Winterwind

INTERNATIONAL WIND ENERGY CONFERENCE

Book of Abstracts **2016**

Winterwind 2016 program

MONDAY 8 FEBRUARY - OUTSIDE SESSION ROOMS

8 FEB

11.00–20.00

Site visit to Mullberget
Hosted by: Mullbergs Windfarm and Siemens

19.00–21.00

Registration
Stand & poster set up

TUESDAY 9 FEBRUARY

9 FEB

08.00–10.00

Registration

10.00–11.30 SESSION 1

ARENA
Inauguration and keynote presentations
Chairs: Jeanette Lindblad and Göran Ronsten

- **North Asia driving the wind industry**
  Sebastian Meyer, Azure International, CN, (28)
- **The European Commission's "WinterPackage" and the latest developments regarding cooperation and market integration of renewable energy**
  Dörte Fouquet, BBH, EREF, DE, (31)
- **Moving forward in a frosty market**
  Daniel Gustafsson, Vattenfall Wind Power, SE, (54)

11.30–13.00 LUNCH & EXHIBITION

12.30–12.55 POSTER PRESENTATIONS

01. **Reliable ice detection for rotor blades to increase availability and yield of wind turbines** — Bernd Wölfel, Wölfel Wind Systems, DE, (3)
02. **In Situ Instrument AB - your overall partner when it comes to measuring wind in any environment —** Emil Lindblom, In Situ Instrument, SE, (33)
03. **Airborne de-icing solution for wind turbines** — Hans Gedda, Alpine Helicopter, SE, (20)

13.00–14.30 SESSION 2

ARENA
Forecasting, cloud physics, aerodynamics
Chairs: Anna Coulson Sjöblom and Hans Bergström

- **Benchmark study of icing forecasts. Do they really add a value?**
  Ben Martinez, Vattenfall R&D, SE, (11)

SOLSKOG
HSE (Health, Safety and Environment)
Chairs: Ylva Odemark and Dag Haaheim

- **Integrated approach to safety and asset performance in cold climates**
  Arve Sandve, Lloyd's Register Consulting, NO, (32)

SNÖJUS
Inspection and repair
Chairs: Helena Wickman and Sven-Erik Thor

- **Assessing the likelihood of hail impact Damage on Wind Turbine Blades**
  Hamish Macdonald, University of Strathclyde, GB, (26)

- **Ice detection methods and measurements**
  Matthew Wadham-Gagnon, TechnoCentreéolien, CA, (34)
- **Towards validation of microphysics schemes in numerical weather prediction models for icing applications**
  Magnus Baltscheffsky, WeatherTech Scandinavia, SE, (23)
- **On-site measurement from cold Climate - possibilities and applications towards validation of CFD model**
  Marie Cecilie Pedersen, Vattenfall Vindkraft, SE, (24)

- **Uncertainty quantification for wind power forecasts in cold climates**
  Esbjörn Olsson, SMHI, SE, (49)
- **IceRisk forecast system for operational wind farms**
  Rolv Erlend Bredesen, Kjeller Vindteknikk, NO, (48)

- **Blade heat system repair, part II**
  Greger Nilsson, Blade Solutions, SE, (18)
- **Quantifying the impact of ice accretion on turbine life for typical Scandinavian sites using numerical modelling**
  Ricard Buils Urbano, DNV GL - Energy Advisory, GB, (42)

14.30–15.30 BREAK – POSTER PRESENTATIONS & EXHIBITION

04. Optimizing wind and icing — Case Finland, Simo Rissanen, VTT, FI, (58)
05. Cost effective system for ice throw detection — Najeem Lawal, Mid Sweden University, SE, (36)
06. A study of maintenance performance indicators for the European offshore wind farms in cold climate regions — Mahmood Shafiee, Cranfield University, GB, (1)

15.30–17.00 SESSION 3

ARENA
Resource assessment, measurements and models

Chairs: Katja Hynynen and Ben Martinez

- **An experimental study on the use of nanosecond-pulsed dielectric barrier discharge plasma actuators for de-icing of aerospace structures**
  Jakob Van den Broecke, Delft University of Technology, NL, (19)
- **Frozen anemometers and bias in the wind resource**
  Lasse Johansson, Sweco, SE, (27)
- **Mast measurements in cold climate challenges and recommendations**
  Sónia Liléo, Sweco, SE, (47)
- **New advances in icing measurements and icing predictions,**
  Øyvind Byrkjedal, Kjeller Vindteknikk, NO, (51)

SOLSKOG
De-/anti-icing including ice detection &control

Chairs: Marie Cecilie Pedersen and Till Beckford

- **Wet-snow production and snowing wind tunnel test for snow accretion and prevention**
  Kengo Satoh, Snow and Ice Research Center,National Reserch Institute for Earth Science and Disaster Prevention, JP, (15)
- **Prediction of production losses in cold climates and ice protection system design by computational fluid dynamics**
  Massimo Galbiati, EnginSoft, IT, (7)
- **Assessment of de-icing and anti-icing technologies in ice wind tunnel**
  Nadine Rehfeld, Fraunhofer IFAM, DE, (2)

SNÖJUS
IEA TASK 19 & PANEL DISCUSSION

Chairs: Carla Ribeiro and Sebastian Meyer

- **Overview of IEA wind Task 19 results from 2013-2015**
  Ville Lehtomäki, VTT, FI, (38)
- **IEA Task 19, standardised methodology for the elaboration of the ice throw risk assessments**
  Andreas Krenn, Energiewerkstatt, AT, (9)
- **Validation of the IEA Task 19 ice site classification**
  René Cattin, Meteotest, CH, (37)
- **Classification based approach for Icing detection**
  Zouhair Khadiri-Yazami, Fraunhofer IWES, DE, (17)
- **Panel discussion:** What should IEA Task 19 take into account when working with the new draft standard IEC 61400-15 “Site energy yield assessment” in 2016-17?
  Ville Lehtomäki, VTT, FI, (57)

17.00–19.00 MINGLE IN EXHIBITION HALL

19.00– DINNER AND ENTERTAINMENT NOTE. WALLMAN SHOW STARTS AT 7PM

WEDNESDAY 10 FEB

10 FEB

08.30–10.00 SESSION 4

ARENA
Strategier EM/Vattenfall/Canada

Chairs: Ville Lehtomäki and Jos Beurskens

- **A Look at wind turbine performance in Canadian icing climate**
  Dominic Bolduc, TechnoCentre éolien, CA, (35)
- **The Swedish Energy Agency strategy within wind energy,**
  Pierre-Jean Rigole, Swedish Energy Agency, SE, (56)
- **An overview of Vattenfall's research within turbine icing – Yesterday, today and tomorrow**
  Ylva Odemark, Vattenfall, SE, (44)

SOLSKOG
De-/anti-icing including ice detection & control

Chairs: Nadine Rehfeld and Matthew WadhamGagnon

- **An approach in using guided waves for ice detection on wind turbines**
  Siavash Shoja, Chalmers University of Technology, SE, (50)
- **Combined effect of the heating and the superhydrophobic coating on the deicing capability of the ultrasonic wind sensor**
  Tomofumi Saito, Kanagawa institute of technology, JP, (12)
- **Performance of two nacelle-mounted ice detectors: a case study**
  Katja Hynynen, Lappeenranta university of technology (LUT), FI, (30)
- **Wind turbine ice detection systems testing**
  David Futter, Uniper Technologies Ltd, UK, (6)
  Real-World icing distribution analysis based on data from surface sensors
  Michael Moser, eologix sensor technology, AT, (53)

10.00–10.30 BREAK - POSTER PRESENTATIONS & EXHIBITION

07. Ice detection via advanced infrared image analysis — Mikko Tiihonen, VTT, FI, (43)
08. Monitoring systems for harsh climate — Patrik Jonsson, Combitech, SE, (25)
09. Recent development on blade mounted and nacelle mounted ice detectors, — Tatu Muukkonen, Labkotec, FI, (46)

10.30–12.00 SESSION 5

ARENA
Production experience, losses

Chairs: Rebecka Klintström and Jakob Van den Broecke

- **Update of DNV GL's empirical icing map of Sweden and methodology of estimating icing losses using further Nordic wind farm data**
  Till Beckford, DNV GL, GB, (14)
- **Methods for estimation of occurred icing losses in operational wind farms, measurements and modelling**
  Johan Hansson, Kjeller Vindteknikk, SE, (16)
- **A roadmap for understanding the performance of numerical weather prediction based models for predicting long-term wind farm production losses due to ice accretion on blades**
  Daran Rife, DNV GL, US, (22)

SOLSKOG
DOM (Deployment, Operations and Maintenance)

Chairs: Sónia Liléo and Andreas Krenn

- **Swedish Wind Energy Association's view on wind energy in cold climates**
  Bengt Göransson, Dag Haaheim, Pöyry Sweden AB, SE / Statkraft Sverige AB, SE, (55)
- **Forecasting wind turbine icing: the value of icing forecasts trading on the day-head energy market**
  Jon Collins, DNV GL, GB, (5)
- **Applications of iced wind turbine noise simulations**
  Richard Hann, Richard Hann Consulting, DE, (21)

SNÖJUS
Standards and Offshore

Chairs: Anne Mette Nodeland and René Cattin

- **Validation of icing atlases based on SCADA data**
  Timo Karlsson, VTT, FI, (13)
- **Pre-certification of cold climate instruments and coatings**
  Tuomas Jokela, VTT, FI, (29)
- **Simulations of drifting sea ice loads on ofshore wind turbine support structures**
  Simo Rissanen, VTT, FI, (45)

12.00–13.30 **LUNCH & EXHIBITION**

13.00–13.25 **POSTER PRESENTATIONS**

10. **Decommissioning of wind farms – ensuring low environmental impact —** Liselotte Aldén, Uppsala University, SE, (8)
11. **Doing a meso-scale re-analysis using the WRFmodel – does it matter for the resulting icing climatology which version of WRF you use? —** Hans Bergström, Uppsala University, SE, (4)
12. **Determination of the actual ice mass on wind turbine blades; Measurements and methods for avoiding excessive icing loads and threads —** Daniel Brenner, Bosch Rexroth Monitoring Systems (BRMS), Dresden,DE, (52)

13.30–15.00 **SESSION 6**

ARENA – PANEL DISCUSSION AND SUMMARY

Safe and reliable operation in cold climate conditions – today and in the future

Chairs: Åsa Elmqvist and Anders Järvelä

Five short presentations prior to panel discussion

- **ENERCON. Experiences with wind energy turbines in icing conditions**
  Anne Mette Nodeland, ENERCON, DE, (10)
- **Vestas cold climate offerings to cope with icing conditions**
  Brian Daugbjerg Nielsen, Vestas, DK, (39)
- **Siemens. Improving output in harsh conditions**
  Annike Skovgaard Sørensen, Siemens Wind Power, DK, (40)
- **Nordex anti-icing system on N131 wind turbines – development and validation**
  Andreas Beyer, Nordex Energy, DE, (41)
- **Dongfang experience in low temperature wind turbine de-icing**
  Honghua Zhong, Dongfang Electric Corporation, CN, (61)
- **Summary (assisted by Jos Beurskens and Sven-Erik Thor)**
  Daniel Gustafsson, Dörte Fouquet, Vattenfall, SE/BBH EREF, DE, (60)

Abstract #: 28 (Oral), session 1:1:1

R&D areas/s: 14. Other

North Asia driving the wind industry

Sebastian Meyer, Azure International, CN,

Sebastian Meyer, Director of Reearch & Advisory, Azure International
Sebastian Meyer, Supervisory Board Member, Clean Energy Mongolia

North Asia is a key region for wind industry globally, with over 50GW already operating in north China and Mongolia. These are cold climate areas. My presentation will update of overall and seasonal performance and extreme weather related conditions. Net performance is affected by curtailment, which has emerged as the leading cause of revenue loss for projects in the region. I will present deep dive analysis of power systems and curtailment drivers as implications for emerging and potential power sector reforms.

Web site: http://www.azure-international.com

Short biography: Sebastian has worked in the wind industry in China since 2004, and has built up a successful research and advisory practice focused on the alternative energy space. Sebastian came to China from London, where he specialized in due diligence supporting project finance and M&A transactions related to alternative energy. He also worked in the transition economies of Europe through the 90's heading the Warsaw equity research team and covering industrial manufacturers and privatization programs for Creditanstalt Investmentbank - the leading western investment bank focused on the region at the time. Sebastian's career spans debt and equity financing, project finance, equity research and valuation, mergers & acquisitions, and management consulting within the context of alternative energy and transition economies.

BACK

Abstract #: 31 (Oral), session 1:1:2

R&D areas/s: 08. Finance, risk assessment and mitigation, 12. Permission and legal challenges, 14. Other

The European Commission's "Winter Package" and the latest developments regarding cooperation and market integration of renewable energy

Dörte Fouquet, BBH, EREF, DE,

Jana Viktoria Nysten (BBH, GER, BE)

The European legislative framework for renewable energy is under revision. The European Commission is planning not only a revision of the Renewable Energy Directive, but we can also expect changes in the Electricity Market Directive which will be relevant for the sector. The trend behind all this seems clear: Europe is moving away from specific support schemes, and towards market integration of renewable energies. Already in 2014, the Guidelines for Environmental and Energy State Aid 2014-2020 introduced a primacy for market premiums over feed-in tariffs and by 2017 renewable electricity projects will have to compete for those premiums in competitive tendering procedures. Another trend is regional cooperation – the more as both the Commission and the Council continue to reiterate that the Energy Action Plans under the „New Governance" after 2020 will build on the Member States coordinating their approaches across borders.

The Member States are already working on this transition: In fact, Germany has just reformed its renewable energy support scheme in accordance with the Guidelines for Environmental and Energy Aid. First experiences with auctions, though currently only with free field PV, exist and for other technologies first rounds are expected before the end of 2016. Similarly, Germany is actively striving for „cooperation" – talks with e.g. Luxemburg about common auctioning rounds are being held and first results may also be expected in the course of 2016.

While market integration is certainly important, and should be the next step, the question arises on how to ensure that Member States do not use "market arguments" in order to lower or even abolish a supportive framework and a sufficient incentives for investors in renewable energy. Price competition – even across borders – should not lead to uneven or suboptimal distribution, e.g. by only supporting certain politically favoured big (offshore) wind parks while neglecting smaller local wind energy potentials. The crux will be finding an appropriate balance.

Especially in view of these developments it is crucial to analyze elements of weakness of current support mechanisms such as the Swedish Norwegian quota and certificate in view of failures to differentiate support levels in relation to the siting of the installation and to draw lessons from other design models better integrating those elements.

Thus, 2016 will bring a lot of new developments for the renewable energy sector, and we should better be informed and prepared to react to them appropriately.

Web site: http://www.bbh-online.de

Short biography: Dr. Dörte Annemarie Fouquet, born in 1957 in Recklinghausen, Germany, joined the law firm of Becker Büttner Held (BBH) in 2010 as a partner in charge of the new Brussels office. Before that, Dr. Fouquet was a partner of Kuhbier Law Firm in Brussels. She is admitted as attorney at the Hanseatische Oberlandesgericht in Hamburg and Membre Associé du Barreau de Bruxelles. During her professional career Mrs. Fouquet has specialised in various legal aspects of energy, environmental, competition and administrative law. Her major focus is energy Law, especially renewable energy law and she is widely known for her long-standing experience and deep understanding not only of the legislative framework, but also of the industry. Before going to Brussels, Dr. Fouquet pursued a career as administrative lawyer in the administration concerning energy and environment in the German City-State of Hamburg. She has extensive experience working with national, international and, in particular, European institutions, including the European Commission, as well as with national and international NGOs, as well as in the administrative support to major RTD projects within the EC framework programs. Both in her capacity as lawyer at BBH and as Director of the European Renewable Energies Federation (EREF), she is a well-reputed speaker at events and regularly authors several publications.

