BOOK OF ABSTRACTS

Winterwind

INTERNATIONAL WIND ENERGY CONFERENCE

2014

Cold climate wind energy solutions

THEORY AND PRACTICE UNDER ONE ROOF

Oral poster presentations in intermissions

Please note: The person presenting is not always the author of the poster.

FEB. 11

13.00–13.25

DE-ICING

– **De-icing of wind turbine blades by means of an helicopter opens up new opportunities**
Hans Gedda, H Gedda Consulting

– **Development of a LESZLPT based numerical method for ice accretion simulation** Robert Szasz, Lund University

– **GreenWind GLOBAL de-icing system** Gernot Schenk, GreenWIND Global

– **Wind turbine blade anti-icing by means of warm air film heating** Lorenzo Battisti, University of Trento

CONSTRUCTION

– **Efficacy of electric motors in cold regions** Umair Najeebmughal, Narvik University

15.05–15.25

DETECTION

– **Combitech – the partner for monitoring** Patrik Jonsson, Combitech

– **Monitoring icing events with remote cameras and image analysis** Dominic Bolduc, TechnoCentre éolien

STANDARDS

– **Extreme cold start-up validation of wind turbine components by the use of a large climatic test chamber**
Pieter Jan Jordaens, Sirris/ OWI-Lab

– **Serious consequences due to excessive ice accumulation on a typical wind turbine**
Abdel Salam Alsabagh, Narvik University

17.15–17.45

– **Structural performance of offshore wind turbine in ice-covered waters** Maria Tikanmäki, VTT

– **Cold climate rotor blade repairs using advanced UV curing resin system** Ville Karkkolainen, Bladefence

– **Commercialization of VTT's know-how in ice prevention of wind turbine blades** Esa Peltola, VTT

– **Developing ice detectors for wind turbines – outlook of requirements and improvements from 1990 till today**
Jarkko Latonen, Labkotec

MAPPING

– **Effect of climate conditions on wind farm performance in cold regions** Geanette Polanco, Narvik University

FEB. 12

10.35–10.55

PRODUCT EXPERIENCE, OPERATIONS AND MAINTENANCE

– **Implementing a 3D CFD model to study the performance of porous fences under harsh climatic conditions**
Yizhong Xu, Narvik University College

HEALTH AND SAFETY

– **A tool for the assessment of stochastic danger levels from ice ejected from wind turbine blades**
Björn Montgomerie, Programografik

– **Ice-infested waters: challenges and possibilities for wind power** Daniel Bergström, Swedish Wind Power Association

PRODUCTION LOSSES

– **A parametric analysis of ice protection systems** Matthew Wadham-Gagnon, TechnoCentre éolien

– **Simulation and validation of the aerodynamic performance of iced wind turbine airfoils**
Richard Hann, University of Stuttgart

13.30–13.55

– **Data driven production optimization from wind turbines** Jonas Corné, Greenbyte

– **Skills and training for the wind industry** Liselotte Aldén, Uppsala University

– **Turbine mounted Lidar for performance optimization: the case of cold climate and complex terrain**
Samuel Davoust, Avent Lidar Technology

– **Comparison of Lidar and mast measurements in complex terrain with/without FCR and CFD correction**
Martin Sigurd Grønsleth, Kjeller Vindteknikk

Winterwind
INTERNATIONAL WIND ENERGY CONFERENCE

FEBRUARY 11

PROGRAM

	A	B	C
10.00–12.00	**OPENING SESSION** Chairs: Johanna Olesen (Swedish Wind Power Association) and Göran Ronsten (WindREN) **Wind energy technology and politics** Andrew Garrad, DNV GL **Winter wind energy research at NCAR** Sue Haupt, NCAR **Industry cooperation necessary to release the opportunities in the north** Alberto Mendez, Vattenfall		
12.15–13.00	LUNCH		
13.00–13.25	EXHIBITION & POSTER SESSION		
13.30–15.00	**FORECASTING OF ICING** Chairs: Sue Haupt (NCAR) and Heiner Körnich (SMHI) – **Developing an icing production loss module for wind power forecasting systems** Timo Karlsson, VTT – **Experiences of modelling icing and uncertainty estimations** Esbjörn Olsson, SMHI – **Validation of icing and power forecasts generated for the O2 wind pilot program** Ben C. Bernstein, Leading Edge Atmospherics	**MARKET POTENTIAL** Chairs: Gail Hutton (RES Group) and Robin Murray (Vattenfall) – **Global cold climate wind energy market potential** Tomas Wallenius, VTT – **Effects and possibilities based on a low price scenario with high volatility** Sten Lillienau, Neas Energy – **Wind power icing atlas – tool for financial risk assessment** Ville Lehtomäki, VTT	**DE-ICING** Chairs: Rebecka Klintström (Vattenfall/ Meventus) and René Cattin (Meteotest) – **Assessing energy production gains in icing conditions when utilizing de-icing equipped wind turbines under different operational modes** Benjamin Martinez, Vattenfall – **Mobile Remote Energy (MORE) for heated wind measurement systems** Andreas Krenn, Energiewerkstatt – **Anti-icing and de-icing of wind turbine blades using microwave technology** Kenth Johansson, SP
15.05–15.25	EXHIBITION & POSTER SESSION		
15.30–17.00	**DETECTION** Chairs: Carla Ribeiro (DNV GL) and Tomas Wallenius (VTT) – **Evaluation of field tests of different ice measurement methods for wind power** Helena Wickman, Vattenfall – **Retrofittable, autonomous and wireless icing and temperature monitoring on rotor blades for efficient anti- and de-icing** Michael J. Moser, Science Park Graz – **Wind turbine icing weather and power forecast algorithm assessements in Scandinavia** Frank McDonough, Dendrite Weather Consultants	**STANDARDS** Chairs: Andrew Garrad (DNV GL) and Sven-Erik Thor (W4E) – **Calculation tool for advanced simulations of turbine behavior at ice conditions.** Hans Ganander, Teknikgruppen – **Site ice classification – case studies and recommendations** Rebecka Klintström, Vattenfall/Meventus – **Input to new IEC 61400-1 design standards from two case studies of iced turbine load analysis** Ville Lehtomäki, VTT – **Risk of structural damage due to wind and icing – modelling extreme weather loads** Bjørn Egil Nygaard, Kjeller Vindteknikk	**REMOTE SENSING** Chairs: Jenny Longworth (Vattenfall) and Martin S Grønsleth (Kjeller Vindteknikk) – **Case study of Lidar in cold climate and complex terrain in Canada** Cédric Arbez, TechnoCentre éolien – **Performance of Lidar in icing conditions – comparison to a 200 m met mast in complex terrain** Zouhair Khadiri Yazami, Fraunhofer IWES – **Wind measurement in extreme conditions** Daniel Marmander, Natural Power
17.15–18.00	NETWORKING MINGLE IN EXHIBITION HALL		
17.15	INFORMAL SESSIONS (PRE BOOKED)		
19.30–0100	DINNER AND ENTERTAINMENT AT SÖDRA BERGET		

Winterwind
INTERNATIONAL WIND ENERGY CONFERENCE

FEBRUARY 12

PROGRAM

	A	B	C
09.00–10.30	**MAPPING** Chairs: Lea Kirsch (Senvion) and Måns Håkansson (Statkraft) – **Inter-comparison of icing production loss models** Neil Davis, DTU Wind Energy – **A study of turbine performance under cold weather driven stable atmospheric conditions in scandinavia** Carla Ribeiro, DNV GL (former GL Garrad Hassan) – **Simple methodology to map and forecast icing** Ville Lehtomäki, VTT	**ENVIRONMENTAL IMPACT** Chair: Anders Enetjärn (Enetjärn Natur) – **What is the point of caring about birds and reindeer – we now know a lot more** Niklas Lindberg Alseryd and Maria Bergstén, Enetjärn Natur – **Year round monitoring of low frequency noise in harsh climates** Antti Leskinen, APL Systems Inc	**CONSTRUCTION & HEALTH AND SAFETY** Chairs: – **Wind-diesel project development in isolated grid communities of Alaska** Douglas Vaught, V3 Energy – **Requirements for wind turbines in harbour areas** Kimmo Palmu, TÜV NORD SysTec – **Operational forecasting of icing and wind power at cold climate sites** Øyvind Byrkjedal, Kjeller Vindteknikk
10.35–10.55	EXHIBITION & POSTER SESSION		
11.00–12.30	**PRODUCT EXPERIENCE, OPERATIONS AND MAINTENANCE-** Chairs: Liselotte Aldén (Uppsala University) and Aart van der Pal (ECN) – **SEU O&M experiences of wind turbines in cold climate – handling risk of ice throw** Thomas Mannelqvist, Skellefteå Energi Underhåll – **Suorva, a 600 kW cold climate research turbine – a journey from 1998 till today** Jan Norling, Vattenfall – **TransAlta's operational experience with blade icing** Jeff Nelson, TransAlta	**HEALTH AND SAFETY** Chairs: Karin Liinasaari (NFV) and Kimmo Palmu (Hamburg Wasser) – **Risk of icefall in the international context** Andreas Krenn, Energiewerkstatt – **Assessment of risks associated with ice throw and ice fall** Rolv Erlend Bredesen, Kjeller Vindteknikk – **Validating an ice throw model – a collaborative approach** Gail Hutton, RES Group – **ICETHROWER – ICE THROW evaluation and risk analysis tools** Bengt Göransson, Pöyry SwedPower	**PRODUCTION LOSSES** Chairs: – **Real time line sag detection** Klaus Känsälä, VTT – **A novel model approach to test de-icing strategies and de-icing efficiency** Stefan Söderberg, WeatherTech Scandinavia – **Quantification of energy losses caused by blade icing and the development of an energy loss climatology using scada data from scandinavian wind farms** Staffan Lindahl, DNV GL (former GL Garrad Hassan)
12.30–13.30	LUNCH		
13.30–13.55	EXHIBITION & POSTER SESSION		
14.00–15.30	**COMMERCIAL EXPERIENCES** Chair: Susanna Baltcheffsky (Ny Teknik) – **De-icing performance warranties – a utility perspective** Daniel Gustafsson, Vattenfall – **Performance of Enercon wind turbines under icing conditions in Europe** Rene Cattin, Meteotest – **Siemens turbines in cold clime** Finn Daugaard Madsen, Siemens Windpower – **Vestas de-icing system** Brian Daugbjer Nielsen Vestas – **Summary of Winterwind 2014 and future directions** Jos Beurskens, SET		

FEBRUARY 13

07.30–15.00	**GUIDED TOUR** **To the wind farm Mörttjärnberget, located in Bracke municipality, southeast of Östersund.**

POSTER

POSTER

DE-ICING

De-icing of wind turbine blade with a helicopter open new opportunities

Hans Gedda, H Gedda Consulting AB
Mats Widgren, Alpine Helicopter AB

Hans Gedda.

Consulting Engineer.

H Gedda Consulting AB

On behalf of Alpine Helicopter Sweden AB

Hans.gedda@telia.com

Phone: 070-377 12 85

De-icing of wind turbine blade with a helicopter open new opportunities.

If you don't have a de-icing system or a system that not work properly, and you are standing due to icing, and the weather forecast predicts good wind condition the next days. Then you can't do anything else except wait with production losses as a result.

Until now there has been no alternative available to remove ice from turbines without a de-icing system or for turbines equipped with a de-icing system that isn't working properly.

But hot water and a helicopter open new opportunities to solve this problem. Hot water is sprayed on the blade in the same way when de-icing an aircraft. The difference is that this is done with a helicopter with hot water (no chemicals) sprayed on the blade to remove the ice. Alpine Helicopter in Sweden has now developed technology for the de-icing of wind turbines from a helicopter. The method has been used in Canada for deicing of wind turbine blade since 2011.

This presentation will show the technology and the advantage with this method. Results and from tests carried out at Uljabuoda wind farm in Sweden and from Canada will be presented together with interesting information. Cost to de-ice a wind turbine with this method pays off after approximately two days of normal (mean) production.

Development of a LES-LPT based numerical method for ice accretion simulation

Robert Szasz, Lund University
Armin Weiss, Lund University
Johan Revstedt, Lund University

In order to avoid the harmful effects of ice accretion on wind turbines blades there is an intensive research to predict the occurrence of icing for given geographic areas. A lot of effort is put also in developing strategies to avoid icing, or if not possible, to remove accreted ice layers. Much less effort is put in the understanding of how ice accretion occurs. Such understanding would help optimizing de- and anti-icing strategies.

There are experiments carried out in wind tunnels with controlled climatic conditions (see e.g. [1] and more recent plans in [2]). Numerical computations can complement such experiments by offering greater flexibility for parametric studies and scaling. Currently, most of the prediction models are based on the Makkonen model [3].

Our goal is to develop a numerical tool to model ice deposition based on a combined Large Eddy Simulation (LES)-Lagrangian Particle Tracking (LPT) approach. The unsteady three-dimensional flow field is computed by solving the incompressible Navier Stokes equations on a cartesian equidistant grid. LES is used to account for turbulence. The solid surfaces are modeled using the Immersed Boundary Method. To model ice deposition, water droplets are released upstream and tracked using LPT. For the time being only aerodynamic forces are accounted for. It is assumed that the droplets freeze instantaneously when they impact on the solid surfaces. The parameters of the droplets at impact are logged. As a second stage, the shape of the blade profile is remorphed to account for shape changes due to the accreted ice.

The method is used to model ice accretion on a NACA 63415 airfoil. The set-up corresponds to the 'In-fog icing event 1' reported in [1]. This work is a continuation of [4] and the focus is on evaluationg the sensitivity of accreted ice layer on the droplet size and on variations of model parameters.

---

1. Hochart et al. Wind Turbine Performance under Icing Conditions, Wind Energy 11:319–333, 2008
2. Hudecz et al. Wind Tunnel Tests on Ice Accretion on Wind Turbine Blades, Winterwind 2012
3. Makkonen, L. Models for the growth of rime, glaze, icicles and wet snow on structures. Philosophical Transactions of the Royal Society, Vol.358, No.1776, pp.2913-2939, 2000
4. Szasz et al. Numerical prediction of ice accretion based on LES and LPT, Winterwind 2013

BACK

GreenWind GLOBAL De-icing System

,

GreenWIND Global History

In 1992, formerly EcoTEMP, began with a unique approach to satelite de-icing systems. Since, EcoTEMP has continued to develop advancements in the automotive and pipeline industries. GWG entered the Renewable Energy market in 2006 with innovative contributions. From inception, GWG has evolved by expanding its development of heating technologies and solutions, responding to the challenges of the renewable energy market. From 2010 through to the present, GWG has equipped several projects in Europe and Canada with customized De-Icing solutions.

Heating Technology RTS

Radiant Thermal Sheet Technology (RTS) allows uniform area heating using scalable voltages up to 400V. The easy Peel and Stick“ installation process can be integrated during the blade manufacturing process, or can be a retrofit system to an existing turbine.

Advantages

1. Exterior heating elements offer higher heat transfer capabilities
2. Lower profile
3. Mating
4. Modular to customers specifications
5. Lowest power consupmtion in the industry.
6. Heater layout simplifies service and maintenance, reducing costs
7. Standard 400V operation
8. New or Retro-fit systems
9. Audible annunciator indicating heat cycle
10. Standard communication interface
11. Turn-Key system with service support

Heating Management - Smart De-Icing

Modular control panels with embedded lightning protection allow manual or remote, for automatic de-icing and anti-icing operations. The application of 1-3 zones per blade supports efficient heating strategies in accordance to varying harsh environmental conditions. System calibrations and specific routines can be set via remote access. Data-Logging and monitoring options can be integrated into the windpark management system.

Ice Detection

Implementing time, temperature parameters or various ice-detection systems provides control in the de-icing process. Before the ice load becomes critical, sensors can avoid the risk of icefall and reduce the material load. Ongoing field test with 4 different types of sensors

Customization

GWG de-icing system can work as stand alone solution or can be integrated with turbine control units. The modular design is adjustable for all types of turbines. Customization according to specific needs, is only one part of the standard GWG process.

Wind turbine blade anti-icing by means of warm air film heating

lorenzo battisti, university of trento

The paper presents the concept of wind turbine blade warm air film heating, an examples of its applicability. This technology can be profitably used both for anti-icing and de-icing purpose. It is based on the generation of a spatially continuous film of warm air, partially or totally enveloping the blade external surface. The film is created by ejection of air from the inside to the outside of the blades through slots or arrays of holes distributed into the wall.

The warm air is supplied to the blade through the root of each blade and then routed to the portions of the wall equipped with slots or holes. The ejection process can be either continuous or cyclic in time by setting a proper intermittency factor.

