

Ice detection

Greater efficiency for your wind turbine generators

Find out more:

- With precise ice detection, you can reduce your wind turbine generator downtime by up to 80% per year
- This will increase the efficiency and service life of your wind turbine generator
- With the reduction in downtimes, you can save approximately 48,000 € per annum

Introduction

Society has been utilizing wind power for centuries. Today, the large wind turbine generators that are used all over the world are an important part of the energy mix, in which the proportion of renewable energies is constantly growing. To ensure that we have a secure energy supply, it is important that the systems are operated reliably at all times.

This means that the wind turbine generators (WTGs) must be protected from failure due to ice. Wind turbine generators have therefore been equipped with ice detection systems for many years. This is done to minimize wind turbine generator downtimes and to extend the service life of the system.

Learn more on the following pages about the different technologies that are used for ice detection on rotor blades and the advantages of a blade-based system. Moreover, we would like to show you how the data from such a system can be evaluated and utilized optimally.

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1 Use of ice detection systems



When does it make sense to use an ice detection system?

Downtimes must be minimized to ensure that wind turbine generators can supply optimum yields. In this context, downtimes caused by ice accumulating on the rotor blades can account for up to 10% of the annual yield¹. There are many causes for this loss of yield. One of the main factors here is shutdowns due to regulatory requirements. In many parts of the world, regulations state that a WTG must be stopped if there is a danger that ice has accumulated on the surface of the rotor blades. Safety is the most important factor behind this regulation.

Another key reason for shutting down turbines due to ice build ups is the effect the ice has on the aerodynamics of the rotor blade. The ice causes

imbalances and vibrations. The system no longer supplies the optimal yield, and at the same time is subject to significantly more wear due to the increased strain.

Regions

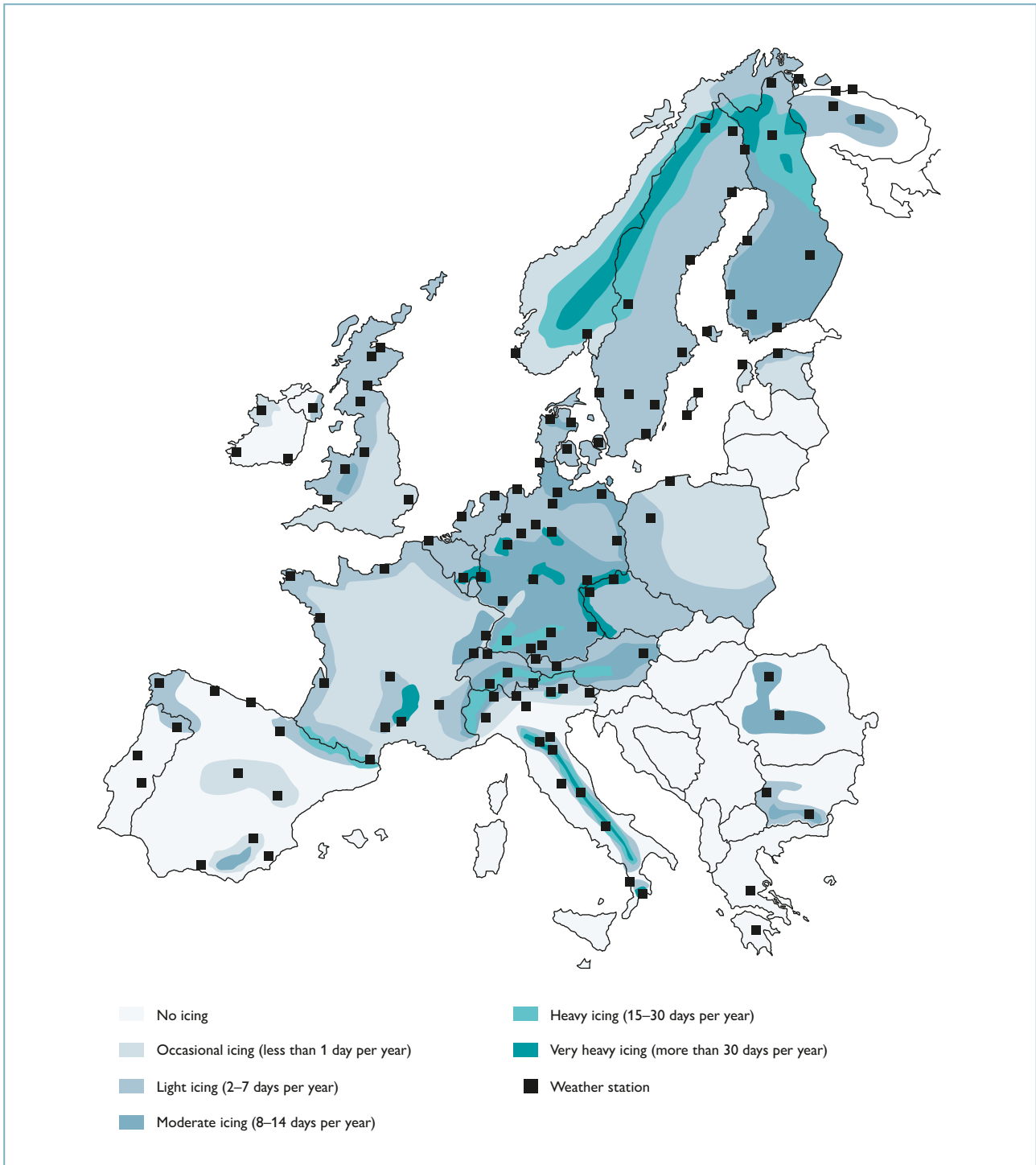
There are large regional differences on regulations regarding ice forming on wind turbine generators. In particular in so-called cold climate regions, WTGs have to be ideally equipped to manage ice build ups on the rotor blades. Many manufacturers offer a special cold climate version of their systems for these regions. These are perfectly equipped for operation in low temperatures, even below -10°C . With a rotor blade heater, for example, safe operation of the system is ensured even under extreme conditions.