BACK

Abstract #: 54 (Oral), session 1:1:3

R&D areas/s: 09. Market potential, 14. Other

Moving forward in a frosty market

Daniel Gustafsson, Vattenfall Wind Power, SE,

Daniel Gustafsson, Vattenfall Wind Power

Vattenfall have a long history in the north of Sweden, starting with hydro power and transmission for over 100 years ago, and continuing with small scale wind power at the end of last century. Five years ago the wind farm of Stor-Rotliden was inaugurated and Vattenfall entered the large scale wind power business with 40 turbines in Västerbotten. Last year Vattenfall realized the wind farm of Juktan with a modern de-icing technology, with performance warranties.
Even though the turbines and de-icing technology is are up and running, there is still work left to optimize and tune the control algorithms.
Due to the technology development and the reduced icing losses the annual production per turbine increased by 60%. For projects in procurement now it is possible to increase the production additionally giving as much as doubled production per turbine compared to Stor-Rotliden.
Vattenfall has a clear strategy to grow even further in renewable energy and to operate 15 TWh by 2020 and 25 TWh by 2025 in all our markets in the north of Sweden.
An important share of this will be the large scale wind farms in our pipeline for the north of Sweden. We have the intension to start procurement of Blakliden and hopefully Fäbodberget during 2016, where de-icing technology will be a necessity and our requirements for the turbine suppliers to supply warranties are firm. With this project cluster of close to 1 TWh in production and the Vattenfall projects with a several hundreds of turbines in permit processes in northern Sweden, it is clear that cold climate and icing issues will need to be a strong focus area going forward.
Thus we have a dedicated RnD team, headed by Ylva Odemark looking into most aspects of this conference. You will hear from a her and a few in her team presenting our projects later during these days.
The Winter wind conferences have done a great job during the last years to bring people together and to facilitate knowledge exchange and research and development initiatives. During these two days we will see openness and willingness to learn and share knowledge from all you participants, which are the corner stones in makinge this a success.
Please approach me or any of my colleagues in Vattenfall with suggestions of common initiatives. We are open to any win-win suggestions!

Web site: http://corporate.vattenfall.se/om-oss/var-verksamhet/var-elproduktion/vindkraft/

Short biography: Daniel Gustafsson has been working at Vattenfall for seven years. Initially he started in the wind & site department, where he started up and headed the research and development programme in icing issues (cold climates). Daniel is now a project manager, mainly focusing in developing projects in the north of Sweden.

BACK

Abstract #: 11 (Oral), session 2:1:1

R&D areas/s: 01. Forecasting, cloud physics, aerodynamics

Benchmark study of icing forecasts. Do they really add a value?

Ben Martinez, Vattenfall R&D, SE,

Karin Salevid (Vattenfall, SE)
Pierre-Julien Trombe (Vattenfall, DK)

We present the results of an icing forecast benchmark study (blind test) carried out at the Stor-Rotliden wind farm during winters 2014-2015 and 2015-2016. 5 different forecast suppliers have participated in the study where the focus has been to thoroughly evaluate the accuracy, variability and spread of 1-day ahead forecasts (12-36h). The wind farm production losses have been estimated using the standardized production loss methodology based on SCADA data which is well described in IEA Task19 ('Cold Climate') [1]. We also present the potential economical savings when using such forecasts and assess the limits in terms of icing site severity to which these forecasts make sense to be considered.
[1] Standardized method to assess production losses due to icing from turbine SCADA data, IEA Task19 reports

Web site: http://corporate.vattenfall.com/about-energy/renewable-energy-sources/wind_power/

Short biography: Ben Martinez has been working in Vattenfall R&D for 4 years. He has been involved in icing research activities ever since he started at the company. These are quite diversified spreading from ice throw to icing physics and production loss model development. Ben has a background in Physics (Barcelona university) and Wind Energy (DTU university).

BACK

Abstract #: 34 (Oral), session 2:1:2

R&D areas/s: 01. Forecasting, cloud physics, aerodynamics, 03. Resource assessment, measurements and models

Ice detection methods and measurements

Matthew Wadham-Gagnon, TechnoCentre éolien, CA,

Nigel Swytink-Binnema (TCE, CA),
Dominic Bolduc(TCE, CA),
Kossivi Tété (TCE, CA),
Cédric Arbez (TCE, CA)

Wind energy projects operating in icing climate may suffer from increased ice induced power losses, the turbines may be subjected to higher loads due to ice on the blades and the operating staff may be exposed to greater safety risks due to ice throw. Ice detection plays a crucial role in the reduction of these challenges during site icing assessment, ice protection system control and ice throw risk mitigation. It may also be used for preventive shut down or for other turbine control optimisation strategies.
This presentation will shed light on several ice detection methods, from techniques using standard meteorological sensors to commercially available dedicated ice sensors. Some methods detect ice on static structures, others on blades. Specialised sensors such as the microwave rain radar (MRR), can provide useful information on precipitation liquid water content, particularly in typical eastern Canadian climate where not only in-cloud icing events occur but a significant amount of icing may happen during precipitations (such as wet snow and freezing rain). All these methods and sensors are currently being tested at the TechnoCentre éolien's Site Nordic Expérimental Éolien CORUS (SNEEC) in Canada.
The methods best suited to determine meteorological icing (i.e. the duration of active ice accretion) or instrumental icing (i.e. the duration of the presence of ice on the instrument) will be discussed. The presentation will also shed light on which methods provide accurate measurements of icing event duration, severity or intensity, and which may likely only be used for long term statistical purposes.

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

Short biography: Matthew Wadham-Gagnon has acquired engineering and project management expertise internationally over the last 10 years. He has been managing projects and conducting applied research related to wind energy in cold climate at the TechnoCentre éolien (TCE) since 2011. Prior to joining the TCE, he developed skills in structural analysis and design of composite structures as well as composite processing. Matthew has a Master's degree in Mechanical Engineering.

BACK

Abstract #: 23 (Oral), session 2:1:3

R&D areas/s: 01. Forecasting, cloud physics, aerodynamics, 03. Resource assessment, measurements and models

Towards validation of microphysics schemes in numerical weather prediction models for icing applications

Magnus Baltscheffsky, WeatherTech Scandinavia, SE,

Stefan Söderberg, WeatherTech Scandinavia, Sweden
Matthew Wadham-Gagnon, TechnoCentre éolien, Canada

There have been several recent efforts to understand ice accretion through measurements and through modelling using input data from advanced Numerical Weather Prediction (NWP). Among the findings is that the timing of icing events is captured quite well by the models while there exist a concern about the validity of the modelled ice load, which is often underestimated. But, at the same time the reliability of the measured ice loads and icing intensities has been questioned. In fact, it has not yet been made clear if the large discrepancies often seen are mainly due to model or measurement errors. Besides trustworthy ice load measurements it has been suggested that measurements of liquid cloud water (LCW) and cloud droplet median volume diameter (MVD) are needed to validate and improve the models.
In a companion presentation, Ice Detection Methods and Measurements, results from an ongoing comprehensive case study at the TechnoCentre éolien's (TCE) test site based in Rivière-au-Renard, Quebec, Canada are presented. The capabilities of specialised ice sensors are compared to other ice detection methods derived from sensors providing data such as cloud base height, relative humidity, solar radiation, wind speed (from heated and unheated anemometers) and temperature. Furthermore, measured profiles from a Microwave Rain Radar (MRR) are used in the comparison.
The present work is part of an attempt to reduce the uncertainties in the modelling chain by investigating the ability of microphysics schemes commonly used in NWP and to find new methods to better understand and characterise icing events by combining measurements with model data. To achieve this data from several measurement sensors are analysed together with high-resolution model data from the mesoscale WRF (Weather Research and Forecasting) model. The focus of the analysis is to investigate how well the model microphysics predicts key parameters for ice accretion such as cloud base height, vertical profile of liquid water content, temperature and phase transitions between rain water and cloud water. Furthermore, the sensitivity of model results to model grid resolution is examined.

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

Short biography: Magnus Baltscheffsky is currently a model developer and consultant at WeatherTech Scandinavia where he has worked for the past 5 years with atmospheric modelling and issues related to the icing climate. He holds an M.Sc. in Meteorology from Uppsala University and has been using the WRF model extensively for the past 7 years.

BACK

Abstract #: 24 (Oral), session 2:1:4

R&D areas/s: 03. Resource assessment, measurements and models

On-site measurement from cold climate – possibilities and applications towards validation of CFD model

Marie Cecilie Pedersen, Vattenfall Vindkraft, SE,

Matthew Wadham Gagnon, TechnoCentre Éolien (TCE), Quebec, Canada
Henrik Sørensen, Aalborg University, Denmark
Benjamin Martinez, Vattenfall Vindkraft, Denmark

Measurements from ice detectors, cameras and other sensors in cold climate can provide crucial information about on-site icing, all the way from ice accretion, instrumental icing to melting. Nevertheless, the harsh climate has been shown to influence on the reliability of the individual measurements. To circumvent this issue, this study aims to construct a complete data-set containing different measurement types, providing a reliable picture of an icing event. From the data-set the possibilities and applications towards validation of an icing model will be evaluated. The icing model used in this study is developed using Computational Fluid Dynamics (CFD). The CFD icing model focuses on the physics of the ice accretion process. Outputs from the model is among others ice height, ice thickness, ice distribution, total ice mass allocated on the object exposed to icing and finally the change in geometry after ice accretion. Thus, it is the aim to define a methodology to validate the CFD output parameters based on the data-set. The CFD model inputs will be derived from meteorological mast measurements including cloud base height and thickness, wind speed and wind direction, humidity, pressure and temperature. The cloud base height provides knowledge about the duration of the ice accretion (meteorological icing period), which is a challenging parameter to estimate. Furthermore, the cloud thickness can help estimate the Liquid Water Content (LWC). The first step of the validation process will be to compare CFD model outputs to ice accretion measured with ice sensors and cameras on static structures (cylinders) as the measurement sets are more complete and the simulations are simpler to run. All measurements are provided by TechnoCentre Éolien (TCE), Canada and the work is conducted during a research visit at TCE.
An analysis of the data-set and the preparation towards a reliable validation methodology of the CFD icing models will be presented, along with the challenges of using on-site measurements for CFD validation and preliminary validation results.

Web site: http://corporate.vattenfall.com/about-energy/renewable-energy-sources/wind_power/

Short biography: Marie Cecilie Pedersen is an Industrial PhD student at Vattenfall Vindkraft and Aalborg University in Denmark. She has a Master's degree in Energy Technology from Aalborg University and she has been working with the topic of wind turbines icing for three years. In January 2014 she started her Industrial PhD with Vattenfall Vindkraft and Aalborg University, which is a three year project. The prime focus of her work is modelling of icing using CFD. During the winter season of 2015-2016 she will be a visiting researcher at TechnoCentre Éolien, Quebec, Canada, which is part of the PhD project.

BACK

Abstract #: 32 (Oral), session 2:2:1

R&D areas/s: 05. DOM (Deployment, Operations and Maintenance), 06. HSE (Health, Safety and Environment)

Integrated approach to safety and asset performance in cold climates

Arve Sandve, Lloyd's Register Consulting, NO,

Arve Sandve
Terje Nilsen

Operations in cold climates represent a significant challenge to safe operations and asset optimization. Snow and icy conditions introduce various risks to wind farm operations: the possibility of ice falling or thrown from wind turbines, slippery conditions during maintenance work and production downtime due to asset failure. In a worst case scenario, such conditions may cause a significant risk to personnel operating the wind farm, or to third parties nearby.

In an ever changing business environment, all businesses are required to optimize asset performance to meet market specific requirements. In an environment where resources are limited and market pressures are ever-increasing, operation and maintenance programmes must be carefully designed. Such programmes should also be developed with a close link to safety. Lloyd's Register Consulting will present tools which apply risk-based or reliability centred assessment techniques optimizing maintenance services, enabling wind operators to optimise their assets.

This paper will also present two case studies focusing on how the wind industry can benefit from experience of maintenance optimisation projects in other industries. The case studies will include: optimisation of existing maintenance program (RCM-O, Optimisation), development of maintenance program (RCM-D, Development) and strategic support of risk based maintenance in other industries.

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

Short biography: Mr Terje Nilsen, Senior Principal Consultant, has more than 25 years of experience within construction/design, safety, risk management, reliability, operation and maintenance in the transport branches of railway and aviation. Nilsen is educated aeronautical engineer and has experience as engineering manager in Scandinavian Airlines System for the Structural, Mechanical and Reliability Engineering department. From the period in SAS he had a number of assignments as member of the internal accident and investigation group for 10 years, ATA (Air Transport Association of America) Maintenance Program subcommittee and McDonnell Douglas Industry Steering Committee for technical development of the aircraft fleet. Mr. Nilsen has issued a number of papers in the area of railway RAMS presented at national and international seminars and conventions as Euromaintenance, World Maintenance Congress, ESRA, ESReDA, etc. Terje has also lectured RAMS courses for the last 12 years for operators and suppliers in the railway industry.

Mr. Arve Sandve has more than 15 years experience from emergency preparedness -and response projects. His experience includes emergency preparedness analysis, emergency response plans and exercises, crisis communication and business continuity management in industry and commerce and public sector. Sandve has also been engaged as HSE lead -and advisor in projects within the energy sector in general and the wind industry in particular, focusing on the development of integrated risk management systems and safe work. Furthermore, Sandve has performed numerous audits and quantitative risk analysis. In addition to training within the field of organizational psychology and management, Arve Sandve holds a Masters degree in Social Science. Sandve is VP Business Development in Lloyd's Register Consulting

BACK

Abstract #: 49 (Oral), session 2:2:2

R&D areas/s: 01. Forecasting, cloud physics, aerodynamics

Uncertainty quantification for wind power forecasts in cold climates

Esbjörn Olsson, SMHI, SE,

Heiner Körnich (SMHI, SE), Jennie Persson Söderman (UU, SE), Björn Stensen (SMHI, SE), Per Undén (SMHI,SE), Hans Bergström (UU, SE)

Forecasting next-day wind power in cold climates is achieved by a modelling chain of a numerical weather prediction model, a model for icing and a model for the power production. A useful prediction requires also an estimate for the forecast uncertainty. Several sources for this uncertainty have been identified: the initial and boundary conditions of the numerical weather prediction model and the model formulations in all components. In this study, we examine the contribution of the different uncertainty sources to the quality of the wind power production forecast.
The numerical weather prediction model employed in this study is the Harmonie/AROME-model developed in collaboration of the meteorological consortia Aladin and Hirlam. It is set up with a horizontal resolution of 2.5 km over Sweden and run within the ensemble prediction system HarmonEPS in order to take into account the uncertainties in initial and boundary conditions as well as model formulations. Further representativeness uncertainty can be included in post-processing after the numerical weather forecast. It is demonstrated how different strategies in combining the ensemble predictions to a wind power forecast yield different forecast quality.
In the next step, the forecast uncertainty is quantified within our forecasting system. Using verification against observations we assess the role of different uncertainty sources and how reliable the uncertainty estimate is as a measure of forecast quality.
This study is supported by the Swedish Energy Agency (Energimyndigheten) under the project number 37279-1.

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

Short biography: Meteorologist at SMHI research department. Main working field is numerical weather prediction. Have been involved ice modelling issues for windpower during ten years. Have also a background as an aviation forecaster, developing methods for forecasting aircraft icing.

Abstract #: 48 (Oral), session 2:2:3

R&D areas/s: 01. Forecasting, cloud physics, aerodynamics, 06. HSE (Health, Safety and Environment), 08. Finance, risk assessment and mitigation

IceRisk forecast system for operational wind farms

Rolv Erlend Bredesen, Kjeller Vindteknikk, NO,

Rolv Erlend Bredesen (Kjeller Vindteknikk, NO)
Michael Pedersen (Statkraft Energi, SWE)

The IceRisk forecast system yields daily forecasts of turbine specific safety distances in the time domain for planning purposes such as e.g. maintenance and visits in the wind farm area. As a pilot project for Statkraft, the IceRisk methodology [1][2][3][4] has been developed further to forecast the onset of risk as well as timeseries of turbine specific safety zones for the wind farm Stamåsen in Sweden. The forecast system will be in operation from the fall of 2015 until at least the spring of 2017.

The motivation for developing the risk forecast system is clear as stated by Statkraft: "Health, safety and environmental matters are the highest priorities at Statkraft Energy. We cannot at any time risk that our own employees or visitors are hurt at any point. That is why performing a risk analysis at our wind farm is a must. This gives us the knowledge of when it is possible to access the turbines itself – but also the knowledge of when we can have visitors in our parks. Making the risks visual will automatically create the awareness that is needed to have a safe working environment".

IceRisk, a state-of-the-art method for assessing site specific risk caused by ice fall or throw from turbines or other tall structures, has been developed in close collaboration between Kjeller Vindteknikk and Lloyd's Register Consulting [1]. The method consists of a detailed meteorological simulation resulting in maps of ice throw probability zones and safety distances for the considered site, followed by a risk assessment. The approach results in a map showing safety zones, i.e. what type of activities are acceptable within the vicinity of the wind turbine or similar installation.

The IceRisk model has since the winter 2013/2014 also been used to forecast safety zones and ice risk periods for the 209 m tele-communication mast at Tryvann in Oslo, which has public activity in the near surroundings. Further refinement and calibration of the model is thought of as an ongoing process based on experiences by active service personnel using the forecast system. If a turbine detects icing, now-casts using realtime hub measurements of wind speed and direction and/or the turbine operational modes (rotational speed and orientation) is also possible but presently not considered.