The mixing produces both an increase of the heat exchange coefficient by convection, dependent on

the fluids own features, and an increase of the air temperature at the surface. The net effect is a decrease of the heat fluxes from surface to the cold stream. After a wide analysis of existing methods, analytical and experimental results are presented.

The preliminary results show that the anti-ice heat flux requirement at the blade surface is reduced up to 70%-80%, compared to extant systems, with a very small amount of heating air. Only warm air (5-10 °C) is needed for anti-ice purpose and the regenerative scheme takes fully advantage from this solution.

Since very low enthalpy is required for anti-icing purpose, compared to conventional systems, the air forming the film can by aspirated through the nacelle rear part or the tower bottom. After being flushed through the electric devices, as the trafo/inverter within the tower or the electric generator within the nacelle, to rise its temperature, it is finally directed in to the rotor.

The local effect on blade wall temperature shoes that film heating allows achieving very smooth and isothermal like blade skin temperature, compared to traditional hot gas systems. The air ejection reduces also the collection efficiency of the blade profile, thus decreasing the quantity of water impinging the surface. From the economic point of view, the operating costs can be advantageously reduced, since air heating can be obtained by regenerative effect. Additionally, the system do not need icing detection system to establish icing onset, since as the wind turbine rotate the flow is automatically established and the anti-icing effect performed.

---

1. Albers A. Summary of a technical validation of. enercon's rotor blade de-icing system. Technical Report PP11035-V2, Deutsche Wind Guard Consulting Gmbh, 2011.

1. Andersen E., Brjesson E., Vainionp P., and Undem L.S. Wind power in cold climate. Technical report, WSP Environmental, 2011.

1. Al-Khalil K.M., Miller D.R., andWright W.B. Validation of nasa thermal ice protection computer codes: Part 3-the validatio chnical Report NASA/TM- 2001-210907,

BACK

1. Makkonen L., Laakso T., Marjaniemi M., and Finstad K.J. Modeling and prevention of ice accretion on wind turbines. Wind Engineering, 25(1):3-21, 2001.

1. Mansson J. Why de-icing of wind turbine blades? In Global windpower, Chicago, March 18-21, 2004.

1. Mayer C. Systme lectrothermique de Dgivrage pour une Pale d'olienne. PhD thesis, UQAR, Rimouski, Canada, 2007.

1. Mingione G. and Brandi V. Ice accretion prediction on multielement airfoils. Journal of Aircraft, 35(2):240{246, 1998.

1. Krenn A., Winkelmeier H., Wler T., and Tiefenbacher K. Technical assessment of rotor blade heating system in the austrian alps. www.energiewerkstatt.org.

1. **21.** Jonsson C. Further development of enercons de-icing system. In Winter Wind, Skelleftea, 2012.

1. Yasilik A.D., De Witt K.J., and Keith T.G. Three-dimensional simulation of electrothermal deicing systems. Journal of Aircraft, 29(6):1035-1042, 1992.

1. Peltola E., Marjaniemi M., and Stiesdal H. An ice prevention system for the wind turbine blades. In European Wind Energy Conference, pages 1034-1037, Nice, France, 1-5 March 1999.

1. Rohsenow W.M., Hartnett J.P., and Ganic E.N. Mass Transfer Cooling, Handbook of Heat Transfer Applications. McGraw-Hill, 2nd edition edition, 1985.

1. Thomas S.K., Cassoni R.P., and MacArthur C.D. Aircraft anti-icing and deicing techniques and modeling. Journal of Aircraft, 33(5):841{853, 1996.

1. Zisik M.N. Finite di_erence methods in heat transfer. CRC Press, 1994.

1. Weighardt K. Hot air discharge for de-icing. Technical Report F-TS-919 RE, Air Material Command - AAF Trans., Dec. 1946.

1. Woigt H. Deutsche patentschrift n.842330, 1949.

BACK

NASA Langley Research Center, 2001.

1. Battisti L. Icing on wind turbines Ph.D thesis 2013 University of Udine.

1. Battisti L., Fedrizzi R., Rialti M., and Dal Savio S. A model for the design of hot-air based wind turbine ice prevention system. In WREC05, Aberdeen, 22-27 May 2005.

1. Battisti L., Baggio P., and Fedrizzi R. Warm-air intermittent de-icing system for wind turbines. Wind Engineering, 30(5), 2006.

1. Battisti L. and Fedrizzi R. 2d numerical simulation of a wind turbine de-icing system using cycled heating. Wind Engineering, 31(1), accepted for publication in 2007.

1. Battisti L., Fedrizzi R., Dal Savio S., and Giovannelli A. Influence of the and size of wind turbines on anti-icing thermal power requirement. In Proceedings of EUROMECH 2005 Wind Energy Colloquium, Oldenburd, Germany, 4-7 Oct. 2005.

1. Battisti L. Anti-icing system for wind turbines. Patents US7637715B2, EP1552143B1 et al., priority 2002.

1. Battisti L. Method for implementing wind energy converting systems. Patents US8398368 et al., priority 2006.

1. Botura G. and Fisher K. Development of ice protection system for wind turbine applications. In Proceedings of the VI BOREAS Conference, Pyhtunturi, Finland, 9 - 11 April 2003.

1. Dalili N., Edrisy A., and Carriveau R. A review of surface engineering issues critical to wind turbine performance. Renewable and Sustainable Energy Reviews, 13:428-438, 2009.

1. Enercon. Enercon e-66 20.70 technical description. Technical report, Enercon International GmbH, 2003.

1. Enercon. Technical description, enercon ice detection system power curve method. Technical Report D0154426-2, Enercon International GmbH, 2010.

1. Gray V.H., Bowden D.T., and von Glahn U. Preliminary results of cyclical deicing of a gas-heated airfoil. Technical Report NACA-RM-E51J29, NASA Langley Research Center, 1952.

BACK

POSTER

CONSTRUCTION

Efficacy of Electric Motors in Cold Regions

umair najeeb mughal, narvik university college
muhammad shakeel virk, narvik university college

Different electric motors have different performance characteristics. In cold regions there is a major constrain lead by the icing load, which can be further amplified by wind loads. If the rotary components are exposed to environment then then this additional load produce noise in useful rotary operations and decrease **efficacy of motor**. Such issues are also not suitable for a healthy operation of electric motors which require continuous feedback for useful operation. Although operating conditions of electric motors in cold icing environment also limit their proper selection, but nevertheless this can be compensated by the alternate solutions. In this research work preliminary analysis has been carried out about the pros and cons of different characteristics of servo, continuous rpm and step motors with reference to the dynamic weather exposure in cold and icing weather conditions.

BACK

POSTER

DETECTION

Combitech – the partner for monitoring

Patrik Jonsson, Combitech AB

Combitech is a leading integrator of monitoring systems for advanced monitoring applications with high demands of availability. Combitech have experience from monitoring systems since the beginning of the 1980's, and has continuously developed the electronics and software skills while carefully taking the experience in account, which is crucial when developing reliable monitoring systems.

The Combitech approach allows integration of sensors from any manufacturer, as well as the development of specific monitoring sensors and systems for individual customers. Combitech can integrate, install and manage field systems and also integrate monitoring equipment with customers' existing equipment. Combitech can handle any type of communication method which ensures a high reliability of data collection. Data collection and distribution can also be hosted by Combitech by our own computer data collection server system. Every project hosted by Combitech is adapted to specific customer needs.

Combitech have developed an ice load sensor called IceMonitor. This sensor is made according to ISO 12494 (atmospheric icing on structures) and monitors the amount of ice aggregating on a vertical steel rod. This sensor is often installed together with different types of ice detectors that indicate the initial icing condition and also together with several different types of meteorological sensors.

An application specifically developed for the wind power industry is the wind portal. In the wind portal data from monitoring stations is presented on a map, historical data can be shown in graphs and camera images of the ice aggregation on the structures can be observed.

Furthermore, Combitech has a close cooperation with the Mid Sweden University regarding research within electronics and sensors. One mentionable research project is the development of a new sensor for detecting liquid water content and medium water volume which has granted funding from the Swedish Energy Agency.

Cameras together with image analysis are considered by Combitech to be highly significant in future monitoring systems. Therefore, Combitech cooperates with the Mid Sweden University regarding image analysis and remote ice detection.

BACK

Monitoring Icing Events with Remote Cameras and Image Analysis

Matthew Wadham-Gagnon, TechnoCentre éolien
Dominic Bolduc, TechnoCentre éolien
Moulay Akhloufi, Centre de Robotique et de Vision Industrielles
Jens Petersen, Repower Systems SE
Hannes Friedrich, Repower Systems SE
Amélie Camion, Repower Systems Inc.

Development of wind energy in cold climates already occupies a significant share of the global installed capacity and is expected to continue to grow over the next few years [1], there are still challenges associated to ice detection. There are multiple ice detection technologies commercially available, all of which have advantages and limitations [2]. Observing ice on a nacelle weather mast or even a rotor blade using a remote camera remains a very effective way of detecting ice.

Observations and findings from 2 remote cameras installed at the Rivière-au-Renard (RaR) wind farm in Canada on a MM92 CCV 2.05MW Repower turbine will be discussed. One camera captured images of the nacelle weather mast while the other was installed on the hub of the turbine and captured images of one of the rotor blades. These cameras have provided valuable insight on ice accretion, ice load during icing events, ice throw and can lead to a better understanding of ice protection systems, which will be presented in this poster.

The human eye and brain may contain some of the best “ice detection algorithms” to analyse images from remote cameras but this process can be tedious and time consuming. The TechnoCentre éolien (TCE) and the Centre de Robotique et de Vision Industrielles (CRVI) collaborated in order to develop an image analysis tool for ice detection and monitoring using the images from the remote cameras installed in RaR. The promising results as well as the limitations of this project will be presented as well as plans for future applications.

---

[1] BTM World Market Update 2012, Special Chapter: Cold Climate Turbines, Navigant Research, Copenhagen, Denmark, March 2013

[2] Fikke, S., et al., COST 727: Atmospheric Icing on Structures Measurements and data collection on icing: State of the Art, 2006.

BACK

POSTER

STANDARDS

Keywords: Reliability, Robustness, Validation testing, Climate chamber, Cold climate regions, Standards & Certification, Test sites, Gearbox, Transformer, Operations & Maintenance, Cold starts-up

Extreme cold start-up validation of a wind turbine components by the use of a large climatic test chamber

Pieter Jan Jordaens, Sirris/ OWI-Lab

Wind turbines are more frequently installed in remote areas where park owners are not affected by the ‘not in my backyard’ syndrome. Very often such sites have profitable wind conditions which makes them attractive to implement turbines, but some of these locations also have to deal with extreme cold. A large amount of such turbines are installed at sites affected by extreme temperatures which in the worst case affect the turbine’s availability if components fail or don’t work efficient due to extreme conditions. OEM’s and component suppliers are more and more aware that extreme temperature events and its effects on their machines need to be taken into account. Modeling is certainly contributing to this goal, but also physical testing and validation tests are required in order to substantiate confidence in its designs and to gain insights in the behavior and performance in extreme conditions. The wind power industry indicates that there is a lack of appropriate climate chambers for physical testing in comparison to other applications that have the same stringent reliability needs (i.e. automotive). To respond to this need, OWI-Lab has built a large 560m³ climatic test chamber. Mechanical, hydraulic and electrical wind turbine components of up to 150 tons can be tested in a temperature range from -60°C to +60°C. The presentation will point out specific case stories from the test lab in the field of cold climate tests. Controlled laboratory tests have been carried out at on a 2.2MW gearbox in order to validate the cold start-up behavior and start-up time of the machine in -40°C conditions. In order to do so, a dedicated test bench was developed and commissioned in September 2013. Next to the mechanical tests OWI-Lab performed electrical tests on wind power transformers. Such systems also need to work at very low temperatures. To ensure the reliability of the system and the possibility to start in cold conditions after some days of no wind and cold ambient temperatures, several tests were conducted in the climate chamber as a proof of proper working. The presentation will recognize the importance of taken into account cold climate conditions and their effect on turbine components, by the use cases. The industry will be made aware of the existence of a dedicated test facility to cope with extreme temperature testing and the need for physical testing.

---

[1] Oceanwise, Theme “testing in wind industry”, Nov 2011

[2] Only a cost optimized and reliable wind turbine is bankable, Huby J., Wind Energy update, Sept 2012

[3] GL Wind Technical Note 067 Certification of Wind Turbines for Extreme Temperatures (here: Cold Climate), Scope of Assessment, Rev 4, Edition 2011

[4] State-of-the-art of wind energy in cold climates, VTT Working papers 152, Oct 2010

[5] IEC 61400-22 Ed.1: Wind turbines – Part 22: Conformity testing and certification.

[6] IEC 60068-2-1 environmental testing – Part 2: tests – Tests A: cold.
Bram Cloet, Stefan Tysebaert, Raymond Van Schevensteen – CG Power Systems Belgium.
Corrosion and low temperature tests on liquid fill[illegible]rmers for offshore applications.

BACK

Serious Consequences Due To Excessive Ice Accumulation on a Typical Wind Turbine

Abdel Salam Alsabagh, Narvik University College
Yigeng Xu, University of Hertfordshire
Mohammad Virk, Narvik University College
Omar Badran, Al-Balqa` Applied University

Icing on wind turbines are known to lower their performance and bring an actual threat for different parts of wind turbine, especially the rotor. This problem is mainly related to cold regions. Arctic and sub arctic areas are intuitively exposed to atmospheric icing, as is high altitude areas. In this paper, two different scenarios of icing will be investigated regarding the vibrational behaviour of a wind turbine rotor. Ice thickness was calculated using ISO 12494 international standard. Three blades with a hub of NREL 5MW are numerically assembled using ANSYS 14.5. Iced wind turbine rotor shows high potential for a possible resonant response excitation with the first natural frequency of the wind turbine tower due to heavy icing. The simulated numerical results for natural frequencies show good agreement compared to those in the NREL 5MW manufactures manual. It is concluded that reduction in natural frequencies of the wind turbine rotor has happened differently as related to each ice accretion scenario. An increase of the dynamic load on wind turbine is expected due to reduction of the natural frequency.

Antikainen, P. a. P., S. (2000). ICE LOADS, CASE STUDY. BOREAS V, Levi, Finland.

Botta, G., Cavaliere, M. and Holttinen, H. (1998). Ice Accretion at Acqua Spruzza and its Effects on Wind Turbine Operation and Loss of Energy Production BOREAS IV, FMI, Hetta, Finland.

Durstewitz, M., Dobesch, H., Kury, G., Laakso, T., Ronsten, G. and Säntti, K., (2004). European experience with wind turbines in icing conditions. European Wind Energy Association London, UK.

Fortin, G., Perron, J., Ilinca, A. (2005). A Study of Icing Events at Murdochville: Conclusions for the Wind Power Industry, International Symposium Wind Energy in Remote Regions, Magdalen's Island, Canada.

Frohboese, P. a. A., A. (2007). "Effects of Icing on Wind Turbine Fatigue Loads." Conference Series 75.2007, Journal of Physics. **75**(1-14)

Fu, P., Farzaneh, M. and Bouchard, G. (2006). "Two-dimensional modelling of the ice accretion process on transmission line wire sand cables." Cold Regions Science and Technology **46**(3): 132–146.

Haaland, S., S. (2011). Estimating Production Loss due to Icing on Wind Turbines. MSc, University of Troms.

HoloOptics (2012). Estimating Energy Production Losses, Comparison with Ice Detection. Cold climate wind energy solutions. W. 2012. Skellefteå, Sweden

Homola, M., C. (2005). Impacts and Causes of Icing on Wind Turbines. I. I. B. PROJECT.

ISO, E. (2001). Atmospheric icing of structures, INTERNATIONAL STANDARD. ISO 12494. Switzerland.

BACK

Jasinski, W., J., Noe, S., C., Selig, M., S. and Bragg, M., B. (1997). Wind turbine performance under icing conditions. AIAA Meeting Papers on Disc, Reno, NV, USA.

John, F. (2001). Wind Power Development in Sub-Arctic Conditions with Severe Rime Icing. Circumpolar Climate Change Summi tand Exposition, Whitehorse, Yukon, Canada.

Jonkman, J. (2006). NRELOffshrBsline5MW. NREL/NWTC. Golden, CO, USA, National Wind Technology Center.

Jonkman, J., Butterfield, S., Musial, W. and Scott, G. (2009). Definition of a 5-MW Reference Wind Turbine for Offshore System Development. N. R. E. Laboratory.

Laakso, T., Baring-Gould, I., Durstewitz, M., Horbaty, R., Lacroix, A., Peltola, E., Ronsten, G., Tallhaug, L. and Wallenius, T. (2010). State-of-the-art of wind energy in cold climates. V.W.P. Finland, Technical Research Centre of Finland. **152**.

