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Winterwind 2012

INTERNATIONAL WIND ENERGY CONFERENCE

Cold climate wind energy solutions

RESEARCH AND APPLICATION UNDER ONE ROOF

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PROGRAM

WELCOME TO WINTERWIND 2012!

WIND TURBINES IN COLD CLIMATE & ICING CONDITIONS: PRESENTATIONS BY MANUFACTURERS & PANEL DISCUSSION

INTERNATIONAL RESEARCH: MAPPING AND FORECASTING

COLD CLIMATE CONSTRUCTION AND LOGISTICS

WORKSHOP

MEASUREMENTS AND SENSORS

ENERGY PRODUCTION IN NORTHERN SWEDEN

INTERNATIONAL RESEARCH: DE-ICING AND ANTI-ICING SOLUTIONS

MAINTENANCE & SAFETY, WORKING IN COLD CLIMATE

Poster presentation for Winterwind 2012

Topic: Market potential

Title: Wind power – the potential, location and numbers of Norrland (and potentially the Barents region).

Authors's names: Vindfyr

Affiliations: Wind power centers in Norrland.

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Abstract for Winterwind 2012

Topic: 1. Marketing

”Vem tjänar på vindkraft?
Samhällsekonomisk analys av storskalig vindkraft, exempel Markbygden etapp 1”

I samband med att vindkraftetableringarna ökar i antal och storlek i norra Sverige ökar också behovet av lokal förankring. Vindkraftcentrum i Barentsregionen startade 2009 och har som huvudsakliga syfte att arbeta för att stötta vindkraftindustrin, men också jobba för att tillvarata nyttan av vindkraftetableringar lokalt och regionalt. Efter två års arbete med detta inser vi på Vindkraftcentrum att allt inte fungerar som vi en gång trodde, och längs resan har vi fått skifta fokus inom vissa områden men också hunnit lära oss en hel del.

Sommaren 2011 anlitade vi IUC Sverige för att göra en grundlig genomgång av vilka de samhällsekonomiska effekterna blir från en storskalig vindkraftpark. I detta fall räknade de på etapp 1 av Markbygdenprojektet, dvs. 314 vindkraftverk inom ett sammanhängande område av Piteå kommun.

Vår önskan är att kunna få en möjlighet att under 20 min. presentera denna analys och hur vi kommer att arbeta utifrån det samt vilka lärdomar vi hittills dragit. Även om fokus för Winterwind har en forskningsinriktning vill vi gärna kunna delta med denna presentation. Detta eftersom Winterwind dels är en mötesplats som lockar vindkraftintresserade även utanför de allra mest tekniskt invigda. Men huvudsakligen för att det är vår uppfattning att alla som arbetar med vindkraft i norra Sverige och andra liknande områden där denna kraftindustri är relativt ny, tjänar på att ha kunskaper kring tillväxt och arbetstillfällen. Alla inom branschen kommer gång efter annan att hamna i situationer där de inför beslutfattare behöver kunna motivera sitt projekt med andra ord än att ”det blåser bra”. Kunskap om de samhällsekonomiska effekterna är alltså bra verktyg för att få kommuner och lokalbefolkning att bättre förstå de positiva effekterna.

Här nedan bifogas två länkar från media som skrivit om presentationen av denna analys:

http://www.energinytt.se/ovriga-artiklar/stora-ekonomiska-vinster-for-samhallet-vid-utbyggnad-av-markbygden-etapp-i/

http://www.pitea-tidningen.se/nyheter/senaste_nytt/artikel.aspx?ArticleId=6499849

Med vänliga hälsningar och förhoppningar om ett positivt besked,

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The benefits of forecasting icing on wind energy production

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Topic no 2 – Mapping and forecasts of icing

Abstract

A model to calculate icing has been developed based on data from the meso scale model WRF. Some Swedish wind farms have experienced monthly production loss of more than 50% for the winter 2009/2010.

By including icing in the forecasts of wind energy production it is shown that the forecast errors can be reduced. This is done by including a model for estimating production losses due to icing in the energy forecasts. The benefits of forecasting of icing are thus illustrated.

For cold climate sites de-icing systems are often suggested in order to reduce the influence of icing on wind energy production. A model is set up to illustrate a turbine de-icing system. By introducing icing forecast into the control algorithm of the de-icing system it is shown how the energy production can be optimized.

Abstract: Wind Tunnel Tests on Ice Accretion on Wind Turbine Blades

Adriana Hudecz, Holger H. Koss and Martin O. L. Hansen

November 15, 2011

The ice built up on wind turbine blades can cause significant production loss and damages on the structure in cold regions and high altitudes. It is highly important to have a clear view of the icing process and the environmental conditions, which influence the ice accretion in order to act properly.

Good and widely used numerical solutions are available on the market. These programs can predict the amount of ice accretion and its effect on aerodynamics and the flow around the airfoils. Ice accretion was modeled in a wind tunnel. The tests have been performed in a closed-circuit climatic wind tunnel at FORCE Technology, Kgs. Lyngby, Denmark. The minimum temperature for the maximum wind tunnel velocity at 25 m/s is -5 ^{o}C. The size of the test section is 2.0 x 2.0 x 5.0 m, which allowed the testing of relatively large scale airfoil.

LM Wind Power Blades has provided a NACA 64-618 airfoil section with 900 mm chord length and 1350 mm width for testing. The ice accretion and the changes of aerodynamic forces have been monitored with different wind velocities, temperatures and liquid water contents for 4^{o} and 11^{o} deg of angles of attack. The results have been compared with results of the numerical programs.

Poster presentation. Topic 2

Presentation at WinterWind 2012; 7-9 February 2012

HIGHEST METEOROLOGICAL STATION IN CANADA DESIGNED FOR COLD CLIMATE AND COMPLEX TERRAIN RECOGNITION
TOPIC #2 – MAPPING AND FORECASTS OF ICING

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ABSTRACT

The Wind Energy TechnoCentre (TCE) has begun in 2009 an R&D program related to the adaptation of wind energy technology in cold climate. To reach his program's goals, several infrastructures are planned on the SNEEC's (site experimental en éolien Corus) wind farm. The SNEEC wind farm is located in the city of Rivière-au-Renard, Quebec, Canada and is composed of two REpower MM92 CCV turbines (4.1 MW in all). The terrain surrounding the wind farm is considered very complex consisting of mountains and deep valleys.(>300 m). Surface roughness is covered by deciduous and coniferous forest. In order to characterize the cold climate conditions and wind resources affecting his wind farm , a 126 meter-height meteorological mast have been recently been installed. This tower is considered to be the highest meteorological station installed in Canada. The final commissioning of this met mast is planned for the 10th of December 2011.

Our podium presentation will describe all details of the met masts configuration, the research objectives and results obtain through analysis of our measurement. Our 126 meter-height tower met mast is mechanically designed to resist combined loads of 40 mm of ice uniformly distributed on the structure and wind speeds up to 55 m/s. This mast is equipped with more than 30 sensors that will be periodically maintained or calibrated in order to ensure a high level of accuracy. To name a few, here are some sensors will be operational shortly: several ice detectors (ceilometer, optical detector, etc), differential temperature probes, humidity sensor, heated and non heated wind speeds and direction sensors, several ultrasonic probes (2D and 3D), rain gauge. SODAR and LIDAR will also be used for comparison purposes.

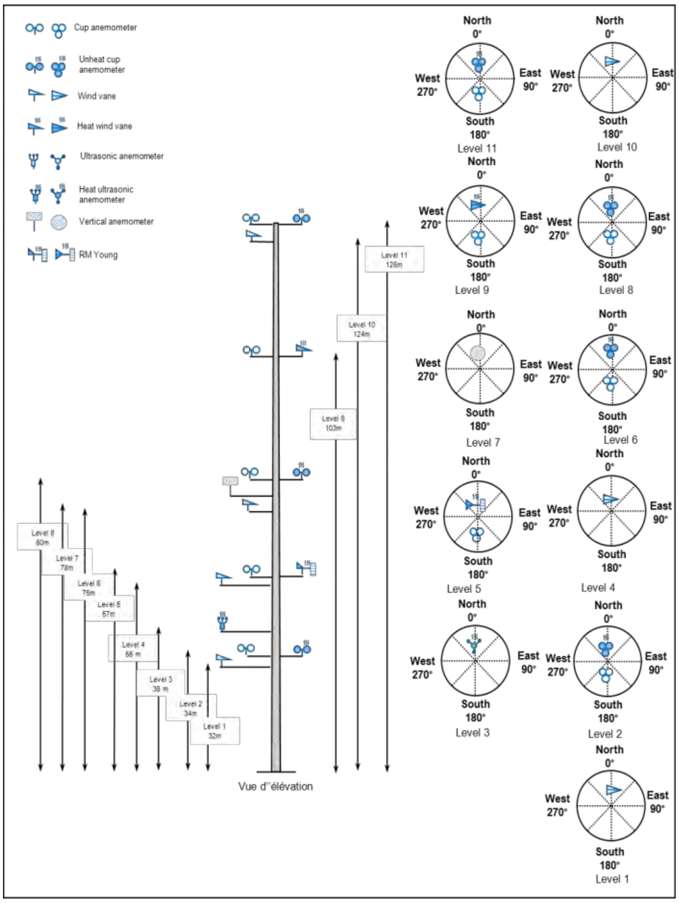

Figure 1 : Met mast configuration – wind sensors only

Finally, our presentation will give results of our investigations on the relationship between thermal stability, cloud height for icing events based on the first winter months of operations. We believe that it will be the first time that empirical demonstration of an interaction between thermal stability and icing fog.

This meteorological analysis between thermal stability, cloud height for icing fog and icing events based on two months data acquisition will be done with these parameters:

- a by icing fog
- atmospheric boundary layer
- thermodynamics conditions
- wind vanes
- sensors related in Nordic climate.

Topic #: 2. Maping and forecasts of icing

Title: WRF Sensitivity Analysis of Boundary Layer Clouds During the Cold Season

Authors: Neil Davis (1, 2)*, Andrea Hahmann(1), Niels-Erik Clausen(1), Mark Zagar (2)
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Abstract:
Icing on wind turbines has been identified as a problem for placing turbines in cold climates. The ability to forecast icing both near term and climatologically could help to minimize losses by allowing turbine operators to identify sites which are prone to excessive icing, and identify reduced output periods ahead of time for pricing on the energy market. One of the first steps in developing a forecasting system for icing is identifying the ability of a mesoscale model to forecast boundary layer clouds, which have been identified as the leading cause of icing events. In this study, three different microphysical schemes each coupled to three different boundary layer schemes were compared with respect to the differences in cloud parameters between 25 m and 200 m above ground level for several locations in Sweden. The primary focus was on differences important to wind turbine icing, namely the liquid cloud parameters and temperature. As an approximation of icing two methods were tested, the first is a threshold method which considered icing to occur when the temperature was below zero and a mixing ratio was above a certain amount. The second icing estimator was created based on a 1D ice accretion model. The periods of icing were compared using these two techniques, and the distributions of wind, temperature, and microphysical parameters were analyzed for both icing and non-icing events. It was found that the interplay between the various schemes is very important for determining the type of cloud parameters output by the model, and therefore the periods of icing which occured.

14/11/2011

Abstract for Winterwind 2012

Topic #2: Method for Estimating Wind Turbine Production Losses Due to Icing

Authors: Ville Turkia, Saara Huttunen, Tomas Wallenius (VTT Technical Research Centre of Finland)

Atmospheric icing is a common weather phenomenon in countries like Finland, Sweden and Canada, and it can have significant effect on wind turbine power production. A simulation method for estimating wind turbine production losses due to icing was developed by VTT Technical Research Centre of Finland (VTT). The method is used in Finnish Icing Atlas made in co-operation by the Finnish Meteorological Institute (FMI) and VTT. Ice and icing mapping was done by FMI using the AROME weather model and a model for icing of standard cylinder described in ISO 12494 standard. This presentation describes the estimation method for power production losses.

In order to identify the power curves of iced up wind turbine for use in Icing Atlas, ice masses accumulated on the blade were considered and a relation to ice mass on a standard cylinder model was established.

Ice accretion on two dimensional wind turbine blades was simulated by using the VTT in-house developed TURBICE software that is based on panel method. As a result, three different ice accretion cases (light, moderate and severe icing) were formed and the iced airfoils were analysed further by CFD simulation. Only the outer third of the blade was considered iced and was divided into two sections. Due to the complexity of wind turbine icing phenomena, only rime ice conditions were considered in this work.

CFD simulations were performed with ANSYS FLUENT. The flow and meteorological parameters were selected to resemble representative icing conditions. For all the simulated cases aerodynamic force coefficients for lift and drag were determined.