[1] Bredesen, R.E., Refsum, H.A., 2015. Methods for evaluating risk caused by ice throw and ice fall from wind turbines and other tall structures. Kjeller Vindteknikk, NO (38). IWAIS 2015. 16th International workshop on atmospheric icing of structures. ISBN 978-91-637-8552-8. Uppsala, Sweden, June 28 - July 3 2015. www.iwais.org

[2] Wadham-Gagnon et al., 2015. IEA Task 19 - Ice Throw Guidelines. Winterwind 2015. http://windren.se/WW2015/WW2015_52_621_Wadham_TCE_IEAT19_IceThrowGuidelines.pdf

[3] Refsum, H.A., Bredesen, R.E., (2015), Methods for evaluating risk caused by ice throw from wind turbines, Lloyd's Register Consulting, NO. Winterwind 2015. http://windren.se/WW2015/WW2015_39_521_Refsum_Lloyd_Ice_throw_evaluating_risk.pdf

[4] Bredesen, R.E., Refsum, H.A. (2014). IceRisk: Assessment of risks associated with ice throw and ice fall. Kjeller Vindteknikk AS. Winterwind 2014.

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

Short biography: Rolv Erlend Bredesen holds a M.Sc. in Computational Science and Engineering from the University of Oslo from 2005. In 2004 and 2005 he was an exchange student at the University of Washington, USA studying mesoscale modeling with the WRF model. His main expertise is within fluid mechanics, computer programming, and wind farm development. He has a long experience applying WRF to wind farm development and lately worked extensively with ice risk analyses.

Professional Experience

- 2010- Kjeller Vindteknikk AS, Advisor
- 2007- Teaching: Numerical methods for partial differential equations, Scientific programming using python language. Examiner for courses on Scientific programming at University of Oslo.

BACK

Abstract #: 48 (Oral), session 2:2:3

R&D areas/s: 01. Forecasting, cloud physics, aerodynamics, 06. HSE (Health, Safety and Environment), 08. Finance, risk assessment and mitigation

- 2006-2010 University of Oslo, Simula Research Laboratory, International Centre for Geohazards (ICG) at Norwegian Geotechnical Institute. Tsunami flow and runup modeling, Efficient numerical modelling, Visualization and CFD.
- 2005, 2006 Kjeller Vindteknikk AS, Advisor. Numerical mesoscale modelling, WRF.
- 2005 University of Washington, Department of Atmospheric Science, Visiting Scientist. Numerical mesoscale modelling (WRF) and benchmarking with analytical models.

Relevant skills

- Mathematical modeling, scientific programming and visualization.
- IceRisk - Assessment of risks associated with ice fall and ice throw.
- Mesoscale modeling - Offshore wind atlas, Offshore extreme wind atlas, wind farm wake-modelling, Large eddy simulations, atmospheric icing, forecasts.
- Efficient dataprocessing - e.g. Norwegian E-39 project with 10 Hz wind speed data
- Advisement on the set up of wind measurement strategies.
- Analysis of icing conditions and return periods for ice loads on e.g. tall towers and powerlines.
- IceLoss - Assesment of production losses due to icing.

As a hang glider pilot he makes the most of the vertical wind component, be it mechanical lift induced by the terrain or the weaker thermals below convective clouds, to soar in the air.

BACK

Abstract #: 26 (Oral), session 2:3:1

R&D areas/s: 01. Forecasting, cloud physics, aerodynamics, 03. Resource assessment, measurements and models, 04. Production experience, losses, 05. DOM (Deployment, Operations and Maintenance), 07. Inspection and repair, 14. Other

Assessing the likelihood of hail impact damage on wind turbine blades

Hamish Macdonald, University of Strathclyde, GB,

Margaret Stack (University of Strathclyde, UK), David Nash (University of Strathclyde, UK)

Depending on site conditions, the typical wind turbine can subjected to numerous environmental conditions over the course of a 20+ year lifespan. With the increasing number of large scale wind farms being proposed in hostile and offshore environments, there is an increased risk of blade damage due to these factors. Hailstone impact is one such factor often considered influential in the erosion of wind turbine blade leading edges. As well as other repercussions, this form of damage can result in the loss in the aerodynamic profile of the blade and contribute to a reduction in the annual energy production of the turbine. The use of meteorological data helps provide insight into the likelihood and develop realistic impact scenarios. It also establishes an important link between the impact occurring on site and experimental analysis performed in the laboratory. Along with UK weather analysis, the preliminary findings of practical investigations will be discussed.

Web site: http://www.strath.ac.uk/windenergy/studentprofiles/2012/hamishmacdonald/

Short biography: Hamish Macdonald is a PhD student studying at the Wind Energy Doctoral Training Centre at the University of Strathclyde. After graduating from the University of Glasgow with a MEng in Aeronautical Engineering, he kick-started his career in renewable energy by constructing and installing a 2kW wind turbine as part of a in a volunteer project in Trujillo, Northern Peru. After returning Hamish worked as a design engineer for a leading biomass installation company in Scotland, before starting his studentship at the DTC.

BACK

Abstract #: 18 (Oral), session 2:3:2

R&D areas/s: 07. Inspection and repair

Blade heat system repair, part II

Greger Nilsson, Blade Solutions AB, SE,

Greger Nilsson (Blade Solutions AB, SE)

Blade heat systems improve turbine efficiency by ensuring production in winter climate. The blade heat systems are either based on convection systems with hot air circulations in the blade or conduction systems using heated blade surfaces. The conduction systems use the electrical resistivity of carbon fibre mats that generate heat when electrical currents are led through them.
Conductive heat systems are energy efficient compared to the convective types, since only a small part of the blades are prone to generate ice crust formation and needs heating. The heat mats are therefore primarily applied on or near the leading edge on the outer half of the blade. Unfortunately, the same area is also the one that is most subjected to ice or lightning damages. Additionally, the conductive heat system itself acts as a lightning rod, increasing the likelihood of lightning strikes. Physical impacts and lightning damages of the conductive heating systems are therefore common, and these damages give rise to hotspots, increasing local temperatures beyond the matrix / epoxy degradation temperature. The hotspots may therefore induce a growth of the damages during operation.
This presentation will present a repair method for blade heat systems. Test specimen containing blade heat system have been manufactured. After an initial thermograph of the specimens, lightning and impact damages were induced, creating hotspots. The damages were then repaired using methods suitable for summer and/or winter use. The repaired specimens have then subjected to fatigue testing to study the mechanical robustness of the repairs.
These repair methods have been used extensively in practice. Turbine blades subjected to both small, impact related damages and larger lightning damages has been repaired using rope access, significantly reducing costs compared to blade replacements.

Web site: http://bladesolutions.se/

Short biography: Owner has extensive background in composite science. Now working with blade repairs and developing methods for blade heat system repairs.
Interested in multihull sailing, tour skating and all forms of skiing

Abstract #: 42 (Oral), session 2:3:3

R&D areas/s: 01. Forecasting, cloud physics, aerodynamics, 06. HSE (Health, Safety and Environment), 08. Finance, risk assessment and mitigation, 14. Other

Quantifying the impact of ice accretion on turbine life for typical Scandinavian sites using numerical modelling

Ricard Buils Urbano, DNV GL - Energy Advisory, GB,

Ricard Buils Urbano, John King, Carla Ribeiro, Till Beckford, Francesco Vanni (all DNV GL - Energy Advisory)

Understanding the effects of ice accretion on wind turbine blades is a topic that has received strong attention in recent years, particularly in Scandinavia where most wind farms will be affected by icing during their lifetime. At the Winterwind 2015 conference DNV GL presented the findings of a study on the effect of icing on performance losses, based on operational SCADA data collected from 18 wind farms in the Nordic region. This showed that losses due to icing can reach up to 10% of annual production at some sites and up to 16% at individual turbine locations.

Most research effort in the industry has been focused on understanding the effects of ice accretion on power performance. Some studies have also investigated the potential effects on turbine life, both through load measurements campaigns and by using numerical modelling tools. Although the results generally predict an increase in turbine loading (and subsequently a reduction in turbine life), the industry is still not always considering the safety implications of icing: for example, often the turbine ice detection alarms are overridden to keep the turbines operating during icing events in order to reduce power losses.

DNV GL has investigated the effects of ice accretion on wind turbine life, combining numerical modelling with the expertise resulting from the analysis of large amounts of operational data from wind farms in icing conditions. The study is focused on conditions typical of the Scandinavian region and presents a sensitivity analysis of turbine loading increases and life reduction as a function of different icing levels. The analysis has been performed using the aero-elastic software Bladed and a numerical model of a wind turbine, representative of the typical wind turbines installed in this region.

Modelling the effects of ice accretion on turbine loading is a challenge in its own right, and the methods and models to represent their effects vary between design standards. Within this study, a range of different methods have been adopted (including the model recently described in the draft of the IEC 61400-1 edition 4 standard) and a comparison between them will be presented.

The results of this study show the importance of assessing the impact of ice accretion on turbine loading and turbine life, with the ultimate objective of maximizing energy capture whilst not compromising on safety. The study also proposes a framework for performing these analyses at a pre-construction stage, to help assessing whether ice prevention or de-icing systems on the blades would be of benefit for the turbine lifetime and not only from a performance point of view.

Web site: https://www.dnvgl.com/energy/

Short biography: Ricard Buils has been working in the wind industry for almost 9 years. He is currently the Head of the Loads Analysis Section at DNV GL – Energy Advisory, within Turbine Engineering department in Bristol. He obtained an MSc in Mechanical Engineering (aeronautics specialisation) from the Universitat Politècnica de Catalunya (ETSEIB) and the Université Libre de Bruxelles in 2006. After gaining experience in wind energy resource analysis at Energy Resources in Barcelona, he joined Garrad Hassan in 2007 (now DNV GL). The Loads Analysis Section offers a vast range of services related to loads analysis and advanced numerical modelling of wind turbines, both for onshore/offshore/floating wind and tidal domains. He has participated in several collaborative research projects within the wind turbine design field, including topics as blade aerodynamics optimisation, turbine loading reduction, floating wind design and probabilistic design methods.
Ricard has been particularly in involved in site suitability loads assessments, i.e. understanding how the turbine loading may differ in real life - site specific conditions from the original type design loading, including the numerical modelling of ice loading.

BACK

Abstract #: 19 (Oral), session 3:1:1

R&D areas/s: 01. Forecasting, cloud physics, aerodynamics, 02. De-/anti-icing including ice detection & control

An experimental study on the use of nanosecond-pulsed dielectric barrier discharge plasma actuators for de-icing of aerospace structures

Jakob Van den Broecke, Delft University of Technology, NL,

Jakob Van den Broecke (TU Delft, NL), Giuseppe Correale (TU Delft, NL)

An experimental study was performed to test a de-icing system based on nanosecond-pulsed dielectric barrier discharge (ns-DBD) plasma actuation. Both the time and energy required to remove a layer of ice from a surface were investigated under cold climate circumstances. The testing facility was the large climatic chamber of the Offshore Wind Infrastructure lab (OWI-lab) and the testing temperatures ranged from -20 to -10 degrees C. All experiments were performed in quiescent air while monitoring room conditions.
Measurements were performed using a high-speed camera to determine the exact time required to remove all ice from the surface. Back-current shunt technique was applied to investigate the energy consumed by the plasma actuator.
Two different test setup configurations were used, i.e. a vertically mounted plate and a horizontal plate. The ns-DBD plasma actuators were integrated on these plates and covered with ice layers varying in thickness between 1 mm and 2 cm. On the vertical plate the tests were performed until the layer of ice slid off the plate. On the horizontal plate the entire layer of ice was melted.
Different plasma actuator configurations were tested with varying dielectric barrier material and thickness. The materials used as dielectric barrier were Kapton® Lexan®, polytetrafluorethylene(PTFE a.k.a. Teflon®) and silicone rubber. The thickness of the barrier materials varied between 0.5mm and 1.5mm. An electrical signal drove the ns-DBD plasma actuator with bursts of high voltage pulses at a frequency of 10 kHz. The de-icing mechanism relied on the ultrafast gas heating near the dielectric barrier surface. In order to increase the surface affected by the plasma actuator discharge elongation techniques were applied.
The study showed that the thermal effect produced by an ns-DBD plasma actuator is strong enough to remove ice from a surface at the temperatures specified in the test. The energy required for the de-icing of a vertical plate is significantly less than the energy required for the complete melting of a layer of ice. The efficiency of the de-icing system was evaluated by comparing the energy consumed by the plasma actuator with a theoretical calculation on the energy required to melt the same amount of ice. Eventually the power required per surface area was calculated for every plasma actuator configuration allowing for a comparison with existing de-icing methods.

Web site: http://www.windenergy.lr.tudelft.nl/

Short biography: Jakob Van den Broecke is currently finishing his MSc thesis at Delft University of Technology in the Netherlands investigating the efficiency and possible applications of nanosecond-pulsed dielectric barrier discharge plasma actuators. Visiting Winterwind 2015, he related the de-icing problem of the wind energy industry to his Msc thesis subject.
After following a 6-month elective track in sustainable energy technologies during his BSc program in Aerospace Engineering he was triggered to dig deeper into ways to make the energy production methods of our future more sustainable. As he wanted to attack these challenges from an aerodynamic perspective, he chose to graduate under the Aerodynamics & Wind Energy department, specializing in aerodynamics. He did a 3-month internship at Australian Lightwing Aircraft where he assisted on the aerodynamic and structural design of the prototype of a fully electrical car: the Road-E.
For the last 3 years, Jakob has combined his Msc studies with a position as university teaching assistant, where he spent 10 hours/week guiding several groups of first and second year students through an aerospace project and reviewing their work. Also during his studies Jakob played a leading roll in the founding of a new international student society, which has grown from 10 to 50 members in the last 3 years. He is also active as a Red Cross volunteer and a scout leader. At the moment he is looking for opportunities to launch his professional career and make a difference in the world of tomorrow.
www.linkedin.com/in/jakobvdb

BACK

Abstract #: 27 (Oral), session 3:1:2

R&D areas/s: 03. Resource assessment, measurements and models

Frozen anemometers and bias in the wind resource

Lasse Johansson, Sweco, SE,

Lasse Johansson (Sweco Energuide, SE)

Frozen anemometers and bias in the wind resource
Whenever measurements are done where temperatures may drop below zero there is a risk of false data from affected wind sensors, be it cup or sonic anemometers (or remote sensors). For anemometers, proper use of adequately heated anemometry is crucial for a reliable result. Anemometers with high-power heating capability are necessary but not sufficient. Cabling, power supply and so on must be adequate as well.
Even if heating has been arranged and maintained with due care, a certain fraction of the observations will probably be affected, but in the case of deficient or no heating, a significant part of the observations will be wrong; anemometers are known to give both too high and too low values when iced.
The analyst must try to firstly find observations affected by freezing and secondly to do something about them before proceeding with the wind resource assessment. There are many strategies for this such as doing nothing, substituting affected observations by observations from another instrument, assumed not to be affected, correcting iced observations up or down and so on.
We will demonstrate a strategy for treatment of measurements affected by icing based on firm statistical ground and give some examples of biases that can thus be avoided.

Web site: http://www.sweco.se/sv/Sweden/

Short biography: Lasse Johansson is a currently a senior consultant in the field of wind resourcing. He has a background in physics, meteorology and statistics and has been working extensively with meteorological and oceanographic measurements for +25 years. He is particularly interested in applying statistical methods in all stages of revenue assessments.

BACK

Abstract #: 47 (Oral), session 3:1:3

R&D areas/s: 03. Resource assessment, measurements and models

Mast measurements in cold climate - Challenges and recommendations

Sónia Liléo, Sweco, SE,

Gabriella Nilsson (Sweco)
Emil Lindblom (In Situ Instrument)

Measuring the wind conditions with anemometers mounted on meteorological masts is a common practice when assessing the wind resources at sites potentially suitable for wind power development. The conduction of wind measurements at cold climate sites present though specific challenges related to the accumulation of ice on the mast structure and on the sensors. Recommended practices on the conduction of wind measurements at cold climate sites have been presented in 2011 by the IEA Wind Energy in Cold Climates working group [1]. There is still however a general need for further discussion on the performance of different sensors under icing conditions, and on how to identify ice influenced measurements. Furthermore, how to handle data gaps resultant from the removal of ice influenced measurements is still a matter of debate.
Wind measurements and camera images from a met mast located at a cold climate site have been used in this study to investigate the performance of four different wind sensors when subject to icing conditions: Thies First Class, Thies Ultrasonic 2D, Vaisala WAA252 and NRG Ice Free. The mast is configured such that an unheated Thies First Class and a heated Vaisala WAA252 are mounted on a top spire, and a heated Thies Ultrasonic sensor is mounted on a heated side boom mounted just below the top spire. The NRG Ice Free sensor is also heated and mounted on a side boom at a lower altitude. Images of the Thies Ultrasonic sensor and of the supporting side boom are recorded by a camera mounted on a perpendicular boom. Camera images and concurrent wind measurements from the four sensors have been analyzed in order to investigate how the sensors perform during icing conditions. A number of icing events that illustrate the difference in behavior of the sensors are presented and discussed. Based on the results obtained, guidelines on how to identify ice influenced measurements from each sensor are presented. Moreover a discussion is conducted concerning the requirements that should be applicable in order to use measurements from the heated sensors to replace ice influenced measurements from the unheated sensors. Under which conditions does data replacement contribute to a lower uncertainty in the wind measurements?
This study raises relevant questions of interest for developers and consultants working with wind measurements at cold climate sites, and presents conclusions aimed to support the analysis of wind measurements, and to reduce the overall uncertainty in the energy yield assessment of cold climate projects.
References
[1] Expert group study on recommended practices: 13. Wind energy projects in cold climates, IEA Wind, 2011

Web site: http://www.sweco.se/sv/Sweden/

Short biography: Sónia Liléo has a PhD in Physics from the Royal Institute of Technology in Stockholm. Sónia has been working with wind power for six years both as researcher and Consultant, having experience from cooperation with developers, research institutions, turbine manufacturers and investors. One of Sónia's personal interests is the study of the Northern Lights, a beautiful phenomenon visible at high latitudes.