Wind and solar power are taking on an increasingly important role in the energy mix of the future.

A distinction is made between two types of cold climate region. Some regions often experience extremely low temperatures. Other regions are subject to significant atmospheric icing.

The IEC standard specifies icing classes to classify the type of icing to be expected².



2 Introduction to the systems



Ice detection system applications and versions

The formation of ice on the rotor blades of a wind turbine generator depends on several factors. Alongside location, the formation of ice on the system also depends on many factors involving the WTG itself. The difference between ice forming on the rotor blade and ice forming on the nacelle is often greater than to be expected. Factors such as geometry, dimensions, movement, and flow velocity, mean that climatic influences exist on the blade that are not present at the weather mast on the nacelle. To ensure that a measuring system provides truly reliable information on the build-up of ice, where it is positioned on the generator has to be taken into consideration. In addition to the operator's interest in reliable system operation, the fact that many regions and countries have statutory requirements for an ice detection system also has to be taken into consideration. In these regions in particular, using a certified system (such as one certified by DNV-GL) is recommended to ensure that the approval process runs smoothly.

Ice detection systems certified for automatic restart have an additional advantage. These systems can eliminate the need for additional testing on-site to ensure they are free of ice. This minimizes downtimes and optimizes the system yield. These systems are particularly recommended in regions where ice build ups occur frequently, because the inspection work necessary and the delays in restarting caused by this work are relatively high.

State-of-the-art ice detection systems enable wind turbine generator downtimes to be significantly reduced in direct comparison to older wind turbine generators. Therefore, in many cases, it makes sense to retrofit an old system, since it will pay off

in a relatively short period of time depending on location. Here, it must be taken into consideration that not all systems are suitable for retrofit, and not all systems are compatible with all system types. Ideally, retrofitting a system that can operate completely autonomously and is not dependent on data from the generator control system is recommended.