Lift coefficient curves had a good resemblance to the reference data, but drag coefficients needed to be corrected in order to account for the ice roughness effects. A Method was applied to separate the effect of surface roughness and to add it to the CFD simulation results. The force coefficients were subsequently put into the power simulation software FAST and power curves for iced up wind turbines were calculated.

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Evaluation of WRF mesoscale model for icing events characterization, some insights on model performance, limits and cappabilities

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Topic: Mapping and forecast icing

Extreme cold climate regions are more frequent in current wind farm developments, which makes adapted site specific resource and environmental characterization for extreme weather conditions more significant. One of the recurrent critical constrains is the lack of long-term observed data in remote areas to estimate probabilities of low temperature and icing conditions occurrence. To overcome this restriction, atmospheric mesoscale modeling solutions are becoming part of the actual micrositting standard methodology justified by very satisfactory models skills experience.

This work shows results from a validation exercise conducted by Vortex with the support of GAMESA to assess WRF performance to track icing and extreme cold events conditions.

Observed data were kindly provided by GAMESA from eight operational windfarms located in Spain, Portugal, Germany, Poland and Sweden. Windfarms were selected to represent different climate and orographic complexity areas to help delimiting model sensitivity to different environmental conditions. Turbine availability and anemometry dysfunction were employed to determine icing intensity indexes as no direct records of ice accretion were available.

A 1KM resolution WRF model hindcasts driven by NCEP CFS Reanalysis were produced to cover the different periods of observed data for each site. Selection of potential icing events was made based on crossed distribution of humidity and temperature. A very high resolution 100m final simulations were produced over the potential icing event periods. Output from these icing detection runs were employed to feed Makkonnen icing accretion model to produce estimation of icing events duration based on icing rate threshold of 10 gr/h.

Results from the validation showed:

1) Very good temperature tracking, with correlations of the order of $R2>0.95$ and >0,98 for daily and monthly correlations respectively.
2) Quite satisfactory predicted hours above 10g/h accretion rate against observational anemometry data. However, specific icing events are not coherent in time as expected. Model performs on a mean value rather than as a purely icing time series generator, which imply that error tends to compensate.
3) Poor correlation between icing prediction and turbines availability. Although at the moment of this research it was not possible to determine how turbine availability can effectively be employed to calibrate model icing detection, a specific research will follow to quantify uncertainty on observed icing detection.
4) Final 100m model runs and observed crossed wind speed/direction distributions show a significant level of similarity, which encourage the use modeling solutions to discriminate extreme and non extreme resource conditions.

Abstract for Winterwind 2012

Topic no 2: Mapping and forecasting of icing

Long-term estimates and variability of production losses in icing climates

Authors: Stefan Söderberg and Magnus Baltscheffsky; WeatherTech Scandinavia AB

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In this study, the model results from the mesoscale numerical weather prediction model WRF (www.wrf-model.org) has been used to estimate annual variability in production losses due to icing in icing climates.

The area covered is Scandinavia, Finland, the Baltic countries, northern Poland, and northern Germany. Initial and lateral boundary conditions were provided by NCEP/NCAR Reanalysis data. WRF was then used to produce hourly data for 30+ years on a 9x9 km^2 model grid.

The estimated ice load is not only dependent on the modelled liquid cloud water but also the wind speed. Hence, one can expect an annual variation in ice load similar to or even larger than what is found in the wind speed. Statistics illustrating the variability of icing on annual to decadal time scales will be presented. The results indicate that a time period of the order of 30 years will be needed in order to get a reasonably stable estimate of the icing climate. Modelled ice load is then used to estimate production losses using modified power curves to find long-term estimates of production losses.

COMPARISON OF VISIBILITY OBSERVATIONS AT A METEOROLOGICAL TOWER TO CLOUD BASE HEIGHT OBSERVATIONS FROM NEARBY AND DISTANT WEATHER STATIONS

Jarkko Hirvonen[1]
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Abstract:

An elevated weather station (Puijo tower) in the of city Kuopio (62°54`N and 27°40`E), Eastern Finland has been producing continuous measurements of temperature, humidity, visibility, wind speed, wind direction and present weather since 2005. The elevation of Puijo tower is 306 m MSL and approximately 220 m AGL, above local larger water body lake Kallavesi.

Recently it has been shown that if the visibility (Puijo-VIS) is poorer than 200 m at the Puijo tower then in-cloud conditions prevail at the tower level.

In this study the data for a period of 2005-2011 will be used to assess the relation of Puijo-VIS to cloud base height (CBZ) observations from several lower level (80-150 m MSL) weather stations with horizontal distances varying from 2 km to 150 km from tower.

Cloud base height observations are of vital importance for many automated systems that are designed to assess icing conditions near the surface or aloft as the presence of a cloud is one prerequisite for icing to occur.

The results from this study can provide useful information about the sensitivity between the presence of cloud at an elevated site (e.g. wind turbine) and CBZ measurements with varying distances.

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Progress in Design of Icing Detection System for Wind Turbine

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In cold climate, wind turbine can experience icing when encountering rain, snow or airflow that contains supercooled water droplets. Ice accretion on the surface of wind turbines is a common phenomenon. It can cause a series of hazards, such as decreasing power coefficient, causing large load imbalance as well as excessive vibration, increasing fatigue loads of blades, even damaging the blades or leading to the collapse of wind turbine.

A design approach of ice detection system for wind turbine is presented in this paper. It can be divided into following five steps. First, build numerical method for ice prediction based on the computational fluid dynamics (CFD) technologies. Second, develop the advanced ice sensors according to the optical property of ice. Third, design the aerodynamic shape of the prober to assemble the ice sensor. Then the relationship between wind turbine icing and prober icing can be analyzed by numerical calculation. Based on which, we can determine where the ice sensor should be installed on the surface of the prober. Fourth, calculate how icing affects the wind turbine's performance and then work out the alarm strategy. Finally, integrate the prober and the electronic system and form the whole ice detection system for wind turbine application.

We have constructed the numerical method of wind turbine icing and developed a fiber-optic ice sensor with a minimum detectable ice thickness of 0.1mm. This paper gives a detailed description about the research progress in the numerical method and fiber-optic ice detection technology.

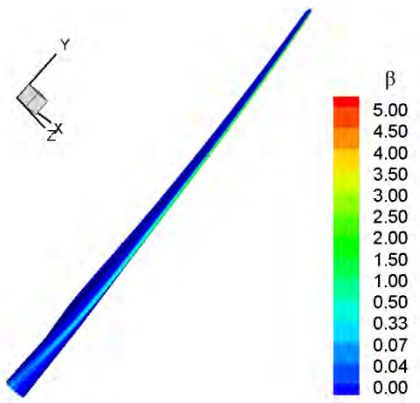

Fig.1 Contours of collection efficiency on blade

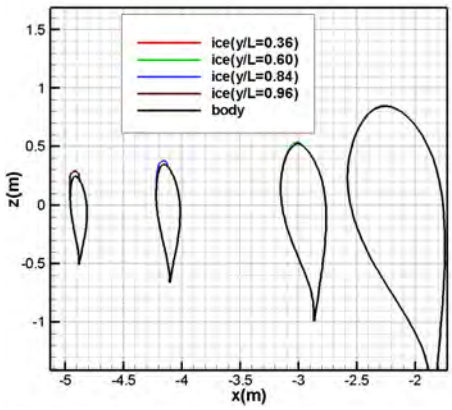

Fig.2 Ice shape at different positions of blade

Fig.3 Two different shapes of sensor

Future wind power forecast errors, and associated costs in the Swedish power system

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Abstract

Wind power is one of the renewable energy sources in the electricity system that grows most rapid, which is in line with both Swedish and EU governmental goals. There are challenges that need to be addressed with a larger proportion of wind power – variability and predictability. Predictability is important since the spot market Nord Pool Spot requires forecasts of production 12 – 36 hours ahead. The forecast errors must be regulated with regulating power, which is expensive for the actors causing the forecast errors. The variability is not addressed in this paper; however, both variability and predictability are connected to the need for the electric power system's ability to regulate power – that is, to be able to produce what the consumers consume.

This paper investigates a number of scenarios with 10 – 55 TWh of wind power installed in the Swedish system. The focus has been on a base scenario with 10 TWh new wind power consisting of 3,5 GW new wind power and 1,5 GW already installed power, which gives 5 GW. The size of the forecast errors of future scenarios have been assumed to develop to a standard deviation at 13% of installed capacity, which is very good since it is around 20% in Sweden today, however in other countries such as Germany, around 15%. The scenarios are based on planned wind farms to make the scenarios as true as possible. Eight different actors with balance responsibility have been created that own all the new wind power (not the already installed) in the scenarios. They have been chosen to differ from small to large and from concentrated location to wide spread – which give present owners of wind farms a possibility to find some of the constructed actor that is similar to their targets. The investigation focuses on

- the forecast error volumes due to wind power forecast errors for the system as well as for different actors,
- the costs associated to the forecast errors,
- the effect of the introduction of four bidding zones in Sweden, and
- options to reduce costs such as reduction of forecast errors by trading at the intraday market, better forecasts, and changed market design.

The main conclusion that is drawn from the study is that the costs for forecast errors for the wind power owners increase from today's costs that is about 5 – 10 kr/MWh to future 30 kr/MWh (3 öre/kWh) with 10 TWh new wind power. It should be noted that the present and future cost is based on very high forecast quality, and as the forecast error quality is much lower today, the cost in reality is about 15 - 20 kr/MWh. So, the increased costs will not be so dramatic in practice. The cost varies between the actors since they have their wind power in different bidding zones and also different concentrations which affect the forecast error volume. It should be noted that these numbers represents higher forecast quality than used today.

Wind turbine blade heating – can it pay even more?

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1. Introduction

Icing has a strong effect on the operation of wind turbines: It influences the aerodynamics of the blades and causes production losses. Moreover, additional ice loads lead to extreme and fatigue loads. Iced wind measurement sensors at the wind turbine's nacelle lead to erroneous behaviour and security stops. Finally, ice throw represents a significant safety risk for pedestrians and service personnel.

Nowadays, only very few turbine manufacturers offer solutions for ice detection and de-icing of wind turbines. Hence, there is only little experience in the effectiveness and the added value of such systems.

In Switzerland, nearly every planned wind park is located in areas where icing is likely to occur during the winter months. Therefore, there is an urgent need to get more information about the performance of wind turbines under such conditions. A unique experiment has been carried out in Switzerland in fall 2009 at two Enercon E-82 wind turbines. They are located in a distance of approximately 300 m to each other in St. Brais in the Swiss Jura at 1'100 masl. Both wind turbines are equipped with the Enercon hot air blade heating.

2. Project description and results

One of the wind turbines was equipped with additional meteorological instruments as well as automatic cameras taking pictures of the blades and the instruments at the nacelle of the wind turbine in regular intervals. Based on these camera images, information on the frequency of meteorological icing (active ice formation) and instrumental icing (ice persistence) could be obtained. Furthermore, the reliability of the ice detection as well as the effectiveness of the blade heating could be assessed.

A comparison of energy production for the two winters between 2009 and 2011 between a wind turbine with and one without blade heating has been carried out in order to assess the benefit of a blade heating over a longer time period. The results show that the operation of the wind turbines without a de-icing device would have resulted in significant production losses and that the blade heating therefore is a valuable tool to increase the production at this site.

However, between 2009 and 2011, the wind turbine needed to be stopped to heat the blades. During the end of winter 2010/11 and during winter 2011/12, the wind turbine will be operated and monitored in a new mode where the blades are heated during operation in order to minimise the losses due to icing even more. Within this presentation, a detailed overview over the additional benefit of the new heating mode in terms of additional production versus more needed heating energy when heating during operation will be discussed. Furthermore, the efficiency of heating during operation will be presented.

Sensor Fusion for a Blade Surface-Mount Icing Detector for Wind Turbines

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Topic:

3. De-icing and anti-icing technologies

Abstract:

Cold-climate operation of wind turbines requires the reliable detection of icing conditions on the rotor blades. A successful sensor is able to detect icing effects under a broad range of environmental conditions at an early stage so that appropriate counter-measures can be taken. Furthermore, from a practical point of view, the sensor ideally does neither interfere with the mechanical structure of the turbine blades nor does it require significant modifications to existing blade designs.
In the previous year, we presented an impedance-type icing measurement system, which is capable of delivering icing information using a small geometric sensor footprint. Having successfully completed laboratory and field tests, we extend this sensor by introducing a sensor fusion concept. The sensor performance can be improved by the consideration of the different optical properties of ice, snow, water and air. Investigations are carried out with respect to the impact on measurement accuracy and detection thresholds. Due to the small sensor outline, multiple units can be deployed along the blades leading edges delivering distribution profiles. Thus, the sensor can be used to selectively control de-icing strategies such as thermal de-icing systems in order to maximize on-grid time and to minimize the amount of energy used for heating.