BACK

Abstract #: 51 (Oral), session 3:1:4

R&D areas/s: 01. Forecasting, cloud physics, aerodynamics, 03. Resource assessment, measurements and models

New advances in icing measurements and icing predictions

Øyvind Byrkjedal, Kjeller Vindteknikk, NO,

Bjørn Egil Nygaard (Kjeller Vindteknikk, NOR)
Øyvind Byrkjedal (Kjeller Vindteknikk, NOR)
Øyvind Welgaard (Statnett SF, NOR)

The ongoing research project FRonTLINES is focused on innovation within icing monitoring and icing measurements, as well as further development of numerical icing models. The underlying idea is to develop a toolbox that combines state-of-the art methods and models to calculate the impacts from frost and rime ice on overhead transmission lines. The tools will be applied both for design purposes and for monitoring lines under operation, including forecasting of potentially critical events. The innovation gained in the project is however, also applicable for wind energy site assessment as well as production forecasting at sites exposed to severe icing climate.
The measurement program comprises three test sites, all located in exposed mountain areas in western and southern Norway. The Instrumentation used at the test sites are:

- A newly developed ice load sensor (KVT Ice-Troll)
- An improved heated web camera system for reliable ice monitoring
- Real-time ice load measurements in overhead line test spans
- Real-time ice load measurements in operational high voltage transmission lines
- Meteorological measurements of all relevant parameters, including a laser precipitation monitor (distrometer)

In addition to field measurements, laboratory experiments will be carried out to investigate how the ice builds up on different power lines configurations at the laboratory facilities of STRI (Sweden) and VTT (Finland). Numerical simulations (CFD) of the ice buildup will be performed by Narvik University College.
In this presentation we give an overview of the setup and instrumentation of the test sites, and provide an analysis of the measurements collected so far. The preliminary results show that the icing predictions correspond very well to the measurements in terms of ice accumulation on test spans and operational transmission lines, but the occurrence of ice shedding from the lines seems somewhat less predictable. We also present some advances made regarding mapping of local icing conditions, including examples of high resolution ice load maps.
The first experiences and results from the new ice load sensor developed at Kjeller Vindteknikk (preliminarily named “KVT Ice-troll”) will be presented. The sensor is constructed according to the ISO description of a standard reference object, and the new design has allowed for forced rotation of the cylinder in combination with automatic load monitoring, and no requirement of added heat.
The FRonTLINES project, lead by Kjeller Vindteknikk, is funded 50 % by the Norwegian Research Council and 40 % by Statnett SF, the transmission system operator in Norway. 10 % is funded by the project partners: The Norwegian Meteorological Institute, STRI (Sweden), VTT (Finland), Narvik University College (Norway) and Kjeller Vindteknikk (Norway).

Web site: http://www.vindteknikk.no

Short biography: Byrkjedal has been working in Kjeller Vindteknikk for the past 8 years, and holds the position of R&D manager. Byrkjedal has a background as a meteorologist and holds a phd in meteorology from the University of Bergen, Norway.
He has been working in the field of meteorological icing during the past 8 years, and has lead the development of the Norwegian wind- and icing atlases and has also created wind and icing atlases for Sweden and Finland. Byrkjedal has also developed a methodology to estimate power losses due to icing based on operational power data from several Swedish wind farms.

BACK

Abstract #: 15 (Oral), session 3:2:1

R&D areas/s: 02. De-/anti-icing including ice detection & control

Wet-snow production and snowing wind tunnel test for snow accretion and prevention

Kengo Satoh, Snow and Ice Research Center, National Reserch Institute for Earth Science and Disaster Prevention, JP,

Shigeo Kimura (KAIT,JP)
Tomofumi Saito (KAIT,JP)
Hiroshi Morikawa (MeRIT, JP)
Tetuya Kojima(MeRIT,JP)
Haruka Endo(MeRIT,JP)
Shigeto Mochizuki(NIED,JP)

Although adhesion force of dry snow is small, wet snow is large adhesion force under the influence of surface tension of water, and cause damage by snow accretion to various structures. However, the method of wet snow created have not been established, snow accretion experiments method and the evaluation of snow accretion prevention are also not a well.

To establish snow accretion experiment method of wet snow is more and more important for various scientists to obtain precise data. However it is difficult to control water content of wet snow. In a lot of cases, dry snow was got blown with water spray using wind tunnel, but it differs significantly from real wet snow accretion mechanism.

The purpose of this paper is to propose a new method to control low percentage water content of dendrite snow using forced ventilation, and to confirm reproducibility of the results. As a result, water content of snow reached about 3％ in 30 cases after 8-12min.

In our laboratory, there is a cold room, snowfall machine and wind tunnel, it is possible to carry out experiments of snow accretion. We compared the effect of several snowy prevention methods. As a result, as compared with the case of only the heater or water repellent coatings, the case of a combination of water-repellent coating and a heater was effective in snow accretion prevention.

Web site: http://www.bosai.go.jp/seppyo/index_e.html

Short biography: Previously worked as researcher at a electric power institute

BACK

Abstract #: 7 (Oral), session 3:2:2

R&D areas/s: 02. De-/anti-icing including ice detection & control

Prediction of production losses in cold climates and Ice Protection System design by Computational Fluid Dynamics

Massimo Galbiati, EnginSoft, IT,

Massimo Galbiati,
EnginSoft SpA, Via Stezzano, 87 - Kilometro Rosso - 24126 Bergamo – Italy
Christoffer Jarpner,
EnginSoft Nordic, IDEON Science Park - 223 70 Lund – Sweden

Prediction of production losses, ice detection, de-icing and anti-icing of wind turbines is becoming a relevant topic for blade and turbine manufactures as installation of wind turbines grows in cold climates. This paper presents how simulation tools can support the prediction of energy losses due to ice both for single wind turbines and for a complete wind farm. Moreover, it is explained how the same simulation tools can be used to design and optimize de-icing and anti-icing systems, both based on hot air and on electro-thermal heating.
Ice accretion on wind turbines occurs when supercooled droplets impinge on the surface of the blades. The shape of the accreting ice can be very different depending on the environmental conditions, hence ice can have very different effects on the performance of a contaminated wind turbine.
Simulation tools, combining Computational Fluid Dynamics with 3D ice accretion, have been used in recent years by wind turbine manufactures for the prediction of ice accretion on wind turbines and for the assessment of performance degradation due to glaze and rime ice.
The prediction of areas interested by ice build-up is also the first step to design effective and efficient Ice Protection Systems (IPS). Anti-icing requirements strongly depend on the icing scenario for which the IPS must be designed and they are mainly defined by two types of unknowns: the region of the blade that has to be heated (coverage) and the power distribution. The optimal definition of coverage and power distribution allows to minimize energy consumption and operating costs of Ice Protection Systems.

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

Short biography: Mr Galbiati has been working on industrial application of Computational Fluid Dynamics for 18 years. He is currently Project Manager at EnginSoft SpA and responsible for a team specialized in simulation of ice accretion, de-icing and anti-icing systems, mainly in the aeronautical and wind energy sectors. He studied Environmental Engineering at the Politecnico di Milano and Economy of Energy and Environment at Scuola Mattei (ENI SpA). After his studies he has worked on Computational Fluid Dynamics and optimization techniques applied to different industrial sectors, with special focus on heat transfer, multi-phase flow and ice accretion simulation.

BACK

Abstract #: 2 (Oral), session 3:2:3

R&D areas/s: 02. De-/anti-icing including ice detection & control

Assessment of de-icing and anti-icing technologies in ice wind tunnel

Nadine Rehfeld, Fraunhofer IFAM, DE,

Björn Speckmann, Andreas Stake, Volkmar Stenzel (Fraunhofer IFAM, Ge)

Ice wind tunnel tests are an important tool to evaluate the performance of anti-icing and de-icing technologies for application fields concerning the atmospheric icing. This applies to aircraft structures and wind turbines; but also ships or trains are being affected by icing. Despite significant differences between these application fields; they all have in common the need for reliable de-icing or anti-icing technologies. Many technologies for anti-icing and de-icing purposes are available on the market right now. However, there are still potentials for improvement or even replacement of state-of-the-art technologies in order to raise efficiency, reduce risks, and improve the performance. Heating mats are one of the current technology steps – but, there are further technologies that can contribute to the improvement of ice protection systems.
We report on evaluation techniques to assess the performance of such ice protection systems. A new ice wind tunnel test facility is available at Fraunhofer IFAM which shows a broad compliance to relevant test standards (e.g. SAE (Society of Automotive Engineers) Aerospace Recommended Practice). Wind tunnel temperatures down to -30°C and wind speed of up to 350km/h can be realized. Defined water injection system produces water spray in the test section for realistic and reproducible ice scenarios. Furthermore, this test facility can be used as ice lab (minus 30°C) for comprehensive ice-related tests, including reliability tests for technical components under icing conditions and ice adhesion tests for evaluation of icephobic materials.
The presentation includes examples of the characterization process of the wind tunnel test section as well as test results from latest test campaigns, including the assessment of passive anti-icing coatings. Especially, ice formation processes and the performance of anti-icing coatings in combination with active heating devices and subsequent run-back ice formation on unheated areas of mock-ups are presented.

Web site:
http://www.ifam.fraunhofer.de/de/Bremen/Klebtechnik_Oberflaechen/Lacktechnik/Funktionelle_Lacke_Beschichtungen/Anti-Eis-Schichten.html

Short biography: Nadine Rehfeld joined Fraunhofer IFAM (Bremen, Germany) in 2008 as Project Leader in the Paint Technology Department. She is a biology graduate and started working on paint-related topics in the aircraft industry in 2006. Since 2008 she specializes in multifunctional coatings with main focus on development and testing of anti-icing coatings. She has been responsible for the R&D activities related to anti-icing technologies. Amongst others, she worked in Clean Sky Program on the screening and assessment of icephobic materials. Currently, she coordinates the EC-FP7 project JediAce dealing with ice protection systems for aircraft applications.

BACK

Abstract #: 38 (Oral), session 3:3:1

R&D areas/s: 10. Standards, 14. Other

Overview of IEA Wind Task 19 results from 2013-2015

Ville Lehtomäki, VTT, FI,

A. Krenn (AT), N-E Clausen (DK), N. Davis (DK), R. Cattin (CH), P.J. Jordaens (BE), Z. Khadiri-Yazami (DE), R. Klintström (SE), G. Ronsten (SE), Q. Wang (CN), M. Wadham-Gagnon (CA), H. Wickman (SE)

IEA Wind Task 19 ”Wind Energy in Cold Climates” is an international expert group that has worked together since 2002 with a mission to safely and cost efficiently increase wind power deployments in cold climates. The present Task 19 working period (2013-2015) is coming to an end (new extension plan 2016-2018 has been approved) and it is time to take a prelook at the most interesting deliverables from Task 19 as summarized below.

T19IceLossMethod free software

The free software T19IceLossMethod (Standardized method to assess production losses due to icing from wind turbine SCADA data) was launched in Sep2015 and can be downloaded from http://www.ieawind.org/task_19.html. This easy-to-use software aims to standardize the production loss method allowing a better intercomparison of different site icing severities and boost the dissemination of icing conditions to lower the cost of future cold climate wind farms.

Available Technologies report (ed 2016)

Previously known as State-of-the-Art report (previous edition 2012), the new Available Technologies (AT) report is targeted for hands-on project engineers and scientist who are solving icing related issues. The AT report summarizes the most essential tools and methods regarding the entire value chain of the cold climate wind development process, from icing maps to O&M and testing. The key messages of the report are provided in solution specific summary tables (below) to enable a quick review of existing technologies in a pre-crunched format including an indication of the Technology Readiness Level.

Solution	Advantage	Disadvantage	TRL
xxx	yyy	zzz	aaa

Recommended Practices report (ed 2016)

Previous edition 2011 of Recommended Practices (RP) report launched the widely adopted IEA Ice Classification site categorization. In the ed 2016, validation of the IEA Ice Classification is presented and potential improvements suggested. The RP report has also a new section for ice throw guidelines summarizing the required steps for standardized ice throw risk assessment studies.

Web site: http://www.vttresearch.com/services/low-carbon-energy/wind-energy

Short biography: Mr Lehtomäki has a MSc in mechanical engineer (product development) and been part of VTT Technical Research Centre of Finland Ltd in Wind Power team as Research Scientist since 2009. His work focuses on ice assessment, iced wind turbine dynamics and icing effects on blades. He is the coordinator of cold climate sub-committee in the revision of IEC 61400-1 ed3->ed4 “Design requirements for wind turbines”. He is Operating Agent of International Energy Agency (IEA) Task 19 “Wind Energy In Cold Climates”. In his spare time, he runs around badminton and floorball arenas and prefers downhill over cross-county skiing.

BACK

Abstract #: 9 (Oral), session 3:3:2

R&D areas/s: 06. HSE (Health, Safety and Environment), 08. Finance, risk assessment and mitigation, 10. Standards, 12. Permission and legal challenges

IEA Task 19 - Standardised methodology for the elaboration of ice throw risk assessments

Andreas Krenn, Energiewerkstatt, AT,

R. Cattin, Meteotest (CH), N-E Clausen (DK), N. Davis (DK), P.J. Jordaens (BE), Z. Khadiri (DE), R. Klintström (SE), V. Lehtomäki (FI), G. Ronsten (SE), M. Wadham-Gagnon (CA), Qiang Wang (CN), H. Wickman (SE)

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 national regulatory authorities towards this topic has been observed and nowadays the elaboration of detailed risk assessments is required in many countries [1].
The new Recommended Practices Report of IEA Task 19 (to be published in 2016) includes general guidelines on which approach is suitable for different locations (ranges from simple estimations based on empiric formulas to detailed risk assessment using ballistic models). Howevr, up to now there are no international recommendations or standards available regarding the required quality of those detailed risk assessments.
When comparing the assessments of different consultants, significant deviations in the methodology and the results can be discovered. Differences can be identified in the mathematical model used for the calculation of the distances (flight behaviour of falling ice fragments, consideration of vertical wind profile and/or topography…), but also in the selection of the underlying data (shape and amount of relevant ice fragments, timely and spatial resolution of used wind speed data…). Moreover, the estimation of the likelihood of human beings in the vicinity of the WT and the subsequent risk assessment are not consistent in the approaches of different consultants.
The start of this study is planned for 2016. At this point of time, IEA Task 19 would like to inform and motivate external experts to participate.
2. Methodology
In order to address the relevant topics, workshops with experts from international consultants and round robin tests will be organised in the course of the upcoming term of IEA Task 19. This way, results from different models and consultants can be compared. In order to keep the comparisons more effective, the individual workshops and round robin tests focus on a clearly defined content (i.e. used mathematical model; input data; assessment of associated risk).
In parallel sensitivity analysis will be carried out in order to identify how the alteration of different parameters (shape and flight behaviour of fragments, location of ice on the blades, timely resolution of wind measurement data…) influences the calculation results.
3. Results
As a result of this upcoming study, a report with recommendations regarding the elaboration of ice-throw / ice-fall risk assessments will be published. This can be used as a basis for a subsequent inclusion in international standards.
Those recommendations will pave the path to a more transparent and science-based methodology in the elaboration of ice-throw-risk-assessments and help to unify authorization practices in the different countries.
4. References
[1] A. Krenn und et al, „Risk of icefall in the international context“; in Winterwind, 2014.

Web site: https://www.energiewerkstatt.org

Short biography: Andreas Krenn graduated at the University of Applied Sciences in Vienna. Since 2006 he has been working for Energiewerkstatt as a project manager for national and international wind energy projects. In 2008 he was assigned as the manager of the company's research department. He is the Austrian representative in IEA Task 19 and the alternate member of Austria in the Executive Committee of IEA Wind. Andreas Krenn is author of several Scientific Papers, Feasibility Studies and Due Diligences.