Such individual systems for ice detection are based on various technologies:

- Ambient temperature
- Ambient temperature and relative humidity
- Anemometer comparison
- Camera systems
- Changes in the performance characteristic curve
- Measurements on the rotor blade



Technician while retrofitting sensors for ice detection on the rotor blade

The fact that the systems listed vary greatly in their accuracy mean that they have differing influences on the yield, but also play an important role in generator safety considerations. As a result, two technical solutions in particular have become established on the market: Nacelle-based ice detection and blade-based ice detection.

Nacelle-based ice detection

Nacelle-based systems are, conventionally, mounted on the WTG weather mast and measure specific meteorological parameters to determine the possibility of ice accumulation. Specific technologies, such as comparing two anemometers or ultrasonic ice detection, are used for this. Regardless of which version is used, none of them measure the ice accumulation on the rotor blade, but rather in a location where entirely different conditions prevail. Despite the high degree of inaccuracy, nacelle-based systems are still being used today. The low price and the low installation costs have a positive influence on the initial costs of the WTG, making the initial investment more attractive. In areas where ice build ups on wind turbine generators are rare, a nacelle-based system can be the best solution. However, increasingly powerful plants also mean that even short downtimes are more expensive.

Blade-based ice detection

In contrast to nacelle-based measurements, blade-based measurement systems measure ice build ups directly on the rotor blades. Here, a distinction is made between two measurement methods. One involves taking measurements on the outside of the rotor blade, and the other involves taking measurements on the inside of the blade, whereby the build-up of ice is calculated from the changes in vibration behavior.

Using an ice detection system directly on the surface of the blade can **reduce downtimes by up to 80% each year**. For example, if downtimes are reduced by 200 hours per year, this results in **savings of € 48,000 per year**, assuming a wind turbine with 3 MW nominal power, 4,000 full-load hours per year, and an 8 cent rate per kWh.³

A comparison of the systems

As described above, the conditions present on the rotor blade differ to those on the nacelle weather mast. In terms of the measuring system configuration, measurements taken on the nacelle have to be subject to significantly higher tolerances than those taken on the rotor blade. This can result in the WTG having to be shut down significantly earlier, with correspondingly higher yield losses. Because the trend is for ever longer rotor blades, the observable difference between nacelle-based and blade-based measurement is a factor that cannot be ignored.

The different conditions on the blade and the nacelle mean that it is not possible using nacelle-based systems to verify with any certainty that the rotor blade is ice-free. This is also the reason why only measuring systems installed on the blade are used in automatic restart applications. Therefore, when deciding upon which ice detection system to use, considerations have to be made regarding how to ensure the WTG can be restarted quickly.

Table 1 shows an overview of the most common systems on the market

Ice detection system	PxC BI	LID-3300IP	fos4ice	IDD Blade	Blade Control
Properties					
Technical solution	Capacitive sensors	Nacelle-based	Fiber-optic vibration sensors	Acceleration sensors	Acceleration sensors
Function					
Stop if ice is present	Yes	Yes	Yes	Yes	Yes
Automatic restart	Yes from 0 m/s	No	Yes from 3 m/s	Yes from 2–3 m/s	Yes from 2 m/s
Technology					
Sensor installation	Taped outside	Screwed onto the nacelle	Glued to the inside	Glued to the inside	Glued to the inside
Electrical cabling in the blade	No	Nacelle	Yes	Yes	Yes
Position of the sensors	Front edge	Nacelle	1/3 of the blade radius	12–18 meters away from the root	1/3 of the blade radius
Number of sensors	Min. 2 per blade	N/A	Min. 1 per blade	Min. 1 per blade	Min. 1 per blade
Min. required wind speed	0 m/s	0 m/s	3 m/s	2–3 m/s	2 m/s
SCADA data necessary	No	No	Yes	Yes	Yes
What is being measured?					
Rotor icing	Yes	No	Yes	Yes	Yes
Instrumental icing	No	Yes	No	No	No
Temperature measurement on the blade surface	Yes	No	No	No	No
Installation and other					
Installation effort	Low	Medium	Medium	Medium	Medium
Maintenance overhead	None	N/A	N/A	N/A	N/A
Retrofit possible	Yes	Yes	Yes	Yes	Yes
App support	Yes	No	No	No	No
Calibration effort	None	None	N/A	N/A	N/A

