BOOK OF ABSTRACTS

Winterwind

INTERNATIONAL WIND ENERGY CONFERENCE

2015

Cold climate wind energy solutions

THEORY AND PRACTICE UNDER ONE ROOF

Winterwind
INTERNATIONAL WIND ENERGY CONFERENCE

FEBRUARY 3

PROGRAM

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FEBRUARY 4

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Abstract #: 58 (Oral)

R&D areas/s: 12. Finance, risk assessment and mitigation

R&D as a prerequisit for successfully utilising the cold climate wind energy market opportunities

Jos Beurskens, SET Analysis, NL

Given the presently installed amount of wind power in areas, which are prone to cold climate (CC) effects (about 20% of the world's capacity), the market potential of CC wind energy and the potential for performance improvement, it is noticed that relatively – and surprisingly - little R&D efforts are being focused on CC issues. During the presentation general R&D topics will be categorised on the basis on their major impacts on energy output (external impacts, system efficiency), improving economics by load reduction, up scaling and system optimisation with the view on grid integration. This will be done for 4 major application areas: moderate climate, offshore, desert and cold climate zones.
Based on these observations a call for intensifying specific R&D and the implementation of innovations will be developed for CC applications. The improvement potential will be illustrated by some specific examples.

BACK

Abstract #: 7 (Poster)

R&D areas/s: 06. De-/anti-icing including ice detection & control

Combitech - when it comes to monitoring

Björn Ollars, Combitech AB, SE

Björn Ollars, Combitech AB
Patrik Jonsson, Combitech AB

When it comes to monitoring you need a reliable partner. Combitech AB is one of Sweden's largest consultancy companies with approximately 1500 employees. Combitech has been working with monitoring systems since the 1980's. Combitech develops electronic equipment and sensors, and also integrates sensors into complete monitoring solutions. Monitoring solutions consists of field sensors and loggers communicating with a server where the valuable monitoring data is stored. Combitech has a battery backed up storage from where data can be distributed to end users through customer adapted web interfaces. Data retrieved from monitoring systems installed at wind parks can be made available by Combitech on the internet, and an example is the online Wind Portal. An example of a sensor developed by Combitech is the ice load sensor IceMonitor used at wind parks and at power lines. The sensor is supplied as a separate sensor unit or together with meteorological sensors, logger unit and communication equipment. Another example of a Combitech solution is the camera monitoring system, where day and night images are taken of wind turbine blades. These images can be used to investigate the presence of ice and to examine damages on turbine blades. Combitech also offers image analysis competence for automatically finding anomalies in retrieved images. Combitech has close research cooperation with universities, and we finance a PhD candidate at Mid Sweden University. Current research project cooperation involves multispectral ice detection methods and the development of a new method for detecting water droplets. Combitech aims to be the most attractive partner available on the market when it comes to advanced monitoring systems. Our success factor is experience together with our competence to realize research results into reliable customer solutions.

Web site: http://www.rwis.net

Short biography: Björn is a consultant within monitoring systems. He works as a project leader in parts of the Pilot Project financed by Energimyndigheten. Björn is responsible for the functionality of the online site Wind Portal as well as Combitech's monitoring system offer, including the IceMonitor sensor. Björn is also a devoted mountainbike rider who likes downhill, especially at Åreskutan.

BACK

Abstract #: 18 (Poster)

R&D areas/s: 06. De-/anti-icing including ice detection & control, 07. Resource assessment, measurements and models

Lidar as ice detector

Timo Karlsson, VTT, FI

Using Lidar as an ice detector

In cold climates icing can have a rather drastic effect on wind turbines. Icing can reduce production, increase vibrations and can cause safety issues in areas around the turbines by increasing the risk of ice throw.

Ice detection is a difficult task to perform reliably and icing conditions can change quite rapidly with height. Several ice sensors have been created, but they all only really are able to detect icing at the sensor location. A remote sensing solution for ice detection is therefore very beneficial.

Lidars are quite commonly used to map wind speeds at different heights. Measurement range of a lidar can reach 200 meters or more. This is easily enough for even the highest modern wind turbines.

VTT has developed a solution that allows the usage of a standard lidar for ice detection. The method has been tested with real hardware and patented [1].

Monitoring the backscatter signal strength of the lidar gives you possibility to track icing condition or icing potential in atmosphere. With this it is also possible to asses icing conditions locally at any height without needing any extra infrastructure. Using the signal information from a lidar and a custom, patented algorithm, it is possible to create an icing warning signal at arbitrary height in real time. No prior measurements are needed; the method can be adapted to local conditions.

Greatest benefit is the ability to use standard hardware without modifications. The ice detection is an algorithm that can be used independently of the normal operation of the lidar. The algorithm can run in real time or can be used after the measurement campaign to asses icing conditions at the site.

A case study of a prototype version of the ice detection method is presented. Lidar generated ice alarm signals are compared to an ice detector signal at the same height. Alarm rates and timings are compared between these two solutions.

References:

[1]
Petteri Antikainen, Andrea Vignaroli, Esa Peltola
Arrangement and method for icing detection
US 20140192356 A1

http://www.google.com/patents/US20140192356

Web site:

Short biography: Timo Karlsson has been working on wind power since 2008 and has been focusing on cold climate wind since joinig VTT in 2011.

Over the last few years at VTT he's analysing the effects of icing on wind turbines, developing ice detection methods and working on ice prevention system development.

He holds a masters degree form Aalto University in Engineering

BACK

Abstract #: 21 (Poster)

R&D areas/s: 06. De-/anti-icing including ice detection & control

Efficiency and influence of heating device on wind turbine blades

Jan-Olov Aidanpää, Luleå Universiy of Technology, SE

Lars Liljenfeldt, Swerea SICOMP, Sweden

Today, there is a strong expansion of wind power in regions with cold climate. Cold climate and risk for icing can cause production losses or reduced service life for the wind power units. Luleå University of Technology, LTU, and the research organization Swerea SICOMP with experience from mechanics in cold climate have been working together in a project within the Theme Group ¨Cold Climate¨ as part of the Swedish Wind Power Technology Centre, SWPTC. The two-year project Efficiency and influence of heating device on wind turbine blades was performed between 2013 and 2014.

Through discussions with wind power owners (Vattenfall and Skellefteå Kraft) we know that the problem of efficiency and durability of de-icing/anti-icing equipment is an important issue. Therefore this project was defined as a first attempt to evaluate if research can assist the industry to develop more effective de-icing units and if it affects the expected life of the blades.

The aim of the project was to develop models and experimental methods to evaluate the efficiency of de-icing equipment and its influence on the expected life of the turbine blades. In addition, new technologies for ice detection have also been evaluated. Experiments have mainly been performed in a climate room at LTU but also on full scale wind turbines. The target was to understand and in future to increase the efficiency of wind turbines in cold climate under icing conditions.
It was early decided that the focus of the study should be on electrically heated carbon fibers in the laminates which is frequently used in wind power blades subjected to icing conditions.

The presentation will include the following topics resulting from the performed study:

- Manufacturing of test panels with heating elements in order to improve the robustness and functionality of the carbon fiber based heating system. Lay-up and the importance of good connection between the carbon fiber laminate and the copper connection is discussed.
- Heating signature of manufactured panels
- A degradation model based on the influence thermal fatigue of composite laminates with incorporated heating device. The results indicate that degradation should not be a problem if the heating device works properly.
- A thermal evaluation technique developed at Skellefteå Kraft by use of a mini helicopter equipped with thermal camera. With this new technique they can evaluate the functionality of the heating system before the winter and thereby increase the availability.
- A test method to study the de-icing process.
- A heat transfer modeled with FEM for de-icing developed by LTU. Different manufacturing methods of the composites with heating device have been evaluated. Different models for different kinds of ice and its heat transfer during de-icing.

Web site:

Short biography: Kompletteras senare

BACK

Abstract #: 3 (Oral)

R&D areas/s: 04. Swedish Energy Agency's CC research program, 06. De-/anti-icing including ice detection & control, 10. HSE (Health, Safety and Environment), 12. Finance, risk assessment and mitigation

De-icing of windpower blades using microwaves and CNT-coatings

Joachim Karthäuser, Re-Turn AS, NO

Kenth Johansson, Mikael Järn, SP, Sweden
Lars Eng, Mikael Nordeng, Stein Dietrichson, Paal Skybak, Re-Turn AS, Norway
Susanne Fogelberg, Göran Gustafsson, PEGIL Innovations AB, Sweden
Bernt Granberg, MW Inovation AB, Sweden
Peter Krohn, Vattenfall Research AB, Sweden

Since 2013, the consortium SP, MW Innovation, Vattenfall R&D, Pegil Innovations and Re-Turn AS investigates deicing of windpower blades using microwaves in combination with suitable e.g. hydrophobic topcoats. The concept is enabled by coating technology involving very efficient microwave absorbers such as carbon nano-tubes (CNT), developed by Re-Turn and now transferred to a new start-up company, Icesolution AS.
The deicing solution involves microwave emission inside the blade, complete coverage of the blade by a thin coating comprising CNT and a conventional top coat for erosion stability. Results are presented regarding
a) fundamental studies such as microwave absorption, suitable materials, deicing trial tests of a 3 m wing segment,
b) coating development, and
c) practical implementation aspects including potential risks, e.g. HSE and technical challenges.
The project "microDEICE" sponsored by the Swedish Energy Agency is ahead of plan. Compared with alternative solutions such as hot air and heating foils, the “wireless” microwave concept promises to be robust, simple, energy-efficient and possibly suitable even for anti-icing during operation. Efforts focus now on implementation on the first larger (2,5 MW) wind turbines in cold climate. Practical challenges on different markets, i.e. retro-fit of existing turbines and new blades, are discussed.

Web site: http://www.re-turn.no

Short biography: Joachim Karthäuser, project leader deicing

Background: chemist, worked for Shell Chemicals, NKT, Linde / AGA in R&D, sales, business development.

Since 2009 project leader at Re-Turn AS (windpower and composite projects), board member since 2012.

Co-founder / board member of SiOx Machines AB (since 2007) and Climeon AB (since 2011).

Abstract #: 32 (Oral)

R&D areas/s: 08. Production experience, losses

Estimating energy losses caused by blade icing from pre-construction wind data and DNV GL's experience analysing scada data from Scandinavian wind farms

Till Beckford, DNV GL, UK

Carla Ribeiro (DNV GL, UK)
Staffan Lindahl (DNV GL, UK)

At the Winterwind conference held in February 2014, DNV GL presented the findings of a study of actual icing losses based on operational SCADA data collected at 10 operating wind farms located throughout Sweden [1]. Throughout 2014, DNV GL has been assessing operational data from additional wind farms located in Sweden, Norway and Finland, as well as data from a great number of pre-construction measurement masts across the same region.

Results from the analysis of these two substantial data-sets are proposed to be presented at this Winterwind conference separately. The focus of this abstract is the analysis of pre-construction meteorological data and how such data can be used to estimate the future losses that are likely to be incurred during the wind farm's operational life-time.

Initially the authors analysed data from more than 60 meteorological masts throughout the Nordic region and investigated the influence of sensor type, sensor heating setups and geographical and climatological characteristics on the level of sensor icing observed in the data. Following this, a model has been developed which converts those observations into a project specific prediction of the mean annual energy losses that are likely to be incurred due to blade icing. This model has been validated against the updated operational data analysed in [1], showing very good agreement in the resulting losses.

Other investigations have shown that anemometer icing consistently occurs when certain climatological factors (namely temperature and relative humidity) come within a certain range, allowing for the construction of a matrix of likelihood of icing as a function of temperature and relative humidity. This will aid in the anemometer quality data processing for cold climates and has also been used to develop a method of icing long-term adjustment.

The inter-annual variability of icing in the wind data has been investigated to understand the impact of the period of measurements on the uncertainty in any energy loss prediction, and it was found to be very significant. A method has been developed which uses the matrixes mentioned above, together with data from long-term sources to extrapolate historical icing events at a site. This gives an insight into the relative harshness of measured winters with respect to the long-term conditions expected, and informs any adjustments to the predicted future energy losses.

Reference:
[1] "Quantification of energy losses caused by blade icing using SCADA data, and the development of an energy loss climatology using data from Scandinavian wind farms", Staffan Lindahl et al, Winterwind 2014.

Web site:

Short biography: Till Beckford has been working as an Energy Analyst at DNV GL for nearly 3 years since graduating, with first class honours, from the University of Bath with an MEng in Mechanical Engineering. At DNV GL, Till has been focused on the Nordic market, predominantly undertaking pre-construction energy assessments for proposed wind farms.

BACK

Abstract #: 12 (Oral)

R&D areas/s: 12. Finance, risk assessment and mitigation

Challenges and possibilities of handling more wind power in the power system - conclusions from Denmark

Jens Tang, Neas Energy, DK

Challenges and possibilities of handling more wind power in the power system - conclusions from Denmark

With the current build out rate we are seeing in Sweden, and if we are going towards 30 TWh, or more, wind power in Sweden, we will face further challenges in keeping the balance in the system. The question is if wind power only is causing problems or if it also offers solutions. In Denmark wind power is to a greater extent being used also for balancing the system. This is probably a future solution also for Sweden.

Wind power provided 33% of Denmark's energy consumption in 2013 and 41% of Denmark's electricity consumption in the first half of 2014. With some strengthening of the grid, Denmark plans to increase wind's share even further, to 50% of consumption. This certainly creates challenges in balancing the system, but apart from exporting/importing electricity and utilizing other power sources such as CHP plants, also wind can be used for balancing.
In the situations where prices are low/negative or there is too much power in the system, which will make the frequency start drifting out of limits, there is the possibility of closing down wind power production. This can be included in the role of the balancing party. Currently Neas Energy has a larger number of customers on agreements where they offer this service. If it is a spot price agreement it is a rather straight forward handling. If the spot prices are negative, the production will be closed down. In a fixed price agreement, the compensation to the wind power producer will be based on a prognosis of what the production would have been if the unit would have been in production.
The presentation will briefly describe the technical solution and a typical case where capacity was closed down. What was the effect for the producer and how did it affect the stability of the system.

Web site:

Short biography: Jens Tang has worked for Neas Energy since 2008, and has the role Vice President, Renewables Generation. This also includes the responsibility of being Team leader for Balancing and Neas Energy's internal Weather Desk. Jens is originally a meteorologist and have large competence and experience in this field. Amongst others he has worked for Danmarks Meteorologiske Institut DMI.

BACK

Abstract #: 4 (Oral)

R&D areas/s: 04. Swedish Energy Agency's CC research program, 06. De-/anti-icing including ice detection & control, 08. Production experience, losses, 10. HSE (Health, Safety and Environment)

Airborne de-icing solution for wind turbines

Hans Gedda, H Gedda Consulting, SE

Mats Widgren (Alpine Helicopter AB)

Hans Gedda.
Consulting Engineer.
H Gedda Consulting AB
On behalf of Alpine Helicopter Sweden AB
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Phone: 070-377 12 85

Airborne de-icing solution for wind turbines.

New research and field tests has made it possible to remove ice and snow from wind turbine blades.

With a helicopter and hot water, Alpine Helicopter AB has made it possible to de-ice a wind turbine blades in two hours rather than waiting for thaw. Until now, there has been no other alternatives than wait for the ice to melt if the wind turbine isn't equipped with a de-icing system. Alpine Helicopter has developed a cost effective no chemicals solution, using regular water and a helicopter to efficiently remove snow and ice from the wind turbine's blades.

The solution is simple: a truck equipped with a fuel tank and oil burner – with the capacity to hold 44m3 water – heats the water from 7ºC to 65ºC in 6,5 hours. The equipment has been developed in collaboration with Skellefteå Kraft AB. Everything is completed for efficient setup in the field with a tank and sprayer under the helicopter. The hot water is then sprayed onto the blades in the same way as when de-icing an aircraft.