BACK

Abstract #: 37 (Oral), session 3:3:3

R&D areas/s: 01. Forecasting, cloud physics, aerodynamics, 02. De-/anti-icing including ice detection & control, 03. Resource assessment, measurements and models, 04. Production experience, losses, 06. HSE (Health, Safety and Environment)

Validation of the IEA Task 19 ice site classification

René Cattin, Meteotest, CH,

V. Lehtomäki (FI), A. Krenn (AT), N-E Clausen (DK), N. Davis (DK), P. Jordaens (BE), Z. Khadiri (DE), R. Klintström (SE), G. Ronsten (SE), M. Wadham-Gagnon (CA), H. Wickman (SE)

In 2011, the IEA Ice Classification was introduced in the report "Recommended Practices for Wind Energy in Cold Climates" written by IEA RD&D Wind's Task 19 - "Wind Energy in Cold Climates (hereafter "IEA Task 19"). This allowed stakeholders in wind energy, for the first time, to classify a wind park site based on the frequency of meteorological icing (ice build-up) and instrumental icing (ice persistence). The site classification consists of five classes. For each class, an indication of the related energy loss is provided.
When the IEA T19 site classification was introduced, the availability of empiric field data for validation was very small. For this reason, no validation of the site classification was possible at that time. Therefore, very wide and overlapping classes needed to be defined.
Since the publication of the site classification, the cold climate market and thus the interest in the site classification have grown significantly. Furthermore, the measurement of meteorological icing and instrumental icing has become much more common in the industry.
Therefore IEA Task 19 decided in 2015 to carry out a validation study of the IEA Ice Classification. IEA Task 19 launched out a comprehensive quest for icing versus power loss data within its network. As instrumental icing is still measured much more commonly and often than meteorological icing, it was decided to limit the validation on the relation between instrumental icing and power loss.
In this validation study, approximately 50 data pairs of instrumental icing versus power loss were collected from different sources and examined. The presentation will illustrate the distribution and the scatter of the data pairs, analyse how good they fit into the different ice classes and show the effect of year-to-year variability on the site classification. The study will also present the effects of de-icing equipment on the power loss.
Furthermore, the results of the analysis provide interesting insights on the current state of the cold climate wind industry and the required work to be tackled in order to fully "unlock the potential" of wind energy under icing conditions. This especially concerns the field of standardization of methods (icing measurements, determination of power loss) and the effects of different operational modes and de-icing equipment.
Finally, the most important updates and improvements of the IEA Ice classification in the new edition 2016 of the recommended practices report will be presented. This will include a more precise definition of instrumental icing, the introduction of rotor icing as well as additional ice load and icing intensity classes.

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

Short biography: René Cattin is a Geographer. He works for Meteotest since 15 years. Today he is member of the executive board of Meteotest. René Cattin has a long experience in the field of icing. He is the Swiss member of IEA Task 19 sind 2009 and also a member of TP Wind. He was project manager of the project "Alpine Test Site Gütsch" under the umbrella of COST Action 727 as well as the test site St. Brais. It is his 8th participation in a Winterwind conference. Outside the office, he is very interested in rock music, currently it is the history of the Sex Pistols which is in his focus.

BACK

Abstract #: 17 (Oral), session 3:3:4

R&D areas/s: 01. Forecasting, cloud physics, aerodynamics, 02. De-/anti-icing including ice detection & control, 03. Resource assessment, measurements and models, 14. Other

Classification based approach for icing detection

Zouhair Khadiri-Yazami, Fraunhofer IWES, DE,

Christoph Scholz (Fraunhofer IWES, DE), André Baier (Fraunhofer IWES, DE), Ting Tang (Fraunhofer IWES, DE), Michael Durstewitz (Fraunhofer IWES, DE)

Icing detection under cold climate is considered an essential issue not only for the wind industry. Already during site assessment and project development a reliable knowledge about on-site icing is of important relevance for choosing an appropriately equipped type of wind turbine. Furthermore, the effects of icing on turbine operation and a trustworthy estimation about icing induced production losses are necessary for an efficient, safe and economic control of de-icing systems.
The detection of icing using solely meteorological data and no instrumentation, e.g. ice sensors or double anemometry, is a big challenge. In this study an innovative approach of ice detection utilizing classification methods and meteorological data will be presented. For the classification several machine learning procedures like pattern recognition with artificial neural network or random forest are used and compared.
In this context we have analyzed the impact and relevance of several meteorological parameters, like temperature, relative humidity, wind speed or sky condition index as input data. As output information about the intensity and duration of meteorological and instrumental icing as well as incubation and recovery periods can be delivered. Depending on the availability of meteorological parameters the reason for start and end of an icing event is also analyzed.
Our approach and the method validation is based on measurement data of three winter periods with more than 128 icing events and 1200 hours of instrumental icing. The measurements were taken from our 200m met mast located on mountain in Northern Hesse in Germany. The mast is one of the highest meteorological masts in Europe and it is equipped with more than 40 meteorological and wind sensors that provide detailed information about atmospheric conditions.
A reliable icing detection using available and simple meteorological data of specific sites will give an additional value in the development of wind energy in cold climate regions. This study shows promising results of icing detection with the presented approach. Additionally it will be shown how this method could be used with numerical weather models for site specific icing detection or even for icing forecasts.

Web site: http://www.energiesystemtechnik.iwes.fraunhofer.de/en.html

Short biography: Mr Zouhair Khadiri-Yazami holds an engineering degree from the University of Kassel, as well as master degree in electrical engineering. He joined Fraunhofer Institute for Wind Energy and Energy System Technology in Mai 2011 and has been working as a research associate since then. Since his master thesis and within several projects Zouhair Khadiri-Yazami has gained considerable experience in wind measurements and especially in LiDAR measurements. Zouhair Khadiri-Yazami is also involved in several projects regarding wind energy in cold climate. Since 2013 he works with the International Energy Agency (IEA) – working group Task 19 "Wind power in cold climates" - as representative of Germany.

BACK

Abstract #: 57 (Oral), session 3:3:5

R&D areas/s: 14. Other

Panel: What should IEA Task 19 take into account when working with the new draft standard IEC 61400-15 "Site energy yield assessment" in 2016-17?

Ville Lehtomäki, VTT, FI,

IEA Task 19

Continuing from IEA Wind Task 19 "Wind Energy in Cold Climates" previous successful panel discussion at WinterWind 2015, a new panel discussion will be arranged with title "What should IEA Task 19 take into account when working with the new draft standard IEC 61400-15 "Site energy yield assessment" in 2016-17?". The panel will be made of Task 19 experts and industry representatives. The panel will be 30min in total length.
If possible, some statistics from WinterWind web survey from conference participants prior to the panel discussion will be used to stimulate the discussions.

Web site: http://www.ieawind.org/task_19.html

Short biography: Mr Lehtomäki has a M.Sc. degree in mechanical engineer (product development) and been part of VTT Technical Research Centre of Finland Ltd in Wind Power team as Research Scientist since 2009. His work focuses on ice assessment, iced wind turbine dynamics and icing effects on blades. He is the coordinator of cold climate sub-committee in the revision of IEC 61400-1 ed3->ed4 "Design requirements for wind turbines". He is Operating Agent of International Energy Agency (IEA) Task 19 "Wind Energy In Cold Climates".

BACK

Abstract #: 35 (Oral), session 4:1:1

R&D areas/s: 02. De-/anti-icing including ice detection & control, 04. Production experience, losses, 05. DOM (Deployment, Operations and Maintenance)

A look at wind turbine performance in Canadian icing climate

Dominic Bolduc, TechnoCentre éolien, CA,

Dominic Bolduc (TCE, CA),
Matthew Wadham-Gagnon (TCE, CA),
Charles Godreau (TCE, CA),
Nigel Swytink-Binnema (TCE, CA),
Christoph Golombek (Senvion GmbH, DE)
Hannes Friedrich (Senvion Canada Inc., CA)

Wind turbines in Eastern Canada are exposed to low temperatures and moderate to severe icing conditions. Ice accretion on wind turbine blades may cause aerodynamic and mass imbalances that can lead to production losses as well as increased extreme loads.
This presentation will provide insight through case studies on the operation of Senvion wind turbines in icing climate from at least three different wind farms in Quebec. These turbines are controlled by a dedicated Ice Operation Mode during icing events, designed to maximise energy yield while ensuring a minimal risk of high extreme loads.
Several wind turbines have been instrumented with additional meteorological sensors and cameras enabling the monitoring and characterisation of icing event duration, intensity and severity. Among these turbines, some are equipped with load sensors providing valuable data in assessing and validating critical load-cases on components such as the blades, main shaft and tower. Other turbines are equipped with prototype hot air de-icing systems designed to remove the ice from the surface of the blades during icing events.
The case studies will provide examples of how the Ice Operation Mode can improve energy yield by avoiding turbine stall in icing events, how ice induced loads should not be neglected, how ice detection plays a crucial role in the control strategy, and how the hot air de-icing system can get a turbine back on the grid and producing energy instead of standing still for days.

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

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

Abstract #: 56 (Oral), session 4:1:2

R&D areas/s: 14. Other

The Swedish Energy Agency strategy within wind energy

Pierre-Jean Rigole, Swedish Energy Agency, SE,

Pierre-Jean Rigole (Swedish Energy Agency, SE)

The Swedish Energy Agency works for a sustainable energy system in Sweden, combining ecological sustainability, competitiveness and security of supply. The Swedish Energy Agency finances research for new and renewable energy technologies, smart grids, and vehicles and transport fuels of the future. Within the wind sector the Agency has a financing budget of about 60 MSEK supporting research and innovation, demonstration and promoting activities. Wind power is expected to play an increasing role for electricity production in Sweden. The Swedish government has set up a planning framework of 30 TWh wind power in 2030, and in 2014 the production reached 11.5 TWh, and preliminary 16.5 TWh in 2015. In order to coordinate its actions to support research within the wind sector, the Swedish Energy Agency has prepared a strategy through internal consultation involving all departments at the Agency as well as by taking in external inputs from the wind energy research and market actors. The strategy isolates three prioritised areas: Wind in Swedish conditions, sustainability and acceptance, and electrical network integration. Wind in Swedish conditions implies supporting activities to installation and operation of wind turbines in cold climate, in forest environment and in the Baltic Sea, pinpointed areas for their significant innovation potential. Sustainability and acceptance area focuses on research and promoting activities on social, economic and ecological impacts of wind deployment locally and national level, and dissemination of knowledge for improved decision process and acceptance. Definitely a crucial area to reach a broad support wind energy growth in Sweden. The third area deals with network integration to develop technical solution and business model for a seamless integration of wind power in the distribution and transmission network. The work with the strategy at the agency will be a continuous activity with expected updates every year.

Web site: http://www.energimyndigheten.se/en

Short biography: Prior to working as the Swedish Energy Agency, Pierre-Jean was Director of Technology at Finisar Sweden, part of Finisar Inc. the world's largest supplier of optical communication products. Prior to Finisar Sweden he was the CTO and founder of Syntune, a company developing and selling widely tunable semiconductor laser diodes. Syntune was acquired by Finisar in May 2011. Pierre-Jean has a Ph.D. on widely tunable laser diodes from the Royal Institute of Technology (KTH) in Stockholm, Sweden. He holds a M.Sc. degree in Sustainable Technology from KTH and a M.Sc. degree in Engineering Physics from the École Nationale de Physique de Marseille, France. During his spare time Pierre-Jean is enjoying spending time with his family and friends and practicing bicycling.

BACK

Abstract #: 44 (Oral), session 4:1:3

R&D areas/s: 02. De-/anti-icing including ice detection & control, 03. Resource assessment, measurements and models, 04. Production experience, losses, 06. HSE (Health, Safety and Environment)

An overview of Vattenfall´s research within turbine icing – Yesterday, today and tomorrow

Ylva Odemark, Vattenfall AB, SE,

Peter Krohn (Vattenfall AB, SE)
Benjamin Martinez (Vattenfall AB, DK)
Marie Cecilie Pedersen (Vattenfall AB, DK)

Vattenfall is aiming at being a leader in sustainable production, and part of this strategy is to grow in renewables and invest in wind power. This winter of 2015/2016 is Vattenfall´s first winter with modern turbines with de-icing technique. During 2016 a procurement process for a high number of turbines is taking place, where de-icing technique and associated warranties will be required. In the coming years several large scale wind farms in the north of Sweden are planned, where icing is known to be a severe issue. In order to deal with this problem, Vattenfall has since 2011 organized a research programme called the Turbine Icing Programme. It includes in-house work as well as collaborations with universities, research institutes, power companies and consultants. Within the programme, we have installed and evaluated several different types of blade- and nacelle-based icing sensors and compared the results to both power output and camera images. Both the availability and the accuracy of the sensors have been found to vary heavily, and the harsh conditions at the test sites make it difficult to obtain reliable results. This work is still ongoing, and new icing sensors and cameras are planned to be installed at one of our newest wind farms. Other current projects include evaluation of de-icing systems, simulations with WRF (Weather Research and Forcasting) models, evaluation of icing forecasts, and the development of a CFD (Computational Fluid Dynamics) model to look at the process of ice accretion. A large effort is also put on issues regarding ice throws, risk analysis and mitigation. Through university collaborations, we are also looking into new solutions and methods, like microwave heating, different types of hydrophobic coatings and measurements of liquid water content.

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

Short biography: Ylva Odemark has been working at Vattenfall R&D for three years. During that time, she has been involved in various projects within both nuclear, wind and biomass. The last 1.5 years she has been managing Vattenfall´s research programme within turbine icing issues. She has a PhD from KTH in Stockholm within fluid mechanics with specialization on wakes behind wind turbines. During her spare time, she likes to go skiing or biking.

BACK

Abstract #: 50 (Oral), session 4:2:1

R&D areas/s: 02. De-/anti-icing including ice detection & control, 06. HSE (Health, Safety and Environment)

An approach in using guided waves for ice detection on wind turbines

Siavash Shoja, Chalmers University of Technology, SE,

Siavash Shoja (Chalmers, Sweden)
Viktor Berbyuk (Chalmers, Sweden)
Anders Boström (Chalmers, Sweden)

Ice accumulation on wind turbine blades is one of the main obstacles preventing wind turbines to operate efficiently in cold regions. Currently there are numerous ice detection systems operating on wind turbines. However an efficient ice detection system for wind turbine applications is not available yet [1]. Studies were done previously showed that using guided waves is a promising approach in order to detect the ice in early stages of accumulation [1, 2]. The aim of this project is to study the possibility of using guided waves to properly detect the accumulated ice on the blade. Quantity and location of ice are the variables which have been tried to be detected by using this approach.
In this study an experimental setup is used in a cold climate chamber. A 8m long composite plate is used as the test object. The test object contains 62 layups of glass fiber and Vinylester which is a common material used in the wind turbine industry. An actuator is installed on one side of the plate and 24 accelerometers are used to detect the signal. To observe the effect of temperature on the material, the experiment was done in a temperature range of 20°C to -15°C. Next ice was built on the plate with different thickness and its effects were studied on the propagated wave. Since doing this experiment is limited and time consuming, a FE model is created and calibrated using experimental measurements. The results of the FE model are in a good agreement with experimental measurements which gives the possibility of using the model for further and advanced study.
Different post-processing procedures are performed on the results of the numerical model and experiments in time, frequency and wave-number domains. Investigating the post-processed results show that quantity and location of ice are detectable using this method in early stages of ice accumulation.
FUTURE WORK
The efficiency of the developed theoretical-experimental methodology is planned to be examined on an actual wind turbine blade. Moreover, the methodology can be adapted and used for NDE purposes makes the system a multifunctional detection/health monitoring system for wind turbines.
ACKNOWLEDGEMENTS
This project is part of a PhD project “Ice detection for smart de-icing of wind turbines” and it is funded by Swedish Energy Agency (Dnr 2013-001475, project 37286-1). The authors would like to thank Mr. Jan Möller for all the technical support in the experimental tests.
REFERENCES
[1] Shoja, S., Berbyuk, V., and A. Boström, (2015), Investigating the application of guided wave propagation for ice detection on composite materials, In Proc. of the International Conference on Engineering Vibration, Ljubljana, 7 - 10 September ; [editors Miha Boltežar, Janko Slavič, Marian Wiercigroch]. - EBook. - Ljubljana: Faculty for Mechanical Engineering, 2015 p. 152-161.
[2] Berbyuk, V., Peterson, B., Möller, J., (2014), Towards early ice detection on wind turbine blades using acoustic waves. Proc. of SPIE, Nondestructive Characterization for Composite Materials, Aerospace Engineering, Civil Infrastructure, and Homeland Security, San Diego, California, USA, March 09, 2014, 9063 pp. 90630F-1 - 90630F-11.