Blade intelligence for comprehensive rotor-blade monitoring

State-of-the-art blade monitoring systems can detect much more than just ice. They are used for comprehensive rotor-blade monitoring. The Blade Intelligence system from Phoenix Contact is exactly such a comprehensive solution that also includes a high-performance ice detection system. With this blade-based system, the sensors for ice detection are glued to the outside of the rotor blade.

A sensor outside on the rotor blade provides the following advantages:

- No cabling for installation
- Minimum maintenance overhead
- Autonomous energy supply

This task can be completed by a small climbing team in just a few days. By measuring the ice outside on the rotor, you have a particularly reliable system for detecting ice. Because the system is also certified for automatic restart, system downtimes due to ice accumulation can be reduced to an absolute minimum.

Another advantage is that it is easy to configure the sensors via app. The app guides the installer through the installation process on site. The installers can document the correct installation of the sensors with photographs. The app also extracts the key sensor data from these photos and transfers it to the WTG evaluation unit. In this way, the configuration is significantly easier and the technicians are spared time-consuming work.



To meet the ever-increasing demands for monitoring wind turbine generators, the Blade Intelligence system from Phoenix Contact uses a powerful PLCnext controller. Its open structure makes it possible to flexibly design the respective solution. This means that this solution can be used not only for ice detection, but also provides the option for load monitoring and lightning detection.

If all three systems are used, then the operator has the perfect overview of the state of the rotor blades on the wind turbine generator. Alongside the powerful and highly flexible controller, an additional advantage is that the system can be retrofitted onto almost all system.

3 Summary



Summary

The more precise the ice detection is, the more precisely the WTG can be controlled. The downtimes can be reduced to a minimum if ice is detected precisely. Ideally, the exact thickness of the ice layer is measured to manage downtimes as precisely as possible. Ideally, the system is certified for automatic restart so that the WTG can be restarted as quickly as possible after downtimes caused by ice build ups.

The possibilities of comprehensive monitoring systems on the rotor blade create synergy effects that can be used for optimized closed-loop control. The combination of different monitoring systems (e.g. additional load monitoring) provides a much more accurate overview of the state of the blades.

When selecting an ice detection system, you should always be aware of what the system needs to do and how it can benefit you. Particular attention should be paid to the following points:



Maintenance-free:

The ongoing costs are kept low



Certified system:

Safety, simplification of work, less work during implementation



Reliability and quality of the technical solution:

Higher yield and lower operative costs, increase in system efficiency, system restart, increased WTG service life



Calibration and cabling not necessary:

The system is quickly up and running



Precise ice detection:

Reduces your downtimes by up to 80% per year



Flexible and modular solution:

Buy what you need and extend as necessary (e.g. additional modules for monitoring)

References

- ¹ See Deutschlandfunk (2014): Mit Hubschraubern gegen die Vereisung (With Helicopters Against Icing), found at: https://www.deutschlandfunk.de/windenergieanlagen-mit-hubschraubern-gegen-dievereisung.676.de.html?dram:article_id=281006 (accessed on 2020-02-02)
- ² See IEC (2019): Wind energy generation systems – Part 1: Design requirements, found at: <https://webstore.iec.ch/publication/26423> (accessed on 2020-04-14)
- ³ See eologix white paper on ice detection

Contact

Book your consultation now.

Would you like information on using our ice detection system in your wind turbine generator?

Write to us. We will contact you as soon as possible.

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