Lacroix, A. a. M., J. F. (2000). Wind Energy: Cold Weather Issues. R. E. R. Laboratory.

Maalawi, K. a. B., M. (2010). "Frequency optimization of a wind turbine blade in pitching motion. Proceedings of the Institution of Mechanical Engineers, Part A." Journal of Power and Energy **224 (A4)**(2): 545-554.

Makkonen, L. (2000). "Models for the growth of rime, glaze, icicles and wet snow on structures." Philosophical Transactions of the Royal Society **358**: 2913-2939.

Morgan, C., Bossanyi, E. and Seifert, H. (1998). Assessment of Safety Risks Arising from Wind Turbine Icing. BOREAS IV. Hetta, Finland.

Risø, N. L. (2002). Guidelines for Design of Wind Turbines. R. N. Laboratory. Copenhagen, Denmark, Wind Energy Department. **2nd Edition**

Ronstren, G. (2012). O2's wind pilot project Large-scale, Cost-effective Wind Energy Development in Icing Climates. Cold climate wind energy solutions, Skellefteå, Sweden.

Seifert, H. (2003). Technical Requirements for Rotor Blades Operating in Cold Climate. BOREAS VI. FMI, Pyhätunturi, Finland.

Seifert, H. a. T., B. (1996). Icing of wind turbines-Final Report. D. W. energies-Institute. Wilhelmshaven, Finland, Finnish Meteorological Institute.

Tammelin, B. e. a. (2005). Wind Turbines in Icing Environment: Improvement of Tools for Siting, Certification and Operation, NEW ICETOOLS.

Virk, M., S., Homola, M., C. and Nicklasson, P., J. (2012). "Atmospheric icing on large wind turbine blades." International Journal of Energy and Environment (IJEE) **3**: 1-8.

Virk, M., S., Homola, M., C. and Nicklasson, P., J. (2010). "Effect of Rime Ice Accretion on Aerodynamic Characteristics of Wind Turbine Blade Profiles." Wind Engineering **34**: 207-218.

Vølund, P. a. A., I. (1997). Measured Ice Loads on Avedoere 1MW Test Turbine. Risø National Laboratory. RISØ. Roskilde, Denmark.

Walsh, M. (2010). Accretion and Removal of Wind Turbine Icing in Polar Conditions. M. Sc., AALTO UNIVERSITY.

BACK

Structural performance of offshore wind turbine in ice-covered waters

Maria Tikanmäki, Jaakko Heinonen, Vilho Jussila, Juha Kurkela

VTT Technical Research Centre of Finland
P.O. Box 1000, FIN-02044 VTT, Finland

Keywords: ice, ice loads, structural performance, ice-induced vibration, ice conditions, ice thickness, ice drift

The main challenge for the offshore wind turbine structures in cold climate is caused by the interaction with the moving sea ice and substructure. The magnitude of the ice load and dynamic excitation due to ice failure are usually dominating the structural design in ice-covered sea areas. A site-specific determination of the ice conditions and an overall dynamic simulation of the wind turbine with the ice interaction enable cost-effective structural design.

Site-specific environmental conditions include the determination of prevailing sea ice conditions like the thickness and drifting speed of ice and identification of different ice features including ridges and rafted ice. Both for the fatigue and ultimate limit state analyses, it is important to make proper stochastic analysis of expected ice conditions in selected recurrence periods.

Due to the height and the cost requirements, the support structures of the offshore wind turbine are typically slender introducing some flexibility at the water level. Consequently, the phenomenon of interaction between the drifting level ice and the structure is a very dynamic process. As the wind turbine generator and the rotor in the tower top are sensitive to vibrations, it is vital for the design purposes to understand ice-induced vibrations in different environmental conditions (ice thickness, wind and ice speed).

A commonly used method to decrease the ice loads is to implement the sub-structure by a cone which switch the ice failure mode from crushing to bending. A numerical feasibility study is introduced to compare a monopole type of the sub-structure with a conical one. Different numerical procedures are introduced for each structural case in the level-ice interaction.

For the ridge-structure interaction, an advanced numerical simulation tool is introduced. As the ice model is able to simulate ridge failure process generally, it can be straightforwardly applied for different structures to analyse the structural performance in the ridge interaction. In addition to the load calculation, the ridge-interaction simulation tool can be applied to optimize the shape and the size of the structure. Different structural concepts of the substructure e.g. monopile, conical shapes or jackets can be studied by the same analysis method.

The main steps of the structural performance studies in the offshore wind turbine for ice-covered waters are introduced by selected case studies.

BACK

Cold climate rotor blade repairs using advanced UV curing resin system

Ville Karkkolainen, Bladefence

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. We also present a case where extensive structural repairs were carried out in Finnish Lapland during January of 2013.

Traditional wet laminating systems used in composite repairs, generally require an ambient temperature of more than +15 Celsius and a maximum RH of 60% 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 and a maximum RH of 90%.

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.

BACK

Commercialization of VTT's Know-How in Ice prevention of wind turbine blades

Esa Peltola, VTT Technical Research Centre of Finland
Petteri Antikainen, VTT Technical Research Centre of Finland
Tomas Wallenius, VTT Technical Research Centre of Finland
Geert-Jan Bluemink, VTT Technical Research Centre of Finland
Jeroen Dillingh, VTT Technical Research Centre of Finland
Sisu Niskanen, VTT Technical Research Centre of Finland

Authors: Esa Peltola, Petteri Antikainen, Tomas Wallenius, Geert-Jan Bluemink, Jeroen Dillingh, Sisu Niskanen (VTT Technical Research Centre of Finland)

Since early nineties VTT has successfully developed knowledge, tools and solutions to keep wind turbine blades free of ice while in operation. The aim and focus in this development work has been to maintain high wind turbine availability and performance with minimal system consumption during severe winter conditions. The carbon fibre based solutions developed cover stall regulated fixed speed rotors from 25 m to 54 m in diameter and pitch regulated variable speed rotors from 80 to 130 m in diameter.

VTT has commercialized the know-how both by licensing it to a 3rd party solution provider in late 1990’s, known in the market as JE-System by Kemijoki Arctic Technology Oy, and later by customising the technology to the requirements of the OEM under commission projects covering the design, manufacturing, pilot implementation, follow-up and licensing of an Ice Prevention System.

In recent years demand for wind energy in Cold Climates has increased significantly as well as demand for an independent supplier of Ice Prevention Solutions.

Based on market feed-back there is a call for product provider instead of a technology development and licensing. The presentation is based on the outcome of an on-going commercialisation project, which is to be finalized in spring 2014. The projects aim is to create a path from technology licensed by VTT to product(s) sold by an existing or a spin-off company.

BACK

Developing ice detectors for wind turbines – outlook of requirements and improvements from 1990 till today

Jarkko Latonen, Labkotec Oy
Tatu Muukkonen, Labkotec Oy

History of Labkotec ice detector development goes back to 1990's when the very first ice detector was installed on a wind turbine blade in the north of Finland. Purpose of the ice detector was to start blade heating. All this happened over 20 years ago; the world was not ready for it yet.

After the 1990's, ice detectors have mainly been used as safety instruments to prevent ice throw by stopping wind turbines in case of icing conditions. Awareness and requirements to ice detection in wind turbines has evolved during the years, which has put a lot of pressure to product development.

Importance and results of several field tests, CFD modeling, testing in icing wind tunnel and comparison of test results to simulations with wind turbine blade are presented in this presentation. Especially the test results from freezing rain and in-cloud icing conditions are shared. With reference to different test setups, lack of harmonized test methods and standards is highlighted.

The ongoing new dawn of wind power in cold climate has again raised the need for ensuring and optimizing wind turbine production in icing conditions, thus setting new requirements for ice detectors. Experiences from the development and tests of blade-mounted ice detectors are presented.

BACK

POSTER

MAPPING

Wind energy, Cold region, AEP, turbulence, complex terrain, CFD.

Effect of Climate Conditions on Wind Farm Performance in Cold Regions

Geanette Polanco, Atmospheric Icing Research Team, Narvik University College, 8505- Narvik, Norway
Matthew C. Homola, Nordkraft Produksjon, 8517- Narvik, Norway

Muhammad S. Virk, Atmospheric Icing Research Team, Narvik University College, 8505- Narvik, Norway

Wind is a widely accepted source of clean and cost effective renewable energy. Energy production from a wind park can significantly be influenced by its operating climatic conditions and location. Cold regions such as Norway has good resource of wind energy, but the severe cold weather conditions in addition to the complex terrain leads to the significant changes in the wind characteristics (*speed, direction and temperature*). In addition to this, atmospheric ice accretion on wind turbine components in cold regions also affects the resultant power production. In this research work, a case study has been carried out where *Nygårdsfjellet* wind farm performance is studied using advanced computational fluid dynamics based numerical tools, for both winter and summer periods. *Nygårdsfjellet* wind farm is located in the surroundings of Narvik, situated in the northern Norway. Actual weather data is taken from climatology located at the wind farm. A set of three wind turbines has been taken into consideration to study the effects of wind resource, atmospheric boundary layer height and resultant turbulence in the wake region of each wind turbine for summer and winter seasons. The turbulence phenomenon in the whole domain is considered by the introduction of the wake models for each turbine. Numerical simulations include a matrix of cases of winter and summer seasons respectively, with the different wake turbulence models available. The resultant annual energy production (AEP) is also compared with the experimental data corresponding to the wind farm.

BACK

POSTER

PRODUCT EXPERIENCE, OPERATIONS AND MAINTENANCE

Implementing a 3D CFD model to study the performance of porous fences under harsh climatic conditions

Yizhong Xu, Narvik University College
Mohamad Y. Mustafa, Narvik University College

Porous fences are one type of artificial devices used to effectively mitigate the damages caused by strong wind and transported drifting snow. In cold regions like Norway, porous fencing systems are being increasingly applied in the form of windbreaks to allow the natural climate to be controlled. There is a strong need to design an optimum porous fence to maximize its performance at minimum cost.

Physical modeling is often conducted in wind-tunnels. Due to the difficulty of full-scaling snowdrifts in the field and the complexity of turbulent flow behind porous fences, this technique has difficulties in satisfying all similitude requirements simultaneously and in providing a comprehensive structure of turbulent flow. Therefore, Computational Fluid Dynamics (CFD) techniques, as an alternative to physical modeling, have been increasingly and successfully applied in the research over the last three decades.

The majority of CFD simulations to study porous fences is performed using 2D models and has been successful in most cases. However, 2D simulations are unable to comprehensively reflect the full structure of air flow and drifting snow in the simulation domain. Besides, they require strict modifications of operating and boundary conditions, and vary almost in each individual case, which increases uncertainty of numerical results. 3D model simulations have the ability to overcome the above issues.

This work demonstrates a 3D CFD model to study the performance of porous fences under wind/snow climate. The following results will be presented and discussed in this work:

- The convenience of re-defining the simulation domain;
- Mesh sensitivity analysis;
- Validation of numerical results against experimental results;
- Single-phase simulation (air flow) and turbulence structures;
- Two-phase (air with drifting snow) simulation and turbulence structures;

The 3D CFD model is proved to be practical and flexible. It is able to provide a comprehensive structure of turbulence and to trace the snow particle movements in the simulation domain. The model can be used to aid the optimum design of porous fences.

This work was financed by the Norwegian Research Council under project number 195153 (ColdTech). We would like to acknowledge the contribution of IKM dsc AS, Norway.

---

[1] N. Tani, "On the wind tunnel test of the model shelter hedge," in *Bulletin of the Natinal Institute for Agricultural Sciences*, 1958.

[2] R. Bagnold, The physics of blown sand and desert dunes, London, 1941.

[3] J. Raine and D. Stevenson , "Wind protection by model fences in simulated atmospheric boundary layer," *Industrial Aerodynamics,* vol. 2, pp. 159-180, 1977.

[4] W. Cornelis and D. Gabriels, "Optimal windbreak design for wind-erosion control," *Arid Enviroment,* vol. 61, pp. 315-332, 2005.

[5] J. Wilson, "Numerical studies of flow through a windbreak," *Wind Eng. Ind. Aerodyn,* vol. 21, pp. 119-154, 1985.

[6] A. S., "Comutational fluid dynamic modelling of drifting particles at porous fence," *Environmental Modelling and Software,* vol. 19, pp. 163-170, 2004.

[7] P. A., "Flow through porous fences in thick boundary layers: comparisons between laboratory and numerical experiments," *Wind Eng. Ind. Aerodyn.,* vol. 88, pp. 75-90, 2000.

[8] P. Richards and R. Hoxey, "Appropriate boundary conditions for computational wind engineering models using the k-e turbulence model," *Wind Eng. Ind. Aerodyn.,* vol. 46 (47), pp. 145-153, 1993.

[9] J. Wilson and C. Mooney, "A numerical simulation of boundary-layer flows near shelterbelts comments," *Boundary-Layer Meteorology,* vol. 85, pp. 137-149, 1997.

[10] G. C., W. W., C. S. and J. L., "3D numerical simulation of wind blow behind a new porous fence," *Powder Technology,* pp. PTEC-09046, 2012.

[11] S. J.L., M. F., B. N. and S.-A. A., "Experimental and numerical study of wind flow behind windbreaks," *Atmospheric Environ.,* vol. 41, pp. 6406-6420, 2007.

BACK

POSTER

HEALTH AND SAFETY

A Tool for the Assessment of Stochastic Danger Levels from Ice Ejected from Windturbine Blades

In cold and tempered regions of the world icing of structures occurs during a period of the year. Windturbines located in these regions will, at icing conditions, attract ice on their blades. A potentially hazardous situation might occur during operation, when the rotating blades eject ice into the air. The author has coded a tool, consisting of a set of programs, which calculate the dynamics of many throws, each one being a discretisation representing the probability distribution of interest in the particular context. To approach an assessment of the danger level, from the falling ice, a chain of activities is needed. In the method presented here some of these are:

1. Get statistical data for ice forms and size including dependence on the size of the blade
2. Get statistical data on where along the radius the ice cracks to release ice blocks
3. Get statistical data on nature's preference for the blade throw angle (at 6 o'clock? 7 o'clock?)
4. Get statistical wind data – distributions of wind speed and the direction of the wind
5. Get terrain data in terms of height curves of the site
6. Calculate trajectories of a pieces of ice – get mass, coordinates and speed at ground impact
7. From the throw results get distributions for mass, momentum and energy at ground impact
8. Classify weights and/or momentum and/or energy to get distributions on the ground
9. For each class obtain probability distribution per m^2
10. Obtain site data relating to probability of presence of people, animals, vehicles etc
11. Multiply class probability by site data probability to get probability numbers for the chosen classes as functions of the landing coordinates
12. Assess insurance costs or private funds required for damage liability

The tool for calculation consists of several co-working programs, whose output is the input to the next program in a sequence leading up to, and including, point 9 in the list above. The subsequent activities, i.e. 10 – 12, must be carried out by the site owner and is not a topic of this report.

The following text refers to the numbering of the listed items above. The work, according to the first five items, represents the effort to provide part of the input set to the program family.

Item 1 – can preferably be obtained from actual investigations of ice ejected from windturbines and found reasonably undamaged on the ground. Data, with such a background, are however scarce. Therefore, the analyst of these problems will have to make do with miscellaneous photographs from various sources. Furthermore the data must be complemented with estimated numbers describing shape and measures of size in order that systematic variations, of the input quantities, can be generated.

Item 2 – This item is also plagued with scarcity of data. Very few people have seen the actual release of ice chunks being ejected from windturbine blades. It is probably safe to say that zero number of people have photographed and measured exactly where the border line between ice chunks were located on the blade. Here only educated guesstimates can function as a base for these inputs. These guesstimates now constitute the base for an algorithm internal to the program, which carries out the throwing.

Item 3 – From which blade angle is ice usually thrown? Even here basic data are missing. Therefore it has been assumed that all angles are equally probable. But, it can also be argued that the ice tends to leave the blade at 6 or 7 o'clock; at 6 because both forces of gravitation and centrifugation coincide most powerfully. The argument for 7 o'clock represents an adjustment of that thought, which represents a delay effect. A distribution of angles around the "preferred" angle can then be used, e.g. a Gauss distribution. The program accepts a distribution, which is constant or Gaussian as defined in the input.

Poster saknas...

BACK

POSTER

PRODUCTION LOSSES

A Parametric Analysis of Ice Protection Systems

Matthew Wadham-Gagnon, TechnoCentre éolien
Dominic Bolduc, TechnoCentre éolien
Hussein Ibrahim, TechnoCentre éolien
Maryse Dufresne, CEGEP de la Gaspésie et des Iles

According to a recent market study [1], 11.5GW of wind energy capacity installed globally in moderate to severe icing climates by the end of 2012, with an additional 8GW expected to be installed by 2017. NRCan [2] estimates cold climates have caused nearly CAD$100M in production losses in 2011 alone and expect losses to reach CAD$192M/year in the next few years when considering added capacity currently under construction or in planning.