Web site: http://www.chalmers.se/en/departments/am/Pages/default.aspx

Short biography: Siavash is PhD student at the department of applied mechanics at Chalmers University of Technology. His background is in numerical modelling of wave propagations in composite structures. Some of his previous works in ice detection problems have been published.

BACK

Abstract #: 12 (Oral), session 4:2:2

R&D areas/s: 02. De-/anti-icing including ice detection & control

Combined effect of the heating and the superhydrophobic coating on the deicing capability of the ultrasonic wind sensor

Tomofumi Saito, Kanagawa institute of technology, JP,

Tomofumi Saito (KAIT, JP), Shigeo Kimura (KAIT, JP), Kengo Sato (NIED, JP), Hiroshi Morikawa (MeRIT, JP), Tetuya Kojima(MeRIT, JP), Haruka Endo (MeRIT, JP), Yoichi Yamagishi (KAIT, JP), Shigeto Mochizuki (NIED, JP), Jarmo Hietanen (Vaisala, FI)

Wind measurements play an important role not only in meteorological weather observations, but also in a production of wind power, air control in airports, and traffic control on motorways and railroads. For instance, operative control of wind turbines and the movement of trains are controlled as a safety measure by judging the instant wind speed values. Hence, if there is issue with the data correctness or the data availability is too low, regulation might lead to an operative limitations or even stoppage of a wind turbine or a train line.
An ultrasonic wind sensor was studied at the National Research Institute for Earth Science and Disaster Prevention, Shinjo Cryospheric Environment Laboratory. Inside the wind tunnel, artificial conditions of snowing were created. The results revealed formation of a primary icing followed with a secondary icing. This might lead to an ice bridge and further to an air gap between exterior transducer surface and secondary ice layer. As a consequence, there can be an effect on the data correctness or the data availability. This finding suggested that preventing the formation of an ice bridge on the transducer surface could be a promising measure for obtaining data correctness and improve data availability of the wind sensor.
In this paper combined effect of the sensor heating and the superhydrophobic coating is studied to further improve sensor performance under challenging weather conditions. The applied sample is the Ultrasonic Wind Sensor WMT700 by Vaisala Oyj. Some of the crucial improvements in this model over the previous ones are a wider heated area including the transducer arms and the top cover, and an increase in the heating power. In particular, installation of heating elements in the upper part of the arm could be expected to avoid the formation of secondary ice on the lower part of the transducer. To further assist avoidance of the icing superhydrophobic coating on the heated area for a quick removal of meltwater from the surface was applied. Preliminary tests indicated that due to the presence of the coating film there are neither negative effects on the ultrasonic transmission nor chemical damage to the transducer material. The improved wind sensors were tested in the snowing wind tunnel and their better performances in terms of ice prevention were confirmed by the absence of the formation of the ice bridge.

Web site: http://www.kait.jp/english/

Short biography: Mr Saito is now a master's course student at Kanagawa Institute of Technology.
His research interest is icephobic-coating applications to wind sensor and antenna.

BACK

Abstract #: 30 (Oral), session 4:2:3

R&D areas/s: 02. De-/anti-icing including ice detection & control

Performance of two nacelle-mounted ice detectors: a case study

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

Katja Hynynen (LUT, FI), Olli Pyrhönen (LUT, FI), Jordi Armet (Alstom, Spain), Irene Romero (Alstom, Spain)

The amount of wind power in cold climate and icy conditions is increasing. Ice accretion on the blades causes power losses and safety risk for the surrounding area due to possible ice throw. There are only few sensors commercially available for ice detection. Methods detecting ice on the blades sound a promising approach, but more reliable results of their performance would be required. Since nacelle-mounted sensors can be easily installed on existing wind turbines, and they have lower investment and maintenance costs compared with blade mounted sensors, they are an attractive choice for turbines with or without blade heating.

In this case study, performance of two nacelle-mounted ice detectors in a wind farm situated in southeast Finland was studied. The study was part of a research project 'Wind power in cold climate and complex terrain' carrying out by Lappeenranta university of technology, Alstom Renovables España, TuuliMuukko and TuuliSaimaa.

The measurement campaign was performed in a wind farm of seven Alstom ECO110 cold climate version turbines in southeast Finland during the six months period 18.10.2014 – 15.4.2015. The ice conditions at the site were observed using two ice detectors installed on the nacelle, that is, sensors A and B. Ice accretion on the blades was observed using a web camera installed on the nacelle. Additionally, weather data from Finnish meteorological institute (FMI) and close-by Lidar weather station were used.

With a web camera, ice was found on the blades during 59 days within the analyzed period. This means that there were ice at least some time of the day during those 59 days and not necessarily whole 24 hours/day. Only rime ice or other thicker, snow-type ice was possible to see with camera. Glaze or other very thin formation of ice could not be seen. However, it is possible, and even probable, that there has been also glaze, and thus, more icy days.

Performance of ice detectors was analyzed by comparing the detectors alarms with weather data and icing diary obtained using web camera. Overall, ice detectors found 76 icing occurrences during the analyzed period. Exact duration of the ice alarms was 264 hours. All the ice occurrences found using web camera were detected by both sensors A and B, or at least one of them. Sensor A detected during 95% (72/76) and sensor B during 97% (74/76) of the proved ice occurrences. No power loss caused by icing was observed by the first alarm. Thus, the performance of the detectors can be stated as very good.

When comparing the sensitivity of ice detectors, it was found that sensor B often detected earlier than sensor A during in-cloud icing. It was also faster or only detecting sensor in probable wet snow conditions. However, sensor A detected earlier more often during precipitation close to zero degrees. According to the results, it can be said that the threshold value of sensor A is most probably higher compared with the default threshold of sensor B, and that is why sensor A often gives alarm before sensor B. On the other hand, sensor B seems to be better in detecting in-cloud icing conditions, because it gives an alarm before sensor A in those conditions. The "false alarms" of the ice detectors, when there was no ice found on the blades using web camera, can probably be explained by the fact that with the camera, it was not possible to detect very small amounts of ice.

As a conclusion, it can be said that both nacelle-mounted ice detectors performed very good. All the proven ice occurrences were detected by the sensors. In the future, to ensure a proper threshold value for the nacelle-mounted ice detector, its performance should be analyzed together with an ice detector that indicates the amount of ice on the blade and the power loss of the turbine.

Web site: http://www.lut.fi/web/en/

Short biography: Katja Hynynen received the M.Sc. degree in energy technology in 2000 and D.Sc. degree in electrical engineering in 2011 from Lappeenranta University of Technology (LUT), Finland.
She is working as a Finnish academy post-doctoral researcher in the Department of Electrical Engineering at LUT. Her research interests include wind resource assessment, influence of cold climate and complex terrain conditions to wind turbine operation and maintenance requirements, and diagnostics of wind turbines.

Abstract #: 6 (Oral), session 4:2:4

R&D areas/s: 02. De-/anti-icing including ice detection & control, 03. Resource assessment, measurements and models

Wind turbine ice detection systems testing

David Futter, Uniper Technologies Ltd, UK,

David Futter (Uniper Technologies, UK); Neil Brinkworth (Uniper Technologies, UK); Thomas Humphries (Uniper Technologies, UK)

Detection of ice on wind turbine blades has been a challenge to the industry, and is important due to the potential harm from ice throw. Following a literature survey in 2014 T&I commissioned testing of the efficacy of ice detection systems based on both ice detection sensors attached to the blades and on data driven methods based on power losses.
Nine Eologix ice sensors have been fitted to the blades of Turbine 1 at Bowbeat wind farm. The sensors are solar powered and transmit information wirelessly. They detect the thickness of ice covering the sensor in four thickness brackets.
For the data driven approach, a method has been developed to detect anemometer and blade icing through the analysis of wind turbine performance and air temperature. This has been used to create a program that generates charts, diagrams, and a body of text for an email report to show the risk of blade and anemometer icing for all 24 turbines at Bowbeat, and the detailed blade icing risk for the turbine with blade ice sensors fitted. The program has been used to send semi-automated email reports to the onshore wind site Bowbeat each morning and evening for January, February, and March of 2015.
For validation purposes a camera capable of remote operation has been installed at Bowbeat wind farm to observe blade ice. Its video feed can be viewed and its orientation can be controlled through the E.ON network.
The outcome from the testing suggests that a combination of data driven and sensor based ice detection could be a viable solution to the reliable detection of ice on wind turbines. Any method in isolation tends to produce too many false positives, but when combinations are considered the results are more reliable. In addition, using a combination of data flows enables the system to function with only one turbine per site having the blade sensors fitted, making this option more cost effective.
It is therefore recommended that a review of safety issues and potential value was assessed on ice affected sites, with the aim of generating a prioritised list for implementation.

Web site: http://www.eon.com/en/about-us/structure/company-finder/eon-technologies.html

Short biography: David Futter has worked as a scientist at the Technology Centre for over 25 years, having joined straight after graduating from Bristol University. He now holds the leading technical role in the field of condition monitoring. He has had involvement with the development and day-to-day operation of the on-line vibration monitoring system for over 20GW of turbine plant in the UK and abroad, and continues to be part of the 24-hour callout service operated by the condition monitoring team. He also helped to develop vibration-based condition monitoring services for auxiliary plant and wind turbines. He carries out on-site dynamic balancing of rotating plant and investigates one-off vibration problems on all types of rotating plant.
He provided technical guidance on the development of the "Advanced Condition Monitoring" (ACM) Service, and continues to provide technical oversight to the service. He has been particularly involved with the use of this service on renewable technologies, and with the technical skills development of the growing monitoring team. He also works on technology tracking and the identification and development of ongoing T&I projects to ensure continuous improvement of the service.
David is a member of BSI committees GME21/5 – Vibration of Machines - and GME21/7 – Condition Monitoring, and also sits on the COMADIT vibration analysis committee which is developing accredited training to ISO 14836-2, and assisted with the editorial committee for an associated textbook. David is accredited to the highest level under this standard. He sits on the Professional Standards Committee of the Institute of Physics, of which he is a Fellow, and acts as an interviewer within the Chartered Engineer process.

BACK

Abstract #: 53 (Oral), session 4:2:5

R&D areas/s: 02. De-/anti-icing including ice detection & control

Real-World icing distribution analysis based on data from surface sensors

Michael Moser, eologix sensor technology, AT,

Thomas Schlegl (eologix, AT)
Michael Moser (eologix, AT)
Hubert Zangl (AAU, AT)

Reliable ice detection is a key feature of wind turbines in cold climates. It is known that the distribution of ice over a turbine's surface can vary significantly. During many icing events, the blade tips tend to aggregate thicker layers of ice than the blade roots. In addition, cloud base heights located within the height range of the rotor can lead to untypical icing distributions. Freezing rain and wet snow once again cause different icing distributions over the rotor, especially during standstill or low wind speeds. For the operator of the turbine, it can be hard to decide about the right moment to restart the turbine in order ensure safety for both turbine and people. Especially with heated blades, the right moment to turn the heaters on and off again can be optimized with knowledge about the ice aggregation over the surface of the blade.
By means of small autarkic wireless sensors attached to the blade surface, detailed information can be gained concerning icing on blade tips, blade roots and in-between, all on the leading edge, trailing edge, suction and pressure sides of the blades. Exact information where the ice is (or is not) can facilitate de-icing and increase yield by re-starting the turbine as early as possible. Measuring the ice load in different levels from 1 mm to more than 10 mm can also be very useful information for wind turbines in cold climates. Additional use of temperature measurements (also included in the wireless sensors and presented last year's edition of the conference) could be used for efficient anti-icing operation.
At the conference, we will present field data from the presented autarkic wireless sensors mounted on various turbine types in different cold climate locations from two winter seasons (2014/15 and 2015/16).

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

Short biography: Michael Moser studied Electrical Engineering and Sound Engineering at Graz University of Technology (TU Graz) and University of Music and Performing Arts Graz. Thereafter, he was a research assistant at the Institute of Electrical Measurement and Measurement Signal Processing (TU Graz), where in 2013 he completed his PhD thesis focusing on energy harvesting and icing detection on electrical power transmission lines. In 2013, he launched Eologix at Science Park Graz together with his co-founders.

BACK

Abstract #: 14 (Oral), session 5:1:1

R&D areas/s: 04. Production experience, losses

Update of DNV GL's empirical icing map of Sweden and methodology of estimating icing losses using further Nordic wind farm data

Till Beckford, DNV GL, GB,

Carla Ribeiro (DNV GL, UK), Francesca Costigan (DNV GL, UK)

During the past two Winterwind conferences, DNV GL presented findings from the analysis of operational data from 18 wind farms in the Nordic region, along with meteorological data from over 60 measurement masts. From the analysis of these datasets an icing map of Sweden was derived showing the expected annual energy loss. The data were also used to improve and validate a method for estimating long-term icing losses using pre-construction anemometer measurements.
Over the past year DNV GL has analysed further operational data from wind farms in the region. The authors propose to present findings from the analysis of these data, extending the empirical icing map both geographically and temporally. DNV GL shall also broaden the geographic scope of previous work, further assess trends between icing and geography, delve further into trends in inter-annual variability and assess the relationship between inter-annual variability of icing and that of wind speed.
In addition, the previous work undertaken by DNV GL demonstrated a strong correlation between icing losses and altitude for turbines located in southern and central Sweden. The authors propose to further investigate this relationship by looking at icing patterns across specific wind farms and ascertaining which meteorological conditions are more conducive to ice accretion and significant ice loads, and how sitting of turbines relative to topographic features influences this.

Web site: https://www.dnvgl.com/energy/

Short biography: Till has been working at DNV GL for the past 3 years since graduating with a mechanical engineering degree from the University of Bath. At DNV GL Till has been part of the Project Development department focusing on the Scandinavian and Finnish markets. In this time Till has undertaken countless pre-construction energy production assessments and helped to develop DNV GL's understanding of icing in cold climates. Till made his Winterwind presenting debut at the 2015 conference and in his spare time enjoys playing music, good food and the odd table tennis match.

BACK

Abstract #: 16 (Oral), session 5:1:2

R&D areas/s: 04. Production experience, losses

Methods for estimation of occurred icing losses in operational wind farms – measurements and modelling

Johan Hansson, Kjeller Vindteknikk, SE,

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This presentation aims to discuss different methodologies for the estimate of occurred icing losses. Several methods for estimating losses in operational wind farms are investigated in the research project ProdOptimize financed within the Swedish research program Vindforsk IV. Read more about ProdOptimize at www.vindforsk.se. The project is composed by three work packages (WP). The results discussed in this presentation are part of WP3 – "Quantification of occurred icing losses", and give a new insight into the challenge of quantifying occurred production loss caused by ice formation on turbine blades. The different methods investigated for loss estimation utilize wind measurements, SCADA data or NWP data. A straightforward method to estimate losses consists of applying the measured wind speed from the nacelle anemometer on a median power curve based on full performance observations of power from the wind turbine. It is however known that the accuracy of the nacelle anemometry is susceptible to changes related to turbine standstill, modifications in the pitch and yaw settings, and most likely also related to the occurrence of icing. The suitability of the different methods investigated in ProdOptimize for estimating icing losses is discussed, and a comparison of the icing losses estimated with different methods is presented.

Wind measurements performed during one winter with a nacelle based lidar system installed on a Swedish wind farm subject to moderate icing conditions have been used in this study. Results are presented on how the wind measurements from the nacelle anemometry relate to the nacelle based lidar measurements during non-icing and during icing conditions. The possible disturbance of the nacelle anemometer caused by the lidar itself is also evaluated.

In the scope of ProdOptimize-WP3 is also the development of the IceLoss model. IceLoss is a tool for estimating the icing losses in a wind farm based on NWP-data. In WP3, the IceLoss model is further developed to perform calculations for individual turbines rather than on a wind farm average turbine. Results from the IceLoss model are presented and compared with losses based on measured data.

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

Short biography: Johan is a meteorologist that began to work as a wind energy consultant in 2010. Before that he worked eight years as a weather forecaster at the Swedish met office, SMHI. At Kjeller Vindteknikk the daily work consists of analyzing wind measurements from traditional met masts and remote sensing instruments, energy yield calculations, estimation of icing losses using the in house developed model IceLoss and analysis of data from operational wind farms. Johan is also the project manager for two research projects, ProdOptimize and LoadMonitor, financed within the Swedish research program Vindforsk IV. During windy days Johan can be found out on the water somewhere in southern Sweden kitesurfing.