Electricity producers operating in cold climates have experienced downtime costs while waiting until the ice naturally melts due to a lack of alternatives. De-icing of wind turbines with helicopter is a new technology, which has been tested on site Uljabuouda in Arjeplog. The tests show very promising results and has the support to further develop the de-icing system between 2014 and 2016 by the Swedish Energy Agency.

This presentation will show the technology and the advantage with this method. Results from tests carried out at Uljabuoda wind farm in Sweden will be presented together with other information.

Web site:

Short biography: Hans Gedda holds a M.Sc. in material science and a Ph.D in laser material processing. Hans has since 2005 been working with development tests and evaluation of de-icing technology. Hans is also involved in the Swedish Wind Power Technology Centre, theme group 6 cold climate as a specialist around issues related to de-icing technology. Hans has worked as a consultant since 2010 in several projects related to icing.

BACK

Abstract #: 35 (Oral)

R&D areas/s: 08. Production experience, losses

Quantification of energy losses caused by blade icing and the development of an energy loss climatology using SCADA data from Scandinavian wind farms

Staffan Lindahl, DNV GL, UK

Staffan Lindahl, DNV GL
Carla Ribeiro, DNV GL
Till Beckford, DNV GL

A major current challenge for the wind energy industry in Scandinavia is to understand the magnitude of energy losses caused by blade icing. Such information is paramount to ensure the financial success of individual wind energy projects and indeed for the Scandinavian wind energy industry as a whole. The ability to both predict future losses and to measure or otherwise understand the actual historical losses is of critical importance. To this end, a number of sophisticated models (atmospheric and others) have been developed, but uncertainty remains regarding their accuracy and validation of these is still limited.
At the Winterwind conference held in February 2014, DNV GL presented the findings of a study of actual icing losses based on operational SCADA data collected at 10 operating wind farms located throughout Sweden [1]. The key results of the study included a description of the techniques used to derive energy loss information from SCADA data, observed relationships between elevation and icing energy loss and seasonal production loss profiles for distinct regions of Sweden. Due to the relatively small data set, substantial uncertainty surrounding the conclusions was however highlighted.
Throughout 2014, DNV GL has been assessing operational data from additional wind farms located in Sweden, Norway and Finland. The techniques described in [1] have been applied to this updated dataset and the observations made have been used to update and refine the conclusions previously drawn [1], and to start to form an understanding of other important characteristics of energy losses arising from icing of wind turbines.
The results of the updated analysis of production data show a strong and general relationship between energy losses caused by icing and simple geographical characteristics. Based on this relationship and the country's topography, an icing climatology (map) is proposed for an area covering most of Sweden. For other regions in Scandinavia, further data and analysis is needed to investigate potential Atlantic coastal effects, effects of latitude and the influence of continental high pressure systems.
The study has furthermore included a consideration of the inter-annual variability of energy losses due to icing, seasonal icing loss profiles, and an assessment of the sensitivity of energy losses to the wind farm control strategy. The results obtained from these assessments will also be presented.
DNV GL has separately analysed data from more than 60 meteorological masts throughout the region and has submitted a second 'sister' abstract for this Winterwind conference. That presentation will present the findings of that study and show how these can be used in conjunction with the results of this analysis, to estimate icing losses in future projects across Scandinavia.

References:
[1] "Quantification of energy losses caused by blade icing using SCADA data, and the development of an energy loss climatology using data from Scandinavian wind farms", Staffan Lindahl et al, Winterwind 2014.

Web site:

Short biography: Staffan Lindahl joined DNV GL in 2006. He is now a senior engineer in the Asset Operation and Management group specialising in the performance diagnostics and optimisation of operating wind plant and post-construction long-term energy yield forecasting. During his period at DNV GL, Staffan has played a key role in designing the processes and associated software tools used for assessing the performance and expected energy yields of operating wind plant, and is now responsible for DNV GL's post-construction energy yield services in the UK, Ireland, Scandinavia and South Africa.

BACK

Abstract #: 42 (Oral)

R&D areas/s: 12. Finance, risk assessment and mitigation

Challenges with financing wind power in cold climate

Paul Stormoen, OX2, SE

OX2 has during the last 5 years constructed more than 500 MW of wind power in cold climate with a majority of the projects financed by industrial and institutional investors. There has been several challenges by being a front runner of attracting non-utilities to invest in wind power and also to appreciate both the risk and opportunities that comes with investments in the northern parts of the Nordics.

Web site: http://www.ox2.com

Short biography: Stormoen is the Managing Director of OX2 Wind since 2011 and has been with the OX2 Group since 2009. He has extensive experience in transaction wind power projects and managing development and construction teams. OX2 Wind is currently established in Sweden, Norway, Finland and Poland.

BACK

Abstract #: 24 (Oral)

R&D areas/s: 01. R&D programs, overview, 04. Swedish Energy Agency's CC research program

Vindforsk IV - update of ongoing projects

Göran Dalén, Vindforsk, SE

Vindforsk IV is a R&D program run by the the Swedish Energy Agency and Elforsk. It runs over a period of 4 years with a total budget of SEK 52 000 000. Eleven projects have been granted and a second call has just been completed.

The aim of the presentation is to give an overview of ongoing work, to discuss possible collaboration with other programs and finally to discuss what the industry is asking for. Today and in the future.

Web site:

Short biography: Worked in the wind business more or less since 1979. Employed by Karlskronavarvet, Vattenfall, Airicole, E.ON and wpd. Involved in several R&D projects such as Maglarp, Nordic 400 + 1000 and Downvind. Work package manager for foundations in the offshore project Baltic 1. CEO of wpd Scandinavia AB and wpd Offshore Stockholm AB. Now my own consultant and chairman of Vindforsk IV.

BACK

Abstract #: 37 (Oral)

R&D areas/s: 08. Production experience, losses

Power production losses due to icing and their relation to icing conditions and operation mode

Silke Dierer, Meteotest, CH

Rebecca Guggerli, Meteotest
Rene Cattin, Meteotest

Wind turbines in cold climate often operate in icing conditions and, thus, experience reduced power production due to disturbed aerodynamic properties of the blades and increased standstill. The current study investigates the power losses due to icing and their relation to icing conditions and operation mode of the wind park.

The study is performed for ENERCON wind turbines in several wind parks in Czech Republic, Germany and Sweden. Cameras have been installed on the turbines pointing at the nacelle sensors and at the blades. The camera pictures deliver information about icing frequency, icing strength and icing intensity. The periods of meteorological icing were subdivided in three classes of icing intensity and the instrumental icing in five classes of ice loads. This classification allows for a detailed analysis of the relation between power production losses and icing strength and icing intensity.

The cameras have been installed in winter 2012 / 2013. Thus, information for two winter seasons is available and the year-to-year change of icing conditions and power losses is discussed.

The wind turbines are operated with different blade heating modes. The comparison of wind turbines with different heating modes that are situated close to each other in the same wind park allows for a detailed analysis of the power production losses. The power production losses for wind turbines without blade heating, with heating at standstill and heating during operation are discussed.

Web site: http://www.meteotest.ch

Short biography: Silke Dierer is head of the modelling department and deputy head of the wind energy department at Meteotest. She has been working in the field of wind energy since 2004. Her areas of expertise include wind resource assessment in complex terrain and in cold climate; she has been involved in several research projects on icing on structures and its impact on wind turbine performance. Silke Dierer holds a PhD in Meteorology from the University of Hamburg where she specialized in wind modeling.

BACK

Abstract #: 54 (Oral)

R&D areas/s: 12. Finance, risk assessment and mitigation

Insurability of cold weather risk and damages

Anders Orebrandt, Marsh, SE

Ice as a risk has to be considered at an early stage when building wind power in cold climate. Developers has to consider changing climatic conditions over the full finance/operating period and ensure they give due consideration to selecting the right winter model, the right O&M contract not just being influenced by price in a competitive market.
Mitigation of risks has to be done at an early stage when negotiating insurance and O&M contracts together with your insurance advisor. Both insurance and O&M contract has to be adapted to the special conditions in cold climate. Risks has to be analyzed mitigated and transferred to an insurance solution or handled in the O&M contracts. This can best be done at an early stage when negotiating all agreements.

Web site: «Presenter_Website_URL»

Short biography: Marsh is a global leader in insurance broking and risk management. Marsh helps clients succeed by defining, designing, and delivering innovative industry-specific solutions that help them effectively manage risk. For the wind power sector this is done by analyzing O&M contracts and transferring risks to an insurance solution.

Marsh's approximately 26,000 colleagues work together to serve clients in more than 130 countries.
ce is not a real problem for the insurers because O&M contracts are primary
Ice has to be considered in the turbine supply and maintenance contracts from the beginning.
Chose a turbine suited and tested and approved for cold climates
Important with SCADA system that is identyfying ice build up and shuts down turbine at an early stage.
Adapt the insurance policy to the maintenance and service agreement
e.g to implement an operational limit in the insurance policy where the turbine has to be stopped.
to implement the same operational limit in the O& M contract.

BACK

Abstract #: 28 (Oral)

R&D areas/s: 04. Swedish Energy Agency's CC research program, 06. De-/anti-icing including ice detection & control, 10. HSE (Health, Safety and Environment)

Ultrasonic guided waves approach for ice detection on wind turbines

Siavash Shoja, Chalmers University of Technology, SE

Siavash Shoja (Department of Applied Mechanics, Chalmers University of Technology, SE)
Viktor Berbyuk (Department of Applied Mechanics, Chalmers University of Technology, SE)
Anders Boström (Department of Applied Mechanics, Chalmers University of Technology, SE)

Wind turbines performing in the cold climate regions are affected by icing which is one of the main contributes to the low performance of the wind turbine. The main consequences of icing are loss of energy production, fatigue loadings, increased noise and etc. In the case of extreme icing, it might even cause operational stoppage. De-icing also requires usage of considerable amount of energy [1]. To avoid the problems and optimize the de-icing systems, having an accurate ice-detection method is essential. Many investigations have been done in this field and many methods and systems of detection are introduced however there is still lack of a proven system which fulfills the needs of ice detection on rotor blade of wind turbines [2]. In this project ultrasonic guided waves approach is considered. A 2D model including one layer of anisotropic material (as composite) and one layer of isotropic material (as ice) is used and the dispersion curves are obtained for different amount of ice. Furthermore, an experimental set-up has also been developed in a Cold Climate Lab at Chalmers University of Technology with a demonstrator for the ice detection system, composite test object and equipment for glaze and rime ice production. The composite material in the test object is the same as normally used in wind turbine blades. In both, theoretical and experimental studies, accumulation of different amount of ice on the composite plate results in detectable changes of the test object's response and gives the possibility to conclude that ultrasonic guided waves is a promising approach for ice detection.

ACKNOWLEDGEMENTS
This research is funded by the Swedish Energy Agency through the project "Ice detection for smart de-icing of wind turbines" (Project: 2013-001475). The authors are grateful to Jan Möller for his contribution to developing experimental set-up at Cold Climate Lab at the division of Dynamics, Chalmers University of Technology.

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[2] Ice sensors for wind turbines. Homola, Matthew C, Nicklasson, J Per and Sundsbo, Per A. s.l. : Cold Regions Science and Technology, 2006, Vol. 46.

Web site: http://www.chalmers.se/am

Short biography: Siavash Shoja
PhD Student, Department of Applied Mechanics, Chalmers University of Technology.
My background is mainly in three fields:
1. Mathematical and Computational modeling of wave propagation in Isotropic/Anisotropic materials
2. FE modeling and analysis of manufacturing processes
3. Design Engineering of mechanical parts/components in aerospace and automobile industries.

BACK

Abstract #: 22 (Poster)

R&D areas/s: 06. De-/anti-icing including ice detection & control

Detection of different phases of water on a wind turbine blade using NIR camera

Lavan Kumar Eppanapelli, Luleå university of Technology, SE

Lavan Kumar Eppanapelli (LTU, SE), Johan Casselgren (LTU, SE) and Sara Rosendahl (LTU, SE)

Today there is a strong development of wind power in northern Sweden, where risk for icing conditions is present. Icing of the blades leads to changing load conditions, production loss and risk of overloading the machine components. When the ice comes off, the ice throw can lead to both physical damage and personal injury. Uncertainties around these issues threaten the planned expansion in the northernmost regions.

To be able to plan and run a profitable energy production from wind turbines in cold climates, the problem of icing needs to be minimized, for example by de-icing. A de-icing equipment consumes up to 10% of the energy that a wind turbine produces1. Hence, good regulation is of importance. The sensors that are currently used to measure ice are often located on the generator, i.e. not in the same climate as the wing, which means that they are not optimal for controlling the de-icing systems. Another way to control the de-icing systems is to examine the production curves this is also a slow system.

Elforsks report2 notes that in the current situation there is a great need for more and better ice measurements, especially on wind turbine blades. Today's instruments are not reliable and accurate enough with the result that there remains considerable uncertainty in the understanding of icing on wind turbines and in the development of new icing models. Prediction of loads and production is also of great importance for the wind turbine durability and economy. In a previous national study3 demonstrated how the ice by asymmetrical effect on the rotor aerodynamics and mass coating affects the power and loads of the wind turbine. Being able to measure the icing and predict icing models for maintenance could be further developed regarding wear as a result of ice load.

At Luleå University of Technology (LTU) research on detecting ice and snow on roadways and railroad tracks been carried out for several years4. The result is a technique using near infrared (NIR) light enabling classification of different phases of water on both the roadway and rail with great certainty. By combining this knowledge and utilizing a new technology NIR camera, a method have been developed that could be used for the detection of water, ice and snow on the wings of wind turbines.

The experiments carried out in a freezer in the laboratory of LTU. The first tests in a controlled environment demonstrate that the technique has great potential enabling presentations of color-coded images, where a certain color represent a certain phase of water. These images have obtained by illuminating light over to a small piece of wind turbine blade at different conditions and by measuring the light reflection response by NIR camera. The illumination source has 3 laser diodes of wavelengths as 980nm, 1310nm and 1550nm. A halogen light is also used along with NIR light, to observe the applicability of these experiments in the real environment, to simulate disturbances that can appear in real conditions.

The results are promising and will be tested on a small wind turbine with the assumption that the method can be extended to the detection of ice on a full-length wind turbine blade. If this is successful the detection of phases of water on blades can be used to improve the regulation of de-icing system and in the modeling of ice aggregation on the blades

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Web site:

BACK

Abstract #: 22 (Poster)

R&D areas/s: 06. De-/anti-icing including ice detection & control

Short biography: Lavan Kumar Eppanapelli has recevied his masters degree from KTH, Stockholm in the area of Sustainable Energy Engineering focussed on wind power systems. He is currently, active as a PhD student at Luleå University of Technology, Luleå since 2014. His area of research includes application of optical systems for wind turbines in the cold climate.

BACK

Abstract #: 41 (Poster)

R&D areas/s: 06. De-/anti-icing including ice detection & control

Experiences from blade-mounted ice detector development

Tatu Muukkonen, Labkotec Oy, FI

Jarkko Latonen (Labkotec Oy, FI)

One of the Labkotec's first prototype ice detector was installed on a wind turbine blade. That took place in the northern Finland over 20 years ago. The prototype ice detector was designed to trigger blade heating when ice was accumulated to the blade surface. This concept was excellent but the timing for business opportunities was wrong. That prototype was never put to production.

Since that time many new wind turbines have been built to cold climate. Due to the icing weather conditions and demands for non-stopping production there are more requirements for ice detection. Because of that blade-mounted ice detector development has been continued in Labkotec together with the development of Labkotec's state-of-the-art nacelle mounted ice detector. New requirements have put a lot of pressure to product development. It is not only the demanding technical challenges but also lack of harmonized test methods and standards.

Experiences from the development of Labkotec's state-of-the-art nacelle and prototype blade-mounted ice detectors will be presented.
Different aspects and boundary requirements for a blade-mounted ice detector will be described. Also the experiences of radio communication
between blade and nacelle in multi-megawatt turbine will be shown. Some field testing results on icing conditions will be summarized.