Production losses due to icing, while site specific, provide insight on the market potential for Ice Protection Systems (IPS). IPS's currently available or in development make use of a variety of technologies, provide different performances and theirs costs vary significantly. A simple yet revealing parametric study based on variables such as site-specific annual production losses due to icing, initial cost, annual maintenance cost and durability of the IPS as well as the capacity of the IPS to recover lost power (i.e. recovery factor) will be presented. Site ice classification proposed by IEA Wind's Task 19 [3] is integrated to the analysis in order to estimate annual production losses due to icing in addition to additional statistical parameters based on previous studies on ice profile classification [4][5]. Parameters that influence the recovery rate of active IPS's such as energy consumption, surface coverage, and the requirement to stop the turbine or not will be discussed.

The results of this study will demonstrate the sensitivity of certain variables and highlight the return on investment for certain combinations of variables. For example, target recovery factors will be proposed for low cost icephobic coatings to provide the same return on investment as highly efficient, but more expensive, active de-icing systems. The methodology proposed to assess the return on investment of an IPS should help set targets for certain technologies that aren't quite there yet as well as help developers or operators make the right choice of IPS with respect to the ice classification of their site.

---

[1] BTM World Market Update 2012, Special Chapter: Cold Climate Turbines, Navigant Research, Copenhagen, Denmark, March 2013

[2] Lacroix, A., Tan, M., Dockrill, P., Assessment of Wind Energy Production Penalties Due to Cold Climate in Canada, CanmetEnergy, Natural Resources Canada, Ottawa, 2012.

[3] Baring-Gould, I., et al., Expert Group Study on Recommended Practices for Wind Energy Projects in Cold Climates. IEA Wind Recommended practices no. 13. 2012. Available at: http://arcticwind.vtt.fi/

[4] Bolduc, D., et. al., Field Measurement of Wind Turbine Icing, IWAIS 2013, St-Johns, Newfoundland

[5] Wadham-Gagnon, M., et. al., Ice profile classification, based on ISO 12949, WinterWind 2013, Ostersund, Sweden.

BACK

Simulation and Validation of the Aerodynamic Performance of Iced Wind Turbine Airfoils

Richard Hann, University of Stuttgart

Atmospheric icing leads to the formation of ice horns at the leading-edge of an airfoil and therefore effectively changes the airfoil geometry. This geometric alteration influences the flow around the airfoil and is likely to affect aerodynamic performance which may reduce power generation and increase loads of wind turbines. For this reason, it is important to be able to understand and predict the effect of icing on the airfoil aerodynamics. Computational fluid dynamics (CFD) can be used to simulate the aerodynamics for complex geometries, such as iced airfoils, in order to determine key performance parameters (lift & drag). As with all simulations in general, it is of paramount importance to validate the numerical results with experiments in order to verify the agreement between model and reality.

This study uses data obtained in wind tunnel experiments by NASA[1] and compares it with numeric 2-d simulations, using TAU, a modern solver for the Reynolds-averaged Navier-Stokes (RANS) equations and XFOIL, a simplified panel-method. TAU has been developed by the German Aerospace Center (DLR) mainly for aircraft applications, but has been successfully applied for wind energy related problems in the past[2]. XFOIL is widely applied for subsonic airfoil design and is using a panel-method, which is similarly implemented in common 2-d icing simulation tools (e.g. LEWICE or TURBICE). Different icing typologies (glaze & rime) have been considered in order to investigate the role of different metrological conditions.

The results indicate that the panel-method shows significant deviations from the experimental results, especially in the significant area around the ice horn. The RANS simulations tend to me more capable and show a good agreement with the experimental results regarding lift and pressure distribution. However, the estimation of the aerodynamic drag has proven to be difficult. The small scale ruggedness of the airfoil results in highly complex geometries which are difficult to discretize and need to be approximated to some degree. The increased surface roughness due to icing was neglected in both, experiment and simulation, although it may yield a significant increase of drag. In conclusion it can be shown that the simplified panel-methods can be applied for simple icing conditions, while RANS simulations are needed for the more complex ice geometries.

---

[1] H.E. Jr. Addy: Ice Accretions and Icing Effects for Modern Airfoils. Technical report. National Aeronautics and Space Administration (NASA), 2000.

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

BACK

Data driven production optimization from wind turbines

Jonas Corné, Greenbyte
Mats Johansson, Greenbyte

A study and examples of how insights in production, wind and operational data can be used to increase availability and power output.

All wind turbines produce a lot of data. This data provides valuable insights to owners and operators. With insights owners and operators can take actions to increase production. Measures are often associated with a cost that needs to be related to what effects that specific action has on electricity production, in financial terms what ROI does the action have.

To trace effects on production back to a specific action is a real challenge. Greenbyte is working on a method to track how specific actions affect production that we would like to share through some specific examples during Winterwind.

The analysis contains data from 100 turbines. We will demonstrate how

- Comparisons between wind farms shed light on under utilized wind turbines
- Insights into a learned power curve can be used to track effects of specific actions on production
- Continuous work with measuring lost production can lead to an O&M approach with continuous improvement

Greenbyte will also raise the question of

- Is there a pragmatic way for the industry to reach consensus on production based availability and lost production?
- Can lost production be divided into owners and manufacturers risk?
- Is there room in the market for independent service providers with incentive based service agreements?

BACK

Skills and training for the wind industry

Author: Liselotte Aldén, Uppsala University Campus Gotland, liselotte.alden@geo.uu.se

The Swedish and the global wind industry have grown rapidly. Wind power were fueling 4,4 % and 3 % of the electricity in Sweden and globally respectively.

As the fast development of the wind industry there has been reported a shortage of 7 000 qualified personnel required by the European wind energy sector each year. This figure could double if the number of graduates taking programmes and courses relevant to the industry does not rise.

A survey within the European Wind Energy Technology Platform showed that 78 % of employers in the European wind industry said it was hard or very hard to find suitably trained staff. There is a lack of training both in theoretical and experiential knowledge to meet the needs for the increase complexity of today's wind farm projects.

The shortage of skills highlights engineers, wind technicians and project managers. The most important skill when recruiting was problem solving attitude.

There are academic wind energy programmes available on Bachelor and Master levels across Europe and North America. However, there is still a lack of training programmes for graduates to develop, build and operate wind farms. Also, to meet the needs of the Offshore wind energy require further programme development.

Training facilities in incorporation directly with the wind industry are wished for. Also, a higher degree of cooperation between training institutions and the industry is highly sought after.

In Sweden there are training programmes for wind technicians at several Vocational Centres. The Universities offers several of engineering programmes which can have training parts on wind power. There is an MSc in Wind Power Project Management programme at Uppsala University Campus Gotland which also offers a vast collection of single subject courses on wind power.

Currently there are about 150 students in wind technician training each year and around 300 students taking single subject courses on wind power. Many students in programmes choose wind power as their thesis topic. During 2011 and 2012 there were 125 theses and 14 PhD/Lic theses written on wind power.

BACK

Turbine mounted Lidar for performance optimization: the case of cold climate and complex terrain

Samuel Davoust, Avent Lidar Technology
Julien Sarry, Avent Lidar Technology
Alban Jéhu, Avent Lidar Technology
Emir Heco, Renewable NRG Systems
Tom Nostrand, Renewable NRG Systems
Andrew Scholbrock, National Renewable Energy Laboratory
Paul Fleming, National Renewable Energy Laboratory
Alan Wright, National Renewable Energy Laboratory

Turbine mounted Lidar are an emerging tool to measure efficiently wind turbine power curves, and to optimize wind farm performance. Using feed-back from over 50 turbine mounted deployments on one side, and environmental tests on the other side, the present study provides operational feed-back for these applications in cold climate and complex terrain.

First, we summarize on the basis of case studies the effects of complex terrain on power performance measurement and optimization applications. It is observed that measurement accuracy is maintained in complex terrain and that specific techniques can be employed to build a site-calibration. Yaw misalignment optimization can have a potentially higher potential in complex terrain than in flat terrain. Indeed, the nacelle transfer function for the wind vane may evolve under complex flow effects. On the basis of these campaigns, both fixed offsets and sector dependent offsets can be observed.

Second, we focus on the behavior of icing and snow conditions on the Lidar system and the measurements. To this end, we report results from snow/icing tests but also measurement availability observed under snow conditions. The results confirmed the capacity to de-ice and de-snow effectively. On the other side, turbine mounted experiments provide measurements even under snow-conditions.

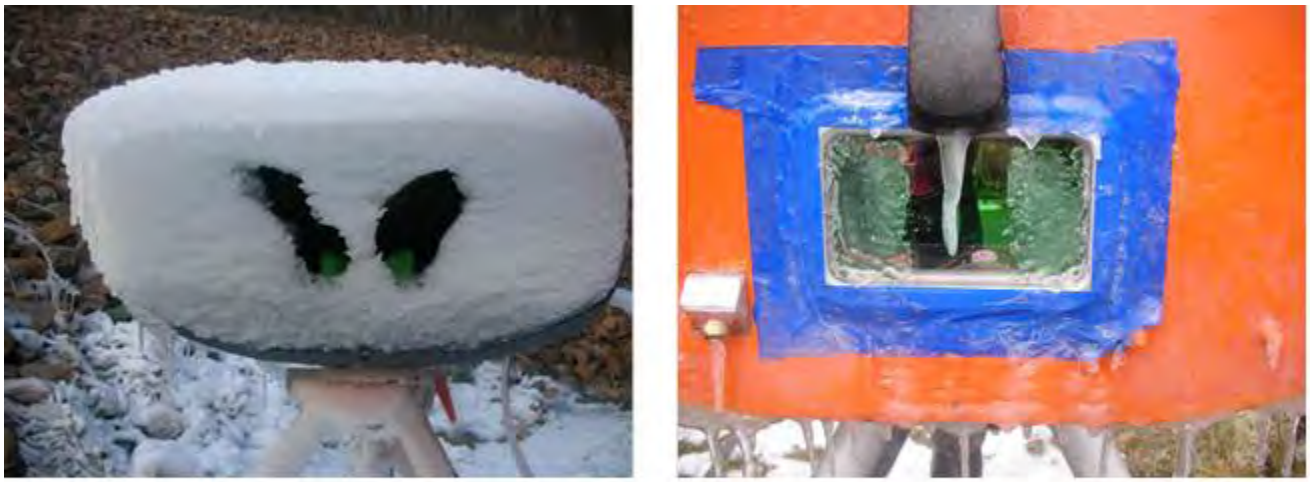


Figure 1 : Evaluation of the effect of heavy snow and freezing rain on the Wind Iris performed a

BACK

Our conclusions are that wind turbine operating in complex terrain may suffer more frequent underperformances, and that Lidar power performance measurement and optimization campaigns may require a longer period than in flat terrain. On the other side, limitation of operating turbine mounted Lidar under freezing or snow condition have not yet been identified to date. 104

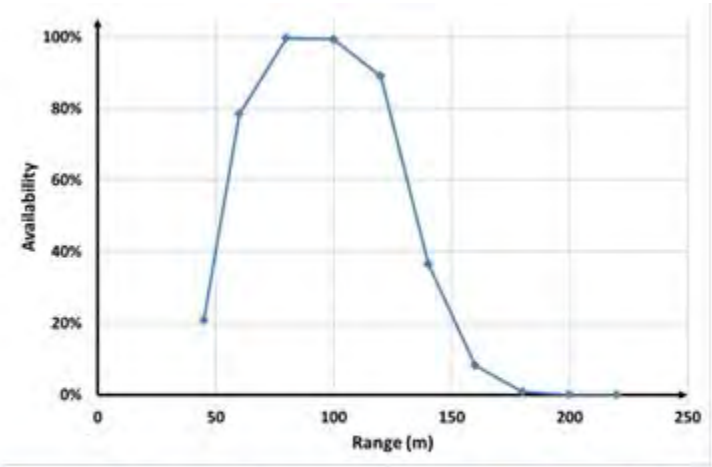


Figure 1 : Lidar availability under snow conditions observed at the NREL-Boulder test site, at 1

BACK

Comparison of LIDAR and mast measurements in complex terrain with/without FCR and CFD correction

Martin Sigurd Grønsleth, Kjeller Vindteknikk AS

The advent and growing acceptance of LIDARs in wind resource assessments is to a large degree driven by the ability to produce results that are quantitatively comparable to conventional cup anemometers in met masts. While LIDARs have proven to give very good results in flat terrain, complex sites require more sophisticated methods since homogeneity in the flow field no longer can be assumed.

In this study, we present results from a short measurement campaign with a Leosphere WINDCUBE v2 LIDAR placed next to a 100 m high mast in complex terrain in Norway. The LIDAR is equipped with FCR(TM) (Flow Complexity Recognition) software, and comparison with mast measurements is given with and without the FCR option active. The results are also compared to data that is corrected with the aim of a CFD model (WindSim).

Although the initial measurement campaign is rather short, this study provides a good indication on strengths/weaknesses in raw/FCR-/CFD-corrected LIDAR measurements and how they compare to a conventional met mast in complex terrain. The measurements will be extended during the summer 2014 in order to provide better statistics.

In the same region, this LIDAR is being moved between different locations every month of the year, and experiences with cold climate, icing, snow and wind conditions will also be presented. A special "LIDAR mounting tower" is in use, which in combination with the LIDARs "winter package" helps to keep the LIDAR snow free.

Measurement data courtesy of Austri Vind DA.

BACK

ORAL

ORAL

FORECASTING OF ICING

Developing an icing production loss module for wind power forecasting systems

Timo Karlsson, VTT
Jari Miettinen, VTT
Ville Turkia, VTT

Tomas Wallenius, VTT

Icing conditions may cause significant wind power production losses, which increases short-term wind power forecasting errors if not properly taken into account. Short-term (typically hours up to two days ahead) forecasting errors increase the need of balancing in power system, which increases the balancing prices in electricity markets, which in turn increases wind power producer's balancing costs. In order to improve the forecasting accuracy and decrease the producer's balancing costs an engineering tool using an icing production loss estimation method was developed.

Real measurements and production data were used to evaluate the method to estimate production losses due to icing. The result is called "Icing Production Loss Module" and it can be used as part of any wind power forecasting system if the system is capable of predicting icing conditions in addition to other weather parameters which are typically used, such as wind speed and direction, and temperature. The module defines production losses based on icing time and wind speed inputs from a weather prediction model.

Production losses are estimated based on icing induced power loss in reference data. Icing periods in real production data were classified based on wind speed and duration of power loss. Statistics of these power losses were then used to estimate the production losses during icing events.

The largest loss in power, relatively speaking, occurs during the first icing hour and can be more than 30% of the power of a non-iced wind turbine. As the icing level lasts longer the power loss gets increasingly more severe. This suggests that even short icing events can have significant effects on wind power plant performance and on short term wind power forecasting. Therefore the Icing Production Loss Module performance is evaluated with a real production forecasting system using historical data. Also, the effects of the module on the forecast error are evaluated.

The development process of the Icing Production Loss Module and results on how the module performs together with a wind power forecast system are presented in Winterwind 2014.

Experiences of modelling icing and uncertainty estimations

Esbjörn Olsson, SMHI
Hans Bergström, Uppsala University
Heiner Körnich, SMHI
Stefan Söderberg, WeatherTech AB
Per Undén, SMHI

During the Vindorsk-III project V-313 a lot of experience in modelling icing has been gained. At WeatherTech and SMHI three different meso-scale high resolution Numerical Weather Prediction (NWP) models were run for three winter seasons over Sweden. The meso-scale models forecast quite accurately temperatures, winds and also most of the icing events. The start, accumulation and end of ice load is often possible to predict, whereas the absolute amounts of ice loads are much more difficult. The ice load measurements are also not so reliable and may have large bias or deviate very much from a cylinder when heavily iced.
The availability of the three different models gives both an increased credibility in mapping of icing and an indication of uncertainty of the model results. The models employ different calculations of turbulence and cloud (condensation and precipitation) processes, which have a large impact on the icing calculations.
Even though the model variables in terms of temperature and existence of clouds may be correct, there is large uncertainty about the cloud water content and even more about the droplet size distribution. These are needed for the ice accumulation calculation in the commonly used Makkonen formula
There are no measured liquid water contents or droplet sizes (apart from some historical campaigns for development of the cloud schemes) so uncertainties in these inputs to icing calculations must be considered. NWP models have inherent uncertainties due to both initial conditions and physical parametrisations in the model. These uncertainties amplify non-linearly in the forecast leading to limited predictability which is typically shorter for smaller spatial scales. Meso-scale models at the km scale include energy at small scales with predictability of the order of an hour or less. The statistical properties of the models are mostly correct, but an ensemble of model runs is needed to sample the probability of an event. This is the subject of this new EM research project at SMHI, Uppsala University (UU) and WeatherTech which will be presented. Also the final and important step, how to translate the predicted icing to the effect on the whole rotor or a wind park is uncertain and can be dealt with statistically. Modelled uncertainties of ice accumulation will be translated into power production uncertainties. A PhD is being recruited by UU and co-supervised by SMHI.