Abstract for Winterwind 2012

Topic: 3. De-icing and anti-icing technologies

Title: Design principles of VTT ice prevention solution

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Atmospheric icing is a common weather phenomenon in winter time in countries like Finland, Sweden and Canada. It is widely known that icing affect to wind turbine operation in many ways, for example reducing power production and causing ice throw risk. These effects can be minimized with effective ice prevention of wind turbine rotor blades and with suitable icing detection.

Thorough understanding of weather conditions, including complex atmospheric icing phenomena, and wind turbine operation are crucial in order to design an effective ice prevention system. Also, due to the multidisciplinary nature of wind turbine technologies, knowledge of many other areas, such as electrics and materials, is needed.

The design process of ice prevention system consists of several steps; for example definition of the functionality requirements and design conditions (weather and operational), heating demand calculations and defining interfaces to turbine's control and electrical system. In addition, laboratory experiments like icing wind tunnel tests are included to design process, to verify the theoretical calculations. VTT has been developing ice prevention solutions since early 90's and will share some of the design principles and experiences in Winterwind 2012.

Topic 3.

Image analysis of icing on wind turbine blades

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Wind energy in cold climate is of high interest at the moment when Sweden is aiming at having 30 TWh of wind power in 2020[1]. In order to achieve this production of wind power, our northern cold regions need to be exploited. These northern cold regions have a challenging climate due to the risk of icing. Icing conditions causes problems for wind mills such as decreased power production and damage to gear boxes and generators. Some techniques for de-icing of wind turbine blades have been developed, and they use heat to remove ice from the turbine blades. Heating of turbine blades is expensive to install and to use, why it should only be switched on when necessary. Optimization of when to turn on the de-icing systems should be done. Today several different methods have been used, for example ice load monitoring with the Combitech IceMonitor and ice detection with HoloOptics T-model for wind turbines. These methods measures the icing on a detection rod, usually located on top of the nacelle. The icing of the wind turbine blades is then supposed to be comparable to these sensors. However, this is not true due to the rotation of the turbine blades, which causes them to pass through several micro climatic zones at different altitudes. In addition to the different heights, the speed of the blades may also cause different icing conditions compared to what is monitored by the sensors at the nacelle. This suggests an ice detection method where the icing of the turbine blades is directly monitored through cameras. As the ice detection needs to be autonomous, image analysis should be utilized that gives warnings according to the amount of ice aggregated on the turbine blades. Previous research done by Combitech and Mid Sweden University has proven good results from detecting ice and snow in laboratory and on field tests on road surfaces[2]. The experience gathered from this research will be used for detecting ice on wind turbine blades. The research performed by Combitech and Mid Sweden University uses meteorological data in addition to image features to further increase the performance of ice detection. Future research includes the development of infrared sensors and cameras optimized for ice detection and discrimination of water in different phases. The weather monitoring platform delivered by Combitech has the ability to handle cameras suitable for monitoring wind turbine blade icing. The computer unit included in these systems has the computer power to perform online image analysis and hence trigger de-icing systems or sending alarms with images to wind mill supervisors. Standard near infrared (NIR) cameras could be used for capturing images of the blades and in the future infrared cameras may also be implemented. This new system based on image analysis ensures a cost-effective and reliable solution for ice detection on wind turbine blades.

[1] http://www.svensk-vindkraft.org

[2] P. Jonsson, "Intelligent Networked Sensors for Increased Traffic Safety," Licentiate Thesis, Department of Information Technology and Media, Mid Sweden University, Östersund, 2011.

Evaluation of icephobic coatings for the application on wind turbines – screening of different coatings and influence of roughness

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Icing of wind turbines does not only affect their energy production performance but also causes mechanical and electrical failures and influences monitoring and controlling as well as safety hazards. Hence, there is an enormous demand for powerful anti- and de-icing methods to keep wind turbines ice-free. Our research focuses on a passive method, namely permanent icephobic coatings that decrease the adhesion of ice to a surface in such a way that accreted ice can fall off from the rotor blades due to accreted mass and centrifugal and vibrational forces. In contrast to active anti- and de-icing methods, the passive ones do not need any external power like heating systems or the like. They take advantage of their physical surface properties.

For the investigation of icephobic properties, ice adhesion measurements were performed with a custom made 0° cone test. Therefore a tensile testing machine for the determination of adhesive strengths in shear was used. For this reason aluminium pins were covered with certain coatings, frozen into an according water-filled mould and their adhesives strengths determined at -14°C at a constant strain rate. This testing method shows a fairly high reproducibility.

Different coatings were investigated in consideration of their icephobic properties, e.g., hydrophilic and hydrophobic coatings, sol-gel based coatings containing fluorinated compounds and viscoelastic rubbers. Teflon and some standard coatings for wind turbines were used for comparison and bare aluminium as the overall reference material. It was found that sol-gel based coatings containing fluorinated polyether show promising adhesion-reduction-factors (ARF) of 20 whereas Teflon possesses only an ARF-value of seven. Coatings that are currently used on wind turbines show an adhesion to ice that is comparable to that of bare aluminium meaning a quite high adhesion to ice. Very low adhesion values are also obtained in the case of coatings consisting of viscoelastic elastomers.

Beside the chemical composition of the surface, the topography of the coatings namely roughness, has an influence on the adhesive strengths to ice. In order to obtain a systematic correlation between surface roughness and ice adhesion, the influence of surface roughness has been examined. Aluminium pins were roughened chemically and mechanically and their ice adhesion was determined. These pins were further coated with a fluorine containing coating in order to study the influence of minimized surface energies. It was shown that ice adhesion increases with increasing roughness. The application of a thin coating on sol-gel basis containing the adhesion lowering fluorine component leads to a decrease in surface energy. Because these layers are very thin, roughness is preserved. Therefore, rough but low energy surfaces could be investigated. It was shown that the shear stress of those coatings is considerably reduced, however rough surfaces show a higher ice adhesion than smooth ones. Those coated pins that show superhydrophobicity display very high adhesive strengths, hence they cannot be denoted as icephobic surfaces.

The combination of data taken from literature and our results coincide very well if the ARF-values are plotted against the contact angle of the coatings. It shows that our method of analysing adhesive strengths is an applicable approach for investigation and development of icephobic coatings.

Topic #: 3 De-icing and anti-icing technologies

Luminescent Technique for Temperature Characterization of Supercooled Water

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De- or anti-icing of an aircraft is necessary for a safe flight operation. Icing is a phenomenon which is caused by a collision of supercooled water frozen to an object (Fig 1). For the in-light icing, it may cause a change in the wing cross section that causes stall, and in the worst case, the aircraft would fall.

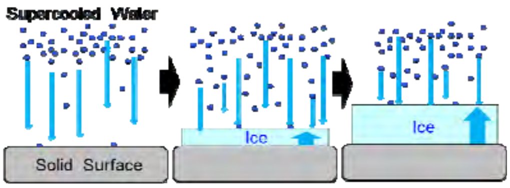

Figure 1: Schematic description of an icing process.

It is important to know how the supercooled water freezes to ice. By the collision of the supercooled water, the water temperature will come back to a freezing point. At the same time, a latent heat will be produced. There will be a heat exchange on a collide surface; however the temperature distribution by the collision is not well understood. To simulate the icing conditions experimentally, an icing wind tunnel has been used. The temperature distribution of the supercooled droplets is assumed to be uniform, approaching the freestream temperature. However, the experimental data is difficult to provide. A conventional thermometer will become collide surface so that its surface will start icing.

In aerospace field, temperature-sensitive paint (TSP) has been widely used for obtaining the surface temperature distribution on a testing article. It is a chemical sensor, using a luminescent molecule (luminophore). It is sensitive to the temperature, the process called thermal quenching. The luminescent image from TSP can be related to the temperature distribution.

We applied this optical instrumentation technique to characterize the temperature distribution of the supercooled water and the collide surface. The measurement system to be presented is shown in Fig. 2. It consists of the luminophore dissolved water, an image acquisition unit, and image processing unit. The image acquisition unit gives excitation to the luminophore water. The luminescent output from the water is acquired by a fast-frame color camera. The luminescent image from the camera is converted to the temperature map through the temperature calibration in the image processing unit.

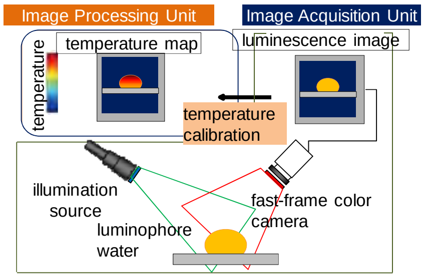

Figure 2: Schematic of the temperature measurement system.

The luminescent image is not only related to the temperature, but also the temperature independent factors. These are the illumination non-uniformity and the change in the camera – water distance. To cancel the temperature independent luminescence, we use a luminophore which is independent of the temperature. The luminescent output from this luminophore only gives the luminescent image related to the temperature independent factors. On top of this, we use a luminophore, which is sensitive to the temperature. The luminescent output from this luminophore is related to the temperature-dependent and temperature-independent image. These luminophores will emit at separated wavelength so that the color camera can capture the temperature-dependent and temperature-independent images simultaneously. By simply ratio the two images, we can extract the temperature image.

In the final version, the temperature calibration of the system will be included. A demonstration of a temperature measurement will be included from a supercooled droplet collided onto a surface.

Thermal analysis of a heated rotor blade for wind turbines

Topic 3: De-icing and anti-icing technologies

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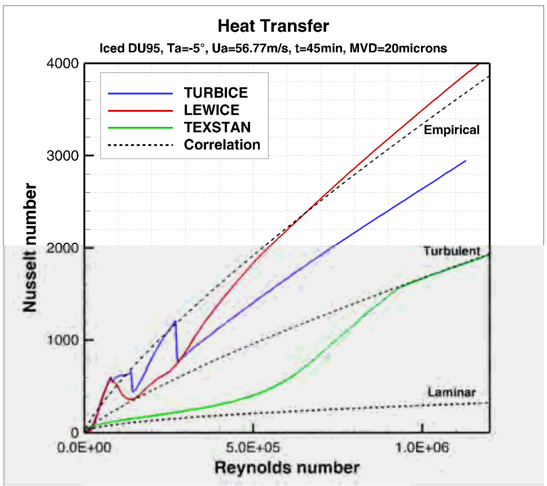
The objective of this investigation is to increase the understanding of the thermodynamics of ice accretion and the estimation of the required amount of heating for a thermo-electrical anti-icing system. This work was done at the Institute of Aerospace Thermodynamics at the Universität Stuttgart with support of Kenersys and VTT.

This study was done by performing and evaluating a thermal analysis of a rotor blade in icing conditions with different numerical approaches. Two-dimensional icing simulations have been carried out with LEWICE 3.2.2 (NASA) and TURBICE 6.0 (VTT). As reference calculations for the convective heat transfer, TEXSTAN, a finite-difference boundary layer solver, has been used, Fig. 1 (a). On a side note, the effects of ice accretion on the aerodynamic performance have been CFD simulated, in 2-D, with the TAU-Code developed by the DLR (German Aerospace Center).

Comparison of the different thermodynamic analysis yields new insights and a better understanding of the governing energy terms and heat transfer processes. Recommendations for the design and operation of a thermo-electrical anti-icing system can be given based on these results and knowledge of the dominating parameters as surface temperature, ambient temperature, median volume droplet (MVD) and liquid water content (LWC), Fig.1 (b).



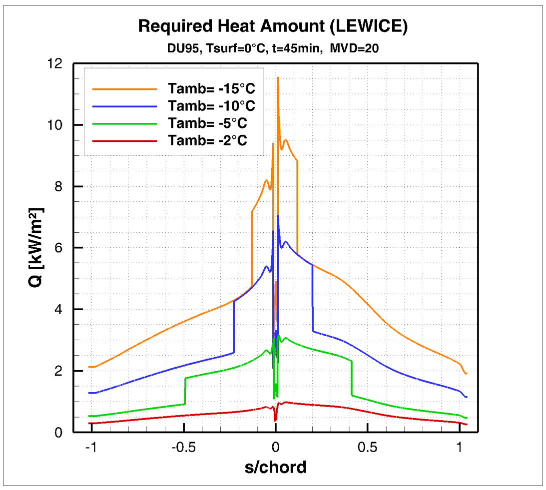


Figure 1: Local Nusselt number (a) and predicted required heat flux for anti-icing (b)

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TopNANO – new Nordic research using nanotechnology to avoid problems with ice

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Ice causes major problems in wind turbines, on airplanes and in 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. The technology is now being developed in the TopNANO project.