Web site: http://www.labkotec.fi/en

Short biography: Focusing on ice detection and applications for about four years now, working currently for ice detectors R&D as Project Manager

BACK

Abstract #: 51 (Poster)

R&D areas/s: 01. R&D programs, overview, 06. De-/anti-icing including ice detection & control

Breaking the ice using passive anti-icing coatings – Lessons learned from the Nordic TopNANO research project

Agne Swerin, SP Technical Research Institute of Sweden, SE

Mikael Järn 1, Kenth Johansson 1, Agne Swerin 1,2, Joseph Iruthayaraj 3, Sergey Chernyy 3, Per Claesson 1,2, Lasse Makkonen 4 and Juha Nikkola 4

1. SP Technical Research Institute of Sweden, Stockholm, Sweden
2. KTH Royal Institute of Technology, Surface and Corrosion Science, Sweden
3. Aarhus University, Aarhus, Denmark
4. VTT Technical Research Centre of Finland, Finland

Ice causes major problems on wind turbines, airplanes and heat exchangers. Today's methods using heating and chemical treatments are expensive, can be inefficient and non sustainable. Nanotechnology can create surfaces where the ice does not stick or is easier to remove.

TopNANO is a Nordic research project with support from the Top-level Research Initiative running 2010-2014 and was recently ended. The aim is on sustainable and efficient methods based on nanotechnology to reduce problems and costs with ice build-up. SP Technical Research Institute of Sweden was project leader with industrial and research partners from four Nordic countries, among others Saab and Vattenfall. The budget was 3,9 M€ with half through industrial in-kind.

SP and KTH focused on robust superhydrophobic surfaces (with proposed ice-phobic properties), water-structure breakers and surface spectroscopy analyses. VTT brought expertise on the physics of ice. Aarhus University and their iNano centre worked on organic surface grafting for water-structure breaking properties. TopNANO engaged industrial researchers, senior scientists, postdocs and PhD students.

For participating industrial companies the TopNANO project runs in parallel with already existing projects and activities in wind, aircraft and heat exchangers. Of key importance for TopNANO is the transfer of knowledge to Nordic industry, and even more importantly, through direct industry-academia collaborations. The aim was also to evaluate new surface materials and benchmark against systems used today and to use the project and partner group as a platform to mount national, Nordic and EU projects.

Ice and frost are nanostructured materials and to develop methodology to combat ice build-up is nanotechnology. The area of passive anti-icing coatings has attracted a lot of interest in recent time, and the more so during the project.

For the initial laboratory experiments the lead ideas were to reduce ice formation by the use of superhydrophobic surfaces or by the use of surfaces exposing chemical groups classified as water-structure breakers. We worked to understand on a molecular level why or why not concepts work. Promising candidates were scaled up for testing of robustness, erosion and in an icing wind tunnel. During two winter seasons we were gained access to Vattenfall's wind park at Stor-Rotliden, Lapland, Sweden to mount samples on top of one nacelle. The rack of samples was monitored by VIS and IR cameras during the whole winter seasons and samples were reanalyzed for their surface properties after dismounting.

Laboratory studies showed that it is not obvious that superhydrophobic surfaces will delay water freezing and the experimental results can be understood based on heterogeneous nucleation theory meaning that ice formation can, in some cases, be promoted when the necessary surface roughness for superhydrophobicity is introduced. A water-structure breaking capability can be added if the counter-ion to charged polymer groups on the surface is changed to e.g. Li ions. It was shown that the ice adhesion was reduced by 40 to 70 % by use of this changed surface functionality.

Concepts were scaled up and tested in icing wind tunnel experiments with good results and winter field tests were performed. However, also after the second winter season testing, most of the samples had lost their ice-phobic properties even for several variations of the two basic concepts. We conclude that the harsh combination of severe weather, erosion and freeze/thaw cycles experienced during the whole winter cannot be mimicked under laboratory and pilot-scale conditions. Both laboratory and pilot experiments are necessary but field tests is a crucial part of anti-icing coating development.

Several of the TopNANO researcher and companies now work in related projects on passive and active anti-icing coatings in projects with national and EU funding

Web site: http://www.sp.se/SV/UNITS/CHEMISTRY/Sidor/default.aspx

Abstract #: 51 (Poster)

R&D areas/s: 01. R&D programs, overview, 06. De-/anti-icing including ice detection & control

Short biography: Agne Swerin is the research director at SP Chemistry, Materials and Surfaces and adjunct professor at KTH Royal Institute of Technology, Surface and Corrosion Science. Prior positions have been with Swedish and North American industrial companies. Current research in novel surface modification focusses on wetting, spreading and liquid penetration phenomena. Swerin is the author of more than 50 publications and 4 patents.

BACK

Abstract #: 8 (Oral)

R&D areas/s: 06. De-/anti-icing including ice detection & control

1,500 Years of Icing on wind turbines – a long term study

Dietmar Tilch, Bosch Rexroth Monitoring Systems GmbH, DE

Co-authors:
Dr. Daniel Brenner
Dr. John Reimers
both Bosch Rexroth, Germany

Icing on wind turbines differs heavily both in quantity and in shapes in different regions of the world. The proposed study summarizes experience from more than 1,500 operational wind turbine years gained in more than 15 countries over the last 10 years. It takes a look at different icing conditions and the different ways to detect them. Comparisons show strengths and weaknesses of available detection methods in different environments illustrating that there is no single one-fits-all solution. Derived out of these comparisons an overview is provided which approach may suit which needs based on the conditional circumstances and operational requirements of the wind turbines.
The study will be supported by quantified measurements of real ice formation events.

The presentation will be provided in a scientific way without any inclination toward particular methods or systems.
The only distinction is that the quantified measurements will be based on measurements gain with the BLADEcontrol ice detector.

Web site:

Short biography: After studying electrical engineering and receiving a PhD at the University of Karlsruhe, Dr. Tilch joined the former Mannesmann Rexroth AG in 1998.
He started as a development engineer in the field of industrial automation. From 2003 to 2008 he worked as development manager for control systems for packaging machines in the USA. In 2010, Dr. Tilch joined the business unit Renewable Energies within Bosch Rexroth where he established the new business field of condition monitoring.
As of April 2011 he is also the managing director of the Bosch Rexroth Monitoring Systems GmbH in Dresden, Germany.

BACK

Abstract #: 10 (Oral)

R&D areas/s: 07. Resource assessment, measurements and models

Benchmark of ice noise modelling

Max Muckermann, E.ON Climate & Renewables, DE

Abstract Winterwind Conference 2015: Benchmark of Ice noise modelling

Ice accretion on rotor blades of wind turbines in cold climates is quite normal and already well known. A resulting effect of iced blades is the increasing of noise emissions. To reduce compliance risk and improve development processes for wind farms, a better understanding of noise emissions due to ice is necessary. In the following I consider the impact of increasing noise and opportunities for modelling.
For wind farm development, software for prediction of noise propagation is already commercially available. But for development in cold climates, the impact of ice noise is not currently considered in these software codes. The need therefore is not to develop a discrete propagation model for noise due to ice. In fact, the task is to find a way to integrate an ice noise model into existing software as a kind of add-in or tool.

- The first step is to get to know what kind of input data is needed when using existing software for noise propagation.

- The next step is to look how one calculates this input data.

The presentation will have a look at two different approaches. Ice accretion on blades impacts the airfoil self-noise. The geometry of the airfoil is changed by ice and hence the air circulation, too. And that impacts the noise generation.

One calculation approach could be to compute the circulation around an iced airfoil. Codes for ice accretion structures on airfoils are available. But is this method close enough to reality? Finally, noise data has to be computed from the results of the air circulation. What are the possibilities there? One critical issue is the likely thickness of the ice layer on the airfoil for computation.

But is such a "bottom up" approach the best way to predict ice noise for practical purposes? How is the noise of wind turbines determined without icing conditions? An experimental alternative to modelling could correlate noise measurements under icing conditions with weather data. Could this be an alternative way to predict noise emission during specific weather conditions? This presentation will look at the pros and cons of such an approach.

Web site:

Short biography: - final year student of mechanical engineering at Bochum University of Applied Sciences, Bochum
- focus on design engineering, which includes: fluid mechanics, energy management, simulation methods
-personal interest: playing the e-guitar

BACK

Abstract #: 19 (Oral)

R&D areas/s: 07. Resource assessment, measurements and models

Case study of Lidar measurements in southeast Finland – Lidar performance and wind conditions in cold climate and complex terrain

Katja Hynynen, Lappeenranta university of technology (LUT), FI

Elvira Baygildina, LUT, Finland
Svetlana Afanasyeva, LUT, Finland
Olli Pyrhönen, LUT, Finland
Jordi Armet, Alstom, Spain
Pau Nualart, Alstom, Spain
Iciar Font, Alstom, Spain

The amount of wind power is exploding, not only on the coasts, but also in inlands. The shear conditions may be challenging in inlands, influencing in the energy production and loads of the turbines. Increasing use of Lidar technology enables easy measurement of wind shear along the whole rotor area

In this case study, the availability of the Lidar and wind shear conditions in a wind farm situated in southeast Finland were studied. The study is part of a research project 'Wind power in cold climate and complex terrain' carrying out by Lappeenranta university of technology, Alstom Renevables España, TuuliMuukko, and TuuliSaimaa.

The measurement campaign was performed in a wind farm of seven Alstom ECO110 cold climate version turbines in southeast Finland. The terrain is mainly forestry, partly industrial area. Wind measurements were performed using Windcube v2 ground-based Lidar during the period 16.12.2013-31.8.2014. Because of the forestry terrain, the Lidar was equipped with Flow Complexity Recognition (FCR) module. Normally the Lidar assumes homogenous flow, which may lead to significant bias in complex terrain [1]. FCR aims to correct this mistake.

The atmosphere in Finland is clean containing only few particles, which sets challenges to the operation of a Lidar. In order to improve the availability of the measurements, the CNR ratio of the device was decreased to -25 dB from the default value of -22 dB. Lidar availabilities > 60% were considered high enough for reliable wind measurements, which lead to recovery rate of 91% for the measurements in hub height and 71% for all heights over the rotor diameter. High visibility of atmosphere was found to be the main reason for the low availability. The episodes of raining, snowing, and fog that decrease the visibility, clearly increased the availability.

The 12 measurement heights available with the ground based Lidar, allowed the study of the wind shear along all rotor area using the following models; power law and modified log law. Comparison of the experimental and predicted wind profile has shown that both power law and log law can accurately represent the site specific wind conditions. In particular, the algorithm to find the best-fit profile using power law and log law has been developed. The results of fitting algorithm indicate that the average wind shear exponent, defined by power law, $\alpha = 0.38$, between hub height and lowest blade tip height, accurately describes the behavior of the measured vertical profile. However, following the generally accepted tabulated value for forested area, the wind shear exponent $\alpha = 0.2$-0.3, cannot characterize wind profile at the site under study. Relating to the modified log law [2], which used to characterize wind flow above a forest canopy, the parameters, such as roughness length Z0, displacement height d and ZU=0 were determined. The resulted fitting curve has proved that the model is applicable to the forestry area. However, the set of parameters of the log law model are found to be inconsistent. According to modified log law, ZU=0 height where the wind speed is theoretically zero, is found to be 77.4 m, thus one can hardly conclude that the log law model parameters have clear meaning. It is reasonable to conclude that the wind flow over forested terrain has complex behavior. Therefore, more analysis is needed to separate effects on wind flow at complex terrain.

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[2] A. L. Rogers, J. F. Manwell, and A. F. Ellis, Wind Shear over Forested Areas, 43rd AIAA Aerospace Sciences Meeting and Exhibit, 2005, Reno, Nevada.

Abstract #: 19 (Oral)

R&D areas/s: 07. Resource assessment, measurements and models

Web site:

Short biography: Katja Hynynen received the M.Sc. degree in energy technology in 2000 and D.Sc. degree in electrical engineering in 2011 from Lappeenranta university of technology (LUT), Finland.

She is working as a Finnish academy post-doctoral researcher in the Department of Electrical Engineering at LUT. Her research interests include wind resource assessment, influence of cold climate and complex terrain conditions to wind turbine operation and maintenance requirements, and diagnostics of wind turbines. Additionally, she teaches wind and solar system technology, and control engineering.

BACK

Abstract #: 13 (Oral)

R&D areas/s: 01. R&D programs, overview, 06. De-/anti-icing including ice detection & control

Icing monitoring for R&D projects

Dominic Bolduc, TechnoCentre Éolien (TCE), CA

Matthew Wadham Gagnon (TCE, CAN)
Jens Petersen (SENVION, GER)
Hannes Friedrich *SENVION, GER)
Amélie Camion (SENVION, CAN)

Over the last couple of decades, the use of cameras for ice monitoring on wind turbines, met masts and instruments has enabled the validation of numerous icing prediction models, ice sensors and heated instruments for the wind energy industry. These electronic "eyes", available 24 hours a day and 365 day a year, are sometimes the only way to confirm the presence of ice on structures. With the advances in image analysis and camera sensors, the technology is now capable of measuring accurate ice accretion on different surfaces and in different light spectrum.

This winter, TechnoCentre éolien (TCE) and Senvion will have 20 cameras installed on 6 turbines in 3 different Quebec wind farms, all dedicated to icing related activities in moderate to severe icing environment. TCE will also have cameras installed on 3 met masts, at two different sites. These cameras will be used for a variety of ongoing projects including:

- ice load assessment;
- ice operation mode optimization;
- de-icing system performance assessment;
- validation of ice detection methods;
- Development automated image analysis for detection using;

With pictures being recorded every 10 minutes, including at night thanks to night vision and/or infra-red illumination, hundreds of gigabits of high resolution images during icing events will be available for analysis. This will lead to the development and optimization of automated image analysis algorithms.

An overview of the different ongoing projects and instrumentation will be presented with the goals and challenges related to ice monitoring with cameras along with preliminary results.

Web site: https://www.eolien.ca/

Short biography: Dominic Bolduc is a research analyst at the TechnoCentre Éolien (TCE) since 2012. He has a Master's degree in Computational Fluid Dynamics from École Polytechnique de Montréal. M. Bolduc is specialized in ice detection methods including double anemometry, power curve deviation, image analysis and specialized sensors. He also works on cold climate related projects like ice protection systems evaluation, site icing classification and ice throws risk assessment.

BACK

Abstract #: 20 (Oral)

R&D areas/s: 01. R&D programs, overview, 06. De-/anti-icing including ice detection & control, 09. DOM (Deployment, Operations and Maintenance), 10. HSE (Health, Safety and Environment)

Long-term online sound monitoring in wind parks

Antti R. Leskinen, APL Systems Ltd, FI

Antti R. Leskinen (APL Systems Ltd, FI)
Roy Hjort (APL Systems Ltd, FI)

Local environment and weather conditions changes the soundscape of a wind parks. Cold climate exposes wind turbines on icing and changing weather conditions can initiate sound reflections to local residential areas. Wind turbine sound changes also due to wear and tear of blades and changing conditions of turbine mechanics. These different conditions can be reason on how and what kind of noise dissipates from the wind park. Changes in sound can occur in the low frequency noise (LFN) area or on higher frequencies depending on the origin of the sound. Long Term noise monitoring in a wind park with LFN monitoring capabilities offers tools necessary to monitor the emissions and immission of the wind turbine noise. Online monitoring provides immediate feedback on noise level changes in 1/3-octave bands within the wind park. Online monitoring tools can be used to follow warranty noise levels of turbines, maintenance of turbines, ice detection on blades and local residential area sound level monitoring. Aures 2.0. OnLine has been developed by APL Systems in cooperation with leading large scale engine manufacture and will work equally well in urban industrial settings as well as rural settings.