Bergström, Hans, Olsson, E., Söderberg, S., Thorsson, P and Undén, P., 2013: Wind power in cold climates – Ice mapping methods. Elforsk rapport nr 13:10.

http://www.elforsk.se/Rapporter/?rid=13_10_

BACK

Validation of Icing and Power Forecasts Generated for the O2 Wind Pilot Program

Ben C. Bernstein, Leading Edge Atmospherics

As part of the O2 Wind Pilot Program, a large database of observations of state parameters, icing load and power output was generated at operational wind farm sites across Sweden. Four meteorological organizations were tasked with the production of forecasts and/or diagnoses of icing- and power-related parameters, including expected power losses due to icing.

To date, all of the organizations have compared output from their own systems to the observations taken at the wind farm sites, providing time-series plots, assessments of biases, errors and in some cases the perceived causes thereof for fields like temperature, wind speed, icing load and power. While such comparisons are quite useful, non-uniformity among the methods used, plotting, etc. have made it challenging for the Wind Pilot Program's "Reference Group" to compare output from the four systems to one another and the observations. In an effort to aid in such analysis, software has been written to merge output from each system with observations from weather masts and turbines, then generate statistics on the ability of each system to predict/diagnose basic weather parameters and the more complex phenomena of icing and its effect on power production. Standardized plots were also generated to help visualize the data and the statisitcal results.

This presentation will focus on the six wind farm sites where turbine data were readily available for the 2012-2013 icing season. Results indicate that each system has its strengths and weaknesses and that verification results can vary significantly depending on the "truth" dataset used and the wind farm site for which the data were examined.

BACK

ORAL

MARKET POTENTIAL

Global cold climate wind energy market potential

Tomas Wallenius, VTT Technical Research Centre of Finland
Esa Peltola, VTT Technical Research Centre of Finland

Installed wind energy capacity in cold climates was around 60 GW at the end of 2012 including both capacity in areas where extreme low temperatures or icing weather conditions occurs. Moreover, nearly 50 GW is forecasted to be installed until 2017. The business potential and demand for cold climate adapted technologies and services is substantial.

These figures came out from a market study dedicated for the first time ever for cold climate wind energy. The study was conducted by IEA Wind Task 19 – Wind Energy in Cold Cimates, an expert group acting under International Energy Association's implementing agreement for wind energy, and published in World Market Update 2012. An insight to this study will be given in Winterwind 2014.

BACK

Effects and possibilities based on a low price scenario with high volatility

Sten Lillienau, Neas Energy
Jakob Vive Munk, Neas Energy

Based on known facts, most long time prognoses currently paint a low price scenario for Nordic electricity prices at least until 2020. On the other hand we will most probably see a higher volatility due to the expansion of renewable production. This will mean challenges in signing long term power purchase agreements and instead motivate a more active sales and hedging strategy looking at short term trading.

The total amount of new production is estimated to a little more than 40 TWh. This is based on the goals of the stimulation programs for renewable electricity production in the Nordic countries and that the new nuclear reactor in Finland (Olkiluoto 3) is taken into operation. This means that we will have an overproduction scenario which will push the prices downwards. Furthermore the coal prices will most probably continue on a low level as long as the general economic outlook does not improve and shale gas production in North America continues according to plan. This all adds up to the low price scenario.

On the other hand the new renewable production capacity also has the effect that prices will be more volatile. Historically the Nordic prices have been influenced by weather (precipitation, temperature etc) whereas German prices have to a large extent been influenced by production costs, such as emission and coal prices. But also the German prices are now to a growing extent being based on meteorology. This became very obvious during the summer 2013.

All and all the changes in the electricity market means threats, but also opportunities.

By focusing on sales with short term hedging according to a clear strategy there will be possibilities to limit risk and on the same time take advantage of higher short term prices when they occur.

A number of examples of principles for hedging will be shown, both for when prices are at an acceptable level and when they are at a critically low level.

BACK

Wind Power Icing Atlas – tool for financial risk assessment

Ville Lehtomäki, VTT Technical Research Centre of Finland
Timo Karlsson, VTT Technical Research Centre of Finland
Simo Rissanen, VTT Technical Research Centre of Finland

Financial risk assessment related to icing of wind turbines is often very difficult in the wind power project site assessment phase. Site measurements are considered to be the best and most reliable source of information to assess icing conditions but are often too short (two years or less in total duration) to predict losses over the lifetime of a wind power project. The quantity and duration of icing events can vary up to 200% in total duration from one year to the next, making short measurement campaigns vulnerable to erroneous long-term assessments. Mesoscale weather models are able to model with decent accuracy also historical, site specific long-term icing effects. But using weather models require extensive expertise & know-how and can be very sensitive to the way the models are used.

Due to the typical shortcomings of on-site measurements (too short) and mesoscale weather models (difficult & expensive), a different approach to assess long-term icing conditions is proposed: The Wind Power Icing Atlas. The Wind Power Icing Atlas is a database of long-term, +20 years of historical measurements and observations from +4000 meteorological stations globally that can be used to predict icing condition for the whole project lifetime and financial risks quickly and efficiently. The main benefits of Wind Power Icing Atlas:

- Inexpensive and fast delivery of results compared to site measurements and weather models
- Unique early site ice classification to design the measurement campaign and quantify financial risks based on +20 years of historical observation data

To demonstrate the power of Wind Power Icing Atlas, 32 measurement stations near large scale wind farms with +30yrs of observation data globally have been selected to assess wind power project lifetime icing conditions. Based on the project lifetime icing conditions, financial risks near the selected weather stations were calculated for an example case of 20 x 3MW wind farm (hub height=100m, rotor size =100m).

BACK

ORAL

DE-ICING

Assessing energy production gains in icing conditions when utilizing de-icing equipped wind turbines under different operational modes

Benjamin Martinez, Vattenfall

In cold climate areas, deploying efficient and wind turbine (WT) integrated de-icing systems can reduce the amount of ice accreted on WT blades, reduce their fatigue, help to mitigate the risk of ice throws and enhance energy production. De-icing systems are generally triggered by ice detectors mounted in the nacelle or directly on the blades. Unfortunately, no ice detector has proven to be sufficiently robust and reliable, so a common practice when detecting ice is to use a combination of ice sensors in conjunction with an indirect technique based on SCADA data. This method is quite conservative, as it allows some non-negligible ice to build-up on the blades before de-icing is initiated. Setting up a more sensible detection measure would inevitably trigger false alarms and consequently reduce production so it is generally unwanted. Due to these inefficiencies, operating de-iced equipped WT’s during icing conditions becomes a very challenging task for operators as power output becomes difficult to maximize and ice throws difficult to mitigate. In addition to this, operators sometimes have to deal with restrictive wind farm permits where they are obliged to stop their WT’s when ice throw risk is foreseen. This usually implies that they can only de-ice once ice accretion conditions are over. It also implies that WT's are allowed restarting only in ice free conditions (assessed via ice detectors or by visual inspection of the blades using WT mounted cameras). In contrast, less restrictive permits will allow restarting the WT’s after de-icing regardless of the weather conditions. Considering all of the above, this study seeks to estimate and quantify the differences in energy production observed when operating under different permit types. Since no field data is available, this estimation is modeled and computed using a new deterministic production loss assessment technique based on Mesoscale, ice accretion [1] and production loss models. The study considers the icing climatology of the Stor-Rotliden wind farm located near Fredrika in Sweden and the de-icing system is assumed 100% efficient and modeled using a constant power consumption assumption. Results based on 2 winter seasons show that operating under less restrictive permits increases the winter energy production by more than 2%.

---

[1] L. Makkonen, *Models for the growth of rime, glaze, icicles and wet snow on structures,* The Royal Society 2000

BACK

Mobile Remote Energy (MORE) for heated wind measurement systems

Andreas Krenn, Energiewerkstatt (AT)
Hans Winkelmeier, Energiewerkstatt (AT)
Christoph Tiefgraber, Energiewerkstatt (AT)
Florian Lachinger, Energiewerkstatt (AT)

1. Introduction

Many cold climate sites offer excellent conditions for wind power production. However, the harsh climate in combination with the remoteness of many of those locations poses special challenges already during investigation of the wind power potential. Due to the lack of possibilities for power connection, but at the same time the need for heated anemometers, external power supply systems are installed. However, the high power demand of the heated sensors (150-350 Watt) and the long periods of sub-zero temperatures lead to large energy consumption. This results in high investment and maintenance costs already during an early phase of project development.

To meet the challenges described, a purpose-made stand-alone power supply system has been developed by Energiewerkstatt.

2. Methodology

As the site-specific conditions are crucial for the energy demand and production, the system is individually assembled with environmentally-friendly energy production components such as fuel cells, PV modules, small wind turbines and battery backup.

The heart of the technology is a specially designed energy management system (EMS), which has low internal energy consumption and manages several control tasks: Firstly, an essential part of the energy demand for the sensor heating is saved by using a site-specific heating algorithm and by taking into account the currently prevailing meteorological conditions. In addition, an advanced temperature management, consisting of a heating and ventilation, allows the battery and the fuel cell to operate at their optimum temperature. Furthermore, to minimise fuel consumption of the fuel cell, this component is only turned on, if the battery capacity is exhausted and no other modules supply energy.

The EMS allows the monitoring of the operation history by remote control and sending of warnings. This way, not only the proper operation is monitored, but also an additional learning effect as to the site-specific adjustment of the heating algorithm is generated. In addition, the prevailing conditions are verified via webcam.

3. Results

A three-year field test at various locations has shown that the system fully complies with the requirements. High data availabilities above 95% and a maintenance-free operation have been achieved. This results in significant savings of investment and maintenance costs for mobile power supply systems.

Anti-icing and de-icing of wind turbine blades using microwave technology

Kenth Johansson, SP
Joachim Karthäuser, Re-Turn AS
Mikael Järn, SP
Göran Gustafsson, Pegil Innovations AB
Bernt Granberg, MW Innovation AB
Peter Krohn, Vattenfall R&D AB
Stein Dietrichson, Re-Turn AS
Lars Dietrichson, Re-Turn AS
Mogens Mathiesen, n-Tec AS

Anti-icing and de-icing of wind turbine blades can be accomplished by microwave irradiation of a coating which contains microwave absorbers, such as graphite or carbon nano tubes (CNT). Radiation is provided through microwave guides which are placed within the wings. Radiation is only absorbed by the coating, not by the composite. As only the lightweight coating and not the heavy composite structure of the wing is heated, a very high energy efficiency and short de-icing times are achieved. The coating is electrically non-conductive despite the content of CNT. No cables are required, and the coating can be repaired like a standard gel coat.

Recently, the Swedish Energy Agency decided to sponsor larger scale verification of this technology. SP as project leader, Vattenfall Research, PEGIL Innovations, MW Innovation, Re-Turn AS and n-Tec AS formed a consortium to upscale this technology from the laboratory to field testing. The project includes further laboratory testing, work on technical aspects such as microwave technology and engineering questions, and work on safety aspects such as radiation levels and lightning risks. Further, one objective of the project is to test synergies with top-coatings showing reduced ice adhesion (passive anti-icing). Such top coatings are being developed in the TOPNANO project, see www.topnano.se.

The presentation will highlight technical market requirements, a comparison of different de-icing strategies, and technical opportunities as well as challenges of the microwave technology.

BACK

ORAL

DETECTION

Evaluation of field tests of different ice measurement methods for wind power

Helena Wickman, Vattenfall
Jan-Åke Dahlberg, Vattenfall
Peter Krohn, Vattenfall

Wind power in cold climate requires ice detectors both during the prospecting phase, in the site assessment, and during production for controlling of the turbines to help mitigate problems due to ice like production losses, fatigue loadings, ice throws and increased noise.

This study aimed to evaluate seven ice detector systems and their ability to detect time periods with ice and ice growth. The usability of the detector data for site assessment and controlling of the turbines was analyzed and discussed.

The tested detectors were: the T 40 series from HoloOptics (HoloOptics), 0872F1 Ice Detector from Goodrich (Goodrich), LID-3300IP from Labkotec (LID), IceMonitor from SAAB Combitech (IceMonitor) and IGUS BLADcontrol from Rexroth Bosch Group (IGUS). Two different combinations of anemometers, used for wind measurements, have also been analyzed for ice detection purposes. The first combination consisted of the three anemometers Thies 4.3350.00.0000 from Adolf Thies GmbH & Co.KG (Thies), Vaisala WAA252 from Vaisala Oyj (Vaisala) and NRG Icefree3 from NRG Systems (NRG). The second combination uses three differently heated NRG anemometers.

Data from field tests in Åsele municipality in the northern part of Sweden has been processed in MATLAB. Indications of ice and ice growth have been compared between the detectors to see how often they indicate concurrently.

The measurements showed that the IceMonitor and the three anemometers indicated the occurrence of ice at the same time most of the time. The detectors with the ability to detect ice growth (Goodrich, LID, T44 and T41, IceMonitor) had a lot fewer concurrent indications. The correspondence between production loss time periods and ice (IGUS) and ice growth (T41) indications were also low. Thus it was concluded that periods with ice were possible to find with a decent precision while ice growth and production loss periods were hard to find with any accuracy.

The biggest limitation to the detectors' functionality was the severe icing events that either hindered the detectors from working properly or broke them completely.

None of the detectors were recommended for controlling of the wind turbines. If the reliability of the detectors during the more sever icing events could be increase they could however be used for site assessment to give a rough idea of the icing climate.

Evaluation of field tests of different ice measurement methods for wind power - focusing on their usability for wind farm site assessment and finding production losses (2013), Helena Wickman (Degree Project in Engineering Physics, Uppsala University)

Analysis of the 3NRG ice detection system - and a comparison with commercially available ice detectors (2013), Helena Wickman (Project in Applied Physics, Uppsala University)

*Elforsk report 13:15, Experiences of differe ments methods (*2013), Helena Wickman

BACK

Retrofittable, Autonomous and Wireless Icing and Temperature Monitoring on Rotor Blades for Efficient Anti- and De-icing

Michael J. Moser, Science Park Graz
Thomas Schlegl, Science Park Graz
Hubert Zangl, Science Park Graz

We present a system of new-generation wireless icing sensors for wind turbines. The sensors, which are truly wireless and do not require maintenance, are easily mounted to almost any point of the blade, hub, nacelle or tower. Thus, icing can be detected exactly where it occurs first, for example, on or close to the leading edge of the blade tip. Temperature is measured with an accuracy of +-0.25°C, icing is detected at layer thicknesses below 0.5 mm. Measurement data is collected by a base station, which can be located on the nacelle, the tower, the transformer substation or on a met mast. This base station can transmit data to an existing SCADA system or directly interface with a anti- oder de-icing system. The sensors can be mounted over heaters or heated areas in order to efficiently control anti- and de-icing systems, which represents an additional advantage of the combined icing and temperature sensor. Furthermore, an ice-free blade surface can be detected uring stand-still of the blade. Laboratory tests have been successfully conducted, field tests under real-life conditions are currently in progress.

BACK

Wind turbine icing weather and power forecast algorithm assessements in Scandinavia

Frank McDonough, Dendrite Weather Consultants

A detailed study of several observed icing and ice shedding events at a wind park in Scandinavia from the winter of 2012-2013 are presented. These events were identified using observed data sets collected from the wind turbines and from a suite of co-located meteorological instrumentation and camera observations. The large and small-scale weather conditions leading to the icing and shedding events are briefly presented. Next, the performance from a set of four forecast algorithms are compared to the observations. The algorithms were designed to predict turbine icing, ice shedding, and the associated power losses and recoveries. The algorithms showed skill predicting the icing, icing related power losses, and ice shedding events. These algorithms may be used in the future by power grid operators to predict both short term icing related wind park power losses as well as potential climate related icing power losses.

BACK

ORAL

STANDARDS

Calculation tool for advanced simulations of turbine behavior at ice conditions.

Hans Ganander, Teknikgruppen AB

Wind turbines at cold climate conditions have been an issue for many years and have now become even more important due to increasing interest for exploitation at such conditions. Main obvious concern is about loss of power due to ice on blades which reduces the aerodynamic performance of the rotor. However there are more aspects of wind turbines operating in such conditions, which all together have led to several R&D projects over the last ten years. There are international and national projects run by e.g.:EU, IEC and Vindforsk, to large extent about meteorology, but also about standards. Parts of the standards (IEC-61400), certification and recommended practices are about requirements for calculations, taking ice on blades into account. Ordinary certification calculations have to assume differences between the blades. At ice conditions blade properties are much more influencing main as well as sub systems of the turbines, which requires improved knowledge and developed methods to get relevant predictions.