TopNANO is a Nordic research project with support from the Top-level Research Initiative and runs 2010-2014. The aim is to develop sustainable and efficient methods based on nanotechnology to reduce problems and costs with ice build-up. YKI, the Institute for Surface Chemistry in Stockholm is leading the project together with industrial and research partners from four different Nordic countries. The project budget is 35 MSEK (3,9 million Euro), half of which is via industrial in-kind contributions.

The Swedish part of the research, performed by YKI, KTH Royal Institute of Technology and SP Technical Research Institute of Sweden, focuses on robust superhydrophobic surfaces and surface spectroscopy analyses. Finnish VTT brings expertise on the physics of ice. Aarhus University in Denmark and their iNano centre works on mimicking nature's way of avoiding freezing inside cells. TopNANO engages senior scientists, postdocs and PhD students.

For the participating industrial companies, the TopNANO project runs in parallel with already existing projects and activities in wind turbine, aircraft and heat exchanger applications. Of key importance for TopNANO is the development of new materials and methods through direct industry-academia collaborations and the transfer of knowledge to Nordic industry.

During the first year of the project, methodologies for characterization of anti-icing coatings have been assessed and developed. For ice adhesion measurements, a method using a peel tester to monitor the force to pull off ice from a surface has been developed. Frost formation is studied using an environmental scanning electron microscope where the chamber pressure can be changed at subzero temperatures. The setup has been improved with a new movie system, transforming the analog signal from the ESEM into a digital signal. With this movie system it is now possible to record movies of frost formation on various surfaces at approximately -15°C. Spectroscopic methods for investigation of solid-water interfaces at subzero temperatures are being developed. The first spectroscopic method that will be utilized is TIR-Raman, and at later stages VSFS spectroscopy will also be considered.

http://www.topnano.se

Project sponsor and partners:

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Estimating Energy Production Losses, Comparison with Ice Detection.

Introduction

This study has the aim to show the energy losses due to icing on wind power plants in cold climates. Several Wind Power Plants are today equipped with de-icing systems to minimize the risk of ice growth on the rotor blades. The decision to install de-icing systems is strategic and a major investment which most be taken early in the design process.The study will show the importants of a dedicated controll system to avoid unnecessary use of the de-icing system. In a dedicated controll system, icing itsself is measured and not general meteorological data.

Method

During the winter 2008 to 2009 the icing situation and the production of a 600kW Vestas Wind Power plant was studied. Ice situation, power output, wind speed, humidity and air temperature was measured. The ice situation was measured by using two T41 Icing Rate Sensors. One sensor was configured to show the icing intensity and the icing rate. The other sensor showed the length of the icing period.
The plants power output was compared with the plants nominal power output. The nominal power was calculated from the power curve of the plant and the wind speed, measured at the site.

Results

The study was conducted during a period of 1500 hours during which, severe icing was present in 246 hours. Of these the plant was stopped due to icing and low winds during 165 hours. These losses are not due to icing but due to low winds. During 24 hours the plant was stopped due to icing only. This loss is equivalent to approx. 1 % of the yearly production. During another 57 hours the measured power was approx. 30% lower than the nominal. This equals 1% production loss. During approx. 50 hours, the measured power was up to 5 times higher than the nominal. A close analysis of the wind measurement shows that this is probably due to anemometer failure, due to icing. In reality there are losses, probably of the same scale i.e. 30% of the power giving another 1% production loss. Medium and light icing was percent in 132 hours, giving a production loss of less that 1%. Medium and light icing during November, December, second half of March and April adds another 1% loss. In this case, production losses due to icing are 4-5%. If this is enough to justify the installation of de-icing equipment is due to many factors. During times without icing the measured power was approx. 96% of the nominal. This is good for a 10-year-old plant. In more than 530 hours, without icing, the measured power was higher than the nominal. It is not uncommon with reduced power for other reasons than icing. In more than 340 hours, without icing, the measured power was less than 80% of the nominal. Depending on criteria, humidity and air temperature indicates risk for ice during 300 – 500 hours, without ice present.

Conclusion

If the case above is applicable to today's power plants, who normally is in the 2 – 2.5 MW bracket, the production loss due to icing has a value of more than 22000 € / year, at today's prices. If de-icing equipment is installed it is important to include an efficient control system to avoid excess use and ensure that de-icing is applied only when necessary. Unnecessary use of the de-icing system causes energy losses and may reduce the service life of the rotors.

Abstract for WinterWind 2012

Topic: 5: Standards, certifications and recommended practices or 10: Other cold climate issues

Title: IcedBlades - Modelling of ice accretion on rotor blades in a dynamic overall wind turbine tool

Authors: V. Lehtomäki[1], S. Hetmanczyk[2], M. Durstewitz[2], A. Baier[2], K. Freudenreich[3], K. Argyriadis[3]

Abstract:

Wind power is one of the fastest growing areas of power production globally, contributing to the mitigation of climate change and to the diversification of energy supply. Northern areas like Scandinavia as well as areas with high altitude feature a high potential for large capacity wind farms thanks to favourable wind conditions and mostly low populated areas. Cold climate together with humid air conditions during winter seasons, leading to ice accretion on the rotor blades, must be considered in loads analysis. Altered aerodynamics due to icing induces structural vibrations and cause large uncertainties for wind turbine design. Inhomogeneous ice aggregation on blades of an operating turbine can lead to high periodic loads.

This poster presents the scope of the ´IcedBlades´ project focussing on the development of a new simulation tool for assessing wind turbine dynamic behaviour in cold climates. During the project, new and updated simulation tools for ice accretion on rotor blades and coupling of this tool to an aero-servo-elastic simulation tool will be developed. Collaboration between VTT and Fraunhofer IWES enables for a rapid transfer of the project work into certification purposes with a WinWinD turbine as a case example. As a result, with this coupled simulation tool a new technical note on icing will be formulated in collaboration with GL Renewables Certification to facilitate the design process of wind turbines for cold climate areas.

The project objectives can be summarized in three main points:

1.) Predicting the power losses resulting from ice accretion on rotor blades.
2.) Gain a better understanding of dynamic loading effects resulting from ice accretion on rotor blades via a validated simulation platform.
3.) Developing a new technical note for icing sites to help wind turbine designers to take into account icing effects of rotor blades more accurately than current guidelines.

Finally, the project results will allow for more reliable, efficient and save operation of wind turbines in cold and icing climate.

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Ice Detection

The Need for Ice Detection Standards

By Jarkko Latonen, Chief Technical Officer, Labkotec Oy, Finland

Icing of wind turbines is a common issue at higher latitudes and at elevated sites, with ice building up on rotor blades, weather sensors and power lines, for example. As well as its effect on energy production efficiency, ice build-up on rotor blades can cause damage to buildings and people near the wind turbines as it is thrown off. Efficient ice detection brings safety to arctic wind turbines. However, until now there have been no set standards or certification tests to assess performance and set best practice for ice detection.

Consequently, Labkotec Oy decided to put its latest generation of ice detector, the LID-3300IP, through a rigorous independent testing regime to ensure that it would meet the standards demanded by modern wind energy operators. In order to get neutral, professional results, Labkotec Oy decided to work with the VTT Technical Research Centre of Finland, which is the largest multi-technological applied research organisation in northern Europe. VTT is a part of the Finnish innovation system under the domain of the Ministry of Employment and the Economy and is a non-profit-making research organisation.

Development of Evaluation Methods

VTT has created in-house methods to evaluate instrumental icing. The method for assessing icing detectors for wind turbines is based on detection time in standard icing conditions. With Labkotec Oy, the Centre has engaged on a pre-certification process which could be the precursor to the development of formal certification rules, standards and best practices for icing or ice detection tests.

Icing Measurement Test Methods

Icing measurement tests were conducted in VTT's icing wind tunnel, which is capable of reproducing standard icing conditions. In the tests, a clean ice detector with factory settings was exposed to the standard icing conditions and the time between the start of icing conditions and the ice alarm of the ice detector was recorded. The icing measurement tests were repeated for five different ice detector units in order to verify manufacturing quality and to get statistical data from the measurements.

Ice accretion calculations on wind turbine blades were conducted with TURBICE software in order to estimate the correspondence between ice detector response time and ice build-up on a wind turbine blade. TURBICE is a comprehensive numerical panel method based on 2D ice accretion software.

Testing Regime

The icing rate is strongly affected by numerous parameters such as wind speed, dimensions of structure, temperature, water content and droplet size. The simulation tests were based on a 44-metre wind turbine rotor blade, and the standard ice alarm response time of the ice detector corresponds to an ice accretion on the leading edge of the blade which increases the chord length by 1.3 centimetres at 85% of the maximum blade radius.

As all the possible weather condition combinations in nature cannot be covered in the test, VTT has defined a set of standard icing conditions which are felt to be most relevant to those experienced during wind turbine operation. Standard icing conditions are defined as temperature -5°C, droplet size 17 micrometres and wind speed 10 metres per second. The droplet size has been defined based on RMC (rotating multi cylinder) measurements. The standard icing conditions are representative for in-cloud icing and the resulting ice type is rime ice.

Results of Icing Measurement Tests

Based on ice accretion calculations, it can be estimated that about 18 kilograms of ice builds up on the blade during the ice alarm response time. Ice was distributed on the 44-metre blade so that ice build-up started at R=10 metres and increased according to the power law curve to 1.3 centimetres at 85% of the maximum blade radius. The average ice thickness was 1 centimetre. The ice was formed only on the leading edge.

Conclusions of the Testing

Thanks to the pre-certification work carried out by VTT in collaboration with Labkotec Oy, there are now an established set of tests and measurements that can be used to define ice detection performance. Thus, a certification procedure can be established in collaboration in the industry.

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Topic & Title: **"Study of Wind Turbine Foundations in Cold Climates"**

Information: Study conducted by Nordisk Vindkraft in co-operation with the Swedish Energy Agency (Energimyndigheten) Case study
A pilot grant report on Havsnäs wind farm, Strömsund, Jämtland.

Contact information: Anders Bernholdsson, Project Engineer, BAS-P
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ABSTRACT

Wind turbines in cold climate are exposed to conditions beyond the usual. One cold climate phenomenon associated with wind turbines is the freezing of the ground adjacent to the foundation, subjecting the foundation of frost heave, thaw settlement and thaw weakening of the soil.

The outline of this study is to briefly explain the problems regarding foundation design in cold climates and to document suitable approaches to the design and construction of wind turbines in cold climates.

The definition of cold regions may be defined in terms of air temperature, snow depth and ice cover on lakes or depth of ground freezing. The problems regarding design of wind turbine foundations in cold climates do not occur in all regions with cold climate, due to the depths of the foundations. If only accounting for Sweden when defining cold climates regarding foundation design, it approximately starts north of 60 ° latitude.

RES GROUP COMPANY

Abstract - Wintervind

Topic: 7. Non-technical considerations

Author: Mariann Mannberg

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Affiliations: Researcher**,** Tomas Riklund AB**,** Acusticum 4, 941 28, Piteå and The Department of Civil, Environmental and Natural resources engineering, Luleå University of Technology

Social Micro-Siting –Increasing Acceptance through Local Adaption

The establishment of land-based wind-farms often requires large land areas affecting a number of contradictory interests including the individual interests of citizens. In Sweden consultation is statutory, prescribed by Swedish Environmental Code including all individuals affected by the project. Projectors often invite to consultative process in a stage where the project has made some progress and where a site-plan is more or less established.

From the citizen perspective, wind farm projects affecting the local area might seem threatening. For instance, for people living in rural areas, the characteristics of the surrounding environment are closely connected to their way of life. Thereby, “threats” towards the local environment might pose a threat to their entire outlook on life. Often this leads to frustration and rage towards the projector.

This presentation introduces the basic features of a consultative process more thoroughly involving and adjusting to citizens and their local community and the distinguishing characteristics of their local physical and social environment, ***Social Micro-Siting***. Social Micro-Siting has the potential to create added value to the participating community and to the projector, increasing the general acceptance of wind-farm localization. As the process is based on ongoing dialogue with the local citizens, it might also provide solutions to complex local issues of a more practical character.