Web site: http://www.apl.fi

Short biography: Antti Leskinen is the CEO and Co-founder of APL Systems Inc. Mr. Leskinen is a serial entrepreneur and has 20 years of experience in international business development. APL Systems has developed a proprietary service platform together with world leading corporate partners. APL Systems Oy has launched several novel and innovative services for noise monitoring. APL is using its own proprietary service platform and software to collect and analyze noise data. The ability to collect the full sound spectrum for a long time period in several locations at the same time gives a unique ability to analyse actual noise emission and immission levels.

BACK

On the Variability of Temperature and Icing Status over the Blades of a Wind Turbine

Michael J. Moser, eologix sensor technology gmbh, Science Park Graz, Austria
Thomas Schlegl, eologix sensor technology gmbh, Science Park Graz, Austria
Hubert Zangl, Alpen-Adria Universität Klagenfurt, Austria

Temperature sensing and detection of icing on rotor blades is crucial for adequate control of anti- and de-icing equipment as well as for keeping people safe from ice throw. The eologix team has successfully demonstrated the feasibility of their unique approach of attaching small autarkic wireless devices to the rotor blades' surface by means of standard erosion protection tape over both heated and unheated surfaces. In the winter season 2014/15, field tests on several turbines exposed to icing conditions are conducted.

Figure 1 shows a single sensor device mounted over the leading edge of a rotor blade.

Figure 2 exemplarily depicts temperature data from multiple sensors distributed over the unheated blades of one turbine. It can be seen that large temperature differences occur over the blade, depending on absolute height, air flow, sun exposure and operational state of the turbine.

At the conference, we will present data from actual icing events from turbines located in alpine regions, discuss the acquired measurement data in detail and deduct the relevant parameters for production optimization for both heated and unheated blades.

Figure 1: Sensor on blade

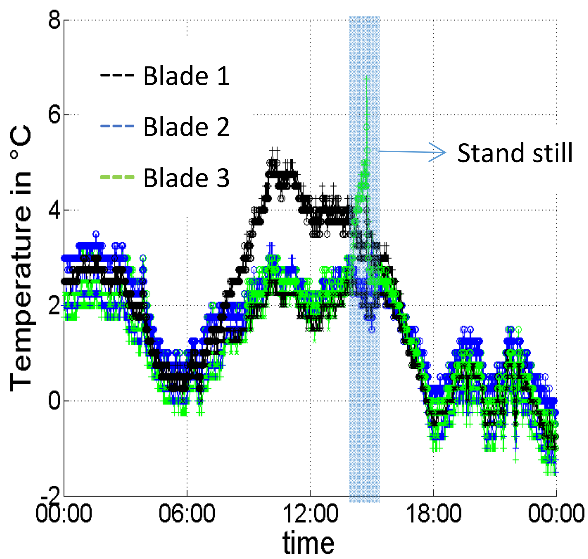

Figure 2: Temperature distribution over blade

BACK

Abstract #: 38 (Oral)

R&D areas/s: 10. HSE (Health, Safety and Environment), Wind turbine noise

Simulating iced wind turbine noise

Richard Hann, Richard Hann Consulting, DE

The vast development of wind energy within the last decade has led to increased public awareness of noise pollution. This has resulted in today's strict noise regulations and substantial scientific efforts to understand and decrease wind turbine noise. However, very little work has been performed to investigate the impact of cold climate conditions on wind turbine noise.

A first numerical study introduced a simulative approach to investigate the increased noise generation of iced airfoils and blades for wind turbines [1]. Based on computational fluid dynamic (CFD) and computational aeroacoustic (CAA) methods, a 2D simulation process chain was developed to estimate the impact of icing on wind turbine noise. The results clearly indicate that icing leads to amplified turbulences and a significant increase in trailing-edge noise.

However, due to the lack of experimental data for validation of the aforementioned study, large uncertainties remain. The simulation of iced wind turbine noise combines a broad spectrum of physical phenomena (e.g. high turbulence, early flow separation, increased surface roughness, convex geometries), which are complex and can only be captured by simplification.

This study discusses the proposed simulation chain (generation of iced geometry, CFD and CAA) and identifies the main challenges and improvement areas. It can be shown that the quality of the results is highly dependent upon the consistency of the input data, the choice of numeric methods (for each step of the simulation chain) and the interface between the models. This highlights the need to further develop a holistic understanding of the interaction between cold climates and wind turbine noise, as well as the potential for further development of this approach.

[1] R. Hann, A. Wolf, D. Bekiropoulos, T. Lutz, E. Krämer: Numerical Investigation on the Noise Generation of Iced Wind Turbine Airfoils. Winterwind 2013

Web site:

Short biography: Richard Hann graduated as an aerospace engineer (Dipl.-Ing.) at the University of Stuttgart in 2013. He is a specialist for computational fluid dynamics (CFD), computational aeroacoustics (CAA) and icing simulation. Richard has been involved with cold climate wind energy since 2011 and has focused on several topics such as anti-icing, performance degradation and noise generation. In the past he collaborated with the wind turbine manufacturer Kenersys GmbH and also with the Technical Research Centre of Finland (VTT). Currently, Richard is researching simulation methods for investigating the impact of icing on the noise generation of wind turbines.

BACK

Abstract #: 47 (Oral)

R&D areas/s: 07. Resource assessment, measurements and models, 08. Production experience, losses

Towards an increased understanding of icing conditions within a wind farm through visualisation of SCADA data in a topographic context

Magnus Baltscheffsky, WeatherTech Scandinavia, SE

Stefan Söderberg, WeatherTech Scandinavia AB, Sweden

Big Data is a buzzword in many industries including the wind power industry and it is often used to describe a massive volume of structured or unstructured data so large that it is difficult to process and analyse using traditional database and software techniques. Progress in this field have resulted in techniques used to process, analyse and visualise Big Data that can be useful when trying to overcome new complex challenges. Production losses due to icing qualify as such a challenge. Finding and understanding its main causes is difficult partly because the production loss due to icing is dependent on many parameters.

This work takes a data driven approach to gain new insights in how production loss due to icing varies within a wind farm. This is done by visualising and filtering SCADA data together with weather data in a topographic context for wind farms in cold climate.

A case study of a wind farm in northern Scandinavia will be used to demonstrate how visualisation can help understand icing. Filtering out data based on ranges of different parameters and time reveals patterns that might help answer questions such as:

- How does local icing vary in complex terrain?
- Is it possible to adapt a wind farm layout to minimise icing problems?
- Can the severity of icing seasons be classified using e.g. wind direction, topography and position relative to open sea?

Web site: http://www.weathertech.se

Short biography: Magnus Baltscheffsky is currently a model developer and consultant at WeatherTech Scandinavia where he has worked for the past 4 years with atmospheric modelling and issues related to the icing climate. He holds an M.Sc. in Meteorology from Uppsala University and has been using the WRF model extensively for the past 6 years.

BACK

Abstract #: 49 (Oral)

R&D areas/s: 06. De-/anti-icing including ice detection & control

Experiences with different ice-detections

Kimmo Palmu, WestWind, FI

Kimmo Palmu (WestWind, FIN)

The increasing use of wind turbines closer to facilities has shown, that suitable open areas for the installation of wind turbines are increasingly difficult to find. Special locations, such as harbour area lead to particular requirements for wind turbines especially if hazardous events (e.g. ice fall & throw) can cause immediate damage due to the special site conditions (shipping, storage, hse).

In the harbour of Hamburg have been constructed several wind turbines. There exist experience of ice throw and the areas beneath and near the wind turbines are used for storage, infrastructure and industry. It was evident that all technologically possible had to be done to assess and reduce the risks of ice fall & throw.

On-time Information about ice Formation on the blades is extremely important. Operational experiences on two different direct measurment Systems: Labcotec and Bladecontrol over a period of three years are presented. These measurements are compared with direct observations and climatological data.

Web site:

Short biography: Hamburg Water (HW), Water utility of Hamburg with ~ 2.500 employees
Project management HSE in case of ice throw from wind turbines (see Publications)
Co-project management wind turbines WWTP Köhlbrand (Nordex N117, 3,0 MW)
Technical consulting and participation in the in tendering/negotiations according to EU regulations.
Project management on all infrastructural measures on the building site: e.g. warfare materials removal, foundations for the cranes, adaptation of the deep foundation for site requirements.
Planning the technical specifications with Nordex and TÜV to meet the requirements in a site close to dangerous materials: redundant safety features; Blade, tower and drivetrain cms; direct ice detaction systems additional fire extinguisher system; IR-lights
Developing a safety concept on a wastewater treatment plant for different alerts like ice throw and fire.
Co-project management wind park Arcelor Mittal Hamburg (2 x +120m, 1 x 100m)
Planning the wind park configuration, planning the infrastructure integration with Arc. Mittal. Preparing the safety analysis together with TÜV considering the site on a steel works near Linde Gas production unit. The project was halted in Sept. 2014, but will be continued 2015.

Technical university of Hamburg (TUHH), Institute of wastewater management
Research project NEST-HTC for hydrothermal carbonization: Fuel and Char from bio solids.
I initiated the Project and set up the project team. It included a lot of work in the wastewater lab including several test rows on aerobical, anaerobical and nutrients analytics.

BACK

Abstract #: 30 (Oral)

R&D areas/s: 03. IceWind (Nordic Council project), 07. Resource assessment, measurements and models

Investigation of nacelle temperature measurements

Neil Davis, DTU Wind Energy, DK

Andrea Hahmann, DTU Wind Energy, DK
Niels-Erik Clausen, DTU Wind Energy, DK
Mark Žagar, Vestas Wind Systems A/S, DK

Temperature measurements are not usually of primary concern for wind park measurements. They have been included as a standard measurement on the nacelle of each turbine for calculating the air density, which is then used to adjust the power curve of the turbine. However, the air density is not sensitive to temperature errors of a few degrees Celsius. In this study, nacelle temperature measurements from two turbines stationed at the Høvsøre test center were compared with mast and modeled temperatures. It was found that there was a large warm bias (2.52 K) in the measured temperature at one of the turbines, and that both turbines showed diurnal deviations in the bias. Suggesting that observed icing cases may be under-counted when a threshold of freezing temperature is used. Additionally, the derived temperatures from the WRF meteorological model had a cold bias compared with all observations. Therefore, forecasts of icing may over-estimate the number of icing events. This was particularly apparent in the spring and fall, where the modeled temperature bias was particularly large.

Web site:

Short biography: Meteorologist with a wide range of research fields, from regional climate modeling in East Africa, to atmospheric chemistry simulations over the United States and United Arab Emirates, to several topics in wind energy. I have completed my PhD in October 2014, which was titled Icing Impacts on Wind Energy Production. The thesis focused on improving forecasting methods for icing impacts.

Personal Interest: Designer board games.

Abstract #: 2 (Oral)

R&D areas/s: 10. HSE (Health, Safety and Environment)

Methods for evaluating risk caused by ice throw from wind turbines

Helge Ausland Refsum, Lloyd's Register Consulting, NO

Helge Ausland Refsum (Lloyd's Register Consulting, NO), Rolv Erlend Bredesen (Kjeller Vindteknikk, NO)

Ice falling or thrown from wind turbines or other tall structures may cause a significant safety risk to both personnel operating the wind farm or facility, or to third parties nearby. Without special competence, it is difficult to understand both when ice can build up in the installation, and when shedding of ice from the structure is likely to occur. Both build up and shedding of ice is highly dependent on metrological conditions, as well as if the structure is fixed or moving. [1, 2, 3]

Currently there are no recognized standards for safety distances or methods for assessing the risk caused by ice fall or ice throw. Approximations for maximum distance of ice throw may be calculated based on simplified formulas taking height of the installation and wind speed into account, but the results of this approach offers limited precision. [4, 5]

Lloyd's Register Consulting has developed a methodology for assessing site specific risk caused by ice fall or throw in close collaboration with Kjeller Vindteknikk. The starting point of such an analysis is detailed meteorological simulations and forecast for the specific site provided by Kjeller Vindteknikk.

The approach used by Lloyd's Register Consulting is based on the Norwegian Directorate for Civil Protection (DSB) guidelines for acceptable risk outside industrial facilities [6], and results in a map showing safety zones, i.e. what type of activities are acceptable within the vicinity of the wind turbine or similar installation.

Guidelines for acceptable risk level, both for personnel operating the facility and third parties, are proposed. The calculated risk for any specific site may take into account local risk reducing measures, and calculate individual risk for different exposure, such as pedestrians and vehicle passengers, separately. [7, 8]

Project developers, installation owners and operators of wind turbines may benefit significantly from this approach, gaining increased certainty about the risk level and extent of area influenced by the installation or wind turbine. This knowledge will enable the stakeholders to put the right safety measures in place. Applying the methodology already at the planning and consent stage of a potential wind farm will help the project developer optimize the layout of the wind farm with respect to safety, and may in some cases also decrease the required safety zones around the facility and increase the allowed operation weather window.

References:

1. Bredesen, R.E., Harstveit, K., Refsum, H. IceRisk: "Assessment of risks associated with ice throw and ice fall.", Winterwind 2014.

2. Bredesen, R.E.: Antennemast Tryvann, Oslo kommune – IceRisk - Beregninger av isnedfall med validering. KVT Report, KVT/KH/2013/R079, Revisjon 15.5.2014, Kjeller Vindteknikk, 2014.

3. Refsum, H.A.: "Risikoanalyse – Antennemast Tryvann – Vurdering av risiko tilknyttet isnedfall", 104282/R1a, Lloyd's Register Consulting, 2014.

4. Bredesen, R.E. og Harstveit, K.: "Raskiftet, kommunene Åmot og Trysil, Hedmark – Konsekvenser av atmosfærisk ising på ferdsel", KVT/REB/2013/R047, Kjeller Vindteknikk AS, 2013.

5. Refsum, H.A.: "Risikoanalyse – Iskast fra Raskiftet vindkraftverk", 104046/R1, Scandpower AS, 2013.

6. DSB Temaveileder ”Sikkerheten rundt anlegg som håndterer brannfarlige, reaksjonsfarlige, trykksatte og eksplosjonsfarlige stoffer: Kriterier for akseptabel risiko”, Mai 2013.

Abstract #: 2 (Oral)

R&D areas/s: 10. HSE (Health, Safety and Environment)

7. Bredesen, R.E.: Antennemast Tryvann, Oslo kommune – IceRisk - Beregninger av isnedfall på bilvei. KVT Report, KVT/REB/2014/R071, Kjeller Vindteknikk, 2014

8. Kjørri, M.: "Vurdering av risiko for bilister på Tryvannsveien i forbindelse med isnedfall fra antennemast Tryvann", 105226/R1, Lloyd's Register Consulting, 2014.

Web site: http://www.lr.org/en/consulting/

Short biography: Helge Ausland Refsum has been employed at Lloyd's Register Consulting's office at Kjeller, Norway since 2013 working with risk analysis, HSE and quality for a wide range of industrial clients. He has more than 10 years of broad work experience from the power, industry and renewable sector. Refsum holds a Master of Science in Engineering within the field of applied physics from the Norwegian University of Science and Technology (NTNU) in Trondheim from 2004.

His personal interests include cross country skiing and mountain biking.

BACK

Abstract #: 23 (Oral)

R&D areas/s: 04. Swedish Energy Agency's CC research program, 05. Forecasting, cloud physics, aerodynamics

High resolution forecast maps of production loss due to icing.

Esbjörn Olsson, SMHI, SE

In March 2014, SMHI together with the Norwegian Met Institute, started a joint production of operational forecasts using a new high resolution model called HARMONIE/AROME. This model is run at 2.5 km horizontal resolution over an area that covers most part of Fenno-Scandinavia. It produces a 66-hour forecast every 6th hour. The model contains a rather advanced cloud parameterization scheme, and it has been shown in previous projects (e.g. Vindforsk V-313) that using cloud parameter output from HARMONIE in ice calculations produces reasonable ice loads using the Makkonen formula. Forecasted icing rate and ice load can be used to calculate a forecast of power production loss. Previously this method has been applied to single wind turbines or wind farms within the OX2 wind pilot project. There is also a demand for this kind of forecasts for a larger area in order to show an overview picture of the expected production losses due to icing. For this new project, SMHI has started to produce high resolution forecast maps of production loss using output from the HARMONIE model. In order to take finer scale topography into account the model data is first interpolated from the 2.5 km horizontal resolution to a grid with 1.0 km resolution and then the model data is vertically adjusted to the 1.0 km topography. The 1.0 km grid also covers most part of Fenno-Scandinavia. Hourly maps up to 48 hours of expected production loss is produced every 6th hour. Sample maps and some preliminary verifications will be shown.

