Wind Energy iQ
Article

Anti-icing and De-icing Technologies for Wind Turbines

Ice presents a major problem for wind turbine blades in cold climates, but there is great potential for wind energy in those environments due to the favourable conditions. Available wind power in cold climates is approximately 10% higher than other areas due to the increased air density at lower temperatures, and according to recent estimates, 45 to 50 GW of power will be installed in low-temperature regions by 2017.

That represents a huge market for wind farm developers and manufacturers alike, and there are several technologies coming to the market which integrate anti-icing or de-icing properties into blades to enable cost-efficient energy production in these applications.

Siemens

Siemens were one of the first companies to investigate de-icing techniques, and actually produced its first de-icing system as far back as 1994. The blade manufacturer has since developed an electrical method for de-icing which uses built-in carbon heating mats on the leading edge to remove ice from the blades. Depending on the ambient temperature and wind speed, a blade can be de-iced in as little as one hour.

The system consists of three elements; an ice detection system, the heating of the blades, and a system to control the strategy for de-icing. The system includes:

Power connections at the root end
Heating elements integrated into the blade surface at manufacture
Control system based on existing sensors
Full retention of the aerodynamic profile
No effect on noise levels

The first generation of Siemens de-icing system was installed and tested in 2011 at two wind farms in Sweden, and currently more than 50% of the turbines Siemens supplies in Sweden are equipped with the de-icing system. The technology is available with the company's SWT-2.3-101, SWT-3.0-101, SWT-2.3-113, and SWT-3.0-113 turbines.

Enercon

Enercon was also one of the early developers

Source: Enercon

Enercon was also one of the early developers of a de-icing system, and their technology combines an ice detection system with hot air circulation inside the turbine blade to melt ice after it has formed.

The ice detection system works on a specially developed power curve analysis method. Various key operating values, such as rotor speed and wind speed, are analyzed during operation, and the data is collected and plotted onto an operating map. Ice build-up on the blades alters the aerodynamic properties and this is shown on the operating map. When certain criteria are fulfilled and the build-up of ice is detected, the turbine is stopped and the de-icing procedure is initiated.

A fan heater installed at the root of the blade circulates a stream of hot air right up to the tip of the blade. The temperature of the blade surface is heated to 0C, and the ice build-up is melted. The exact thawing time depends on ambient temperatures, but once thawing is complete, the turbine is restarted free of ice. The sophisticated ice detection part of the system, means that at sites with minimal risk of icing, the de-icing procedure can take place while the turbine remains in motion, thawing thin layers of ice at an early stage of formation, but if ice continues to form it becomes essential to stop the turbine while the process takes place.

Nordex

Turbine manufacturer, Nordex, has developed its own innovative solution to icing, for its N100 and N117 turbines, which is aimed predominantly at the European and North American markets.

The system consists of one ice sensor and heating elements on parts of the leading edge of each rotor blade. The sensor continuously monitors ambient conditions and reports the status to the wind turbine's operation management system. If data indicates the presence of conditions liable to cause icing, the heating elements are automatically activated. The system does not require the turbine to be shut down for de-icing, and automatically removes any ice that has formed on the leading edge.

The system was first demonstrated in the field by Nordex in 2010, when it tested prototypes for a Scandinavian utility at an N100/2500 wind farm. Results were directly compared with a turbine located at the same site, but without the de-icing system. The outcome was an increased yield of 8% for the whole of 2011, and an increased yield of 25% in the months with severe icing conditions.

The internal power consumption of the Nordex system is less than 0.3%, and this was factored into the test results. The system has been purposely configured for minimal power consumption, with the heating elements fitted only where they are required, and immediately below the surface to minimize heat loss.

The system will be used in the 150 MW Blaiken wind farm in Sweden, where Nordex is installing 60 N100/2500 turbines, due to be completed in 2015.

Vestas

Source: Vestas

Vestas has also recently released its own version of de-icing technology, which in a similar vein to Enercon's system, uses the circulation of hot air to heat the blades and melt the ice.

The Vestas De-icing System has been made available for the company's V112-3.3MW turbine, and it has already received initial orders, while a prototype has been installed in Sweden.

The system consists of a heating unit in the hub to distribute hot air throughout the blades, and a control unit which is integrated into the turbine's SCADA system. Sophisticated algorithms determine the point at which potential power loss caused by icing becomes greater than the potential power loss when the turbine is shut down for de-icing. The de-icing procedure takes approximately two hours, and the system targets only the critical areas of the blade.

The system is designed to de-ice the outer 1/3 of the blade full chord, and the outer 2/3 of the leading edge towards the tip end, to maximize power curve recovery. This targeted approach does not compromise de-icing efficiency according to Vestas, but is critical in regaining full power curve quickly. It also reduced the risk of run-back icing, and can minimize the danger of ice throws from the blade tip.

VTT

The VTT Technical Centre in Finland has developed an electro-thermal heating system for turbine blades, as part of the challenge to increase wind energy power in the country from 0.3% to 6% by 2020.

The principle of the system is electro-thermal heating using electrically conductive fibre mats that are integrated into the rotor blade. A smart control system activates the heating to prevent the build-up of ice on critical parts of the blade. Rather than stopping the turbine for de-icing, the system is able to run during normal operation of the turbine, thus reducing downtime.

The system has already been installed in over 40 turbines ranging from 600 kW to 3 MW, and has been demonstrated in over 200 heating seasons combined; it also consumes less than 2% of a turbines annual energy output.

Gamesa

Turbine manufacturer Gamesa is working with VTT to develop de-icing technology for its platform of 5 MW turbines, and this year revealed a new anti-icing paint specifically designed to prevent ice build-up on turbine blades.

The 'Bladeshield' anti-icing paint prevents the formation of ice on the surface, but also increases the paint's resistance to corrosion, where similar solutions can reduce it. The paint was developed under the Azimut project for the development of offshore technology, and is the result of three years of research into the use of new raw materials in wind energy – specifically the application of nanomaterials in the development of coatings.

The bladeshield system is the result of the development of an innovative procedure for obtaining the mix, as the additive is dissolved first in the ideal dispersing agent and then in the paint base. This leads to a homogenous mix which improves the paint's anti-erosion and durability properties.

The paint was developed primarily as part of the Azimut project to improve blade paint's resistance to corrosion, and although nanomaterials have made it possible to improve ice-prevention properties as well, it remains to be seen how effective the solution will be in real world conditions.

Summary

Wind energy in colder climates is set to grow rapidly in the coming years, and if the latest estimates are correct, there will be an increase of 72% of installed capacity in ice-prone areas from 2012 to 2017.

There are some incredibly interesting technologies for anti-icing and de-icing coming to the market, with electro-thermal heating and air-circulated heating active methods already being installed in working turbines. The trend at the moment appears to be towards these active de-icing technologies, with passive anti-icing paints and coatings less prevalent. However, the experience of the first turbines with de-icing technology in colder climates will be invaluable for the industry, and there is no clear distinction at this stage of which type of technology will prove to be most effective in the long-term.

By Wind Energy IQ