A new methodology to increase fatigue life and optimise design and maintenance operations for wind turbines in forest and cold climate environment

A research proposal

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The development of wind turbines in forest environment leads to larger and more flexible structures. Additionally, in cold climate, icing causes a variety of mechanical problems for wind turbines: downgrade turbine aerodynamics performance due to a change in blade geometry; decreased fatigue life due to unbalanced ice load; resonance due to the change of natural frequencies. Consequently, the fatigue and damage problems due to dynamic vibrations are increased for wind turbines in forest and cold climate environment. This has a direct influence on the cost of the maintenance and repair operations.

The purpose of the project is to develop a methodology to optimise the maintenance operations and increase the performance of wind turbines regarding fatigue life and dynamic stability. For that, a simplified but accurate numerical mechanical model of the whole wind turbine will be developed and in-situ measurements (monitoring operations) will be performed.

The motivations for such an approach are the following ones:

- By continuously measuring the dynamic vibrations and strains in the structure it will be possible to predict damage and to give a better estimation of the fatigue life of the different components. This leads to an optimisation of the maintenance and repair operations.

- The proposed numerical model of the whole wind turbine will be based on corotational beam elements. This gives the simplicity of a multi-body formulation and the accuracy of a full FEM model. In-situ measurements will be used to calibrate the numerical model. In particular, the influence of the ice on the dynamic properties of the whole wind turbine will be quantified.

- In situ measurements and numerical analyses will be used to optimise the design of wind turbines and to develop new control systems. The idea is to introduce the non-linear dynamics effects in the control systems so that not only the wind power capture is maximised, but also that the static and dynamic loads supported by the different components are reduced.

Nordic Mojo

Flexible and light platform for wind turbine wing service

Design parameter

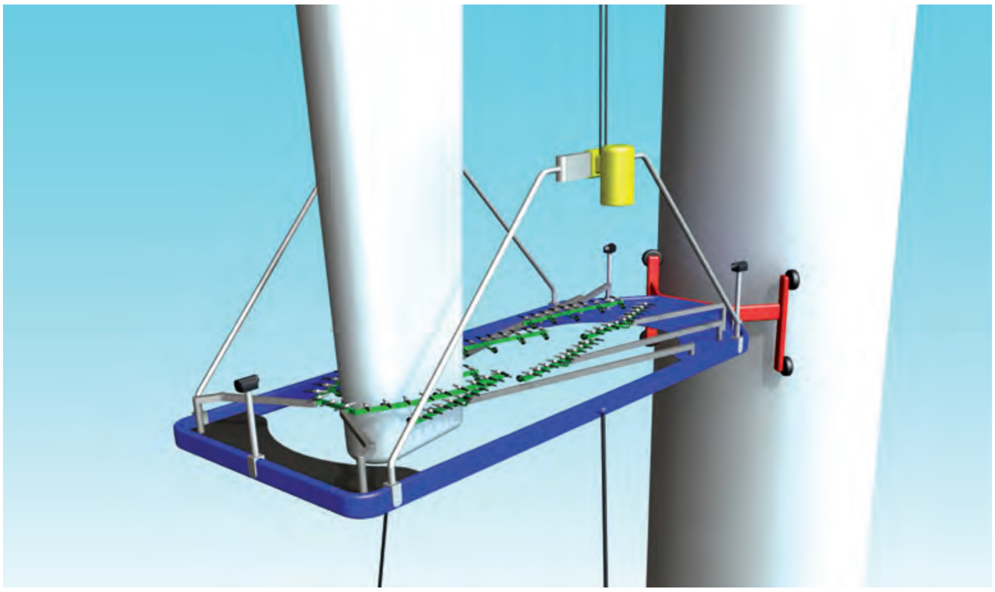
Our design is aimed at creating a price-effective and easily handled platform which can inspect and wash wind turbine wings, perform active deicing and assist passive deicing.

• The platform is based on modules. Each module is made to fit its specific function so that you only lift the hardware needed to do the particular job.

• The platform shall cover 5 different functions 1. Wash the wing 2. Inspect the wing 3. Apply an ice inhibiting coating 4. Active deice a wing 5.Apply an icephobic coating.

• The platform shall be as light as possible, max 150 kg, so that: 1. max 2 persons are needed to lift and assemble it. 2. it can be lifted using existing fittings in the nacelle. 3. it can be transported in a delivery van or trailer.

• The design shall find the best environmental solutions for the platforms construction and function.

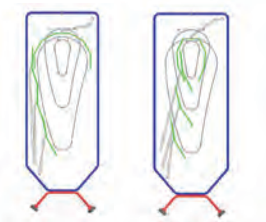


The platform reaches the wing tip and the hardware grasps the wing. The hardware performs the intended function. In this example it is washing the wing. Video cameras are mounted on the platform so the crew can follow the hardwares performens on screens in the van.

The idea

• The platform is dismantled under transport.
• At the site the platform is assembled and the platform foot is placed into the tower.
• The crew lower two very light polyester bands, down from each side of the nacelle.
• The bands are fastened to the winches which lift the platform. The winches are mounted on a yoke which lifts the platform. The yoke can be adjusted to balance the platform.
• Hardware for the specific function are mounted on the platform and cables and hoses are connected.
• The hardware are set in the open position and the platform is lifted up to the tip of the wing.
• The platform is guided into place and the hardware grasp the wing and perform the intended function.
• There are video-cameras on the platform so the crew can follow the work being done on their screens.
• After the intended function is completed the platform is lowered so that the hardware can be changed to another function or the next wing can be swung into place.
• When work is completed the crew disassemble the platform and pack it into the vehicle.

The hardware for active deicing runs on a rail mounted under the platform. It consists of two parts, the sensor which defines the wings position and the beam projector which deices the wing.



The arms of the hardware can always adjust to the wing shape.

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TOPIC #10 – CANADIAN R&D ACTIVITIES ON WIND ENERGY PRODUCTION IN COLD CLIMAT AND IN COMPLEX TERRAIN

Hussein Ibrahim[1], Christian Masson[2], Cédric Arbez[1], Mariya Dimitrova[1]

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ABSTRACT

Wind energy development in many countries is faced with cold climate conditions that require adapted technologies and techniques. Canada is a prime example for this kind of weather and many research activities focus on the specificties of wind energy in cold climates. The most important research initiative regarding the wind energy sector in the country is the Canadian Wind Energy Strategic Network (WESNet), a NSERC funded Strategic Research Network. It regroups highly productive researchers across Canada and is supported by the government, the industry, associations and institutions. The WESNet mandate is to address the growing need for qualified professionals, promote wind energy as an economically competitive and environmental supplement to energy portfolios, and develop innovative solutions to key issues faced by the industry, particularly cold climate issues. Currently, seven cold climate projects are under way within the network: 1) Wind turbine composite materials for the Canadian context, 2) Wind tunnel investigations of impact on turbine blade profiles, 3) Forecast of icing events, 4) Icing event monitoring, 5) atlas of icing events at a high resolution, 6) Ice accretion modeling on wind turbine blades, and 7) Design of ice-free anemometers. These projects are carried out by prominent researchers from many universities and involve three major groups (the Canadian research chair on the Nordic Envionment Aerodynamics of Wind Turbines (NEAT) at École de Technologie Supérieure (ÉTS), the Anti-icing Materials International Laboratory (AMIL) at Université du Québec à Chicoutimi, and the TechnoCentre éolien, a full-size installation in a Nordic region. The research team can found its work on essential resources such as wind turbines farms, meteorological towers, icing monitoring towers, refrigerated wind tunnels, simulation software, super-computers, and excellent laboratories.

In presentation (or poster), we will present the WESNet projects, partners and initiatives in greater detail and describes the research projects that focus specifically on cold climate challenges. It gives an in-depth description of the research axis within this field and outlines the key issues and main contributions and up-to-date results.

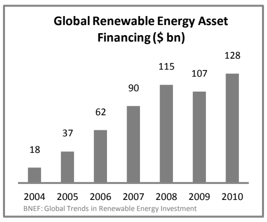
SUSI PARTNERS SUSTAINABLE INVESTMENTS

<u>Institutional Interest and Cold Climate Wind</u>

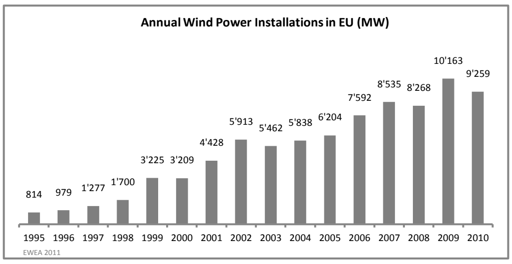
Otto von Troschke & Victor Weisberg

SUSI Partners AG ¦ Feldeggstrasse 12, CH-8008, Zürich ¦ +41 44 386 98 00

Strained by the volatility of equity markets and the uncertainty of bond securities, a growing number of institutional investors are looking to increase and diversify their fixed-income holdings to both real and responsible assets such as infrastructure. Infrastructure, with emphasis on energy, is continually attracting large institutionals due to the satisfying return profile of such assets. Well structured infrastructure investments can serve to improve the risk-return profile of an investor's overall portfolio on account of their low level of correlation with traditional asset classes and stable long term return profile. This, in addition to mounting concerns of global climate change, allows institutionals to consider renewable energy infrastructure investments as assured assets that can withstand macro-economic hiccups.



Historic growth in renewable energy continues to show increasing investment appetite and the financial capacity is clearly escalating for such assets. With limited and drawn-out siting potential across several Continental European economies, Western European investors are now faced with two choices: move offshore or into frigid environments. Physical and chemical weathering poses significant challenges to all of humanity's built infrastructures. Cold climates in particular are demanding environments, and present an increase need for environmental engineering and design to combat the physical elements against degradation. Though offshore power production can offer more favorable feed-in tariffs and higher wind potential, the associated risks and downtime with saline environments curb investment enthusiasm; additionally the time horizon for such projects is vast. Since 2001, Finland's VTT Technical Research Centre has producing leading research on wind energy in cold climate. The intergovernmental program published two papers (151 & 152) analyzing the added dynamics of wind power in these freezing environments. While cold climates offer potential costs for wind investors, the rewards are obvious. Firstly, denser air increases efficiency capacity well above 25% - significantly improving power output per meter/second wind speed. Moreover, since cold climates have had partial development interest, the siting prospects for wind-parks are vast and attractive returns are attainable with limited investor competition.



Finland, with their recently institutionalized feed-in tariff policy, promises to become Europe's fastest growing wind energy market. The government target of 6 TWh allows for the equivalent installation of about 2'500 MW (16x current capacity). With over 6'000 MW in development (according to the Finnish Wind Power Association), Finland is expected to fulfill their current mandate before the end of 2015. The attractive jump-start bonus (21.8 EUR / MWh above the base tariff of 83.5 EUR / MWh), which allows for three years of enhanced results, is the major driver for this forecast. Continued government support (e.g. clarity on the development procedure, limits for environmental assessments, grid connection confidence) can further aid in achieving Finland's (and Europe's) renewable energy targets. This certainty will remove development risk, aid in the continued advancement of cold climate wind turbine generators, and allow for greater allocation by institutional investors.

Comparables

Country	*Installed Wind Capacity 2009 (in MW)*	*Population 2011*	*GDP 2010*	*Currency 2011*	*Electricity Production 2009 (in kWh)*	*Electricity Consumption 2009 (in kWh)*
Finland	146	5.2 m	$ 239.2 b	Euro	67.9 b	83.09 b
Norway	431	4.7 m	$ 255.3 b	Norwegian krone	129.9 b	115.6 b
Sweden	1'560	9.1 m	$ 354.7 b	Swedish krona	129.4 b	132.1 b
Denmark	3'465	5.5 m	$ 201.7 b	Danish krone	34.1 b	33.4 b
Estonia	142	1.2 m	$ 24.70 b	Estonian kroon	8.8 b	7.1 b
Germany	25'777	81.4 m	$ 2.940 t	Euro	556.4 b	544.5 b

Project investors would also like to see greater competition amongst developers and more conservative wind analysis. We are well aware of the market cost of installations and have been disappointed with poor wind report investment bases. A more appreciated business model is via a performance sharing contract, allowing the developer to receive benefit over the lifetime of the project rather than a flat upfront payment. This can allow investors to approach developments at the Greenfield stage, giving more assuredness in project realization and higher upside potential to the developer over the 15+ year life of the wind park. Bridge financing options are also welcomed by project investors to delay the full investment and to shorten the "dead" equity phase. Increasingly, turbine manufacturers can provide this service and aid in the optimization of wind parks.

SUSI Partners AG is a Swiss based fund management company with an institutional investment consulting arm in renewable energy. The company acts as a Fund Advisor to a Luxembourg renewable energy fund.