References:
Elforsk Report 13:10 Wind power in cold climates. Ice mapping methods.

Web site: http://www.smhi.se

Short biography: Meteorologist, SMHI R&D department, Meteorological analysis and prediction.
High resolution Numerical Weather Prediction.
Forecasts of icing on structures and aircraft.

BACK

Abstract #: 40 (Oral)

R&D areas/s: 03. IceWind (Nordic Council project), 07. Resource assessment, measurements and models

Analysis of spatial and temporal variability in icing conditions and production losses due to icing using a new long-term icing climate database

Stefan Söderberg, WeatherTech Scandinavia, SE

Magnus Baltscheffsky, WeatherTech Scandinavia AB, Sweden

IceWind is a project focusing on wind engineering in cold climates. It is funded by the Top-level Research Initiative and has participants from Denmark, Finland, Iceland, Norway and Sweden.

Within the IceWind project, a study of the temporal and spatial variability of icing conditions in Scandinavia and Finland was performed. A meteorological database with hourly data from 1979 to 2014 was created using the mesoscale numerical weather prediction model WRF (www.wrf-model.org). The database includes WRF model data with 9km, 3km, and 1km model grid resolution. Initial and lateral boundary conditions were given by ERA Interim, a re-analysis dataset provided by ECWMF.

The spatial and temporal variability in icing conditions is illustrated by yearly maps of icing hours. These results are compared to yearly average wind speeds and it is shown that the year-to-year variability in icing conditions is much larger than in the wind speed.

Examples of estimated production losses due to icing are given for several sites in Finland and Sweden. It is shown that the variability in icing conditions and production losses are significant, not only from year-to-year but also from site to site. Hence, for a correct site assessment it is of great importance to have an understanding of the local icing conditions, its year-to-year variability and its impact on production losses due to icing.

Web site: http://www.weathertech.se

Short biography: Dr. Söderberg has extensive experience in boundary layer meteorology and numerical modelling in complex terrain. He has been working with atmospheric numerical models since 1999 and holds an MSc in meteorology from Uppsala University and a PhD in dynamic meteorology from Stockholm University. After working for 7 years as a scientist at the Department of Meteorology, Stockholm University, his interest in renewable energy and wind power in particular, brought him back to Uppsala in 2006 where he founded WeatherTech Scandinavia. Dr. Söderberg is currently a senior consultant and researcher at WeatherTech Scandinavia specialized in wind resource and icing climate studies.

BACK

Abstract #: 14 (Oral)

R&D areas/s: 06. De-/anti-icing including ice detection & control, 07. Resource assessment, measurements and models, 12. Finance, risk assessment and mitigation

Influence of wind conditions under icing conditions on the result of a risk assessment

Felix Storck, TÜV NORD SysTec GmbH & Ko. KG, DE

Influence of wind conditions under icing conditions on the result of a risk assessment

The increasing use of wind turbines has shown that open areas for the installation of wind turbines are increasingly difficult to find. Particularly, if the wind turbines are very close to residential areas, industrial areas or traffic infrastructure, the operation of wind turbines may cause hazards that should be assessed. Especially in winter it increases the risk that people can be hit and objects can be damaged by ice fall and ice throw. So if minimum distances to objects at risk cannot observed, risk assessments have to be performed.
The risks for persons and protection objects and the radius of falling ice depends on the site-specific wind conditions, like the distribution of wind direction and wind speed as well as on the distance of the objects to the wind turbine. Therefore it is necessary to determine the wind conditions under icing conditions as accurately as possible to identify the risk as precisely as possible.
Particularly the wind conditions should be analysed very carefully because wind statistics based on long-term data could be totally different to those based on data for icing events.
On basis of climatic field data, wind statistics (wind direction, wind speed) were analysed for condition of icing events as well as on climate statistics (temperature, humidity). These wind statistics were compared to wind statistics based on long-term data. Furthermore the data were used within a risk assessment (fictitious case study).
Therefore the data of 30 different weather observation stations in Germany were analyzed and three different scenarios were developed:

1. For the long-term data (the whole dataset of the weather station),
2. for climatic icing conditions (0,5 °C and 95% relative humidity based on different literature [1], [2]) and
3. for conditions of icing events (icing has been observed at the observation site).

The results shows that, the weibull distributions of the two icing scenarios are more pointed in a lower wind speed range. The mean wind speed is generally lower. Also, the frequency distributions are different in the three given scenarios.
Due to the higher mean wind speeds of the annual climatic data, the simulated icefalls in the fictitious case study for the risk assessment achieve a greater range resulting in larger risk areas. Additionally, the frequency distribution of the wind direction can change significantly under icing conditions, and a difference in the hit frequency could be determined. That affects different shapes of the risk area.
The use of the annual climate data for the risk assessment proved as conservative in the case study but by considering the wind conditions under icing conditions / icing events, a precise delimitation of the risk areas could be achieved.
Further this is not only important for the evaluation of the possible risks but for a accurate prognosis of the annual energy yield, e.g. it could be crucial for the economic feasibility of a planned wind farm at an exposed “icing-risk” site.

References
[1] Finish Meteorological Institute: Wind Energy in cold climate (WECO). 2003.
[2] MeteoSchweiz: Atmospheric Icing on Structures Measurements and data collection on icing: State of the Art. 2006.

Web site:

Short biography: First name / Surname: Felix Storck
Employer: TÜV NORD SysTec GmbH & Co. KG
Employer Address: Grosse Bahnstrasse 31
22525 Hamburg, Germany

Abstract #: 14 (Oral)

R&D areas/s: 06. De-/anti-icing including ice detection & control, 07. Resource assessment, measurements and models, 12. Finance, risk assessment and mitigation

Phone: +49 40 8557-2025
E-mail: fstorck@tuev-nord.de
Nationality: German
Date of birth (Place of birth): 17.09.1985 (Muenster, Germany)
Current position: Expert for Site Assessment
Areas of expertise / Key qualifications: Risk Assessment

Work experience

Since 09/2014
Expert at the the TÜV NORD GmbH & Ko. KG, Department Wind Energy, Section Wind Site Assessment (Main activities: Risk Assessment)

15.10.2013 – 19.07.2014
Master Thesis at the TÜV NORD GmbH & Ko. KG, Department Wind Energy, Section Wind Site Assessment, Hamburg

15.05.2013 – 15.08.2012
Internship at the TÜV NORD GmbH & Ko. KG, Department Wind Energy, Section Wind Site Assessment, Hamburg

15.10.2012 – 31.03.2013
Research associate at the Institute of Environmental and Sustainability Communication (INFU), Leuphana University Lueneburg

19.03.2012 – 30.06.2012
Internship at the GIZ Lima, Perú and the Ministerio del Ambiente Perú

15.10.201 – 03.02.2012
Tutor and Research associate for the course "Responsibility in Science", Leuphana University Lueneburg

8.11.2010 – 08.02.2011
Internship at Institute for Ecological Economy Research (IÖW), Berlin

01.04.2009 – 31.10.2010
Student employee at the anemos Gesellschaft für Umweltmeteorologie mbH, Lüneburg

Education

18.10.2010 – 16.05.2014
Master of Science: Sustainability Science (Leuphana University Lüneburg)

27.02.2012 – 31.08.2012
Exchange Semester at the Pontificia Universidad Católica del Perú

01.10.2007 – 31.10.2010
Bachelor of Science: Environmental Sciences (Leuphana University Lüneburg)

Personal skills and competences

Mother tongue: German
Other languages: English (C1)
Spanish (B2)

Abstract #: 14 (Oral)

R&D areas/s: 06. De-/anti-icing including ice detection & control, 07. Resource assessment, measurements and models, 12. Finance, risk assessment and mitigation

Computer skills

Profound knowledge of MS Office; MS OneNote; Adobe Photoshop; Zotero;
Good Knowledge of Wolfram Mathematica; ESRI ArcGis (ArcMap); WASP; WindPro; Adobe InDesign

BACK

Abstract #: 25 (Oral)

R&D areas/s: 07. Resource assessment, measurements and models, 13. Market potential

Wind Power Icing Atlas (WIceAtlas) – icing map of the world

Simo Rissanen, VTT Technical Research Centre of Finland, FI

Ville Lehtomäki (VTT, FI)

Cold climate wind energy markets will exceed a cumulative installed capacity of 100GW by end of 2015 [1]. Despite it's large installed capacity, the cold climate wind market faces special challenges versus "standard" climate regions mainly in6 the form of icing related risks. In analyzing icing related risks for planned wind power projects in cold climates, icing maps are considered as the first source of information. However, the typical end –user (financier, project developer or analyst) currently phases some challenges in using the available icing maps:

- Most icing maps are done using weather simulation models of high complexity resulting to increased uncertainty without through model validation
- Icing maps are usual done country by country thus a larger overview of icing risks of the entire world is missing
- High interannual variability of icing is not considered
- Typically each icing map has its own icing severity classification from country to country making comparisons difficult
- What are finally the expected production losses? Map specific meteorological icing severity does not tell the answer but is more of a risk indicator.

Site measurements are still considered to be the best and most reliable source of information to assess icing conditions but are often too short (two years or less in total duration) to predict losses over the lifetime of a wind power project. The quantity and duration of icing events can vary up to 200% in total duration from one year to the next, making short measurement campaigns vulnerable to erroneous long-term assessments.

Due to the above challenges and needs, a different approach for mapping of long-term icing conditions is proposed: VTT's Wind Power Icing Atlas (WIceAtlas). WIceAtlas is a huge database of long-term, +20 years of historical measurements and observations via remote sensing from +4000 meteorological stations globally. By using IEA Ice classification [2], it is possible to map the expected long-term production losses due to icing. WIceAtlas can be used for financial risk assessment of icing conditions for the entire project lifetime. This financial risk can be done quickly and efficiently as all data exists on VTT servers.

With VTT's WIceAtlas, the world's first icing atlas of average icing conditions for a typical 3MW turbine will be revealed to help developers have a first idea of the severity of icing conditions for different regions around the world. With the WIceAtlas, we will also:

- Demonstrate that altitude above ground level is a key parameter in evaluating icing risks
- map the high interannual variability of icing emphasizing the need for a making long-term correlation between 1-yr site measurements to 20yrs of historical data.

WIceAtlas results will be validated with site measurements from Sweden, Canada and France.

References:

[1]: Navigant Research, 2013. World Market Update 2012 , Chicago. Illinois: Navigant Research, ISBN: 978-87-994438-4-0

[2]: IEA Task 19, 2011 Edition. IEA Wind Recommended Practice 13: Wind energy projects in cold climate report

Web site: http://www.vtt.fi/research/technology/wind_power.jsp?lang=en

Short biography: Mr Rissanen has been a Research Scientist at VTT Technical Research Centre of Finland between 2003 and 2006 and again since 2011. His work focuses on dynamic modelling of wind turbines, ice load analysis, ice assessment, and icing effects on blades. He has worked on several international research projects related to dynamic modelling of wind turbines and ice load analysis.

Abstract #: 25 (Oral)

R&D areas/s: 07. Resource assessment, measurements and models, 13. Market potential

BACK

Abstract #: 43 (Oral)

R&D areas/s: 03. IceWind (Nordic Council project)

Validation of icing and wind power forecasts at cold climate sites

Øyvind Byrkjedal, Kjeller Vindteknikk, NO

Henrik C. van der Velde, (Kjeller Vindteknikk, NO)

Operational forecasting of power production, icing and production losses due to icing has been carried out for five wind farms in Sweden during the winter 2013-2014. Both wind farms experienced periods with severe icing during the winter resulting in periods with large power losses. The forecast simulations are run 4 times daily, each with a lead time of 48 hours.

The power forecasts with and without losses due to icing is compared to the hourly production data from the wind farm. It is evident that the accuracy of the forecasts is improved when the power losses caused by icing are taken into account resulting in a reduction of the mean absolute error (MAE) of the forecast by up to 0.07 when the power losses due to icing are included. The correlation coefficient between forecasted and actual power is increased by approximately 0.15 when the power losses due to icing is included. The correlation coefficient typically reduces while the MAE increases with increasing lead time.

The results show that the number of cases when the power is over predicted is reduced when including power losses due to icing, while the cases of under predicting the power losses is somewhat increased.

Icing has been identified from the turbines using an algorithm described by Davis et al (2014). The periods where icing has been identified from the operational data has been compared with the forecasted icing periods. Verification of the model shows that 75% of the cases identified as icing from the turbines are predicted with a low false alarm rate of 5%.

During the winter 2014-2015 the operational forecasting of icing will continue. The icing forecasts can also be used to forecast periods when there is an elevated risk of ice fall or ice throw from turbines and masts. The prediction of the buildup of ice and periods with ice shedding from the mast has been demonstrated for a 200m high telecom mast in Oslo during the winter 2013-2014.

Web site:

Short biography: Byrkjedal has been working in Kjeller Vindteknikk for the past 8 years, and has currently the R&D manager of Kjeller Vindteknikk. Byrkjedal has a background as a meteorologist and holds a phd in meteorology from the University of Bergen, Norway.

He has been working in the field of meteorological icing during the past 8 years, and has lead the development of the Norwegian wind- and icing atlases and has also created wind and icing atlases for Sweden and Finland. Byrkjedal has also developed a methodology to estimate power losses due to icing based on operational power data from several Swedish wind farms.

Abstract #: 46 (Oral)

R&D areas/s: 03. IceWind (Nordic Council project)

On the influences of icing on regional forecast errors

Jari Miettinen, VTT - Technical Research Centre of Finland, FI

Øyvind Byrkjedal (Kjeller, NO)
Hannele Holttinen (VTT, FI)

Icing will impact short term forecasting of wind power locally and wind power plant level during icing events. Icing will cause production losses and if not taken into account when making the forecast, the forecast will overestimate the production during icing and also after icing events as long as the ice will stay on the turbine blades.

In this paper icing forecasts for some sites in Sweden and Finland are made. The potential of icing forecasts to improve forecast accuracy are assessed. The power forecasts with and without losses due to icing is compared to the hourly production data from the wind farm. It is evident that the accuracy of the forecasts is improved when the power losses caused by icing are taken into account resulting in a reduction of the mean absolute error (MAE) and bias of the forecast to be reduced.

The extent of icing events can often be quite wide spread so that icing is influence the energy production for several wind farms on a regional scale. The impact of icing events can last for days to weeks especially in cases where the turbines are not equipped with anti- or deicing systems. The large geographical spread of the forecast errors caused by icing can lead to wind farms underperforming in the whole electricity price area with the result of a larger demand for balancing power.

By including the influences of icing on the forecasts wind energy production for the largest wind farms in northern Sweden it is shown that the aggregated regional forecast errors are reduced.

Web site:

Short biography: Jari Miettinen is working for VTT in the Wind Power team and currently he is pursuing for a PhD degree with a topic related to forecasting errors of large scale wind power. He's doing the PhD for Lappeenranta University of Technology.

BACK

Abstract #: 6 (Poster)

R&D areas/s: 04. Swedish Energy Agency's CC research program

Influence of ice accretion on the noise generated by an airfoil section

Robert Szasz, Lund University, SE

Matilda Ronnfors (Lund University), Johan Revstedt (Lund University)

Ice accretion is a major concern for wind turbines installed in cold climate areas. The deposited ice changes the cross section of the wind turbine blades reducing their efficiency. A more severe issue is the imbalance caused by the extra mass due to icing which may lead to damages of the wind turbine. Furthermore, it was observed that icing changes the pattern of the radiated noise. A proper understanding of these changes can be useful both to avoid wind turbines exceeding the noise limits imposed by legislations, and to detect ice accretion in an early stage.