In order to cope with that the simulation tools have to be extended to deal with ice on blades. In short, the extensions include aerodynamic properties as well mass properties described along the blades individually. Regarding details the following aspects have to be involved to describe an iced rotor for a certain ice situation

- **Ice type**: Knowledge about aerodynamics of iced profiles
- **Blade ice situation**: define **ice type** (aerodynamics) and ice mass along the blade
- Calculate blade modes for actual **blade ice situations,** aerodynamics as well as mass due to ice are included.
- Define the **iced rotor**, based on **blade ice situation** for each one of the three blades, regarding equal and individual changes between the blades.

For a generic turbine impact of complex ice conditions will be presented, e. g. to what extent aerodynamics on one hand and ice mass on the other hand influences different components of the turbine. Except for power loss it will be shown that load disturbances occur in supporting structure components and subsystems as yaw system, pitch system and drive train, due to the consequences of unequally iced blades. Thus the ability to calculate turbine behavior at ice conditions is crucial for design, exploitation and de-icing system.

BACK

IEA TASK 19 Site Ice Classification – Case Studies and Recommendations

Rebecka Klintström, Vattenfall AB (SE)
Niels-Erik Clausen, DTU Wind Energy (DK)
Andreas Krenn, Energiewerkstatt Association (AT)
Matthew Wadham-Gagnon, TechnoCentre Éolien (CDN)
Tomas Wallenius, VTT (FIN)
Zhang Qiying, Guodian United Power Technology (CHN)
Göran Ronsten, WindREN, (SE)
René Cattin, Meteotest (CH)
Michael Durstewitz, Fraunhofer IWES (D)

Deployment of wind energy in cold climate (CC) areas is growing rapidly. The main issues of wind energy in CC arise from icing of wind turbine rotor blades which reduces energy yield, mechanical life time of turbines and increases safety risks due to ice throw. Another aspect of CC is low temperatures, which can affect turbine's mechanical lifetime. Wind resources in CC areas are typically good and large-scale exploitation of cold climate sites has started, but despite of new technical solutions for wind turbines for CC the question of the effects by CC on wind resource assessment still remains.

Cold Climates is defined by Task 19 – Wind Energy in Cold Climates, a research collaboration under the IEA Wind, as regions where icing events or periods with temperatures below the operational limits of standard wind turbines occur, which may impact project implementation, economics and safety. The severity of the CC issues at the site under interest is to be determined in the resource assessment phase.

In the "Recommended practices for wind energy projects in cold climates" report IEA Wind Task 19 introduce a site ice classification allowing planners to classify a project according to the site-specific icing. The presentation at Winterwind 2014 will focus on case studies of icing of sites in Canada, Switzerland and Sweden. The sites differ in terms of available measurements and measurement periods, as well as in in terms of turbine types and technologies. The sites are furthermore assumed to experience differences in the icing climatology with regards to icing frequency, duration of meteorological icing and duration of instrumental icing. Different methods to determine ice severity classifications for these sites will be discussed along with applications and improvements. The results from the case studies will be a step towards understanding how to best make use of a site ice classification and improve resource assessments in CC areas.

BACK

Input to new IEC 61400-1 design standards from two case studies of iced turbine load analysis

Ville Lehtomäki, VTT Technical Research Centre of Finland
Simo Rissanen, VTT Technical Research Centre of Finland
Klaus Sandel, Senvion (REpower)
Wolfgang Moser, Nordex Energy
Jochen Schenk, Nordex Energy
Matthew Wadham-Gagnon, TechnoCentre Eolien

Northern areas 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.. However, specific challenges arise in Cold Climate conditions as humid air conditions during winter seasons, leading to ice accretion on the rotor blades, decrease power production and may change turbine dynamics. Altered aerodynamics and additional blade ice masses due to icing can cause uncertainties for wind turbine design.

In order to better understand the structural dynamic effects for turbines in icing conditions, two unique and high class load measurement campaigns on two separate continents were conducted in order to investigate the effects of iced blades on main turbine components. Both turbines were without anti – or de-icing systems. Loads were measured from one Repower MM92 2MW turbine at TechnoCentre Eolien Riviere-au-Renard, Quebec, Canada research test site during winter 2011-2012 and from one Nordex N100 2.5MW turbine at Jokkmokksliden, Sweden for winter 2012-2013. Mechanical loads were measured from both turbines with strain gages from multiple locations. Different ice detection methods were used in order to distinguish meteorological icing events.

Both measurement campaigns showed similar results in terms of fatigue and ultimate load analysis. The fatigue or ultimate design lifetime of individual blades were not reduced compared to normal, non-iced operational values. While fore-aft (longitudal) tower base fatigue loads show a decrease due to the reduced rotor thrust, the side-to-side (lateral) bending moments increase. The increase in lateral tower base fatigue loads is mainly due to additional rotor imbalances. Shift in turbine operational point (delayed rated power and changes in blade pitch behaviour) may lead to unwanted controller behaviour and should be investigated with load simulations for turbines installed in Cold Climate conditions. However, more research is still needed in order to fully understand the complex phenomenon of iced blade effects of other structural parts of the turbine.

The load analysis results from the two measurement cases are used to develop new Cold Climate class turbines for the next edition of IEC 61400-1 “Design requirements for wind turbines” in addition to new Cold Climate specific design load cases in order to ensure safe and reliable turbine operation in Cold Climate conditions.

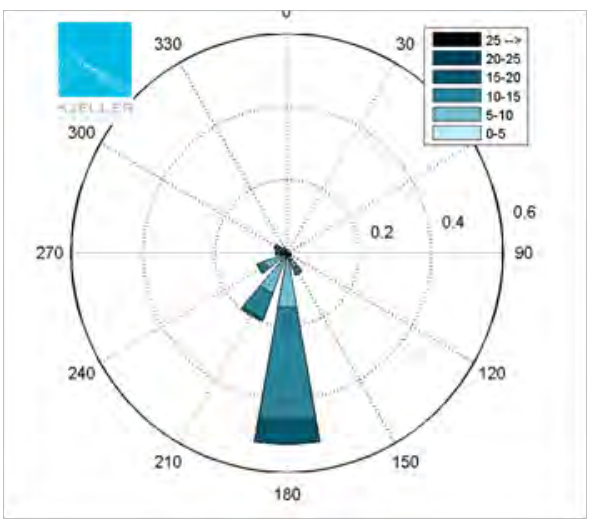
BACK

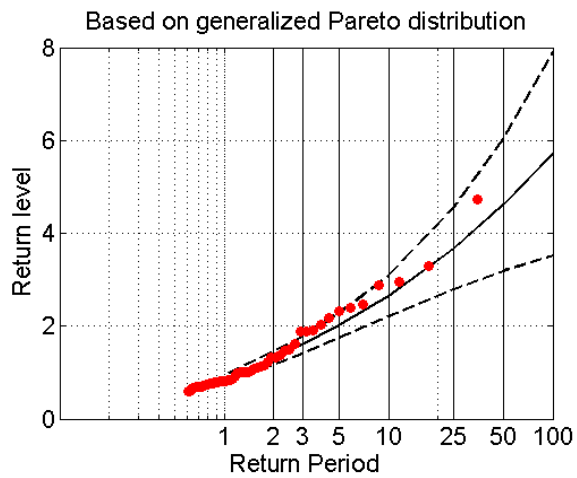
Risk of structural damage due to wind and icing - Modelling extreme weather loads

Bjørn Egil Nygaard, Kjeller Vindteknikk AS

All structures need to be designed to withstand local extreme weather like strong winds and heavy ice loadings. For projects in remote, cold climate areas, information on such the extreme weather is often unknown, and represents a substantial uncertainty to both operational reliability and installation and maintenance costs. Ice loads, wind gusts and their combined impact may severely affect measurement masts and instrumentation, turbines themselves or any connecting overhead power lines.

We present how Kjeller Vindteknikk utilize model generated weather data to analyze different icing types, wind gusts and estimate their extreme values with corresponding return frequencies, as exemplified in the figures below. Such analyses are currently being used as basis for mechanical design in several projects for the power grid industry, for construction of telecommunication towers and installation and instrumentation of measurement towers.





Left: Wind rose based on hours with icing intensity over 50 g/h. Right: Estimation of return periods for accumulated ice load based on 35 years of WRF data.

BACK

ORAL

REMOTE SENSING

Case study of Lidar in cold climate and complex terrain in Canada

Cédric Arbez, TechnoCentre Éolien
Mathieu Boquet, Léosphère
Raghu Krishnamurthy, Léosphère

The Lidar installs in cold climate is a new practice from the wind industry to assess the resource. According to BTM market study, 22 GW of new wind farms will be developing in cold climate in North America. To follow this tendency, this paper will focus on the technological validation of LIDAR in cold climate in completion with the current best pratice. In order to validate this technology in North America, TCE performs a measurement campaign at R&D SNEEC site , located at Rivière-au-Renard, Québec in Canada. This site is considered complex terrain and is qualified as cold climate according to the GL Technical note 69 .

In completion of the test performed at Anse-a Valleau a WINDCUBE V2 Lidar has been installed to perform an additional measurement campaign near a met mast of 126 m height during 4 months near Rivière-au-Renard site. This met mast is equipped with more than 30 sensors especially ceilometer, standard differential probe, heated and unheated anemometer installed at 5 levels, wind vanes. The data acquisition is synchronized at 1Hz with the Lidar through Osisoft Pi archive system.

Regarding this measurement campaign, TCE and Léosphère focuses on 4 analyses:determine the data availability of the Lidar;study the operational limitation that occurs during the operation due to cold climate; (manner to install and communicate) complex site calibration; global performance of Lidar in wind uncertainties in complex terrain.

First, Leosphere and TCE will analyse data to ensure the functionality of remote sensing device in cold climate especially. The data availability of the Lidar has been calculated at each 10 min. to qualify themselves. In order to verify the operational performance of Lidar, we focus on the reason of low data availability period for the raw data. The goal is to ensure the condition when the Lidar loses the data and correlate it with meteorological condition. At the end, a cross comparison between the met mast wind speed and direction have been calculated to ensure the best performance of this technology in cold climate and complex terrain.

---

[1] Navigeant Research, http://www.navigantresearch.com/research/world-market-update-2012

[1] VTT, Capacity in CC (up to end 2012) and forecaster(2012-2017) in MW, consulted http://www.vtt.fi/files/news/2013/tuulivoima/Capacity_in_CC_English.pdf

[1] A.Albers et al. “How to gain acceptance for LIDAR measurements”, Deutsche WindGuard, 2008

[1] GL Technical Note 069, Reco

[1] Pelletier, M. and al., Lidar validation in complex terrain, EWEC 2011.

Performance of LiDAR in Icing Conditions - Comparison to a 200m met mast in complex terrain

Zouhair Khadiri-Yazami, Fraunhofer IWES
Michael Durstewitz, Fraunhofer IWES
André Baier, Fraunhofer IWES
Tobias Klaas, Fraunhofer IWES

LiDARs (light detection and ranging) as ground based remote sensing devices offer an appealing alternative to traditional wind measurements using anemometers mounted on masts. They are mobile and allow the measurement of wind profiles at multiple heights without the need to erect an expensive tower. Due to its measurement principle LiDAR measurements are not directly influenced by low temperature and high humidity. Therefore LiDARs are suitable for measurements in cold climate and icing conditions. However the availability of LiDAR measurement in icing conditions could decrease due to the clear atmosphere at very low temperatures.

This study deals with the performance of LiDAR in icing condition. The LiDAR measurements of a pulsed LiDAR are compared to wind measurements from the 200m metrological mast of Fraunhofer IWES. The mast is one of the highest meteorological masts in Europe. It is equipped with more than 40 sensors. Several cup and sonic anemometers, which are heated, unheated and half heated, are installed at multiple heights (at least every 20 m). Additionally several meteorological sensors and a ceilometer provide detailed information about atmospheric conditions.

The met mast is located on a small mountain called Rödeser Berg about 30 km from Kassel in northern Hesse, Germany. Several LiDAR and mast measurements are carried out on the ridge of a hill with a height of about 260 m above the surrounding terrain and 400 m above sea level. With about 500 hours of instrumental icing being measured in the winter 2012/2013 the location offers ideal conditions to study instrumental icing and the performance of LiDAR measurement under icing conditions.

In addition to the comparison of measurements this study shows the influence of icing of the local wind regime. The impacts on energy losses and yield estimation are discussed as well.

BACK

Wind measurement in extreme conditions

Daniel Marmander, Natural Power

Wind measurements and flow modelling are a part of almost every successful wind power project development. For a site in complex terrain, measurements and advanced modelling is even more important. The success of the project will heavily depend on the outcome of the measurements and models working well and being used in the best possible way.

In the Nordic countries the challenges of complex terrain are more often than not combined with icing and low temperatures as well. Some sites will be complex in a broad range of aspects; local recirculation zones, no-laminar wind flow, low clouds, high turbulence, severe icing, low temperatures and high maximum wind speeds. In combination with the site being very remote and hard to reach, such sites often pose a great challenge with regards to measurement quality and model accuracy.

In order to address the above challenges, a measurement campaign using a combination of CFD modelling and multiple different measurement instruments has been designed. Both conventional measurement masts and remote sensing devices have been used. At multiple locations conventional mast measurements and remote sensing devices have been co-located in order to fully assess the potential differences. An assessment has been made with regards to the success of the modelling and measurement campaign during the worst conditions of the year; the winter months.

The assessment addresses the questions about:

- How well the remote sensing devices perform with regards to availability, when being deployed in what might be considered as the worst possible conditions.
- How well the flow model performs in a complex terrain, where very local flow distortions are expected to occur.
- How well a conventional measurement mast performs compared to a remote sensing measurement during severe icing conditions, with regards to flow distortion as a result of ice build-up on the mast structure.

BACK

ORAL

MAPPING

Inter-comparison of icing production loss models

Neil Davis, DTU Wind Energy
Andrea Hahmann, DTU Wind Energy
Niels-Erik Clausen, DTU Wind Energy
Mark Zagar, Vestas
Øyvind Byrkjedal, Kjeller Vindteknikk
Timo Karlsson, VTT
Ville Turkia, VTT
Tomas Wallenius, VTT
Magnus Baltscheffsky, WeatherTech Scandinavia

Developing a method for predicting power loss due to icing is of great concern for developers looking to build wind farms in cold climate locations. As part of the Ice Wind project four different ice production loss models have been developed at DTU, Kjeller Vindteknikk, VTT, and WeatherTech Scandinavia. We have compared these models at 15 wind parks spread across Canada and Sweden for the winter of 2011-2012. The models were first fit using the winter of 2010-2011 for these same wind parks. To isolate the performance of the ice model and production loss model, all tests used the same meteorological model results provided by Vestas. The four methods are described briefly below.

- The DTU approach involves using the iceBlade icing model to predict ice mass on the blade of the turbine from the meteorological results, and then uses a statistical model to estimate the production loss based on iceBlade and meteorological model inputs.
- Kjeller uses the Makkonen icing model to estimate ice load on a standard cylinder and then estimates the power using a 2 parameter power curve with production as a function if ice load and wind speed.
- VTT’s Icing Production Loss Module is based on a statistical analysis of production loss observations. It is independent of weather and ice modeling, and can be easily incorporated to any short term wind power forecasting system, its original development target, or used in long term production loss estimation.
- In WeatherTech Scandinavia's method, output from the WRF-model is used as input to an Artificial Neural Network, which has been trained using observed clean and iced production. The power loss model, WICE, has been tested for different turbines and in many different locations. WICE can be set up for use as a forecasting tool or as an assessment tool.

BACK

A STUDY OF TURBINE PERFORMANCE UNDER COLD WEATHER DRIVEN STABLE ATMOSPHERIC CONDITIONS IN SCANDINAVIA

Carla Ribeiro, DNV GL (former GL Garrad Hassan)
Benjamin Buxton, DNV GL (former GL Garrad Hassan)
Simon Cox, DNV GL (former GL Garrad Hassan)

In Winterwind 2013, DNV GL, formerly GL Garrad Hassan (GL GH), put forward the initial results of an investigation into the effects of atmospheric conditions experienced in Scandinavia on the performance of wind turbines [1]. The authors have demonstrated that highly stable atmospheric conditions are frequently encountered in this region and therefore potential effects on turbine performance should be investigated.

