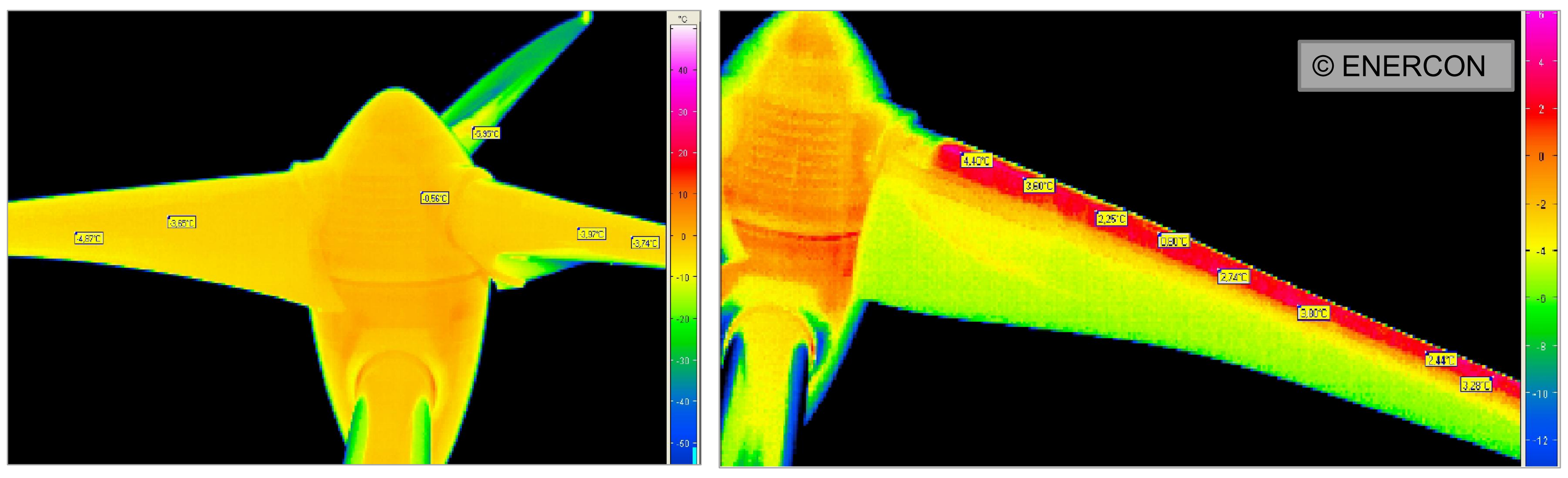

Fig. 2: Thermography of the 1st heating system before and after switching on the heating

METHODOLOGY

To assess the reliability of the two different heating systems, in a first step a detailed analysis of the operation mode during the last four years has been performed (Figure 3).

2006 (07–12)	2007 (01–12) / 2008 (01–05, ★ 06)	2008 (07–12) / 2009 (01–12) / 2010 (01–04)
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 method Automatic turbine cut-off Manual switch on of blade heating Manual turbine start ★) Exchange of all rotor blades	**Operation mode:** Ice detection by power curve method Automatical turbine cut-off Manual heating switch-on Manual turbine start	**Operation mode:** Ice detection by power curve method Heating and anti-icing during operation

Fig. 3: Operation modes at WF Moschkogel

The ENERCON turbines automatically shut down as soon as ice accretion on the blades is detected. The detection of ice happens via the power curve method, which is 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). This 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. A disadvantage of the power curve method is that it is not able to detect ice during standstill of the rotor.

The monitoring of blade heating is based on 10 min time series data, recorded by the wind turbines, i.e. wind speed, temperature, power output and status data (Figure 4). No additional measurements of pressure, humidity or ice-detection have been performed.