Our goal is to develop tools to predict the emitted noise levels in icing conditions. The noise will be computed in a hybrid manner. First, the flow will be computed by solving the incompressible Navier Stokes equations and using Large Eddy Simulations to account for turbulence. The flow solver will provide the acoustic sources which will be read in the acoustic solver, based on Lighthill's analogy, in the second stage of the process.

The proposed model will be used to compute the noise generated by a NACA 63415 airfoil. Two cases will be computed, one for a clean airfoil and one where ice accretion changed the airfoil shape, corresponding to the 'In-fog icing event 1' reported in [1]. The effect of icing on the pressure and velocity fields, acoustic sources and radiated acoustic field will be reported in the final paper.

1. Hochart et al. Wind Turbine Performance under Icing Conditions, Wind Energy 11:319–333, 2008

Web site:

Short biography: Dr.Szasz has obtained his Ph.D. at Lund Institute of Technology in 2004. Since then he is working at Lund University focusing on CFD computations of turbulent reacting and nonreacting flows and aeroacoustics. Since 4 years he is also involved in computations of flow fields related to wind turbines. Currently he is working amongst others on ice accretion modelling.

BACK

Abstract #: 17 (Poster)

R&D areas/s: 10. HSE (Health, Safety and Environment)

Assessment of ice throw and ice fall risks nearby wind energy installations

Michaela Kaposvari, TÜV SÜD Industrie Service GmbH, DE

Thorsten Weidl (TÜV SÜD, Department Risk Assessment, GER)
Michaela Kaposvari (TÜV SÜD, Department Wind Cert Services - Site Assessment, GER)

Wind energy is the leading source of renewable energy in Germany, supporting the ambitious targets for moving towards a nuclear free and carbon free generation profile. As Germany is densely populated the building of new wind parks is subject to a quite complex approval procedure. One important topic during this planning and approval stage is the assessment of the risk of ice throw and ice fall near wind energy installations.

Wind turbines in Germany are not allowed to operate during ice formation on rotor blades, the installation of a functional detection system for icing combined with the subsequent shut-down of the turbine has to be confirmed in the approval process. Residual risk of ice fall from stopped turbines has to be investigated depending on the local situation, especially when special objects are located nearby.

TÜV SÜD developed a procedure for project developers planning on-shore wind

parks to meet the demands of the German authorities regarding the risk of ice throw and ice fall.

A simulation model was implemented to determine the possibly affected area around a wind turbine subject to ice fall and a following procedure to quantify and assess this risk.

The ice fall calculation uses average local wind conditions such as the sectoral distribution of wind speed and direction at the desired location to perform Monte-Carlo-simulations for defined scenarios which are only distinguished by the properties of the ice piece to fall off.

Based on the results of this calculation it has to be decided whether or not a detailed risk analysis has to be performed. This depends on the before mentioned affected area and the local situation, e.g. special objects such as parking areas, streets or motorways, paths or ways just for pedestrians within the hazardous area around the planned wind turbine.

Once the decision is made that a detailed risk assessment is necessary, for each planned wind turbine and each object of interest a complex investigation is initiated. This consist of the severity judgement on the one hand, based on the Probit function, and of the frequency of being hit by a piece of ice on the other hand, which is based on the results of the ice fall expertise and developed farther to assess the risk as accurate as possible. Due to the complexity of the situation this method is still being continuously improved.

One of the central tasks performing the risk analysis is a proper classification of the objects defined in the expertise with respect to the potential presence of people there, which is the major influencing factor of the risk.

We will give a survey of the state of the art for risk analyses of ice throw and ice fall with a description of the method how we use it today.

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Abstract #: 17 (Poster)

R&D areas/s: 10. HSE (Health, Safety and Environment)

René Cattin, Alpine Test Site Gütsch – Handbuch und Fachtagung (Schlussbericht), Bern, 31.12.2008

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Assessment of ice throw and ice fall risks nearby wind energy installations, Weidl, Kaposvari, 12th International Probabilistic Workshop, Weimar 2014

Web site: http://www.tuev-sued.de/windenergie

Short biography: Michaela Kaposvari, originally from Hungary, graduated from university with diploma in meteorology in Munich, Germany. Since 2011 Michaela is working for TÜV SÜD in the department of site assessment in Regensburg, Germany, with specialisation of the analysis of sound and shadow immission and ice fall from wind turbines in the approval procedure of wind farms in Germany.

Abstract #: 53 (Poster)

R&D areas/s: 03. IceWind (Nordic Council project)

Three-dimensional numerical simulation of a model wind turbine

narges tabatabaei, Luleå University of Technology, SE

Narges Tabatabaei
Michel Cervantes
Chiragkumar Hasmukhlal Trivedi
Jan-Olov Aidanpää

In recent years, wind energy has become one of the most economical renewable energy technologies. Today, electricity generating wind turbines employ proven and tested technology, and provide a secure and sustainable energy supply. Windmills are now introduced in cold areas for which they are not designed. So, different problems may occur such as cracks, separated flow, unbalance, etc.
In this paper the numerical simulation of an upwind 3 blades wind turbine is presented; a base model to later simulate icing in cold climate windmills and investigate the effect on the structure. The model wind turbine has been tested in a wind tunnel at the Norwegian University of Science and Technology (NTNU). The object of the present study is to investigate different simulation strategies in order to reduce the computational effort for future flow structure simulation (FSI) in the presence of ice.
The complete domain has firstly been simulated as reference. Then, using the assumption of axis-symmetry, one third of the rotor has been considered and periodic boundaries applied to include the effects of other blades. To take in the effects of wind turbine wakes, the wind entrance and exit have been considered 4 and 5 diameters upstream and downstream of the rotor plane, respectively. Furthermore, the effects of the tower and the shaft are included in a full scale model of the wind tunnel. Structured hexa mesh have been created using Ansys ICEM. The flow is solved using Ansys CFX 15.0 software and the Shear Stress Transport model (SST) is used to obtain the solution.
The generated power and the thrust force are calculated reasonably well. The aim of this project has been to launch a reliable simulation of a wind turbine, to model icing in next step. We will yield 3-D ice shapes over the blade bodies and study its effects on the wind turbine performance in further phases.

Web site: http://www.ltu.se/staff/n/nartab-1.116681?l=en

Short biography: I have worked in the field of turbo-machinery for 7 years, as academic studies and at industry as well. It was consist of the turbo parts of a micro-jet engine, gas turbines in gas export stations and etc. Now my research focus is on the field of wind turbine in cold climate. I'm working on it as my PhD project which is a part of a team working on wind turbine in Luleå University of Technology (LTU).

BACK

Abstract #: 16 (Oral)

R&D areas/s: 02. IEA Task 19 (IEA RD&D Wind), 03. IceWind (Nordic Council project), 05. Forecasting, cloud physics, aerodynamics, 07. Resource assessment, measurements and models, Wind Tunnel Experiment

Wind tunnel ice growth on a blade profile and representative cylinders

Neil Davis, DTU Wind Energy, DK

Niels-Erik Clausen (DTU Wind Energy, DK)
Holger Kos (DTU Byg, DK)
Joshua Redento de Souza (DTU Wind Energy, DK)
Marijn Joseph Louis Verdult (DTU Wind Energy, DK)

One of the challenges in forecasting icing events is the complex flow around an airfoil. To counter this complexity cylinders are often utilized for estimating the collision efficiency of water droplets in the flow around the airfoil. In this study, three representative cylinders were tested to determine the optimal size for the cylinder to be used in the forecast models. A climactic wind tunnel located at Force Technology and developed in collaboration with the Technical University of Denmark, was designed so full size sections of bridge cabling could be studied. This allowed for a 2-m section of a wind turbine blade with a NACA 0015 profile to be tested for ice accretion. In addition to the airfoil, which was utilized from a previous study, three fiberglass-epoxy cylinders were constructed with diameters of 32, 58 and 105 mm. These represented the leading edge radius, maximum height, and double the maximum of the height. The study found that the best use of the cylinders was to use the leading edge radius for calculating the collision efficiency, and the maximum height for calculating the cross-sectional area of the airfoil.

Web site:

Short biography: Meteorologist with a wide range of research fields, from regional climate modeling in East Africa, to atmospheric chemistry simulations over the United States and United Arab Emirates, to several topics in wind energy. I have completed my PhD in October 2014, which was titled Icing Impacts on Wind Energy Production. The thesis focused on improving forecasting methods for icing impacts.

Personal Interest: Designer board games.

BACK

Abstract #: 5 (Oral)

R&D areas/s: 01. R&D programs, overview, 08. Production experience, losses, 12. Finance, risk assessment and mitigation, 17. Other RD&D program or major project, Test & demonstration

Why performing climatic chamber testing on wind turbine applications?

Pieter Jan Jordaens, Sirris - OWI-Lab, BE

As most renewable energy systems are located outdoor, some in harsh locations from the extreme cold of Inner Mongolia, Scandinavia, Canada or North Dakota to the damping heat in desert areas in the US or Australia, critical attention must be paid to the suitability, reliability and robustness of the equipment in such hostile environments. Mitigating risk of potential failures due to extreme temperatures (differential thermal expansion, brittle materials & potential cracks, highly viscous oils,…) early in the development phase, can lead to reduced maintenance costs on the long term. This has been the main driver for the OWI-Lab laboratory in performing extreme temperature testing in a large climate chamber on multiple turbine components and systems associated with wind energy projects. Apart from the strategy of laboratory testing for design verification as a focus, also the need for additional field testing and health monitoring in the operational phase is addressed in this study.

The vast majority of wind turbines have been installed in 'moderate' climates, but more and more wind turbine assets are installed in challenging and remote locations such as offshore, sub-arctic locations, on mountains or in deserts. For these applications, appropriate and dedicated specifications of the turbines and their components need to be developed. Cold weather packages have been developed and commercialized to extend the operational and stand-still temperature limit range of the wind turbines in cold climate and sub-arctic locations, to temperature limits of -30°C in operation and -40°C in stand-still.

These cold weather packages however also lead to additional "parasitic" power consumption for the heating of several turbine components. To maximize overall performance and profitability, these solutions need to be optimized in terms of levelized cost of electricity and risk reduction. Even for regions with moderate climatic conditions, temperatures may unexpectedly exceed the wind turbine operational and surviving limits.

In order to understand why climate chamber testing could be beneficial in the product development cycle of wind turbines and their components, we summarize some examples of equipment tested in the laboratory. Also during the design phase attention must be paid on certain events and components with regard to cold climate wind turbines. This need is explained with case studies from cold climate related failures of operational wind turbines.

The study contains test examples and real life case studies of different wind turbine components and their link to low temperature testing in laboratory conditions. Also the relation of the laboratory testing with field experience and failures which occurred with relation to cold climate are addressed to underline the importance of design verification testing for cold climate. Not only their importance of robustness and reliability is explained, also their relation to operational safety and maintainability.

The cases addressed in the study contain:
1. Mechanical & hydraulic components
a. Cold start-up test case of a gearbox
b. Effect of cold temperature on hydraulics
c. Climate chamber testing of Pitch & yaw systems

2. Electrical components
a. Cold start-up testing of liquid filled transformers
b. Cold start-up testing of cast resin transformers
c. Low temperature testing of switch gears
d. Low temperature effects of slip rings in generators

3. Effect of low temperatures on structural components
a. Blades
b. Concrete foundation and tower

Abstract #: 5 (Oral)

R&D areas/s: 01. R&D programs, overview, 08. Production experience, losses, 12. Finance, risk assessment and mitigation, 17. Other RD&D program or major project, Test & demonstration

Web site: http://www.owi-lab.be

Short biography: Pieter Jan joined Sirris in 2010 as a project leader in the Sustainability Department. His first task was to meet the challenge of rolling out the Offshore Wind Infrastructure (www.owi-lab.be) project from scratch. After that, he focused on project management, operationalizing and developing the R&D services of the project. In cooperation with the Vrije Universiteit Brussel (VUB), he was responsible for the development of measuring and testing equipment, to gain a better understanding of the operations of existing offshore wind turbines and their components, with a view to creating novel, improved designs and optimized maintenance strategies.

Today, Pieter Jan is responsible for further operationalizing and optimizing of the Application Lab's existing services. Furthermore, he takes care of business development within the OWI-Lab, to set up new innovation projects and shared R&D projects in cooperation with the industry and academics.

Before joining Sirris, Pieter Jan obtained a Master's degree in Electro-Mechanical Engineering from the International University College Group T in Leuven, where he also joined an additional study: International Postgraduate Programme in Entrepreneurial Engineering.

BACK

Abstract #: 9 (Oral)

R&D areas/s: 05. Forecasting, cloud physics, aerodynamics

Validation of new model for short-term forecasting of turbine Icing

Beatrice Brailey (DNV GL, GB)

Craig Collier (DNV GL, USA)

Purpose

We present a forecast model capable of predicting both the likelihood of turbine blade icing, and an estimate of the degraded power production due to ice loading. When combined with high accuracy wind energy forecasting models, accurate icing forecasts and power loss prediction provide financial benefits for energy trading and grid operation. The theoretical background of the model and a basic overview of the mechanics of the algorithm will be presented. Validation results will be provided for three wind farms in Scandinavia in order to demonstrate the additional value of icing modelling within wind energy forecasting. Conference attendees will be provided a demonstration of the improvements realized by these new forecasting methods, with an emphasis on their utility to owners, operators, and investors of wind farms in cold climates.

Abstract

High quality wind energy forecasting has been shown to be financially beneficial to energy traders and grid operators. This study shows how the turbine ice accumulation model can add further value when combined with state-of-the-art wind forecasting. Additionally, we shall demonstrate how an improved probabilistic forecast for icing can be successfully integrated into an advanced warning system, with application for safe and efficient wind farm maintenance.
Advanced warning of winter storms and icing conditions at a wind farm site can guide operators on anticipatory corrective actions, in some cases through an “Icing Conditions Action Plan” (NERC, 2012). Improved prediction of such events can guide plant and system operators toward the appropriate response for maintaining grid reliability. For wind power forecasters, icing events often contribute to large forecast error, but more importantly may result in improper training of power models, when such events are not properly diagnosed. Numerical weather models generally predict ice concentration and/or ice accumulation probability by way of cloud and precipitation schemes, which heavily rely on predictions of environmental relative humidity and temperature. This study shall present a model for the direct prediction of turbine ice accumulation, and validate the method against data from three wind farms in Scandinavia.

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R&D areas/s: 05. Forecasting, cloud physics, aerodynamics

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http://www.nco.ncep.noaa.gov/pmb/codes/nwprod/sorc/ncep_post.fd/AVIATION.f

Web site:

Short biography: Jonathan Collins
Global Head of Practice for Short Term Forecasting at DNV GL. After receiving his Masters degree in Physics from the University of Bristol in 2006, he joined the short-term renewable generation forecasting team at DNV GL and has 8 years of experience working on the company’s forecasting services and methods, helping customers to maximise the value of their renewable assets and incorporate renewable energy onto grid systems. During this time he has worked in a range of markets across Europe, India, East Asia and North and South America and has responsibility for the ongoing technical development of DNV GL’s market-leading forecasting methods.

Abstract #: 27 (Oral)

R&D areas/s: 02. IEA Task 19 (IEA RD&D Wind), 06. De-/anti-icing including ice detection & control

Operation of wind parks under icing conditions - a balancing act between production and safety

René Cattin, Meteotest, CH

René Cattin, Meteotest

Atmospheric icing has a significant impact on the development and the operation of wind parks. Ice disturbs the aerodynamics of the rotor blades and thus causes production losses. Iced wind measurement sensors at the wind turbine's nacelle lead to erroneous behaviour and security stops. During project development, wind measurements are disturbed by icing resulting in a higher uncertainty of annual energy production (AEP) calculations and a higher cost of investment. Finally, ice throw and ice fall from the iced wind turbine rotor blades represent a significant safety risk for passersby and service personnel.