BACK

Abstract #: 22 (Oral), session 5:1:3

R&D areas/s: 03. Resource assessment, measurements and models, 04. Production experience, losses

A roadmap for understanding the performance of numerical weather prediction based models for predicting long-term wind farm production losses due to ice accretion on blades

Daran Rife, DNV GL, US,

Carla Ribeiro (DNV GL, UK), Daran Rife (DNV GL, USA)

Accurate methods for generating the climatology of turbine icing conditions remain elusive, and yet icing poses one of the greatest challenges to operating turbines in cold climates. Current state-of-the-art approaches range from purely empirical models to sophisticated numerical weather prediction (NWP) based systems. While results from these NWP-based systems are promising, there remains significant room for improvement, particularly as there has been limited validation of the results to date.
This talk will provide an overview of the various methods employed by the industry to predict icing losses using NWP-based systems, with the aim of illuminating their strengths, assumptions, limitations, and particularly their uncertainties. We will discuss the use of NWP models to predict meteorological parameters, such as temperature, wind speed, cloud liquid water content and hydrometeor types. We will outline how the predictions are subject to a variety of unavoidable sources of error and uncertainty, including the input datasets, the lateral boundary conditions, the numerical approximations and the representation of physical processes that strongly drive the winds and icing load within the boundary layer. We will also discuss the use of these predictions to drive ice load and production loss models, which are also subject to sources of uncertainty, including assumptions regarding droplet size and the assumed relationship between icing events and power loss.
The authors will conclude by providing the industry with recommendations and a validation roadmap to better identify and quantify a given method's deficiencies so that they can be readily understood and remedied. Such metrics should allow assessment of the quality of the predictions of these episodic but highly significant events, and also fully account for the limited predictability of very small scale wind flow and cloud microphysical features.

Web site: https://www.dnvgl.com/

Short biography: Daran serves as Global Head of Mesoscale Modeling at DNV GL. He has over 21 years of extensive experience in mesoscale modeling and downscaling, and has authored or co-authored 18 peer-reviewed publications and numerous conference presentations.He was Associate Editor for the scholarly journal Weather and Forecasting from 2009-2014. In 2013 he was honored with the American Meteorological Society Editor's Award for that same journal.

BACK

Abstract #: 55 (Oral), session 5:2:1

R&D areas/s: 05. DOM (Deployment, Operations and Maintenance), 06. HSE (Health, Safety and Environment)

Swedish Wind Energy Association's view on wind energy in cold climates

Bengt Göransson, Dag Haaheim, Pöyry Sweden, SE / Statkraft Sverige, SE,

Dag Haaheim, Statkraft, SE
Bengt Göransson, Pöyry, SE
Mattias Wondollek, Svensk Vindenergi, SE

The large potential for land based wind power is situated in northern part of Sweden where the cold and remote environment imposes greater challenges from a health and safety perspective. Cold climate imposed unsafe conditions and hazards must be identified and risks assessed and controlled both during project planning phase and operations.
In order to minimize health & safety hazards in our industry, the Swedish Wind Energy Association has initiated several working groups aiming at producing guidelines on industry best practice. One of these working groups has been focusing on cold climate operations where the need for certain guidelines has been identified for the following sub-areas: Internal and external communication, Turbine specific ice mapping, Turbine technical measures and Operational strategy.
With these guidelines put into practice the industry want to minimize the risk of cold climate related accidents.

Web site:

Short biography: Bengt Göransson, Pöyry
More than 30 years of experience in windpower, presently working as technical consultant. Bengt is project manager for the cold climate research project Icethrower. His special interest is in risks around iced wind turbines.
Dag Haaheim, Statkraft
Dag has worked with health and safety issues in wind power for more than 5 years. He has certain interest in Cold climate related matters as Statkraft develops and operates large wind farms in cold areas in Norway and Sweden.
Both Bengt and Dag are active members of the Advisory Committee for Health and Safety at Swedish Wind Energy.

BACK

Abstract #: 5 (Oral), session 5:2:2

R&D areas/s: 01. Forecasting, cloud physics, aerodynamics, 09. Market potential

Forecasting wind turbine icing: the value of icing forecasts trading on the day-head energy market

Ayumu Suzuki, DNV GL, GB,

Beatrice Brailey (DNV GL, GB)

At the Winterwind 2015 conference DNV GL presented the results of validation of a model for the short-term forecasting of turbine blade icing. Since this time, the model has been implemented and validated in a live forecasting environment and the financial benefits of including icing forecasting in real-world energy trading scenarios have been evaluated.
Icing has been shown to cause significant power losses in wind turbines situated in cold climates, such as Scandinavia. Studies have shown that over the course of a year wind farms can lose up to 13% of power due to icing losses, with monthly losses up to 50%. Individual icing events can lead to full power loss for a wind farm for over a week at a time. Quantitative fore-warning of such events is therefore a necessary requirement in incorporating the generation from these wind farms on the grid system.
DNV GL has designed a model which estimates icing losses as part of a short-term wind energy forecast, using an ensemble of meteorological condition forecasts to predict the presence or absence of icing conditions, an adapted Makonnen model to calculate ice load on turbine blades, and a power reduction model to make icing corrections to the forecast energy production. The model has in the past been validated against 2 years of SCADA data from 3 wind farms in Sweden, and was shown to improve forecast accuracy, reducing annual MAPE by up to 1%, and reducing MAPE by up to 5% for months where periods of icing occur.
This year, we shall present validation from the live operation of the model over the most recent winter. We will extend this to present the results of "market value analysis" for the icing model, showing the approximate increase in revenue that can be generated by trading the resulting forecasts on the Elspot day-ahead energy market and therefore the significant financial benefit to end-users of incorporating accurate icing forecasts within DNV GL's wind power forecasting system.
References
Bernstein, B., F. McDonough, M. Politovich, B. Brown, T. Ratvasky, D. Miller, C. Wolff and G. Cunning.: Current Icing Potential: Algorithm Description and Comparison with Aircraft Observations. J. Applied Meteorology, 44, 969-986, 2005.
Clausen, N-E. G. Giebel, H. Holttinen, K. Jonasson, A.K. Magnusson: IceWind – Improve Forecast of Wind, Waves and Icing R&D project. www.icewind.dk, RISO.
Dierer, S., R. Oechslin and R. Cattin: Wind turbines in icing conditions: performance and prediction. Adv. Sci. Res., 6, 254-250, 2011.
Foder, M.H.: ISO12494 "Atmospheric Icing of Structures" and How to Use It. Proc. of the 11th (2001) International Offshore and Polar Engineering Conference, June 17-22, 2001.
Frohboese, P., and A. Anders: Effects of Icing on Wind Turbine Fatigue Loads. J. Physics: Conference Seiers 75 (2007).
Geibel, G..: The State-Of-The-Art in Short-Tern Prediction of Wind Power: a Literure Overview. ANEMOS, 2003.
Ljungberg, K. and S Niemelä: Production of Finnish Icing Atlas. ES1002: Workshop. March 22nd-23rd, 2011.
Makkonen, L., Laakso, T., Marjaniemi, M., and Finstad, K. J. Modelling and prevention of ice accretion on wind turbines. Wind Engineering, 25:3-21, 2001.
Parkes, J.R., Wasey, J., and Tindal, A.J. "Wind Energy Trading Benefits through Short Term Forecasting" EWEC 2006
Zhao, B.: NCEP subprogram Aviation.f, 2005, http://www.nco.ncep.noaa.gov/pmb/codes/nwprod/sorc/ncep_post.fd/AVIATION.f

Web site: https://www.dnvgl.com/services/short-term-forecasting-3848

Short biography: Ayumu Suzuki is a Forecast Analyst at DNV GL (formerly GL Garrad Hassan). After receiving his Masters degree in Electrical and Electronic Engineering from the University of Bristol in 2008, he joined the short-term renewable generation forecasting team at DNV GL and has nearly 8 years of experience working on the company's forecasting services and methods, helping customers to maximise the value of their renewable assets and incorporate renewable energy onto grid systems. During this time he has worked in a range of markets across Europe, India, East Asia and North and South

Abstract #: 5 (Oral), session 5:2:2

R&D areas/s: 01. Forecasting, cloud physics, aerodynamics, 09. Market potential

America and has been part of the ongoing technical development of DNV GL's market-leading forecasting methods. Outside of work, Ayumu is a keen record collector and regularly DJs in Bristol, UK.

BACK

Abstract #: 21 (Oral), session 5:2:3

R&D areas/s: 06. HSE (Health, Safety and Environment)

Applications of iced wind turbine noise simulations

Richard Hann, Richard Hann Consulting, DE,

Richard Hann (Richard Hann Consulting, DE)

The vast development of wind energy within the last decade has led to increased public awareness of noise pollution. This has resulted in today's strict noise regulations and substantial scientific efforts to understand and decrease wind turbine noise. However, very little work has been performed to investigate the impact of cold climate conditions on wind turbine noise.
A first numerical study introduced a simulative approach to investigate the increased noise generation of iced airfoils and blades for wind turbines [1]. Based on computational fluid dynamic (CFD) and computational aeroacoustic (CAA) methods [2], a 2D simulation process chain was developed to estimate the impact of icing on wind turbine noise. The results clearly indicate that icing leads to amplified turbulences and a significant increase in trailing-edge noise.
However, due to the lack of experimental data for validation of the aforementioned study, significant uncertainties remain. The simulation of iced wind turbine noise combines a broad spectrum of physical phenomena (e.g. high turbulence, early flow separation, increased surface roughness, convex geometries), which are complex and can only be captured by simplification.
This study discusses possible applications and benefits of iced wind turbine noise simulations for the industry. Identifying the potential purposes of aeroacoustic icing simulations is essential for choosing appropriate computational methods. Furthermore, the uncertainties in the numerical results need to be addressed specifically for the intended application. In addition, each element of the simulation chain (generation of iced geometry, CFD and CAA) has to be selected based on an assessment of computational complexity and accuracy. These challenges highlight the need to further develop a holistic understanding of the interaction between cold climates and wind turbine noise, as well as the potential for further development of numeric simulation tools.
[1] R. Hann, A. Wolf, D. Bekiropoulos, T. Lutz, E. Krämer: Numerical Investigation on the Noise Generation of Iced Wind Turbine Airfoils. Winterwind 2013
[2] T. Lutz, B. Arnold, D. Bekiropoulos, J. Illg, E. Krämer, A. Wolf, R. Hann, M. Kamruzzaman: Prediction of flow-induced noise sources of wind turbines and application examples. International Journal of Aeroacoustics, volume 14; issue 5-6, p. 675-714; 2015.

Web site:

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

BACK

Abstract #: 13 (Oral), session 5:3:1

R&D areas/s: 03. Resource assessment, measurements and models, 04. Production experience, losses

Validation of icing atlases based on SCADA data

Timo Karlsson, VTT, FI,

Timo Karlsson (VTT, FI)

Icing of wind turbines is a big liability when building wind power in cold and icing climates. In many cases, the losses due to icing can be larger than 10 % of annual production. There are large local and annual variation in icing conditions which makes ice assessment important when considering wind farm construction in cold climate areas.
Icing conditions in Nordic have been mapped by several icing atlas projects. The goal of these tools is to make a tool for assessing icing on a given site. Most ice atlases are based on weather models and observations.
There are several wind power plants already constructed in cold and icing regions in the Nordic countries. Site operators have noticed severe operational losses due to icing at these sites. Using the actual, observed production losses as a measure of icing at a wind power site is the most accurate way to see the icing conditions at the site as it relates to wind power production.
IEA task 19 has developed a standardised tool for evaluating icing conditions and production losses based wind turbine SCADA data. This tool can be used on the production data to produce an icing estimate based on observed data. Estimating icing conditions from production data is an easy way to see the actual observable effects icing has on park operation.
By comparing the estimates given by several different icing atlases to icing estimates from actual production SCADA data, it is possible to validate the icing atlases ad see how the model results compare to real production data. For purpose of this study, data from a site in Northern Sweden, spanning several years, was made available. Several different icing atlases covering this area were also available for the purposes of this study.
An ice assessment based on estimates calculated from the production data is presented and compared to estimates drawn from several different icing atlases. The accuracy of icing atlases is evaluated based on the production data based ice assessment.
Using long term weather observations, an overview of yearly variations of icing can also be made to see how well historically ice modelling and observations agree at these sites. The long term view also puts the production data based assessment on correct historical perspective and evaluate the variability of icing at the site.

Web site: https://ieawind.org/task_19.html

Short biography: Timo Received his M.Sc. degree form Aalto University in 2012, from the School of electrical engineering, with speciality in automation and control engineering. He has been employed at VTT since 2011 working as a research scientist in VTT Wind power technologies group. During his time at VTT Timo has been working on numerous R&D projects related especially to wind power in cold climates. These include ice detection method development, ice assessment, production data analysis and ice prevention system development.

BACK

Abstract #: 29 (Oral), session 5:3:2

R&D areas/s: 10. Standards

Pre-certification of cold climate instruments and coatings

Tuomas Jokela, VTT, FI,

Mikko Tiihonen (VTT), Lasse Makkonen (VTT) & Geert-Jan Bluemink (VTT)

At the end of the year 2012, 24% (69 GW / 282 GW) of the globally installed wind power capacity was deployed in the Cold Climate regions. The forecasted global wind power capacity for the years 2013 – 2017 is 243 GW, of which 20 % will be deployed in Cold Climate areas. Therefore, the market potential of the Cold Climate applications for wind power industry is vast. /1/
Cold Climate equipment and solutions, especially the different anemometer, ice detector and coating markets in the wind power industry, resemble “the Wild West”. Different instruments measure different values and, therefore, it is difficult for wind power developers to evaluate, what kind of detector solutions would fit best for their needs. At the same time the investment procedure will be a more challenging task to tackle. At the moment there are no standards and/or guidelines to verify the instruments and coatings for the cold climate conditions. Controlled laboratory environment is needed to solve the above mentioned challenge.
VTT icing wind tunnel facility has a unique potential for creating new ideas, testing prototypes and their functionalities, optimizing design and performing verification of different products in controlled testing environment. VTT is currently the only independent research institute in the world that can provide pre-certification tests for different instruments, coatings, products and concepts for Cold Climate conditions.
VTT icing wind tunnel is placed in a cold climate chamber with operational temperatures of +23°C...-25°C and flow velocity up to 40 m/s. Test section dimensions are 700 mm x 700 mm x 1000 mm and the section is equipped with heated windows. The mass flow rate of the atomizing air and sprayed water is controlled by calibrated equipment during the tests. Proper lighting in the test section provides possibilities to take high quality photos and videos during the tests. Glaze, rime and mixed ice can be formed on the surface of different test specimens. Ice accretion tests are repeatable and the circumstances in the test section during the tests are similar as in the natural in-cloud icing cases. The median volume diameter (MVD - μm) of the water droplets was verified by a third party during the spring 2015 /2/.
VTT has also developed a new method to measure ice adhesion forces on different coating materials in two directions: in “pulling mode” (tensile strength) and in “twisting mode” (torque). The main advantage of this test method is the accuracy and the repeatability compared to the rotational ice adhesion testing method. VTT icing wind tunnel is used for accreting ice on the test specimen in natural in-cloud icing conditions. Irregular specimen shapes can also be applied and, thus coating tests can be performed on e.g. a wind turbine blade section. Multiple coating specimens can be tested simultaneously to have faster and comparative results. It is also possible to analyse the durability of the coating materials in the VTT test facilities. /3/
It is essentially important to further develop the technical solutions for wind turbines operating in Cold Climates. Standards and testing procedures for instruments, ice detectors and coatings for wind turbines which operate in Cold Climate conditions are still insufficient.

References:

1 BTM Report. 7 Special Chapter: Cold Climate Turbines (“CCTs”)
2 Droplets Size Distributions Measurement by Finnish Meteorological Institute (FMI), Atmospheric Composition Research with CAPS (Cloud, Aerosol and Precipitation Spectrometer Probe) at VTT Icing Wind Tunnel 2015.
3 Makkonen, L., 2012: Ice adhesion – theory, measurements and countermeasures. Journal of Adhesion Science and Technology 26(4), 413-445.