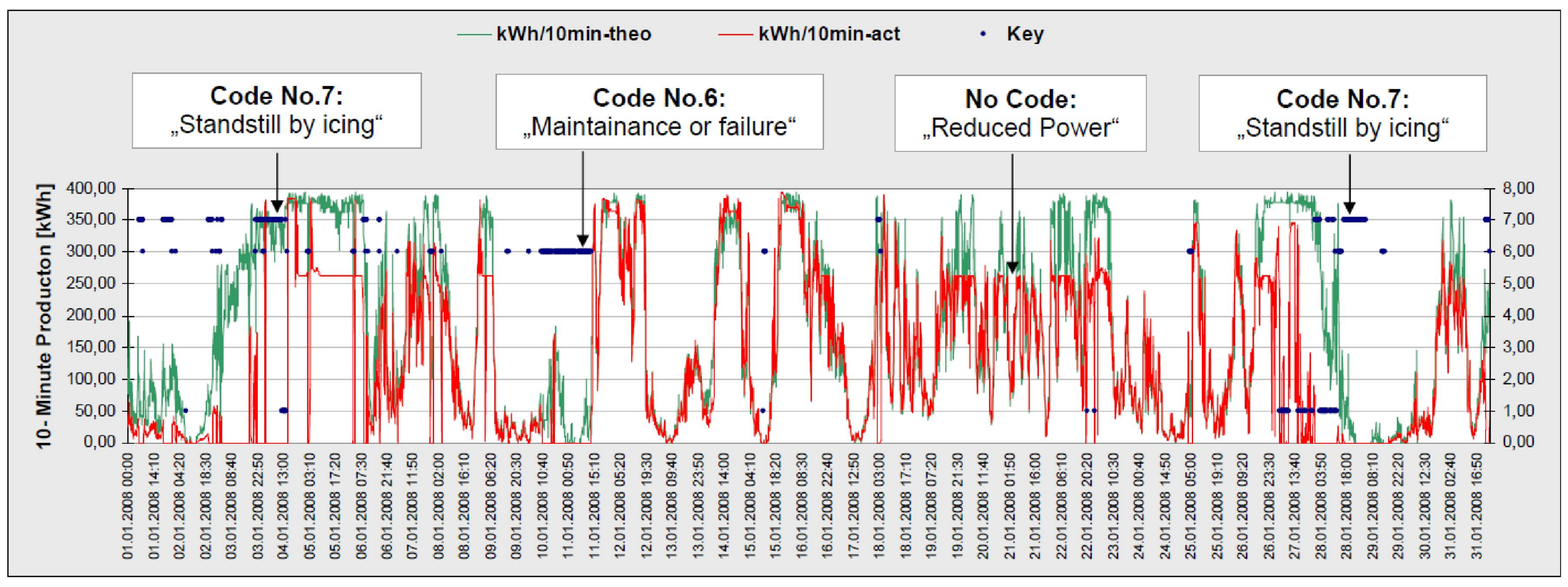

Fig. 4: Operational data (example January 2008)

The calculation of production losses due to icing (and other turbine errors) is based on comparison of the actual 10-minute energy production against the theoretical energy production calculated from the power curve and the wind speed data of the anemometers on the turbine nacelle. Through that approach statistics have been prepared regarding the reasons for operational standstills, which (amongst others) reveal how high the energy loss of individual turbines is due to icing. Additionally the two different rotor blade heating systems used at WF Moschkogel have been compared and assessed using that approach.

RESULTS

As a result of the analysis (Figure 5) the theoretical availability of the turbines (without losses due to icing) has been plotted against the actual availability (including standstill due to icing).

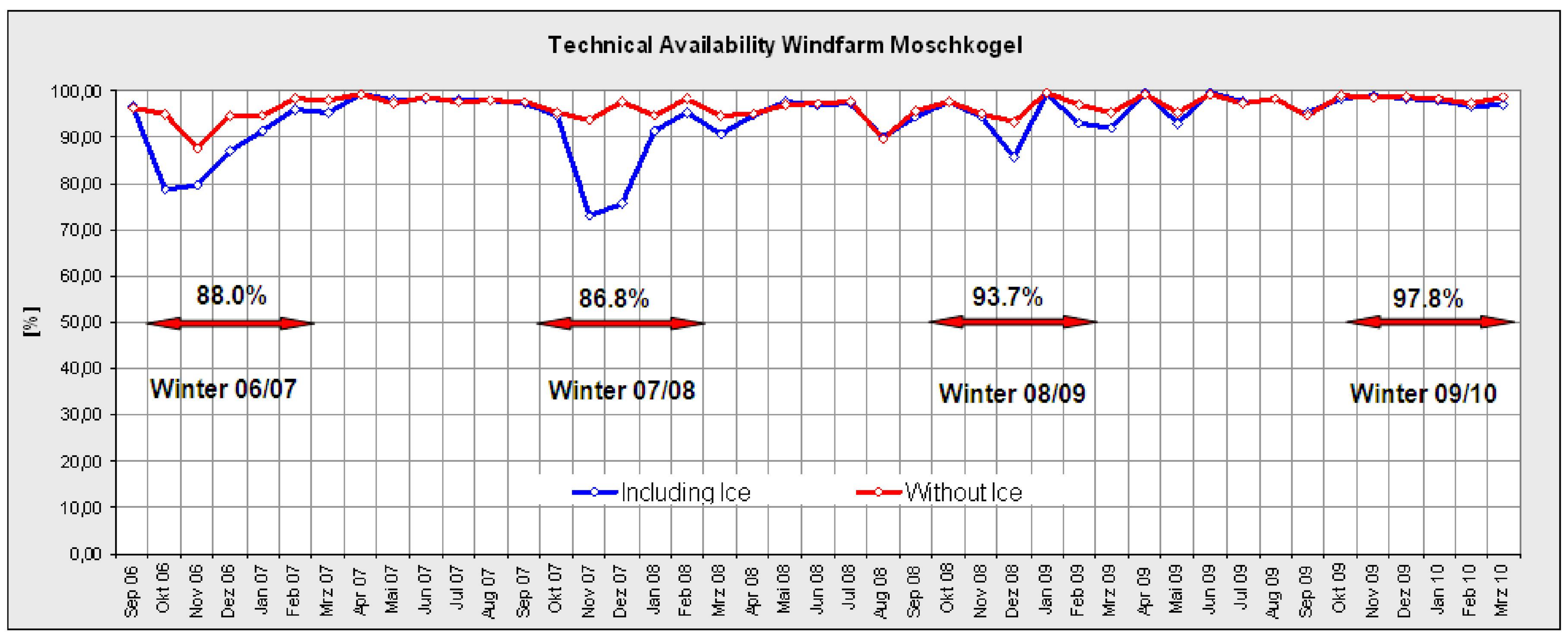

Fig. 5: Technical availability with and without ice

From the result above the following conclusions can be drawn:

- The heating system using warm air circulation leads to an improved availability
- 'De-Icing' & automatic re-start works in principle, 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 automatic operation and 'Anti-Icing' during operation
- ENERCON heating system has to been accredited by the authorities.

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