Today, there is an emerging market for wind energy projects in cold climate. Market studies expect further strong growth of the cold climate sector in the next years, comparable to the growth forecasts for offshore wind energy. At the same time, sinking electricity prices increase the pressure to maximize the production of existing wind farms operating under icing conditions in order to stay profitable.

In this context, an optimized and efficient operation of wind parks under icing conditions has become a very important issue for operators. When operating a wind park under icing conditions, safety and production need to be balanced in an optimal way: The safety of all passersby and the service personnel needs to be guaranteed at all times. This means that a wind turbine with iced rotor blades must not be operated when there is a risk of anybody being injured by ice shedding. On the other hand, the operator wants to avoid unnecessary downtimes due to false alarms or caused by delayed restart of the turbines. If a de-icing system (system to remove ice from the blades) is installed, it needs to be controlled in an optimal way to obtain the best possible performance.

In order to reach an optimal performance of a wind park under icing conditions, an efficient and reliable turbine control is the key for success. It is crucial that the turbine is able to detect ice on the rotor blades reliably and as early as possible in order to either stop the turbine and/or to activate a de-icing system. Consecutively, there has to be another system for "no ice" detection, i.e. a device which states that the rotor blade is free of ice and thus normal operation of the wind turbine can be resumed. The goal is to keep the period of production loss as short as possible.

There exist numerous approaches to detect "ice" or "no ice" on rotor blades. In fact, the two systems are not necessarily the same; some instruments are capable to detect the presence of ice on the rotor blades but are not able to determine if a rotor blade is free of ice. While there are a number of suitable and established approaches for "ice" detection, the "no ice" detection is today often still performed by on-site visual inspections. Depending on the availability of staff und the accessibility of the site, this procedure can lead to significant delays in restarting the wind park. Technical options are available on the market, but there is still a strong requirement for further development and extensive field testing of these systems in order to gain more experience and confidence and develop more robust, significant and reliable systems. Special focus has to be put on ice detection systems measuring icing directly on the rotor blade and to the "no ice" detection in particular

This presentation will outline the concept and the need of "ice" and "no ice" detection on wind turbines, elaborate the importance of rotor blade based ice detection compared to nacelle based systems and give an overview on existing technical approaches available today. Finally it will try to summarize the requirements to improve wind turbine control under icing conditions in the future.

Web site: http://www.meteotest.ch

Short biography: René Cattin has a masters degree in Geography. Since 2001 he works at Meteotest. Today he is member of the executive board and head of the Energy & Climate departement. René Cattin has a long experience in the field of icing. He is the Swiss memeber of IEA Task 19 and also a member of TP Wind. He was project manager of the Swiss project "Alpine Test Site Guetsch" under the umbrella of COST Action 72 and the test site St. Brais. He has attended every international edition of Winterwind so far.

Abstract #: 27 (Oral)

R&D areas/s: 02. IEA Task 19 (IEA RD&D Wind), 06. De-/anti-icing including ice detection & control

BACK

Abstract #: 15 (Oral)

R&D areas/s: 06. De-/anti-icing including ice detection & control, 11. Inspection and repair

Blade heat system repair

Greger Nilsson, Blade Solutions, SE

Blade heat systems are due to ice crust formation required to maintain wind turbine efficiency and ensure production during winter conditions. Usually, blade heat systems are based either on hot air circulation within the blade or on heating the blade surfaces directly. In the direct heat systems, the heat is generated through directing electrical current through carbon fibre mats with low conductivity. The direct heating method is the predominantly used method for carbon fibre composite blades and is more energy effective than circulating air, since it can be limited to areas subjected to ice crust build-up. The heating mats are therefore primarily applied on or near the leading edge on the outer half of the blade. Unfortunately, this is also in this area exposed to collisions and lightning strikes which both may damage the direct heating systems. The exposure to lightning strikes is unfortunately also enhanced by the carbon fibre mats acting as unintentional lightning rods.

When the carbon fibre mats are damaged, the damage generates a hotspot as the electrical currents are rerouted around it. At these hotspots, laminate temperatures may exceed the matrix/epoxy degradation temperature, which is potentially dangerous since the operation of the heat system may aggravate the damage, eventually leading to extensive damage.

A hotspot repair method was developed, first as a laboratory procedure using small-scale blade heat systems with lightning and impact damages showing hotspot behaviour. The damages were repaired using methods suitable both for summer and winter use. The repaired specimens was then subjected to fatigue testing to ensure reliability. After laboratory tests, the repair methods have been used in up tower blade heat system with good results.

Web site:

Short biography: Owner and MD, Blade Solutions
Previously worked as researcher at a composite institute.

Spend at lot of time on skis or sailboats.

BACK

Abstract #: 26 (Oral)

R&D areas/s: 04. Swedish Energy Agency's CC research program, 05. Forecasting, cloud physics, aerodynamics, 08. Production experience, losses

Probabilistic forecasting of icing and production losses

Jennie Persson Söderman, Uppsala University, SE

Björn Stensen (SMHI, SE), Esbjörn Olsson (SMHI, SE), Per Undén (SMHI, SE), Heiner Körnich (SMHI, SE), Hans Bergström (UU, SE), Anna Sjöblom (UU, SE)

The phenomena of icing on wind turbines are causing significant problems for the wind power production and safe operations. The prediction of icing is therefore essential for wind energy in cold climates. However, modelling of icing on wind turbines and of the related production losses has been shown to be a challenge. The results from icing models contain uncertainties arising from the predicted meteorological conditions, from the employed ice growth models, and from the empirical production loss models. This study is part of a project supported by the Swedish Energy Agency (Energimyndigheten). As a first step, we examine the contribution of the meteorological uncertainties to the icing and production loss forecasts. A mesoscale ensemble prediction system, HarmonEPS based on the numerical weather prediction model Harmonie/AROME, is used for a probabilistic meteorological forecast. The ensemble prediction system consists of 11 members and has been run for up to +48 hours for a two week period in the winter 2011/2012 with a horizontal resolution of 2.5 km. Meteorological parameters forecasted by each ensemble member are used as input to the icing model, generating an ensemble of the icing intensity. The production losses due to the icing are estimated from the icing intensity. The purpose of the study is to estimate the skill and spread of the ensemble prediction system concerning meteorological parameters at the height of wind turbine nacelles and to investigate the resulting uncertainties for icing models and for production losses. We are examining whether the ensemble provides a good approximation of the forecast error of the icing model and for the estimations of production losses. The first result of the study is presented in this poster.

Web site:

Short biography: I am a PhD student in meteorology at Uppsala University. The PhD position is a part of the project “Mesoscale Ensemble Prediction Systems and Ice Modelling for Wind Turbines” in cooperation between Uppsala University, SMHI and WeatherTech, supported by the Swedish Energy Agency (Energimyndigheten). I took my masters degree in meteorology at Uppsala University this summer and started working on the project in august.

BACK

Abstract #: 50 (Oral)

R&D areas/s: 02. IEA Task 19 (IEA RD&D Wind), 10. HSE (Health, Safety and Environment)

Ice throw guidelines

Matthew Wadham-Gagnon, TechnoCentre éolien, CA

Andreas Krenn (Energiewerkstatt, AT), Rebecka Klintström (Meventus, SE), Ville Lehtomäki (VTT, FI), Silke Dierer (Meteotest, CH), René Cattin (Meteotest, CH), Benjamin Martinez (Vattenfall, SE), Gail Hutton (RES, UK), Alan Derrick (RES, UK), Rolv Erlend Bredesen (Kjeller Vindteknikk, NO)

There are specific meteorological conditions that will lead to ice accumulating on wind turbines and particularly on their blades. Even beyond the meteorological event, ice may persist on the structure until it melts, sublimates or falls off. If the turbine is in operation, ice may be projected from the blades (ice throw) and land on the ground at a greater distances than if the ice were to simply fall off (ice shed).

The level of risk associated with ice throw or ice shed will depend on frequency of icing events as well as the frequency of usage of the area surrounding the turbine where ice pieces can land. Appropriate measures must be taken to prevent injury or material damage due to ice shed and ice throw, both during the planning phase of a wind farm and during the operation phase.

Members of Task 19, IEA Wind's work group on wind energy in cold climate, along with additional industry partners are collaborating in order to produce guidelines aimed at helping developers, operators as well governing authorities ensure safe operation of turbines installed in regions with icing climate.

An overview of the guidelines will be presented along with a risk assessment matrix providing a simple approach to managing the risk of ice throw and ice shed based on frequency of icing and frequency of usage of the spaces surrounding a wind turbine.

Web site: http://www.eolien.qc.ca

Short biography: Matthew Wadham-Gagnon has developed his engineering expertise internationally over the last 10 years. He has been managing projects related to wind energy in cold climate at the TechnoCentre éolien (TCE) since 2011. Prior to joining the TCE, he developed skills in structural analysis and design of composite structures as well as composite processing. Matthew has a Master's degree in Mechanical Engineering. In his free time, when not building his house, Matthew enjoys skiing and sailing.

BACK

Abstract #: 45 (Oral)

R&D areas/s: 09. DOM (Deployment, Operations and Maintenance), 11. Inspection and repair

New approaches on rotor blade repairs in winter conditions

Ville Karkkolainen, Bladefence, FI

Rotor blade repairs have traditionally been very costly and difficult, sometimes even impossible, in cold climate areas, especially during winter time. We present experiences of rotor blade repairs in harsh winter conditions, conventionally thought as impossible for blade repairs. We also present a case where extensive structural repairs were carried out in Northern Sweden during January of 2014.

The difficult winter repairs of rotor blades is achieved by combining advanced repair method with an on-site and up-tower environmentally controlled working space. Traditional rotor blade repair have relied on favorable summer weather conditions and wet laminating systems which generally require an ambient temperature of more than +15 Celsius and a maximum RH of 60% to work properly. These requirements create significant challenges in cold climate areas and usually leads to reduced repair window during the summer season.

Additionally, repairs done with traditional wet laminating systems require substantial curing times of up to 24 hours which further reduces the effectiveness of traditional blade repair approaches. A combination of environmentally controlled working space and advanced repair method, a permanent quality repair is achieved, even in winter time, in significantly reduces time scales. This leads to significant savings in lost production due to down time.

http://www.windpowerengineering.com/design/materials/new-materials-methods-promise-blade-repairs-winter/

Web site: http://www.bladefence.com

Short biography: Mr. Karkkolainen has been an entrepreneur and an enthusiastic business developer for past 12 years selling his first company in the field of IT in 2008. After that he was a member of the board in one of the largest marketing communication companies in Finland when the company was listed to NASDAQ OMX First North market. Since 2010 he has been managing director of Bladefence with the aim of being the leading provider of wind turbine blade inspection, maintenance and repair services in the Nordic countries.

BACK

20/11/2014

Abstract for Winterwind 2015

Title: A generic model for ice growth and ice decrease process

Author: Saara Kaija, Jeroen Dillingh[1] (VTT Technical Research Centre of Finland)

Cold climate markets will exceed a cumulative installed capacity of 100 GW by the end of 2015 [1]. The cold climate wind markets have special challenges as compared to the "standard" climate regions mainly in the form of the icing related risks. Historically, ice accretion on stationary structures has been under careful scientific research and specific icing models have widely been used in the wind power industry.

The current icing models are only used for estimating the ice accretion process, whereas the decrease process of ice from the turbine blades is neglected almost completely. The decrease process is, however, of great importance especially for power production forecasting in icing conditions, and it also enables more accurate long term corrections in the ice assessment studies.

The importance of the ice decrease process for the accuracy of for example the production forecasting and AEP estimation in cold climates is highlighted by acknowledging that majority of the ice decrease in Scandinavia occurs in sub-zero temperatures [2]. Thus, in addition to melting, also the sublimation of ice must be considered as the ice decrease process is being modelled. A typical icing event can last from few hours to multiple days or even weeks, and it usually constists of periods of both the ice growth and the ice loss.

VTT has developed a new generic icing model that combines the ice accretion and ice decrease processes, thus enabling more accurate approach on icing. The new icing model is able to calculate the ice thickness growth rate and the ice mass growth rate, as well as the ice thickness decrease rate and the ice mass loss rate. Due to its generic nature, the new model can easily be implemented into different forecasting and assessment tools.

The model uses the common approach of a circular cylinder representing the wind turbine blade leading edge. It is a time dependent tool and can thus be combined directly with the measured weather data. Input requirements consist of parameters that are usually available in the wind power projects e.g. wind speed, temperature, air pressure and relative humidity.

The sublimation and the ice growth entities have been compared to the experimental data represented in literature. Own experiments in the Icing Wind Tunnel of VTT have also been used for validating the results, as well as a case study with NREL 5MW wind turbine.

[1] Navigant Research. 2013. World Market Update 2012. Navigant Research. Chicago, Illinois, USA. ISBN: 978-87-994438-4-0

[2] Lehtomäki, V. et al. 2014. Input to new IEC 61400-1 design standards from two case studies of iced turbine load analysis. Winterwind 2014 Conference. Östersund, Sweden.

[1] This paper is based on work initiated by late Jeroen Dillingh (1974 – 2014).

BACK

Abstract #: 52 (Oral)

R&D areas/s: 02. IEA Task 19 (IEA RD&D Wind), 08. Production experience, losses

IEA Task 19: Standardized method to evaluate production losses due to icing using only SCADA data

Ville Lehtomäki, VTT Technical Research Centre of Finland, FI

Timo Karlsson (VTT, FI), Silke Dierer (Meteotest, SU), Dominic Bolduc (TechnoCentre Eolien, CA), Matthew Wadham-Gagnon (TechnoCentre Eolien, CA), Rebecka Klintström (Meventus, SE)

An increasing amount of wind energy is being deployed in cold climate (CC) conditions. By 2017 a total cumulative capacity of 120GW is expected in CC conditions representing 24 % percent of total global onshore wind capacity, a capacity three times larger than offshore [1].

The international task force IEA Task 19 has worked together to increase wind energy deployment in CC areas since 2002 [2]. One of the main challenges the current CC wind industry faces is the build-up of ice on rotor blades resulting to production losses. However, estimating the production losses due to icing has been challenging as a large variety of different production loss methods are used. Typically a constant -15% or -25% of the clean power curve for each 10-min SCADA point is used as an indication of icing. Similarly standard deviation (or multiples of it) has been widely used to define iced turbine production losses. Both of these methods result to different results and are not necessarily representing the actual ice build-up and removal process to wind turbine blades reliably enough. Also the availability of dedicated and reliable ice detectors is rare and thus the production loss method should be done with existing turbine measurements, mainly standard SCADA data.

IEA Task 19 has three main motivations on why a standardized production loss calculation method is needed:

1. There is a large need to compare different sites with each other
2. To validate the IEA Ice Classification [3]
3. Evaluate effectiveness of various blade heating systems versus non-heated systems

To address the above needs, IEA Task 19 will present a novel and robust method on how to calculate production losses due to icing (shortly "T19IceLossMethod") by using only standard 10-min SCADA data. The T19IceLossMethod does not require icing measurements as input. The T19IceLossMethod was developed in order to 1) minimize the uncertainties from false icing event alarms and 2) focus on method robustness. Operational and stand-still production losses due to icing are separated and a standard documenting template is proposed.

The T19IceLossMethod uses the rotor as an ice detector. The 10th percentile of output power for each wind bin and as minimum three consecutive data points are used to define icing event start-stop time stamps. Production losses are calculated by comparing expected power to actual power for operation during defined icing events. Ice related stand-still situations are calculated case-by-case by analyzing turbine operation modes prior and after stand-still situations.

The T19IceLossMethod will be verified extensively with site measurements from Sweden, Czech Republic and Canada. Finally, the IEA Ice Classification will be compared to the site measurements.