Under stable atmospheric conditions turbulence intensity levels are typically low (< 10%). Thus low turbulence is seen as a proxy for atmospheric stability. These conditions materially differ from the wind flow conditions for which power curves are usually valid. GL GH has therefore been investigating potential effects on their performance by studying power performance measurement (PPM) data from a number of regions across the world, and in [1], specifically for Scandinavia.

Previous results [1] showed that when comparing production under low turbulence to high turbulence, there was a loss of performance in the rising part of the power curve. However, the opposite was true in the wind speed range of 8 m/s to 12 m/s, the so-called “knee” of the power curve. In [1], GL GH also shows that the site calibration performed as part of the PPM should be dependent on the atmospheric conditions experienced at the test site. The investigation suggests that an improvement in the site calibration procedure, considering different speed-ups for different atmospheric conditions, reduces the differences in performance seen under low and high turbulence, and when this was considered, there was no overall loss or gain of performance under low turbulence. Such a procedure is in fact proposed in the new draft of the IEC standard 61400-12-1 for the PPM of wind turbines.

In [1], GL GH considered 5 PPMs. In this study, the authors propose to increase the number of PPMs under consideration, with the aim of creating a body of evidence that is statistically significant. Furthermore, we propose to increase the sophistication of the analysis by considering not only turbulence but also shear as a factor affecting performance.

Through analysis of the expanded database of PPMs, GL GH considers the new IEC recommendations and establishes the magnitude of contribution of stable atmospheric conditions to the performance of wind turbines experienced in cold climates.

---

[1] Ribeiro C., Cox, S., Lindahl, S., 2013. “An investigation into turbine performance under cold weather driven stable atmospheric conditions in Scandinavia”. Winterwind Conference, Sweden, 2013.

BACK

Simple methodology to map and forecast icing

,

There is a strong need to assess the icing conditions over the lifetime of a wind power project to evaluate icing related risks. However, due to the complexity of icing in terms of performing and analysing on-site measurement or simulations with weather models makes icing assessment a large challenge. There is a need for reliable and simple ice mapping and forecasting methods.

Highlighting the most important conditions during icing events for wind turbines is selected as a starting point for more simple ice mapping techniques. In order to better understand the important and typical variations in measured icing conditions and their effects to blade aerodynamics, a sensitivity analysis of wind turbine blade iced airfoil aerodynamic performance to icing parameters of liquid water content (LWC), median volumetric diameter (MVD), temperature (T) and icing duration were considered. Eight different scientific studies of icing wind tunnel measurements for 2-dimensional airfoils were analysed and resulting iced airfoil results were divided into 4 categories: Start, Light, Moderate and Extreme Icing. All 4 categories (in total 58 iced airfoil lift and drag performance measurements) showed similar results for the aerodynamic performance degradation: airfoil lift decrease and drag increases rapidly as a function of angle of attack (AoA) indicating earlier stall effects for the airfoils.

The duration of icing conditions was found to be the most important parameter in assessing icing conditions. The sensitivity analysis revealed that typical variations in nature for LWC, MVD and T had only minor aerodynamic performance penalty effects. However, as icing conditions start, ice accretion deteriorates the airfoil aerodynamic performance (and wind turbine output power) very quickly, in less than 15 minutes.

From the study performed it can be concluded that the severity of icing is dominated by the duration and number of icing events over the lifetime of a wind power project. From an ice forecasting and mapping viewpoint, icing can be considered as an on/off criterion for wind turbines.

VTT’s “Wind Power Icing Atlas” is a tool to predict the duration of specific wind power project lifetime icing conditions and financial risks quickly and efficiently. The Wind Power Icing Atlas is a database of long-term, +20yrs of historical measurements and observations from +4000 meteorological stations globally.

ORAL

ENVIRONMENTAL IMPACT

What is the point of caring about birds and reindeer? We now know a lot more!

Niklas Lindberg Alseryd, Maria Bergstén, Anders Granér, Andreas Bernhold, Anders Enetjärn, Enetjärn Natur AB

Enetjärn Natur has experiences from several major control programmes related to wind farms in Northern Sweden, and important conclusions from the studies will be presented.

Reindeer husbandry - We have several ongoing control programmes for reindeer husbandry, including one at Gabrielsberget, Nordmaling. Our conclusion is that this wind farm has resulted in negative effects on the reindeer and on reindeer husbandry. The reindeer use of the wind farm area and its near surroundings has decreased by 50 percent according to interview data. Our observations of GPS-tracked reindeer indicate that there was no undisturbed grazing behaviour within a 2 km radius from the centre of the wind farm. However, the results show that undisturbed grazing behaviour did occur at distances of 2 km or more from the centre of the wind farm area, a result similar to some other research studies. Our analysis also shows that the reindeer actively choose areas with high quality grazing. We believe that this fact has not been taken into account in previous environmental assessments and we argue that this should change in the future.

Birds - The control programmes on birds include studies ranging from breeding bird surveys in alpine environments (Uljabuoda) to migration studies at a coastal site close to Umeå. The results from Uljabuoda indicate that the wind farm has not caused any significant negative effects on the local birdlife. For example, the number of nesting Golden plovers initially decreased during the construction of the wind farm but has now recovered.
The coastal study shows that migrating birds avoid the wind power farm rather than pass through. Prior to construction an average of 40% of the registered birds flew through what is now the wind power farm and the area immediately surrounding it, compared to 7% after the establishment. However, for gulls and birds of prey, e.g. Rough-legged buzzard, a relatively large proportion of the migrating birds have continued to pass through the wind power farm. No bird fatalities have been detected during the survey.

What is a relevant control programme? - When control programmes are called for by the authorities – what options are there for a planner to respond? How do we identify the specific aspects that are relevant, and how can we predict if enough data of good quality can be collected to answer the question; Were there any consequences?

Enetjärn Natur 2011. Windpower on Uljabuoda. Follow-up of the plant's impact on birds, predators and reindeer. Report 2011. Enetjärn Natur on behalf of Skellefteå Kraft. (In Swedish)
Enetjärn Natur 2012. Control program for migrating birds at Hörnefors wind farm. Progress report from the 2011 survey and summary of results 2003-2011. Enetjärn Natur on behalf of Umeå Energi. (In Swedish)
Enetjärn Natur 2013. Wind power in Markbygden. Follow-up program for fauna and flora. Annual Report 2012. Enetjärn Natur AB on behalf of Markbygden Vind. (In Swedish)
Enetjärn Natur 2013. Windpower on Gabrielsberget. Follow-up of the consequences for reindeer. Fifth year results. Enetjärn Natur on behalf of Gabrielsberget Vind. (In Swedish)

Year Round Monitoring of Low Frequency Noise in Harsh Climates

Antti Leskinen, APL Systems Inc.
Timo Mämmelä, APL Systems Inc.
Roy Hjort, APL Systems Inc.
Kari Saine, Wärtsilä Finland Inc.

The Scandinavian winter poses technical and logistic challenges for those of us who deal with measuring noise in outdoor conditions. Extreme cold puts a strain on both measurement equipment and those operating them. Still, noise issues are not confined to the warmer months. The acoustics of any given environment will change as the seasons change. How does one keep track of the day to day changes in the acoustic surroundings? The most obvious answer is to develop the technology necessary to continually measure noise in the Scandinavian climate. Low frequency noise (LFN) is one those areas that cause often problems for wind power operators as well as industrial operators such as e.g. diesel engine manufacturers. Low frequency noise dissipates slowly and may be a source for irritation and concern for those living around the source of the LFN. Continuous monitoring will give the tools necessary for dealing with LFN issues as the effects of any changes made to production cycles or production methods will be seen immediately in the measurement results. Aures 2.0. OnLine has been developed by APL Systems in cooperation with Wärtsilä Finland and will work equally well in urban industrial settings as well as rural settings.

ORAL

CONSTRUCTION & HEALTH AND SAFETY

Douglas Vaught
V3 Energy, LLC
Eagle River, Alaska, USA
dvaught@v3energy.com
www.v3energy.com
+1 907.350.5047

November 16, 2013

Subject: Abstract for Winterwind 2014, International Wind Energy Conference

Title: Wind-Diesel Project Development in Isolated Grid Communities of Alaska

Development of wind power in small, isolated grid villages and communities in Alaska requires consideration not only of cold climate effects on wind turbine operations, but also interaction with diesel generators. Projects of this nature are known as wind-diesel hybrid systems and principles of design are applicable to similar communities in circumpolar and other isolated regions of the world.

The primary consideration with wind-diesel design is the penetration level, defined as the percent of wind power supplying the electrical load. In general, there are four penetration categories recognized in Alaska village wind power work: very low, low, medium, and high. Electrically, very low penetration is analogous to wind turbines connected to a large grid where wind turbines contribute a minor percentage of load, both average and instantaneous. Low penetration wind contributes at most 20% average supply but increases instantaneous to over 100%. This requires grid stability mechanisms and diversion of energy to non-AC loads. Medium penetration substantially increase instantaneous wind input, requires grid stability control and adds additional control measures to avoid energy saturation of non-AC loads. High penetration adds the advantages and complexity of electrical storage and diesels-off operation.

A primary limitation of isolated grid (village or small community) wind-diesel projects is availability of suitable wind turbines. The world wind market has migrated to megawatt plus capacity turbines for utility-scale projects, but village-scale wind needs are generally 100 to 500 kW and few new models are available in this range. Remanufactured wind turbines from utility wind farm re-powering projects are a possibility and present some advantages compared to new. For both new and remanufactured village-scale turbines, there appears to be relatively limited de-icing/anti-icing and cold climate capability available and research is somewhat limited by market forces.

Assessing options with wind-diesel system design requires not only wind resource assessment, but also modeling of static energy balance to assess the impact of wind generation with different turbines at various penetration levels. Dynamic system modeling is employed to assess grid stability at high wind penetration with complex control mechanisms. Economic models are used to evaluate project benefit-to-cost considerations.

Requirements for wind turbines in harbour areas

Jan Hauschild, TÜV NORD SysTec
Kimmo Palmu, Hamburg Wasser
Dirk Bauer, Hamburg Wasser
Frederik Lautenschlager, TÜV NORD SysTec

Requirements for wind turbines

The increasing use of wind turbines in Germany has shown, that suitable open areas for the installation of wind turbines are increasingly difficult to find. Special locations, such as harbour area lead to particular requirements for wind turbines especially if hazardous events (e.g. ice fall & throw) can cause immediate damage due to the special site conditions (shipping, storage, hse). Risk assessments are necessary due to hazardous initiating events like e.g. ice fall & throw (Hauschild, J. et al. 2011, Hauschild, J. et al. 2013).

Site specific Conditions

In the harbour of Hamburg have been constructed several wind turbines. There exist experience of ice throw and the areas beneath and near the wind turbines are used for storage, infrastructure and industry. It was evident that all technologically possible had to be done to assess and reduce the risks of ice fall & throw. Different boundary conditions play an important role within a site specific risk assessment. With respect to ice fall & throw the icing frequency, the wind conditions (distribution of wind direction and wind speed) and the distances to the endangered objects have to be considered. For Hamburg there exist measured wind data on condition of icing events.

Expected Results

On basis of climatic field data wind statistics (wind direction, wind speed) were analysed. Based on the icing data from the Hamburg airport climate station could the wind statistics be analysed on condition of icing events. The comparision of wind statistics based on an annually data basis and based on the icing date shoved great differences in both wind directions and wind speed. To validate this result, the O&M data was compared with the icing occasions. The evaluated wind data will be used within a risk assessment (fictitious case study – harbour area). The results will be compared and discussed and especially the differences in the results between annual data and icing conditions data are visualised. Moreover methods to reduce the risks of ice fall & throw will be described and discussed based on the results of the case study.

REFERENCES

Hauschild, J. et al. 2011. Monte-Carlo-Simulation zur Risikobewertung von Windenergieanlagen. Düsseldorf: VDI-Verlag, Tagungsband TTZ 2011. "*Monte Carlo-Simulation for the Risk Assessment of Wind Turbines, ice fall & throw - ERAWind: Environmental Risk Assessment of Wind Turbines*"

Hauschild, J. et al. 2013. Methoden zur Risikobeurteilung von Windenergieanlagen. Düsseldorf: VDI-Verlag, VDI Bericht 2210, 2013. "*Methods for the Risk Assessment of Wind Turbines, ice fall & throw; roto blade brekage, tower collapse - ERAWind: Environmental Risk Assessment of Wind Turbines*"

Agora Energiewende 2013, Kostenoptimaler Ausbau der Erneuerbaren Energien in Deutschland, Oktoberdruck, Berlin "*Cost optimised development of renewable energy in germany*"

Operational forecasting of icing and wind power at cold climate sites

Øyvind Byrkjedal, Kjeller vindteknikk

Operational forecasting of power production, icing and production losses due to icing has been carried out for two wind farms in Sweden during the winter 2012-2013. Both wind farms experienced periods with severe icing during the winter resulting in periods with large power losses. The forecast simulations are run 4 times daily, each with a lead time of 48 hours.

The power forecasts with and without losses due to icing is compared to the hourly production data from the two wind farm. It is evident that for both wind farms that the accuracy of the forecasts is improved when the power losses caused by icing are taken into account. For both wind farms the mean absolute error (MAE) of the forecast is reduced by 0.02 when the power losses due to icing are included. The MAE for the two wind farms when power losses due to icing is included is 0.11-0.15 for wind farm A for different lead times, while 0.10-0.13 for wind farm B. The correlation coefficient between forecasted and actual power is increased by approximately 0.05 when the power losses due to icing is included. The correlation coefficient at lead time 12 hours is 0.78 for wind farm A and 0.88 for wind farm B when power losses due to icing are included. The correlation coefficient typically reduces while the MAE increases with increasing lead time.

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

During the winter 2013-2014 the operational forecasting of icing and continues. Forecasts of icing and power for several wind farms will be carried out. The model simulations will also be used to forecast the presence of dangerous ice amounts in a 200 m tall telecom mast in Oslo.

ORAL

PRODUCT EXPERIENCE, OPERATIONS AND MAINTENANCE

SEU O&M experiences of wind turbines in Cold Climate- Handling risk of Ice Throw

Thomas Mannelqvist, SEU

2013 SEU gave a presentation regarding O&M of Wind Turbines in Cold Climate. This year we would like to share Our gained experience, one year later. SEU will present Our risk assessment and analysis together with examples what can happens when snow and ice falls from turbines.

As Skellefteå Kraft's In-house Maintenance BA, SEU is responsible for Skellefteå Kraft's Wind Sites Blaiken/ Jokkmokksliden/ Storliden and Uljabouoda in total 88 WTG's all designed for Cold Climate now we are on the road to design ore working enviroment in proximety of the WTG´s.

Suorva, a 600 kW cold climate research turbine – a journey from 1998 till today

Jan Norling, Vattenfall

The Suorva wind turbine was one of the first cold climate equipped wind turbines in Sweden. The 600 kW Bonus turbine, now Siemens, was during late 90's one of the commercial mass-produced workhorse with nearly 3000 turbines produced. In 1998 Vattenfall invested in this single turbine for research and development purposes. It was proven base technology, with some cold climate additions and located in a new harsh environment. The turbine was built on a ridge 470 m above sea level in the LuleåRiver valley, 100 km north of the polar circle. Therefore an evaluation programme was linked to the construction and operation. This was carried out between 1998 and 2001.The evaluation programme consisted of seven areas: acoustics, acceptance, operation & maintenance, land use & environment, power performance and ice & loads. The results showed that it was realistic to develop, build and operate cold climate wind turbines although there were some challenges.Today, 10 to 15 years later a lot of projects have been and are developed in Sweden's most northern part, in cold climate. Did the evaluation programme help in that development? Further on, the challenges identified at that time, are they still challenges? Do the suppliers have the needed cold climate equipments in their product catalogues? The presentation will cover the project from construction and operation, assessment programme and the situation today in that context.
Key words: Wind turbine, Bonus, Siemens, Suorva, Sweden, cold climate, blade heat system, anti-icing system, Vattenfall

---

TransAlta's Operational Experience with Blade Icing

Jeff Nelson, TransAlta

TransAlta's Kent Hills wind facility began commercial operations in late 2008. During the winter operating months the site has experienced extensive blade icing conditions which contributed to a significant loss in production. In addition, these conditions have led to safety challenges for both O&M staff and the public who use the area for recreational purposes. There are no ice detection, prevention or removal capabilities on the V90-3.0.

Early experiences with icing led TransAlta to take the approach that proactive pausing of the turbines was the best method of preventing long term lost production. Limiting the amount of ice that builds up on the blades, makes it easier for the unit to shed at re-start. This is especially important if the weather is below freezing for extended periods of time. However, this becomes challenging during after-hours periods when no personal are monitoring the ambient conditions at site.