SIEMENS

Abstract - Winter Wind 2012

Blade De-icing a historic perspective in Siemens

Author: Finn Daugaard Madsen

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7330 Brande
Danmark

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Goal: To illustrate the development of blade deicing 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 wing heating systems, which were put up in different locations on the northern hemisphere in the 90's, where the turbines and wing heating-systems still are functional today.

The wing heating system has since then been developed even further to deliver a complete "cold-climate-system" for our turbines. The designers at Siemens Wind Power De-icing systems will continue their development and optimization to ensure that wind turbines installed in cold climate regions all over the world can produce electricity even under extreme weather conditions.

MESSAGE

Date: 10 November 2011

To: Swedish Wind Power Association

From: Vestas Wind Systems A/S, Technology R&D MOSL

No.: 1

Re.: Abstract to Winterwind 2012

CC: V-NEU and GMCI

Dear Programme Committee

Please receive this abstract for presenting the Vestas de-icing activities at the Winterwind 2012. We would like to be a part of topic 3. De-icing and anti-icing technologies.

Title; Vestas de-icing development
Authors´s names: Søren Plagborg and Morten Sloth
Affiliations: Member of the SWPA

We would like to conduct an oral presentation of the testing we have done during the last two years and present the results achieved. Additional we present the development and test plans going forward.

The presentation includes pro and cons of the different technology tracks seen from the Vestas point of view including a risks evaluation.

The future for de-icing solutions at Vestas includes the development and test activities we are conducting to ensure business case certainty to our customers and the roll out plan for the turbine fleet.

Kind regards

Morten Sloth
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M +45 4040 2881
mosl@vestas.com
http://www.vestas.com

Operational experience under icing conditions of REpower MM-Cold-Climate-Version turbines under the influence of different icing solutions

At the Winterwind conference 2008 operational experience with the Cold Climate Version (CCV) of a REpower MM82 operating in the Inner Mongolia, China has been presented. On this site the turbine is exposed to extremely cold but dry climate. Since then REpower has entered the Scandinavian and the Canadian market in which cold and humid climates dominate. Such a climate favours ice accretion on rotor blades and therefore demands particular requirements in terms of turbine operation.

To gain experience on turbine operation under icing conditions REpower has installed two REpower MM92 CCV turbines beginning of 2010 in Rivière-au-Renard, located in Québec, Canada, close to the sea. Due to the humid climate over winter the turbines are exposed to different types of icing.
The turbines are owned and operated by a research institute for wind technology (TechnoCentre éolien), which in cooperation with REpower investigates in research and testing of different icing-solutions (ice detection, de-icing-systems and anti-icing systems).
The cold and humid climate in the Gaspé region is comparable to cold climate sites in Scandinavia.

For winter 2011/2012 REpower uses two more icing test sites to build up more operational experience and to enhance the testing of icing solutions.
The first test site is as well in the region of Québec, Canada, consisting of MM82 CCV and MM92 CCV turbines and being part of a frame contract of more than 477 turbines for Quebec. Dedicated turbines are equipped with icing solutions (different anti-icing and de-icing technologies) and comprehensive measurement equipment to allow for detailed measuring data analysis.
Furthermore REpower is operating an European icing test sites (Erzgebirge - Czech Republic). The site is also exposed to severe icing conditions and is used for research and development activities on rotor-blade based-ice-detection sensors, anti-icing-systems and operating control solutions.
In 2012 REpower will erect a wind farm in Alaska. These turbines will be exposed to extreme cold climate conditions.

The presentation will give an overview of the operational experience with REpower turbines on sites with severe icing conditions taking into account the gained knowledge of the different icing solutions (Ice-detection, Anti-Icing, De-icing) and operation control strategies to deal with ice on rotor blades.
The present operational experience shows that thanks to REpower' s robust aerodynamic design the power performance of REpower turbines is not as much as influenced by icing as expected. Therefore for specific site conditions a dedicated combination of anti-icing systems and intelligent operating control may turn out to be a sound alternative to active de-icing system.

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Topic: De-icing and anti-icing technologies

Title: Operating experience with an anti-icing system

by Ingo Hirschhausen, Martin Löfstrand, Dr. Astrid Löwe, Dr. Ines Runge
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+46 - 18 - 185 900

In the last decade the global importance of wind energy as a renewable energy source has increased dramatically. By the strong increase of the number of turbines, the most popular locations are already built up. Out of necessity to open up new sites, more and more turbines are set up onshore, also in extreme climatic regions.

If wind turbines operate in extreme climatic regions special conditions of the turbine must be expected. For example in cold climatic regions the icing of the blades changes the aerodynamic profile of the blade and reduces the efficiency of the turbine. Furthermore, by the additional weight of the ice the plant safety is limited. Therefore in areas with icing conditions it's important to protect the turbine from this overload.

In autumn 2010 NORDEX SE installed four N100/2500 turbines in northern Sweden. With a rotor sweep of 7,854 square meters, these turbines operate particularly profitably in medium and low wind regimes. In the wind park "Jokkmokksliden" three prototypes with anti-icing systems and one reference machine were tested. The goal for the first winter was to check the performance of the different anti-icing-systems in comparison to the reference turbine. One anti-icing system was selected to be installed on additional 6 turbines in the wind park Jokkmokksliden and 8 turbines in the wind park Storliden, built up in 2011.

The presentation shows the experiences with the selected anti-icing system. Therefore an overview about the conditions in the Wind Park and examples of the icing of the blades is presented. Particular attention is paid to the efficiency of the systems.

ENERCON
ENERGY FOR THE WORLD

Abstract
Winter Wind 2012

Further development of ENERCON's de-icing system.

Topic #:	3
Author:	Christoffer Jonsson
Affiliation:	ENERCON Gmbh
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During the last decade ENERCON has developed a de-icing system that has been proven to work in harsh icing climates with good results. The de-icing system has been installed all over the world and experience has been collected from numerous sites. ENERCON is one of the leading manufacturers in the de-icing and anti-icing area.

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.

Abstract for Winterwind 2012

WinWinD continues to lead the development of wind turbines for cold climate after the success of the Ice Prevention system that WinWinD developed for Skellefteå Kraft`s Uljabouda project, a system that now has worked very well for 2 hard winters.

WinWinD will use all the experience gathered in order to further develop solutions needed for successful wind farm investments in cold and icy climate.

WinWinD is a Finnish turbine manufacturer. The home market for our turbines is normally north of the 58 dgr latitude, which makes it especially important for us to have high quality solutions for cold climate operation.

In 2013 we will therefore introduce our new WinWinD 3 “arctic version” including Ice Prevention for the 120 m rotor. This will be the largest turbine with Ice Prevention in the market and exceptionally well suited for Northern Swedish and Northern Finnish wind locations.

This abstract is for Topic 2 of Winterwind 2012: Mapping and forecasts of icing

Simulation of icing events over Gaspé region

Jing Yang[1] [1], Wei Yu[2], Robert Morris[1] , Julien Choisnard[3], Alain Forcione[3], Slavica Antic[3]

[1] *Adaptation and Impacts Research Section, Climate Research Division, Environment Canada*

[2] *Environmental Numerical Prediction Research Section, Meteorological Research Division, Environment Canada*

[3] *Hydro Québec, Montreal, Canada*

In coastal areas and high topography regions, icing is an important issue from the wind energy perspective. It occurs on transmission lines and the blades of wind turbines, which are usually installed in these high wind resource regions. The icing of rotor blades and wind gauges results in wind turbine performance degradation and/or safety shutdowns. Observations from the historical icing events (2008~2010) over Gaspé region indicated that accreted ice resulted in much less generated power than the theoretical value. Two icing events which occurred over Gaspé region in February and April 2009 were simulated with the regional GEM-LAM mesoscale model of the Canadian Meteorological Center (CMC). The simulation is designed using a double-nested grid, with horizontal grid spacings of 3-km and 1-km, respectively, and 56 vertical levels. This allowed us to get high resolution results in time and space. CMC operational forecast data are used as the initial conditions and the lateral boundary conditions for the domain of the 3-km coarse-resolution run. The 1-km simulation was initialized three hours after the 3-km run to allow for model spin-up, with the boundary conditions supplied by interpolating from the 3-km run outputs. Multi-moment microphysics scheme is used in GEM-LAM. This explicit precipitation scheme predicts the mixing ratio, number concentration of individual hydrometeors (such as cloud droplets, rain droplets, ice, snow, graupel, and hail) and gives the detailed temporal evolution of the particle size distribution and cloud liquid water content. The simulated near surface wind and temperature from GEM-LAM compared well with in-situ observations from three wind farms of Gaspé region. The start and duration of icing events can be determined with the simulated near surface wind, temperature and cloud liquid water content determine. These meteorological fields, together with median volume diameter of the cloud droplets, are used as inputs to a cylindrical sleeve icing model to obtain the icing rates and amounts. To see the icing effects on power loss, the simulated accreted ice amounts will be compared with the power loss, and the comparison results will be presented at the conference.

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Mapping of icing in Sweden – On the influence from icing on wind energy production

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Topic no 2 – Mapping and forecasts of icing

Abstract

Analysis of meteorological observation data of ice loads from 8 sites in Sweden has lead to a development of the model used to calculate icing from model simulations. Data from the meso scale model WRF is used to calculate ice loads. It is shown that the model results validates well with the observation with regards to timing of icing events and sublimation/melting events. However, the model tends to underestimate the observed ice load.

Sublimation of ice under conditions with cold and dry air have proved to be an important effect that causes ice removal at Swedish cold climate sites. Sublimation has been included in the calculations of ice loads on the standard body. The effect of sublimation is assumed to be even more important for removal of ice from wind turbine blades.

Some of the Swedish wind farms have experienced large production losses due to icing. Some wind farms experienced monthly production loss of more than 50% for consecutive months during the winter 2009/2010. During the winter 2010/2011 the icing climate has been less challenging, and the production losses due to icing have been lower. For the winter 2009-2010 the model seems to capture production loss periods (both timing and magnitude) quite well. For the last winter, with less pronounces icing events, we find a larger scatter between modeled production loss and the observations. The modeled ice load and estimated production losses show a large variability on a year-to-year basis. For some sites it is shown that the interannual variability in icing will dominate over the variability in wind speed with regards to annual energy production.

Suggestions will be made on how to improve the models further.

Based on the new model development, Kjeller Vindteknikk has developed an icing map for Sweden. This map shows the frequency of icing events, and shows the number of icing events at fro different categories of icing intensity.

EXAMINATION OF REAL-TIME LAPS-LOWICE RUNS OVER SCANDINAVIA FROM THE 2011-2012 ICING SEASON

Ben C. Bernstein[1], Jarkko Hirvonen[2], Erik Gregow[2], and Ian Wittmeyer[1]
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[2]Finnish Meteorological Institute, Kuopio and Helsinki, Finland

Abstract:

Using the Finnish Meteorological Institute's (FMI's) version of the Local Analysis and Prediction System (LAPS) model as input, the LOWICE system provides real-time, high-resolution, diagnostic icing and meteorological grids across Scandinavia. Fields include the expected temperature (T), wind speed (v), supercooled liquid water content (SLWC), icing rate, icing load on a reference cylinder and an estimation of wind energy power loss due to the presence of ice.

At numerous sites across the domain, these LAPS-LOWICE fields are generated at the height of wind turbine hubs and/or instrumentation suites, allowing the opportunity for direct comparison. These include numerous instrumented towers at wind farm sites owned by O2 Windkompaniet across Sweden and at FMI's Puijo tower, located in Kuopio, Finland. All of these sites are situated in interesting, if not challenging icing environments. Their instrumentation suites include measurements of temperature, wind speed, present weather, visibility and icing, as well as web camera images that can be very useful for the documentation of icing events.

New aspects of the real-time LAPS-LOWICE will be presented and maps and time-series plots of it's output will be compared to observations made at the O2 sites and/or the Puijo tower for a variety of icing and non-icing events from the current (2011-2012) icing season.

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Abstract for Winterwind 2012

Topic no 2: Mapping and forecasts of icing

Windpower in cold climates – Vindforsk project V-313.

Authors: Hans Bergström and Petra Thorsson; Uppsala University
Stefan Söderberg; Weathertech Scandinavia
Esbjörn Olsson, Per Undén; SMHI

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Wind turbines in cold climate regions are likely to be affected by atmospheric icing. This may affect production and loads, and may due to ice throw also be a risk to people being in the neighbourhood of the turbines.

The goal of Vindforsk project V-313 is to get knowledge necessary to make detailed and site specific estimates of icing, and how the icing affects wind power production. The project has been on-going for 2 years now, and a number of weather forecasting models have been run for the winter seasons 2009-2010 and 2010-2011.