References:

[1]: Navigant Research, 2013. World Market Update 2012 , Chicago. Illinois: Navigant Research, ISBN: 978-87-994438-4-0

[2]: for more IEA Task 19 details, please see http://arcticwind.vtt.fi/ and http://www.ieawind.org/

[3]: IEA Task 19, 2011 Edition. IEA Wind Recommended Practice 13: Wind energy projects in cold climate report

Web site: http://arcticwind.vtt.fi/

Short biography: Mr Lehtomäki has been a Research Scientist at VTT Technical Research Centre of Finland since 2009. His work focuses on ice assessment, cold wind turbine dynamics, and icing effects on blades. He is the coordinator of cold climate sub-committee in the revision of IEC 61400-1 ed3->ed4

Abstract #: 52 (Oral)

R&D areas/s: 02. IEA Task 19 (IEA RD&D Wind), 08. Production experience, losses

"Design requirements for wind turbines". He is Operating Agent of International Energy Agency (IEA) Task 19 "Wind Energy In Cold Climates".

BACK

Abstract #: 39 (Oral)

R&D areas/s: 04. Swedish Energy Agency's CC research program, 05. Forecasting, cloud physics, aerodynamics, 06. De-/anti-icing including ice detection & control

Measuring air liquid water content by shadowgraph image analysis for wind turbine icing detection

Staffan Rydblom, Mid Sweden University, SE

Staffan Rydblom and Benny Thörnberg
Mid Sweden University
SWEDEN

In order to determine icing conditions and to make icing forecast information, it is required to know several parameters such as wind speed, air pressure, temperature, LWC and MVD. LWC is the concentration of water in the liquid form of water drops in an aerosol (fog) and its droplets median volume diameter is MVD. Unfortunately, these parameters are very costly or difficult to measure using existing measurement equipment. Ongoing research project at Mid Sweden University is aiming at developing a new method for cost efficient direct measurements of LWC and MVD.

We have shown that it is possible to derive LWC and MVD directly from images of the water droplets using a shadowgraph system consisting of: CMOS camera with a telecentric lens, a LED flash illumination and a computer for image processing and analysis.

A work in progress, a pre-study of such an optical array probe intends to give answers to the following three research questions: (1) How small and how large droplets can be measured using low cost optical components? (2) What accuracy and precision are expected for measurements of droplet diameters? (3) What illuminative power is required to get good enough exposures at given maximum wind speed?

Early results indicate that it is possible to define measurement volumes of air through image edge detection in combination with analyzing diameter and signal to noise ratio for each particle. This means that the inspected volume of air for one single image will be dependent on droplet size as well as also intensity of light and exposure time (dose). Wind speeds in the range of 25 meters per second and shadowgraph imaging in free air will require as low exposure times as 50 nanoseconds to avoid motion blurring. It is yet to be verified what optical components can be used to ensure such low exposure times at maintained light dose. We have been able to verify the imaging systems ability to detect water droplets in fog generated by an ultrasonic emitter. These experiments will be extended into building an environment for laboratory system tests under more controlled climates, a work that involves the use of climate chamber.

The harsh environment for a sensor used outdoor in cold, humid, windy climate is another big challenge that cannot be underestimated. How to protect the sensor itself from icing while at the same time analyzed air during measurements should not be affected? We believe in using an arrangement for free air measurements that will have the least possible affect on airflow. Heating will be necessary to protect the instrument from icing and condensation.

Finally, we plan for comparative studies in field using Fog Monitor FM-120 from Droplet Measurement Technologies as a reference.

Web site: http://www.miun.se/stc

Short biography: Staffan Rydblom was born in Sweden 1975 and received his M.Sc in applied physics and electrical engineering from Linköping Institute of Technology, Sweden in 2001.
From 2002 to 2013 he worked with software and hardware systems engineering at Bombardier Transportation, Permobil and ABB.
Staffan is currently a PhD student at Mid Sweden University.

BACK

Abstract #: 1 (Oral)

R&D areas/s: 06. De-/anti-icing including ice detection & control

Siemens turbines in cold clime

Bo Birkemose, Siemens Wind Power, DK

Abstract - Winter Wind 2015

Siemens Turbines in Cold Clime

Author: Bo Birkemose

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7330 Brande
Danmark

Mobile number : +45 30374947

Goal: Illustrate the development of cold clime turbines and blade de-icing based on former and current developments in this area.

Contents: Siemens Wind Power (formerly Bonus) was among the first wind turbine manufacturers to develop wind turbines specifically designed to operate in colder climates.

The cold climate turbine development led to integrated blade heating systems, which were installed at different locations on the northern hemisphere in the 90s.

The blade heating system has since then been developed even further to deliver a complete “cold-climate-system” for our turbines. The design of Siemens Wind Power Blade De-Icing Systems has proven its reliability and efficiency the last 5 winter seasons and will undergo continuous optimization to ensure that Siemens wind turbines installed in cold climate regions all over the world can produce electricity even under extreme weather conditions.

Web site: http://www.energy.siemens.com/hq/en/renewable-energy/wind-power/

Short biography: Finn Daugaard Madsen
Developed Siemens Wind Power De-icing system and worked on different project related to the challenges of operating turbines in cold clime

Positions:
2010 - Innovation Manager – Siemens Wind Power
2008 - 2010 Think Tank Manager – Siemens Wind Power
2006 - 2008 Key Account Manager – Primo DK
1987 - 2006 Project Director – Concept lab LEGO
Education:
Diploma of leadership
Mechanical engineer

BACK

Abstract #: 11 (Oral)

R&D areas/s: 06. De-/anti-icing including ice detection & control, 08. Production experience, losses

Anti-Icing System on Nordex wind turbines – lightning protection and operating experience

Jochen Birkemeyer, Nordex Energy GmbH, DE

Ines Runge (Nordex Energy GmbH, DE)

Nordex offers for the N117 an Anti-Icing system (AIS). The blade is a hybrid glass-carbon design. The heating system is an electrical resistance heater integrated in the blade leading edge close to the surface. The first series of the heating-system has been installed on a N100 turbine in 2010 in Sweden.
The N117 AIS prototype has been installed in 2013. Since the integration of electrical conductive components in rotorblades is challenging with respect to lightning protection, most manufacturers have chosen a hot-air heating system. Hot air systems have in general very limited de-icing functionality in wind turbine operation mode – mostly restricted to idling condition of the rotor. The Nordex Anti-Icing system is fully operating during turbine operation.

The heating system consists of several components as heating mat, sensors and switch cabinets for power supply, signal processing and control.
The elements of the heating system have been qualified within mechanical and electrical tests. Furthemore the temperature distribution on the blade surface has been validated. Component as well as full-scale tests have been conducted and will be presented. The presemtation shows also the operating experience with the Anti-Icing system with focus on the ice-detection.

Web site:

Short biography: Mr. Jochen Birkemeyer has twenty years experience in aerodynamics of wings and rotor blades and more than twelve years experience in the design of wind turbine rotor blades. He works as head of Blade Engineering at Nordex. He is responsible for blade aerodynamics, structural mechanics, material qualification, blade testing and Anti-Icing technology.

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Abstract #: 31 (Oral)

R&D areas/s: 06. De-/anti-icing including ice detection & control, 08. Production experience, losses, 09. DOM (Deployment, Operations and Maintenance), 13. Market potential

ENERCON rotor blade heating system (RBHS) and icing measurement campaign

Alexander Winter, Enercon GmbH, DE

Eva Sjögren (Enercon, SE)
Sales Manager
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During the last decade ENERCON has developed a Rotor Blade Heating System (RBHS) that has been proven to work in harsh icing climates with good results. The RBHS has been installed all over the world and experience has been collected from numerous sites.
ENERCON is always focusing on research and development, so also in the de-icing and anti-icing area. The drive to always make our systems more efficient has led to new results that will provide even more reliability and possibilities for our customers to optimize the production and the safety of our turbines. Technical features of the ENERCON RBHS will be presented and discussed. In addition new results of the performance of ENERCON wind energy turbines equipped with RBHS, from different sites with different icing conditions, will be shown.

Web site: http://www.enercon.de/de-de/

Short biography: Dipl.-Phys. Alexander Winter
Project Engineer
Yield Estimation Team
Site Assessment Department

BACK

Abstract #: 33 (Oral)

R&D areas/s: 06. De-/anti-icing including ice detection & control

GAMESA solutions for cold climate conditions

Erik Åslund, GAMESA Wind, SE

Michael Henriksson (GAMESA, SE)
Irene Alli (GAMESA, ES)
Pramod Maheshwar (GAMESA, USA)
Pablo Jimeno (GAMESA, ES)

As wind farms are being built in cold climate conditions, icing events pose an increasing risk to turbine safety and operation that has to be addressed by the wind turbine manufacturer. The impact of ice build-up leads to, amongst others, reduced turbine availability, reduced power production and potentially damaging loads.

In order to address these problems, Gamesa has developed several tailor-made solutions that mitigate the impact of ice formation on wind turbine performance and safeguard operation during the icing events. The different solutions will be elaborated in detail in the paper/presentation and all together form a wide portfolio that efficiently addresses the varying needs originating from different sites, different customers and a range of icing conditions.

A brief overview is given below.

1. BladeshieldTM. Passive reduction of the ice formation on the wind turbine blades. This solution consists of a hydrophobic paint which has a dual purpose: it prevents the formation of ice and furthermore boosts the blade's resistance to erosion. The application has been widely tested in a laboratory setting and will be validated on a commercial wind turbine in Finland in the winter of 2014-2015.
2. Improvement of the control strategy and efficient detection of ice. The Ice Detection System (IDS) is a solution that detects ice build-up on the blade surface and enables the wind turbine control to take specific actions when considered necessary to maintain safety. The control system processes the information obtained from several sensors located on the wind turbine and analyses in real time possible efficiency losses that may be associated with the presence of ice on the blade surface. The wind turbine resumes normal operation when the environmental conditions permit or once the ice has melted naturally.
3. Blade De-icing System (BDS). A solution for low to medium intensity icing sites based on hot air circulation. This system incorporates a heater-ventilator element that forces hot air through the internal blade structure in order to free the blade surface of any ice formation. The solution includes an advanced control strategy that measures energy losses due to icing and activates the heater system when a de-icing cycle is deemed necessary. This combination greatly boosts turbine availability and energy production during the cold months.Validation of the BDS has been carried out at laboratory and field validation is scheduled during the winter 2014-2015 in Sweden
4. Ice Prevention System (IPS). A solution for high intensity icing sites based on active ice prevention, avoiding ice build-up during the wind turbine operation. The system avoids ice build-up on the blade during operation, therefore without the need to force a stop on the wind turbine. The system incorporates the introduction of an electrical circuit in the blade leading edge so as to heat up the blade during rotation. Wide validation of the IPS has been carried out at laboratory and field validation is scheduled on the prototype installed in Finland during the winter 2014-2015.

Web site: http://www.gamesacorp.com

Short biography: Working in the Swedish wind industry since 2009,
active in Vindforsk through Fortum 2009-2011
Working in GAMESA since 2011

BACK

Abstract #: 56 (Oral)

R&D areas/s: 06. De-/anti-icing including ice detection & control

Vestas cold climate offerings

Brian Daugbjerg Nielsen, Vestas Wind Systems, DK

Brian Daugbjerg Nielsen (Vestas Wind Systems A/S, DK)

Product overview
Design
Performance
Field Testing

Web site:

Short biography: Product Manager at Vestas.
In wind since 2006

R&D areas/s: 06. De-/anti-icing including ice detection & control, 08. Production experience, losses, 12. Finance, risk assessment and mitigation

Performance assessment of ice protection systems for wind turbines

Esa Peltola, VTT Technical Research Centre of Finland, FI

The global fleet of wind turbines in light icing conditions is more than 40 GW and is estimated to grow with 20 GW by 2017 [1] , and in moderate to heavy icing conditions 11 GW and 8 GW respectively. Owners and operators are already suffering from significant financial losses due to icing, the estimated value of these losses in Canada only is 200 M$/a [2]. They aim at minimizing the losses by implementing new operation and control strategies into existing wind farms based on

- active blade ice protection using either surface mounted elements or hot air circulation
- combination of ice detection systems and
- improved methods for forecasting of icing events during the operation,

Active ice protection systems of wind turbine blades are offered as options by growing numbers of wind turbine OEM's. The systems differ from each other in terms of their approach, principal mode of operation, method of ice protection and operational control as shown in Figure 1.

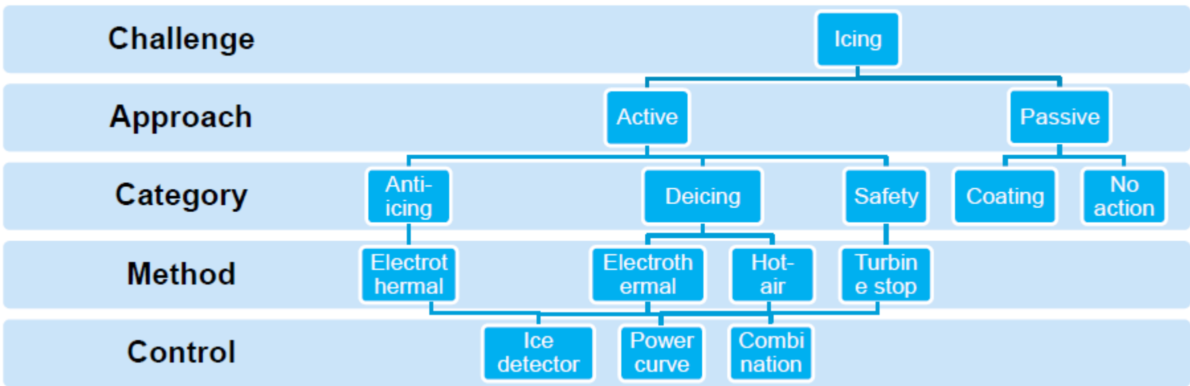

Figure 1. Approaches to blade ice protection [3].

There is a need for performance assessment for all these approaches. This would help project developers to reduce their financial risks in the choice between turbines with different blade ice protection systems based on their performance and cost over lifetime.

Using VTT's background on blade heating system development we have developed approach and method for the performance assessment of active blade ice protection systems. The method for performance assessment includes a.o.

- the performance limitations of the systems, including e.g. temperature limits for anti-icing or arial limitations of the heating
- system control principles and it's limitations
- production recovery enabled by the blade heating system
- own consumption
-

References:
[1]: Navigant Research, 2013. World Market Update 2012, Chicago. Illinois: Navigant Research, ISBN: 978-87-994438-4-0
[2]: Wadham-Cagnon et al, 2014. Smartly Investing In Ice Protection Systems To Effectively Reduce Financial Loss. In Wind Power Monthly forum Optimising Wind Farms in Cold Climate, Helsinki Nov 26-27 2014
[3]: Lehtomäki V. and Peltola E. Blade Protection Systems and Their Performance Under Cold Climate Conditions. In Wind Power Monthly forum Optimising Wind Farms in Cold Climate, Helsinki Nov 26-27 2014

Abstract #: 57 (Oral)

R&D areas/s: 06. De-/anti-icing including ice detection & control, 08. Production experience, losses, 12. Finance, risk assessment and mitigation

[4]: IEA Task 19, 2011 Edition. IEA Wind Recommended Practice 13: Wind energy projects in cold climate report

Web site: www.vtt.fi

Short biography: Esa Peltola joined VTT Technical Research Centre of Finland in 1980, where he has been working as research scientist, team leader, key account manager and at present as principal scientist in Wind Power team. Since late 1980's he has been active in the areas of R&D of wind energy systems and technology, especially for arctic environment within several national and EU-projects. He has also worked for industry in commercialization of blade heating technology and wind farm development, construction and operation in cold climate. He used to be the Operating Agent of International Energy Agency (IEA)R,D&D Wind Task 19 "Wind Energy In Cold Climates".

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