In the summer of 2010 TransAlta undertook a project to review the current market for ice detection, de-icing and anti-icing technologies and previous research projects. Through this project it was determined there were no well-established standards for operators to reference for icing detection, prevention and removal.

Based on this research and the assistance of other groups who have tested similar technology, TransAlta implemented several initiatives to help minimize down time. In 2010/2011 TransAlta implemented several met tower ice detectors, several nacelle top cameras and icing operating procedures for the 24/7 TransAlta Wind Control Center. Through these efforts TransAlta was able to reduce lost production.

The implementation of the ice detector provided effective notification to both on site staff and the afterhours monitoring center located in Alberta. Through this early warning indicator site was able to verify ice buildup on the nacelle top camera and verify if the actual power curve was degrading due to ice buildup on the blades. Factoring in the weather forecast for either warm or cold weather, operations were able to make the decision to shut down the turbines.

In 2011/2012 TransAlta installed blade vibration monitoring as an added measure to detect icing events and optimize shutdown in an automated manner.

Rene Cattin - COST Action 727 - Alpine Test Site Gütsch

ORAL

HEALTH AND SAFETY

Risk of icefall in the international context

Andreas Krenn, Energiewerkstatt (AT)
Niels-Erik Clausen, DTU Wind Energy (DK)
Matthew Wadham-Gagnon, TechnoCentre Éolien (CDN)
Tomas Wallenius, VTT (FIN)
René Cattin, Meteotest (CH)
Göran Ronsten, WindREN (S)
Rebecka Klintström, Vattenfall (S)
Michael Durstewitz, Fraunhofer IWES (D)

Zhang Qiying, Guodian (CHN)

1. Introduction

The potential risk of falling ice from wind power plants has been known for quite some time. Due to the rapid growth of wind energy projects in locations prone to icing, an increasing interest of many national regulatory authorities towards the assessment of the risk of falling ice fragments has been observed.

As part of the work of IEA Task 19 ‘Wind Energy in Cold Climates’, it turned out that this matter is dealt with very differently in the partner countries. While some partner countries have set remarkably restrictive measures in international comparison, other countries treat this issue less far-reaching.

At the same time, in many countries, the lack of transparency and accountability in the regulatory requirements poses an obstacle in the planning and permitting process.

2. Methodology

In order to survey the usual approval procedures and the international stipulations in the approval process, a questionnaire is created, which is passed to each partner of the IEA Task 19 for processing.

In this questionnaire, the legislative framework conditions in the partner countries and the common licensing practices are collected.

In a first step, the criteria for the determination of the extent of the safety zones around the wind turbines are evaluated. Furthermore, it is examined which requirements from the notification of approval must be complied with. Essential in this context is in which way ice is detected, if there is a commitment to shut down the turbine with iced-up blades, if rotor blade heating systems are prescribed by the authorities and which measures need to be implemented for the signposting and safeguarding of ice fall or ice throw endangered areas.

3. Results

As a result, the requirements and differences of each partner country of IEA Task 19 as to the licensing practices and the legislative requirements regarding the assessment of the risk of falling ice fragments from wind turbines are shown in a comparison. This way, the path leading to transparent and science-based methods and furthermore to improve and unify authorization practices can be paved.

IceRisk: Assessment of risks associated with ice throw and ice fall.

Rolv Erlend Bredesen, Kjeller Vindteknikk AS
Knut Harstveit, Kjeller Vindteknikk AS
Helge Refsum, Lloyd's Register Consulting - Energy AS

When ice that has built up on a turbine blade is released it can be thrown hundreds of meters in the worst cases. The piece of ice may hit people, animals or property around the turbine and consequently cause severe damage.

IceRisk is a state-of-the-art method for assessing the risk related to ice throw and ice fall from turbines or other tall structures such as met- and telecom- masts. The ice throw risk zones and safety distances calculated with IceRisk can give useful information in the process of licensing of a wind farm project, development of preventive measures and routines for the personnel that will work in the wind farm during winter. The method has been utilized on large telecom masts and wind farms with public activity in the surroundings. The results are presented as maps showing how the probability for ice impact varies within the wind farm. The results are also supplemented with a damage risk evaluation which is performed in cooperation with Lloyd’s Register Consulting.

IceRisk calculates the impact position and impact energy of the ice pieces released from different positions on the blades. Heavier ice pieces can be thrown further than light pieces, but light pieces may drift longer distances in strong winds. The degree of danger associated with being hit by an ice piece depends mostly on the impact kinetic energy and the consistence of the ice piece.

IceRisk have been used to assess the risks related to ice falling from a 209 m telecom mast at Tryvann, Oslo. Ice cubes (rime ice) with a weight of more than 150 g falling from the mast was considered dangerous as the impact energy can exceed 40 Joules.

The IceRisk model is linked to a hindcast archive with timeseries of meteorological parameters such as icing, wind speed, wind direction and temperature from the last 33 years. This archive was used to define the periods of icing and the associated ice amount in the structure. In 4-5 % of the time (year) dangerous ice pieces could fall from the telecom mast. There are large variations from winter to winter but on average there are 4 yearly episodes with dangerous ice in the mast. The furthest drift distance was found to be less than the height of the construction. Ice loads are forecasted with an operational forecast model during the winter 2013-2014, and systematic registration of ice fall will be performed during the season.

BACK

Validating an Ice Throw Model - A Collaborative Approach

Gail Hutton, RES Group
Alan Derrick, RES Group
Matthew Wadham-Gagnon, TechnoCentre Éolien
Dominic Bolduc, TechnoCentre Éolien

The ability to map and quantify the risk of ice strike around a turbine deriving from ice thrown from the blades is critical to understanding the safety of a wind farm operating in a cold climate. The quantification of risk should allow not only for a better agreement on safety policy but also for a better understanding of risk to on-site staff.

At WinterWind 2013 RES presented results from a theoretical model of ice throw. This type of model has proven very useful in addressing public safety concerns both in Sweden and beyond but is, of course, based on a number of assumptions or simplifications. Validation, based on observational ice throw data, should be a key part of the modelling process.

The TechnoCentre Éolien (TCE) has been collecting observational ice throw data from its cold climate test site in Gaspé, Canada for over two years, building up a database with details of over 300 ice throw fragments. This includes information on weight, throw distance and orientation, and the corresponding climatic conditions relating to each ice throw event.

As a result of meeting at WinterWind 2013 RES and TCE have formed a collaborative research agreement, using the TCE database of observed ice throw to examine the assumptions of the RES ice throw model and to validate the results from this.

This presentation will demonstrate key results from this research partnership. In particular, it will highlight the main findings from the validation and the improvements in modelling that have arisen from these. Future applications of the ice throw model will also be discussed.

BACK

ICETHROWER – ICE THROW Evaluation and Risk analysis tools

Bengt Göransson, Pöyry SwedPower
Erik Aretorn, Dala Vind AB
Rebecka Klintström, Vattenfall Vindkraft AB
Björn Montgomerie, Programografik
Jörgen Svensson, Skelefteå Kraft AB

Today the risks with staying inside or in the vicinity of windfarms during the winter season are uncetain as well as which safety distances should be applied due to the risk of ice throw. This project aims to strengthen the knowledge of the risks in Sweden and develop a practical tool for Swedish stakeholders to calculate risks and throw distances. The project consists of a part for collection of site data from three windfarms in Sweden with different specifications, as well as development of one physical and one statistical model to simulate ice throw and to calculate risks.

Three wind farm owners, Dala Vind, Vattenfall Vindkraft and Skellefteå Kraft, will collect data from wind turbines with and without blade heating during the winter season 2013-2014. Data will be collected in a database and will be used to a) develop a statistical simulation model; and b) verify the existing Swedish aerodynamic model KASTIS developed by Programografik and Vattenfall.

The sub targets of the project are:

- Produce a database for ice throws from heated and non-heated wind turbines in cold climate;

- Examine the collected data and evaluate the importance of a blade heating system;

- Develop a statistical model and refine the existing KASTIS model by calibrating against the database;

- Combine the two models and achieving a practical tool for calculation of the ice throw risk; and

- Give operators a tool for ice throw risk calculation together with other recommendations.

The database and the developed simulation tools will be public.

The project is supported through a grant by Energimyndigheten in the frame programme Vindkraft i Kallt Klimat (Windpower in Cold Climate).

ORAL

PRODUCTION LOSSES

Real time line sag detection

Klaus Känsälä, VTT Technical Research Centre of Finland
Kalle Määttä, VTT Technical Research Centre of Finland

Electric distribution network breakdowns can cause significant damage to business and society and provoke dissatisfaction among consumers. Breakdowns caused by accumulated snow and ice, or any other significant extra load like hard wind in mountain areas, can be prevented using advanced sensor solutions technologies.

The solution developed by VTT is based on advanced technology that combines online sensor data measurements, real time wireless data transfer, and energy harvesting technology to a compact package which can be easily mounted on the power line. Due to remote locations it is critical that the lifetime of the sensors is long – lifetime expectancy needs to be 8-10 years without maintenance. When the sensors are mounted on these “hot spots” real time remote monitoring of the extra load becomes possible. The rigorous data analysis combined with web-based service enables accurate line maintenance tasks planning and prevents line damages and break downs in electricity distribution providing significant savings in maintenance costs.

This condition based remote monitoring system operating non-stopping a-round-the-clock brings also significant cost reductions and increases security when problems are solved in advance and focus the maintenance operations can be targeted accurately.

Line Sag detection system has been tested on power lines during two years with collaboration of Finnish energy distribution companies. Results from testing in harsh winter conditions prove that both the measuring technology and wireless data transfer system are performing very well. VTT has got patents pending on this technology in Europe, USA, Canada and Russia.

The presentation will give a comprehensive picture about the operating principles, performance and business opportunities of the line sag detection system.

A novel model approach to test de-icing strategies and de-icing efficiency

Stefan Söderberg, WeatherTech Scandinavia AB
Magnus Baltscheffsky, WeatherTech Scandinavia AB

When planning a wind farm in areas prone for icing conditions one of the questions that has to be considered is whether or not turbines with a de-/anti-icing system should be installed. Some turbine manufacturers offer turbines with such systems. A few solutions have been around for some time while other are relatively new on the market. De-icing strategies and how icing is detected vary between the systems. In this study a novel test of anti-icing/de-icing systems is performed. The purpose of the test is to get a principal understanding of how a de-icing system can reduce the production losses depending on the chosen strategy.

The basis for the study is a dataset consisting of modelled atmospheric data acquired from a high resolution WRF model (www.wrf-model.com) run. Using an in-house developed model for estimating production losses due to icing, time series of clean and iced production are generated. The production loss model has been developed and tested using production data from several operational wind farms. It can be set up for resource assessment studies and as a forecasting tool for production losses due to icing. Using the information available from turbine manufacturers different models for the de-icing system was formulated. A series of experiments applying different de-/anti-icing strategies were set up to facilitate estimating how the different systems can reduce the production losses.

It is found that a de-icing system in general reduces the production losses. However, depending on which icing conditions and at which temperatures the system can operate the reduction of the production losses can vary by several % of AEP. It is also illustrated that the de-icing strategy to a large extent influence how much extra energy that can be gained. Having a system that can be used while the turbine is still producing will decrease the production losses much more than a system that only can operate when the turbine is idling or is stopped.

BACK

QUANTIFICATION OF ENERGY LOSSES CAUSED BY BLADE ICING AND THE DEVELOPMENT OF AN ENERGY LOSS CLIMATOLOGY USING SCADA DATA FROM SCANDINAVIAN WIND FARMS

Staffan Lindahl, DNV GL Energy (formerly GL Garrad Hassan)
Carla Ribeiro, DNV GL Energy (formerly GL Garrad Hassan)
Mathew Levinston, DNV GL Energy (formerly GL Garrad Hassan)

A major current challenge for the wind energy industry in Scandinavia is to understand the magnitude of energy losses caused by blade icing. There is a need to both understand the actual historical losses and to estimate future losses, not only for pre-construction energy assessments, but also to inform the site selection process and to improve short-term production forecasting.

Consequently, recent times have seen substantial R&D effort in this field. The majority of the research to date has been focused on sophisticated modelling techniques (atmospheric or others) to predict the build-up of ice on the blades, in combination with predictions of the degradation in aerodynamic efficiency due to blade ice load. The results obtained from such models may differ substantially and typically have a high degree of uncertainty.

This paper will demonstrate how detailed icing loss information can be mined from observational data stored in standard wind turbine SCADA databases. A method is proposed by which the actual historical energy losses caused by blade icing can be accurately quantified the SCADA data in combination with industry standard, and state of the art, SCADA power curve analysis techniques.

The authors will describe how the proposed method has been applied to a large number of operational Swedish wind farms to quantify the actual blade icing energy losses. This has been done for the operating life of each wind turbine at each wind farm.

It will be shown how these results have been summarised to create an individual project seasonal blade icing energy loss profile, and how these, in turn, have been used to create a regionalised map ("climatology") of typical seasonal icing loss profiles across Sweden. This map of loss profiles can, when combined with project specific seasonal production profiles, provide a good basis upon which to estimated future long-term mean annual icing losses.

Finally the paper will propose how analysis of SCADA data can provide detailed understanding of the characteristics of the ice build-up process. This is achieved through analysis of the rate of power curve performance degradation at a time-resolution of 10 minutes for multiple wind turbines in the same wind farm. It will be proposed that this type of observational data analysis can provide a robust foundation against which the models used to predict blade ice accretion and energy losses can be validated.

ORAL

COMMERCIAL EXPERIENCES

De-icing performance warranties – a utility perspective

Daniel Gustafsson, Vattenfall

Background

For most of the wind turbines' key performance characteristics, such as power
However, for the performance of de-icing systems no standardized warranty are

Why warranties are needed

In any investment decision for a new wind farm, all risks should be properly
For a wind farm owner warranties will provide a good indication of the expect

How performance can be warranted

To discuss how a warranty can be formulated one needs to consider the three s
Based on this, the preferred warranty would the performance of the full syste
Alternative, the warranty could be focused on the performance of the sub-syst
Lastly, the warranty could be limited to the functionality, guaranteeing that

As a principal, the ownership of a risk should be by the party best equipped

BACK

Performance of Enercon wind turbines under icing conditions in Europe

René Cattin, Meteotest
Silke Dierer, Meteotest
Rebecca Gugerli, Meteotest
Markus Müller, Meteotest

Sara Koller, Meteotest

During winter 2012/13, ENERCON wind turbines in several wind parks in Europa were monitored in order to evaluate their performance under icing conditions. The wind parks were located in Switzerland (St. Brais), Czech Republic (Kristofovy Hamry), Germany (Molau) and Sweden (Dragaliden, Middagsberget and Gabrielsberget). The wind turbines were equipped with one camera pointing at nacelle and two cameras pointing at the blades. Furthermore, the operational data of the wind turbines was examined.

In a first step, the icing conditions at the sites were analysed. Based on a classification of camera images, the IEA ice class of each site was identified. Furthermore, the periods of meteorological icing were subdivided in three classes of icing intensity and the instrumental icing in five classes of ice loads. This allowed for a more detailed interpretation and comparison of the different icing climates at the test sites. Finally, the typical wind conditions (wind speed and wind direction) during icing events were studied.

In a second step, the performance of the blade heating was examined in general with regard to the icing conditions and in selected case studies. The rotor blade heating of the different wind turbines were operated in various operational modes within the same wind park. This allowed for a detailed comparison of the performance of different heating strategies during icing events and a quantification of the overall icing losses with regard to the site-specific icing climate.

Finally, a detailed case study of the performance of the wind turbines during an extreme icing event in January 2013 at the wind park Kristofovy Hamry in the Czech Republic will be shown.

BACK

SIEMENS

Abstract - Winter Wind 2014

Siemens Turbines in Cold Clime

Author: Finn Daugaard Madsen

Affiliation: Siemens Wind Power

Contact address: Borupvej 16
7330 Brande
Danmark

Mobile number: +45 30374947

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

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

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

The blade heating system has since then been developed even further to deliver a complete “cold-climate-system” for our turbines. The design of Siemens Wind Power Blade De-Icing Systems has proven its reliability and efficiency the last 4 winter seasons and will undergo continuous optimization to ensure that Siemens wind turbines installed in cold climate regions all over the world can produce electricity even under extreme weather conditions.

Vestas De-icing System

Brian Daugbjerg Nielsen, Vestas Wind Systems A/S

Presentation of preliminary test data of the Vestas De-icing System. In the upcoming winter season 2013-2014, 2 V90-3.0 MW equipped with concept prototype (product generation 1) will be tested on a Canadian site. 1 V112-3.0 MW equipped with modified prototype (product generation 2) will be tested in a Swedish site. Furthermore, the Vestas De-icing System design drivers will be presented, with an elaboration of the next steps in Vestas Cold Climate Strategy.

Expected duration: 30-45 min