Results comparing the different model outputs and measured icing data will be presented. It is shown that the model outputs in principle follow the timing of icing events quite well, while results about ice amount may differ significantly both comparing model results and comparing with observations.

It is important to have reliable data when comparing model output to measurements. This has been shown not always to be true. Sometimes it has even been doubtful whether the measurements are to be judged as more correct than the model results. Some results will be presented illustrating the difficulties in interpreting measured icing data.

On-going work regarding methods to develop an icing climatology without the need to model 30 years of weather will be presented. Results from work along two paths will be presented. Either high resolution modelling will be done using a choice of 'typical months' to represent the long-time climate, making it unnecessary to model 30 years. The choice could then be based upon classifications of the large scale flow (pressure) regimes. Or the icing climate could be made for 30 years using a coarse model resolution, and the results then downscaled to a high resolution using high resolution model results only for shorter periods.

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Abstract.
Winterwind 2012
Skellefteå, Sweden

Titel: Storskalig vindkraft i kallt klimat????

Mellan 2011 och 2015 bygger Skellefteå Kraft och Fortum under det gemensamma bolagsnamnet BlaikenVind AB en av Europas största vindkraftparker i Blaikenområdet i norra Sverige. Fullt utbyggd kommer vindkraftparken att bestå av upp till 100 vindkraftverk.

Projektet ger stor erfarenhet om utmaningarna med att etablera storskalig vindkraft i kallt klimat.

Den frostbenägna marken ställer vissa krav t.ex. vid kabelförläggning och där möjligheterna har funnits har man valt att använda dränerade bergförankrade fundament.

För en vindkraftpark belägen i kallt klimat måste man även hantera riskerna med servicearbeten vintertid. En vindkraftpark i fjällmiljö ställer speciella krav på logistik, transporter samt behov av vinterväghållning, t.ex. snöröjning med hjälp av snöslunga. I och med den speciella miljön har man även tittat över behovet av att använda bandvagnar för underhållsinsatser vintertid.

Title: Large scale wind power in cold climate

Between 2011 and 2015, Skellefteå Kraft and Fortum will under the joint company name of BlaikenVind AB, build one of Europe’s largest wind farms in the area of Blaiken in the northern Sweden. Fully developed the wind farm will consist of up to 100 wind turbines.

The project provides great experience on the challenges to establish large scale wind power in cold climate.

The frost-prone land imposes certain requirements for example during the cable routing and where it has been possible they have used drained rock anchored foundations.

For a wind farm in cold climate the risks during service work in wintertime also have to be under consideration. A wind farm in mountain landscape also places special demands on logistics, transports and the need for road maintenance during the winter, eg. snow removal using a snowblower. Due to the special environment the need of using tracked vehicle for maintenance effort during the winter has been taken into account.

Abstract to Winterwind 2012, Skellefteå, Sweden 2012-02-07 & 08

Design of base slab structures for fast construction on "Cold Sites"

Sten Forsström, sten.forsstrom@sweco.se
Senior Adviser at SWECO Infrastructure AB, Stockholm

Abstract:

The owner of any construction project aims at short construction times. This aim is especially applicable for power plants with high investment costs and cash flow benefits associated with the start of generating electricity

For isolated construction sites it is generally important to reduce the man-hours required. This assumption is particularly valid for the time critical man-hours on cold climate sites where weather conditions, in principle, may prevent work during more than half of the year. For a wind power plant, the final erection of tower, nacelle and blades must be carried out prior to the seasonal occurrence of snow, ice and low temperatures. On the other hand this work can be completed within a few days only. The site-specific work of the base slab can start at the end of springtime. The on site construction works must be finalized within just a few months.

The obvious answer to the cold climate site requirements is to prefabricate the foundation in an intelligent manner.
-For sites close to a concrete batch plant it might be preferable to procure the concrete mass from such a plant. The reinforcement might, also during cold periods, be made as large units assembled either in a workshop or on site. (The cheapest option would be chosen)
-For sites "far away" from concrete batch plants, the main part of the concrete structure should be prefabricated as elements with the weight and dimensions as limited by the road conditions. The splicing of the elements is made on site during "summer conditions". On sites with "severe weather conditions" conventional concrete pouring might be avoided and replaced with methods including cement grouting instead of concrete pouring.

Sustainable solutions for faster construction of the higher tower and foundation

Nilsson, M., Veljkovic, M., Luleå University of Technology
Forsström, S., SWECO

The Swedish electricity generation from wind power rose by 40 percent in 2010 compared to 2009 and now represents 2.4 percent of all electricity consumption in Sweden. A total of 304 new wind turbines were installed in 2010 with a combined power of 603 MW, which is the largest expansion to date These are the new figures from the Swedish Wind Energy Agency, according to www.energinyheter.se. The Agency has previously determined that Sweden will need between 3000 and 6000 wind turbines by 2020 in order to produce 30 TWh, this would equal to 20 percent of current electricity consumption which is Swedish Wind Energy's goal.

Many of these wind turbines will be installed in the northern part of Sweden where the turbines has be build higher than 100 m to gain the stabile and more constant winds. These requirements impose new demands on the turbines design as well on bearing structural components, towers and foundations. It is expected that the price of the tower and the foundation, including the transport and construction, for the new generation of tower may be between 35-45 % of the total investment costs.

The paper reviews possible solutions for towers and foundations that fulfilled above mentioned requirements, emphasizing solutions that may lead towards less expensive solutions. An economical and environmental assessment for the whole life cycle of the structure, the tower and the foundation, for wind turbines 100 m hub height is made focusing on the embodied equivalent CO_2 emissions and energy consumed in production and execution of the towers.

A comparison between the three most common tower types is done: tubular steel towers, concrete towers and hybrid steel-concrete tower with alternative solutions for foundations. The main innovations are in the execution of the towers and the foundations. The experience gained on the most recent research and development projects creates basis for quantification of various solutions presented. A special attempt will be made to evaluate benefits and drawbacks of building in the cold climate. The following alternatives will be compared:

- prefabricated vs. in situ cast foundations, and
- concrete, hybrid vs. steel towers.

WORKSHOP - Where do we go from here?

8 February, 08.30–10.00

In this workshop Researchers and the industry will meet to discuss cold climate issues and recommendations for future research.

A large part of the Swedish research related to wind power in cold climate and icing of wind turbines is carried out with the research program Vindforsk. The current phase of the programme ends at the end of 2012. In planning a new phase of Vindforsk and other research activities it is important to have a clear picture of what is carried out in the international arena and to have ideas on specific needs for future R&D efforts.

A study on the research status and research needs is currently being carried out by René Cattin from Meteotest in Switzerland as part of the preparation of a new phase of Vindforsk. The study covers the current research and development status and future research needs. This study will be presented as part of the workshop.

The first half hour of the workshop will be used for presentations of.

- Results from IEA task 19 Expert group study on recommended practices for wind energy projects in cold climates" by Tomas Wallenius, VTT.
- Icing of wind power: A survey of research efforts and needs by Rene Cattin from Meteotest.
- Plans for a test center for wind power in cold climate, Matthias Rapp, Swedish wind power technology center.

After these presentations there will be discussion about research- and development needs. The discussion will be guided by moderator journalist Jonas Hållen and include an expert panel and the audience at the workshop.

The panel consists of:

René Cattin Meteotest
Lars Tallhaug, Kjeller Vindteknik
Jos Buerskens, SET Analysis
Dag Haaheim, Vattenfall
Søren Plagborg, Vestas
Martin Lindholm, E.ON

Be prepared for the workshop by reading a draft of the survey report: Icing of wind power: A survey of research efforts and needs. Download the report Icing of wind power here.

Enter the discussion

What's the most important issues in wind power in cold climate? What kind of research do we need? Enter the discussion in Winterwind's LinkedIn group (only for conference guests) or on Twitter #ww2012.

Send questions or remarks that you think should be covered during the discussion at the workshop by en email to the program leader of Vindforsk, Anders Björck

Winterwind Abstract
Topic number: 2, 3, 5 and 8
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The Effects of Cold Weather on Wind Data Quality

An empirical study on how data produced from met mast and SODAR is affected by cold weather.

Wind measurements are performed in order to decrease risk and to estimate production levels in wind power projects. Wind measurement equipment is affected by cold weather which can result in long periods of unreliable data that increase uncertainty in production estimations.

Through the development of the wind data management tool Breeze and through analysis of thousands and thousands of files with actual wind measurement data from all over Sweden, Greenbyte has obtained unique insights into how data quality from wind measurements is affected by cold climate. Greenbyte is currently compiling statistical information from the data analysis into a presentation that we would like to share with you during the Winterwind 2012 conference.

The analysis contains data from around 100 wind measurements conducted in Sweden. Data is broken down into

- Data from northern Sweden (above 62 degrees north)
- Data from southern Sweden (below 62 degrees north)
- Data that originates from SODAR measurements
- Data that originates from met mast measurements

The results of the data analysis will be presented in graph and table form. This includes

- Aggregated data quality during a normalized year for all data in the study
- Data quality for all met mast in the study during a normalized year
- Data quality for SODAR in the study during a normalized year
- Breakdown of geography

While analyzing the data, Greenbyte formulated several questions of special interest that will be addressed during the presentation. These questions include

- Is SODAR data quality affected more or less by cold weather than met mast data quality at comparable heights?
- Are some ranges of temperature more or less problematic than other ranges?
- How well does a heated anemometer perform compared to a non-headed anemometer in a cold climate?
- Which precautions can be taken to minimize negative cold climate implications on data quality?
- How should measurement data that has been negatively affected by cold climate be handled?

Winterwind 2012
Topic 10. Other cold climate issues

Windcube Measurement Data Correction by CFD Method for Fjeld Region

T. Jokela[1], P. Antikainen[1], A. Vignaroli[2], F. Öhrvall[3], T. Mannelqvist[3] & D. Eriksson[3]
[1]VTT Technical Research Centre Of Finland, [2]WindSim AS & [3]Skellefteå Kraft AB

Abstract

VTT and Skellefteå Kraft AB organized a measurement campaign in the time period of 24.2.-11.5.2011 at a site in Northern Sweden. This site is located on top of a hill, roughly 500 meters above sea level and it is covered with conifer trees. Also the ground relief at the hilltop is quite unconstant. In the winter season the temperature can change from 0°C down to -30°C.

There were three main topics, 1) to investigate how precisely Windcube vs. Sodar and Windcube vs. meteomast data correlate to each other, 2) to analyse and correct the Windcube data which is biased in complex terrain with the WindSim CFD software with neutral atmospheric settings 3) to monitor the Windcube operating performance in arctic conditions.

In the first phase, from mid-February until mid-March, the Windcube was deployed next to the Sodar. During the second phase, from the end of March until mid of May, an obstacle free deployment place for the Windcube was found next to the Skellefteå Kraft AB´s meteomast.

With help of this site data, the aim is to be confident with Windcube and Sodar measurements and also investigate how complex terrain and wake effect have an influence on these measurements. In the near future this measurement and analysis method could help to give more precise wind data from higher levels, without erecting an expensive meteomast during the wind resource assessment period.

At the moment, Windcube data can be corrected using WindSim’s Remote Sensing Correction tool. There’s no commercial correction tool available for the Sodar device. Therefore, during the analysis process also the Sodar level of error that appears due to complex terrain effect is estimated. Correlation between meteomast and corrected Windcube data will be evaluated.

Both campaigns clearly show how vital it is to understand how arctic conditions and complex terrain effect have to be taken into account in Remote sensing measurements. Accurate wind resource measurement data enables a more precise estimation for turbines annual energy production.

Identification of ultrasonic anemometer’s invalid data transmission

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Ultrasonic(US) anemometer is an anemometer of high accuracy and responsiveness. However, in cold climates, it has been reported every now and then that it transmits invalid output. The term invalid output here means a velocity of wind that exceeds the mean value highly and may not be considered to appear during the certain period of measurement from the not only statistical but also meteorological point of view. Such transmission in cold climates can be attributed to ice and/or snow accretion on the transducers of the anemometer in light of meteorological conditions. Hence, the influences of icing and snowing on wind measurement by ultrasonic anemometer were examined by carrying out the icing wind tunnel test with the goals to ultimately seek the measures to modify the instrument or the method to omit the invalid from the series of collected data in a proper manner. Two US anemometers from Finnish manufacture Vaisala and one from Gill of UK were used. In the wind tunnel test section, a snowfall condition was created by the snowfall machine setup on the ceiling. Moreover, in order to clarify how ice accretion causes the irregularity in data output, the test with artificial ice deposits on the transducers was conducted.

Intelligent load control for heated wind measurement sensors

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1. Introduction

Many sites in the Austrian Alps offer excellent conditions for wind power production. However, the remoteness and the harsh climate pose special challenges already during the investigation of the wind power potential.

In order to decrease the uncertainties in wind measurement results and energy yield calculations, respectively, heated anemometers are used at many of those project sites. Due to the lack of possibilities for power connection, external power supply systems are installed.

However, the heating algorithms of those sensors follow very simplified approaches. E.g. for several sensor types the heating is turned on as soon as the temperature drops below 4°C and continues heating throughout the entire negative temperature range.

The high power demand of the heated sensors (several hundred Watt) in combination with long periods of sub-zero temperatures leads to large energy consumption, which poses serious challenges to the external power supply units.

2. Methodology

In order to be able to assess the existing control algorithms of the heated sensors, a testing rig was installed at an alpine site in the Austrian Alps at an evaluation of 2.600m a.s.l. The rig was equipped with four heated and one unheated anemometer together with a thermo- and hygrometer and a webcam for evaluation purposes.

After the 1 ½ years´ measurement campaign the required heating hours and the respective monthly energy demand have been calculated for four different scenarios:

- Actual meteorological icing periods based on evaluations from the webcam
- Estimated icing periods according to comparison of heated and unheated anemometers
- Estimated icing periods according to synoptic considerations
- Estimated icing periods according to standard algorithms of heated wind measurement sensors

3. Results

The evaluation showed that the standard temperature-controlled approach of the heated sensors has significant weaknesses for the site especially during the winter months.

However, during the summer months the energy demand based on the simplified temperature approach is just slightly above the demand calculated from more detailed considerations.

4. Outlook

The investigations regarding required energy demands for heated anemometers might not only stimulate new approaches regarding heating control of those sensors, but also lead towards a more comprehensive classification of sites under icing conditions.

SKELLEFTEÅ kraft

Abstract

Winterwind 2011

Title: Uljabuouda Pilot Project

The presentation is reporting experiences from the Uljabuouda Pilot Project, finally reported to the Swedish Energy Agency in October 2011.

During the period of 2007-2010 Skellefteå Kraft AB erected a wind farm comprising 10 3 MW wind turbines on the mountain Uljabuouda in the municipality of Arjeplog. The turbines are of the type WWD-3 with a hub height of 80 meters and a rotor diameter of 90 meters.

The Uljabuouda wind farm is one of the first erected above the treeline in the Swedish mountains. The wind turbines are adapted to cold climate equipped with an ice prevention system for the blades.

The process of obtaining the necessary permits for the erection of the wind farm was lengthy and lasted during the period of 2000 to 2008.

Also the procurement process took longer than expected. During the period of 2006-2008 when the procurement was performed it was difficult to find a supplier who could offer wind turbines equipped with a deicing system.

In December 2006 the Uljabuouda project was granted a subsidy from the Swedish Energy Agency, the maximum of 35 million Swedish crownes. The final investment costs of the project will be higher than previously estimated. The main reason for this was the prevailing market conditions during the procurement period.

The Uljabuouda wind farm is in full operation since the winter of 2010/2011 and so far our experiences are that the ice prevention system is working well even at harsh icing conditions.

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Topic: 3 or 4

Evaluation and experiences from the Vindpilot project at Dragaliden and Gabrielsberget

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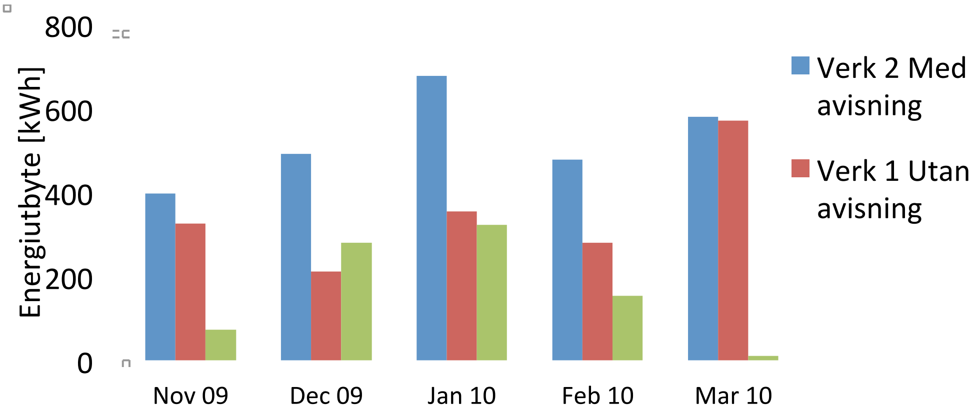
During the winter season 2009-2010 Svevind carried out a de-icing test together with the turbine manufacturer Enercon. At the site Svevind have 12 E-82s 2 MW. Enercons de-icing system is based on a hot air technique and the air flows through the wings. The system is “on” during running phase of the turbine which means that ice build-up is prevented. The intention with the test was to see just how efficient the hot air system is at the Dragaliden site.

The Dragaliden site is situated around 80 km west of Piteå and is a pilot project to the large Markbygden project.

Results of the tests shows that with de-icing system installed the profit (in energy) are up to 54 %.



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Abstract to Winterwind 2012, Skellefteå, Sweden 2012-02-07 & 08

O2's wind pilot project –
Large-scale, Cost-effective Wind Energy Development in Icing Climates

Göran Ronstren, goranronsten@windren.se
Project manager, O2 Vindkompaniet

Abstract:

O2's wind pilot project "Large-scale, Cost-effective Wind Energy Development in Icing Climates" includes

- Measuring icing at 11 different locations in 13 ice measurement stations
- Evaluation of production losses with respect to icing
- Improved modelling of icing
- Modelling of ice-induced production losses
- Evaluation of ice induced loads
- Testing, design and construction of a prefabricated gravity foundation

and last. but not least

- The installation, operation and evaluation of 40 de-icing systems

Results from the above activities will be presented.

**Figure 1: Ice build-up along the leading edge of the blade.
This turbine has since long stopped producing.**

Aalborg, 15 November 2011

Abstract Winterwind 2012

Topic: Electricity prices in Northern Sweden, a traders perspective

Title: Market conditions and experiences with the new swedish price areas, with a focus on SE1.

What can we learn about the future price formation from the first few months of spot prices and balancing costs?

Which spot prices can we expect in the future, what are the price effects from increased wind power in Norway and Sweden, increased cable capacity, the changing Finnish power balance in etc?

What are the prices in the forward market, is there a risk premium in the forward prices, how liquid is the forward market for SE1 and SE2?

What are the longer term perspectives in the forward market?

These questions will be answered through a 20 minutes presentation

Author(s): Jacob Vive Munk and Morten Madsen

Affiliation: Nordjysk Elhandel

The presentation will be held in English

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November 15, 2011.

De-icing and anti-icing technologies

Abstract.
Winterwind 2012.
Skellefteå, Sweden

Benefit and expected gains with use of de-icing technologies.

In recent years the interest of establishment of wind power in cold climate has increased, particularly when coming up at higher altitudes. This is because the wind conditions, generally increases by 0.1 m / s per 100 m of altitude for the first 1000 m. Available wind power is also approximately 10% higher due to increased air density at lower temperature resulting in an additional argument for establishment of wind power in cold climates.

The risk with establishment of wind power in cold climate during winter operation is reduced production or in the worst case downtime due to icing.

Last winter Skellefteå Kraft AB (SKAB) carried through an evaluation over de-icing system to be used for their ongoing establishment of wind power in cold climates in order to minimize production losses due to icing.

Currently SKAB runs a project Measurements Analysis Wind Power for Icy Climates (MAWIC) together with Fortum. The purpose with the project is to get a greater understanding of how ice accretion affects the operation and production. The outcomes of the project are expected to be increased knowledge and experience of maintenance on turbines equipped with de-icing system for improvement and optimizing of control algorithms with focus on best possible life cycle costs.

This presentation provides an overview of SKAB:s final choice of de-icing technology and a presentation over the ongoing MAWIC project between SKAB and Fortum. Interesting results and experiences from the project will be presented.

Abstract for Winterwind 2012

Topic: 5. standards, certification and recommended practices

Tittle: State-of-the-art of ice detection

Authors: P. Antikainen, T.Wallenius , J. Dillingh, E.Peltola, M.Tiihonen

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Abstract:

Ice detection is s a critical measurement in wind power for icing and cold climate. The purpose for using ice detectors needs to be defined for choosing the right type of ice detector. For wind power use, ice detectors are used for controlling the anti-icing system, for example blade heating, as well as to control the operation of turbine to prevent ice throw near populated environment.

This presentation will cover overview of commercially available detectors, some on the development stage and a proposal for classification of ice detectors for atmospheric icing.

China Low-temperature Wind Turbine Design and Application

(Abstract)

Chinese Wind Energy Association

China wind power installation hit 44,733 MW in 2010, of which more than 80% were MW class turbines. In China, rich wind resource areas were North China, Northeast China and Northwest China where have the lowest temperature of minus 40 ℃. Therefore, turbines installed in those regions are low temperature type and take the market share of 70% which makes low-temp wind turbine design reliability and application one of the most critical problem in China wind power sustainable development. This paper will introduce series of low-temp resist solutions and applications in China MW class wind turbine and hence to propose for new research programs.

Abstract for Winterwind 2012
Topic no 8: Operations and maintenance

Rotor Blade repairs in cold climate using advanced UV curing resin system

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Abstract

Composite repairs have traditionally been very costly and difficult, sometimes even impossible, in cold climate areas. We present experiences of working with an advanced UV curing composite repairs system that was specially developed for cold climate operations.

Traditional wet laminating systems used in composite repairs, generally require an ambient temperature of more than +15 Celsius to work properly. This requirement creates significant challenges in cold climate areas and usually leads to reduced repair window during the summer season. With UV curing systems blade repairs are possible in temperatures as low as +5 Celsius.

Additionally, repairs done with traditional wet laminating systems require a curing time of up to 24 hours. With UV curing systems a full cure is achieved in minutes, depending on the size of the repair. This leads to significant savings in lost production due to down time.

When combined with regular inspections and early detection of damages, UV curing systems are likely to reduce rotor blade induced problems and increase production through reduced down time.

Topic 6: Health and Safety

Ice throw reloaded – studies at Guetsch and St. Brais

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Icing is an important issue when operating wind turbines in high altitude or arctic areas as it can cause significant production losses and represent a safety risk.

In 2004, a 600 kW Enercon E-40 wind turbine with integrated blade heating was installed on Gütsch mountain, Switzerland, at 2'300 m asl. As the wind turbine is located close to ski slopes, ice throw was considered as an important safety issue. During four winters between 2005 and 2009, the area around the wind turbine was inspected after every icing event for ice fragments that had fallen off the blades. Distance from and direction relative to the turbine as well as size and weight of the recovered fragments were mapped and, together with photos, collected in a data base. In total, more than 220 ice fragments could be recorded and analysed

This study is still unique in the world and therefore referenced many times. However, the final and detailed results have not been presented so far at international conferences. This presentation aims to fill this gap during Winterwind 2012. Analysis of the distribution of the ice fragments around the wind turbine, typical and maximum size, weight and distance, type of ice as well as correlation between wind statistics and the location of the ice fragments as well as between weight and distance of the ice fragments will be presented and discussed. Finally, a resulting simple model to simulate ice throw around a given wind turbine will be introduced.

As the wind turbine at the Guetsch is rather small compared to nowadays standard wind turbines, the question was often raised, how these results can be transferred to larger wind turbines. In order to get more information on this, the same experiment will be repeated at the St. Brais site in the Jura Mountains during winter 2011/12. At St. Brais, there are two Enercon E-82 with 78 m hub height. Both wind turbines are also equipped with a hot air blade heating.

First results of this new study will also be presented at Winterwind 2012.

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Winterwind 2012

Date November 14, 2011

Bengt Göransson

ABSTRACT

Topic: Standards, certification/Health and safety

Title: How dangerous are wind turbines in cold climate regions? Can we do something about it?

Author: Bengt Göransson, Senior Engineer, Windpower

This presentation gives a report on the status of the ongoing work to update the health and safety standard EN50308 which deals with requirements for wind turbines with respect to the Machinery Directive. It gives e.g. requirements for eliminating the hazard of having lumps of ice thrown around the turbine.

The presentation tries to clarify the current view from different actors on the wind market regarding safety issues with focus on ice throw, i.e. government, county boards, courts, developers, etc.

A risk assessment for examples of wind turbines in cold climate in Sweden is presented and gives some examples of hit frequencies of ice lumps at different sojourns in a windfarm, with respect to travel, length of stay and time of the year.