Web site: http://www.vttresearch.com/services/low-carbon-energy/wind-energy

Short biography: Tuomas Jokela
Date of Birth:
2.12.1974, Helsinki, Finland
Education:
06/2010 - Helsinki University of Technology (M.Sc), mechanical engineering
11/2000 - Mikkeli University of Applied Science (B.Sc), measurement and instrumentation
Working at VTT:

Abstract #: 29 (Oral), session 5:3:2

R&D areas/s: 10. Standards

I have been workig at VTT as a Research Scientist from 6/2010. My tasks have been related to different measurements tasks, for example metmast and lidar measurements related projects. I have also been working with the icing wind tunnel related customer driven development projects.
During my freetime I am an enthusiastic trail runner! :-)

BACK

Abstract #: 45 (Oral), session 5:3:3

R&D areas/s: 11. Offshore

Simulations of drifting sea ice loads on offshore wind turbine support structures

Simo Rissanen, VTT, FI,

Simo Rissanen (VTT,FI)
Jaakko Heinonen (VTT,FI)

The Baltic Sea features a potential for large capacity wind farms because of relatively high and constant wind velocities. At the beginning of 2015 there was 2200 MW of announced offshore projects in Finland [1]. Mostly shallow coastal areas enable cost-efficient foundation and grid connection. However, in the northern sea area - Gulf of Bothnia - the sea freezes annually. Sea ice loads and ice-induced vibrations due to drifting ice field introduce the most significant uncertainties in the support structure design for offshore wind turbines.
The magnitude and time variation of ice load depends on various factors, like the thickness and velocity of the ice as well as the size and shape of the structure. The ice load magnitude and time variation depends on the failure mechanism of ice, which is strongly governed by the shape of the structure at the water level. Typically, for the level ice, one of the following failure modes takes place: bending, buckling, cracking/splitting or crushing. For the load design, ice crushing is usually the most important because it induces a dynamic excitation on the structure. Also, the loads related to crushing are usually higher than in the other failure modes. Ice cone at the waterline can be used to change failure mode from crushing to bending and thereby ice loads will be decreased. However, ice cone increases wave loads.
FAST (Fatigue, Aerodynamics, Structures and Turbulence) aeroelastic simulation code was used to investigate structural performance of offshore wind turbines. The structural model was based on the NREL offshore 5-MW baseline wind turbine. Ice loads to monopile foundation are compared to coned structures with different cone angles. Loads were analyzed by calculating relative change of lifetime for main components using damage equivalent loads (DELs). Also wave loads are considered. Simulations with different ice velocity and different ice thicknesses are needed for lifetime analysis. Tower vibrations due to ice are strongly dependent on water depth as height of the structure plays an important role in the dynamics. Therefore two different water depths were studied.
References:
[1]: IEA WIND 2014 Annual Report, August 2015, ISBN 978-0-9905075-1-2, https://www.ieawind.org/annual_reports_PDF/2014/2014%20AR_smallfile.pdf

Web site: http://www.vttresearch.com/services/low-carbon-energy/wind-energy

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

BACK

Abstract #: 10 (Oral), session 6:1:1

R&D areas/s: 02. De-/anti-icing including ice detection & control, 04. Production experience, losses

ENERCON experiences with wind energy turbines in icing conditions

Anne Mette Nodeland, ENERCON, DE,

Anne Mette Nodeland (ENERCON, DE), Eva Sjögren (ENERCON, SE)

During the last two decades ENERCON has developed a Rotor Blade Heating System (RBHS) that has been proven to work in harsh icing climates with good results. The RBHS has been installed all over the world and experience has been collected from numerous sites.
ENERCON is always focusing on research and development, also in the ice detection and de-icing area. The drive to continuously improve our systems has led to new results that will provide more reliability and solutions for our customers to optimize the production and the safety of our turbines. The first part of the presentation will give an overview of the technical features of the ENERCON Ice Detection and RBHS, including the new technological developments. Thereafter, our research campaign to validate the performance of the Ice Detection and RBHS under different icing conditions will be presented and discussed.

Web site: http://www.enercon.de/en/home/

Short biography: Katharina Roloff works as an ice expert in the yield estimation team in Enercon site assessment department. Examples of her tasks include wind and ice measurements under icing conditions and energy loss due to icing on the rotor blades. Her technical background she has from Gottfried Wilhelm Leibniz Universität in Hannover, where she did a master of science in meteorology followed by two years as a researcher in the field of aircraft icing associated with several relevant collaborations and internships.

BACK

Abstract #: 39 (Oral), session 6:1:2

R&D areas/s: 02. De-/anti-icing including ice detection & control

Vestas cold climate offerings to cope with icing conditions

Brian Daugbjerg Nielsen, Vestas, DK,

Brian Daugbjerg Nielsen, Senior Product Manager, De-icing, Vestas

How do we keep wind turbines operating smoothly in challenging weather conditions? Building on years of engineering expertise, we propose 3 options ensuring consistent and compliant output during icing and in cold climates without negative impact on the turbine design in terms of noise levels, energy production or lightning risk.

Web site: https://www.vestas.com/

Short biography: Responsible for current and potential new product options with focus on designing processes and tools, which ensure a strong business case.

Abstract #: 40 (Oral), session 6:1:3

R&D areas/s: 02. De-/anti-icing including ice detection & control, 04. Production experience, losses, 09. Market potential

Siemens - Improving output in harsh conditions

Annike Skovgaard Sørensen, Siemens Wind Power, DK,

Annike Skovgaard Sørensen (Siemens Wind Power, DK)

For continuous de-icing innovation and increased customer benefit, future research into ice characteristics and behavior is necessary to standardized methods of describing icing conditions, increase de-icing efficiency, and warrant the additional performance

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

Short biography: Annike has a mechanical engineering background but has so far "only" applied her engineering skills to influence Siemens R&D department. Her career path has always been in sales and she enjoys the cooperation with clients and to support them in getting their projects from the development stage to operating wind farms. After having worked with wind power in Denmark for almost 15 years she chose at the end of last year to follow an old dream and, consequently, moved to Sweden with her family. Here she will continue to work with wind power, but now with primary focus on Sweden. One of her big passions is to do horseback riding in the nature with her 9 year old daughter. It's therefore very appropriate that the Sørensen family has moved to the Lennartsnäs peninsula, where there are the most horses and horsetracks per km2 than anywhere else in Sweden.

Abstract #: 41 (Oral), session 6:1:4

R&D areas/s: 02. De-/anti-icing including ice detection & control

Nordex Anti-Icing System on N131 wind turbines – development and validation

Andreas Beyer, Nordex Energy, DE,

Danela Jacob (Nordex Energy GmbH, D)
Ines Runge (Nordex Energy GmbH, D)
Stefan Magnus (Nordex Energy GmbH, D)
Eike Labach (Nordex Energy GmbH, D)
Dr. Jochen Birkemeyer (Nordex Energy GmbH, D)

Since 2010 Nordex has been offering an Anti-Icing system (AIS) for its N100 wind turbines. In 2013 prototypes of the N117 have been installed and Nordex is now going the next step, which is erecting prototypes of the N131 with AIS in winter 2015.
Besides the adaption of the AIS to the longer blade all components of the AIS such as heating element, sensors and switch cabinets for power supply, signal processing and control have been optimized to achieve a safe, reliable and efficient operation and to further reduce the maintenance effort. A simplification of maintenance procedures could be achieved, which leads to reduced operating costs of the system. Nevertheless the key features of the Nordex AIS remain unchanged: the AIS is fully operational during turbine operation, it provides high energy deposition on the blade surface to minimize ice formation even in strong icing conditions and the turbine availability and production can be significantly increased.
The components of the AIS for N131 wind turbines, the heat distribution as well as the lightning protection system have been intensively studied and qualified during inhouse testing, simulations and together with third party institutes. A brief overview of results will be presented.

Web site: http://www.nordex-online.com

Short biography: Andreas Beyer is responsible for the Product Management Team at Nordex. The responsibilities of the group cover the entire portfolio and includes also cold climate turbine variants as well as the Nordex Anti Icing- and ice detection systems. Andreas works for Nordex since 2010 when he started as a Senior Product Manager in the newly created Division of Product Line Management. Prior to joining Nordex, Andreas held various project- and product management positions e.g. with General Electric and Philips to name a few - overall he's worked in the capital equipment industry for over 19 years. Andreas has graduated as Diplom-Ingenieur in electrical engineering at the Hamburg University of Applied Sciences and holds a Bachelor degree in Robotics from the University of Portsmouth. Andreas lives in Hamburg, Germany with his wife and two kids. He is a private pilot, likes skiing, and enjoys spending time with family and friends when time permits.

BACK

Abstract #: 61 (Oral), session 6:1:5

R&D areas/s: 02. De-/anti-icing including ice detection & control

Dongfang experience in low temperature wind turbine de-icing

Honghua Zhong, Dongfang Electric Corporation, CN,

ZhongHonghua (Dongfang, CN),
Xu Guangyu (Dongfang, CN),
Zheng Beichao (Dongfang, CN)

Dongfang Electric Corporation Limited has been keeping close watch on cold climate wind turbine technology advancement in recent years. The DF110 low temperature type wind turbines equipped with de-icing system have been put into operation in the wind farm in Nordic area. Before that a lot of test and data analysis work has been carried out on the prototype machine equipped with this de-icing technology in the test wind farm. Some related progress has also been achieved in such field as control algorithm and lightning protection technology for the de-icing system. At the same time, Dongfang has been making continuous effort to improve in the ice detect technology too, which makes the de-icing system work more effectively.

Web site: http://www.dec-ltd.cn/en/

Short biography: Zhong Honghua currently works at the project managememt section in Dongfang with site experience in the low temperature type wind turbine project undertaken by Dongfang in Nordic area.

Abstract #: 3 (Commercial Poster), session 7:1:1

R&D areas/s: 02. De-/anti-icing including ice detection & control

Reliable ice detection for rotor blades to increase availability and yield of wind turbines

Bernd Wölfel, Wölfel Wind Systems, DE,

Dr. Peter Krämer
Dr. Carsten Ebert
Dipl. Ing. Bernd Wölfel

Abstract: Reliable ice detection for rotor blades to increase availability and yield of wind turbines
Since the efficiency of wind turbines (WT) is primarily reflected in their possibility to produce energy at any time, the down times of WTs due to "conventional" inspections for damage or ice detection are costly and unwelcome for WT investors.
It is for this reason that the Wölfel Group has developed a wide product line-up with vibration-based SHM systems for damage and ice detection in rotor blades, foundation and tower monitoring (onshore and offshore), load monitoring, vibration reduction systems, etc., to give wind turbine operators the opportunity to reduce the number of WT inspections and increase availability and yield.
The centerpiece of this paper is the presentation of the sensitive ice indication on each blade, the communication to the turbine controller and the advantages of the automatic restart function to increase availability and yield of the wind turbine.
In this context the following will be presented:

- Functionality of the system
- System robustness for the harsh environment
- Sensors types and application
- Communication with turbine controller, monitoring center, etc. will be illustrated.
- The importance of ice detection on rotor blades
- Aspects and the cost-efficiency of the system will be briefly discussed too

At least some examples of long-time monitoring regarding ice detection at different wind turbines will be discussed.

Web site: http://www.woelfel.de/

Short biography: Bernd Wölfel; Civil Engineer; Married three children; Working for Wölfel Beratende Ingenieure, specialized in structural engineering in the field of wind energy; developing and implementation of structural health monitoring of on- and offshore wind in Europa.
Personal interest is cycling and music

BACK

Abstract #: 33 (Commercial Poster), session 7:1:2

R&D areas/s: 02. De-/anti-icing including ice detection & control, 05. DOM (Deployment, Operations and Maintenance), 07. Inspection and repair

In Situ Instrument AB - your overall partner when it comes to measuring wind in any environment

Emil Lindblom, In Situ Instrument, SE,

Anders Berglund, In Situ Instrument AB, SE
Mikael Sundberg, In Situ Instrument AB, SE

Since the beginning of 1980 and due to the wide field experience In Situ Instrument contributes to superior problem solving that leads to more robust solution under a wide variety of situations.
In Situ Instrument is the most experienced company when it comes to measuring wind in cold climates. With more than 400 delivered measuring systems through the years, mostly where Nordic climate prevails, In Situ Instrument has become world leading in this category.
In October 2015 In Situ Instrument delivered a system to the highest wind measuring mast in Scandinavia with a height of 183 meters, this is a very advanced system including a proprietary product that makes it possible for the logger to handle four 2D Ultrasonic anemometers.
In Situ Instrument has developed a range of own products, some examples are effective structural heating models, a heated radiation shield and a camera heating module with varying effect depending on the temperature and wind speed in the surrounding area. All of the in-house products are developed as a result of customer needs and when already existing products must be improved to meet the demands that are required.
In Situ Instrument covers the whole spectrum of construction from the planning phase all the way to reliable and bankable data. Our commitment is to deliver the utmost quality in everything we do to ensure the highest standards of service.

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

Short biography: Kompletteras senare

Abstract #: 20 (Poster), session 7:1:3

R&D areas/s: 02. De-/anti-icing including ice detection & control

Airborne de-icing solution for wind turbines

Hans Gedda, Alpine Helicopter, SE,

Mats Widgren (Alpine Helicopter AB, SE)

Alpine helicopter AB has developed a cost effective no chemicals solution, using regular water and a helicopter to efficiently remove snow and ice from the wind turbine's blades.
The solution is easy: a truck equipped with a fuel tank and oil burner – with the capacity to hold 44m3 water – heats the water from 7ºC to 65ºC in 6,5 hours. The equipment has been developed in collaboration with Skellefteå Kraft AB and the truck also has a fuel depot for the helicopter. Everything is completed for efficient setup in the field with a tank and sprayer mounted under the helicopter. The hot water is then sprayed onto the blades in the same way as when de-icing an aircraft.
De-icing of wind turbines with helicopter is a new and tested technology, which has been exercised on site Uljabuouda in Arjeplog. The tests show very promising results and has the support to further development between 2014 and 2016 by the Swedish Energy Agency and Vindforsk..
This presentation will show the technology and the advantage with this method. Results from tests carried out at Uljabuoda wind farm in Sweden and from Canada will be presented. Cost to deice a wind turbine with this method pays off after only two days of normal production.

Web site:

Short biography: Hans Gedda holds a M.Sc. in material science and a Ph.D in laser material processing. Hans has since 2005 been working with development tests and evaluation of de-icing technology. Hans is also involved in the Swedish Wind Power Technology Centre, theme group 6 cold climate as a specialist around issues related to de-icing technology. Hans has worked as an own consultant since 2010.
In the summer, when he is not working with issues around de-icing he prefers to drive around his old Volvo car from 1965.

BACK

Abstract #: 58 (Poster), session 7:2:1

R&D areas/s: 03. Resource assessment, measurements and models

Optimizing wind and icing: Case Finland

Simo Rissanen, VTT, FI,

Ville Lehtomäki (VTT, FI)

The cold climate wind energy market is expanding rapidly due to its excellent wind resources. However, in cold climate sites icing causes productions losses which increases uncertainty in project profitability. Therefore it is important to perform icing assessment in parallel with wind resource assessment. As first in the world, VTT has combined two different atlases: Global wind atlas [1] and Wind power icing atlas (WIceAtlas) [2]. Neither of these atlases is sufficient for wind farm siting, but combined wind and icing atlas can be used for screening of optimal areas for wind power production.
DTU's Global wind atlas provides wind resource data at a one-kilometer resolution. The dataset uses micro-scale modelling to capture wind-speed variability. WIceatlas is based on weather observations and terrain elevation. Observations are from ~4500 weather stations around the world. Only stations with more than 20 years of data with 70% availability are used in WIceatlas and therefore long term average and interannual variation of icing can be calculated. Site measurements are still considered to be the best and most reliable source of information to assess icing conditions but are often too short duration to predict losses over the lifetime of a wind power project. WIceAtlas can be used together with site measurements to define icing severity during measurement campaign compared to long term average.
In this poster, optimization of wind and icing is demonstrated for Finland. Wind power production is estimated using Global wind atlas and Weibull wind speed distribution. Expected power calculated for typical 3 MW wind turbine. Icing losses are based on meteorological icing of WIceAtlas and connected to IEA Ice Classification to evaluate production losses due to icing. Data from several weather stations are used for calculation icing in every point of map. WIceAtlas production loss has been calibrated with site measurements from Sweden, Canada and Finland. Global wind atlas based production map and WIceAtlas production loss map combined to Finnish wind power optimization map. Finland has been selected as demonstration case in this poster. Both of the atlases are global and optimization can be made for any country or globally.
References:
[1]: Global Wind Atlas, DTU Wind Energy, http://globalwindatlas.com/
[2]: Rissanen, Wind Power Icing Atlas (WIceAtlas) – icing map of the world, Winterwind 2015 presentation

Web site: http://www.vttresearch.com/services/low-carbon-energy/wind-energy

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

BACK

Abstract #: 36 (Poster), session 7:2:2

R&D areas/s: 02. De-/anti-icing including ice detection & control, 06. HSE (Health, Safety and Environment)

Cost effective system for ice throw detection

Najeem Lawal, Mid Sweden University, SE,

Najeem Lawal (Department of Electronics Design, Mid Sweden University, Sundsvall, Sweden)
Patrik Jonsson (Combitech, AB, Östersund, Sweden)
Benny Thörnberg (Department of Electronics Design, Mid Sweden University, Sundsvall, Sweden)

Cold climate affects the performance of wind turbines in more complex manner than other climates. Related problems include ice formation, de-icing and ice-throw. Consequences of icing condition in cold climate include lower turbine efficiency, increase range of audio distances, threats to operator safety and high maintenance cost. Of critical concern is ice-throw in and around the wind farm to operator safety and residents. The un-predictable nature of ice-throw occurrences and its long range increase the need for more knowledge regarding icing condition in cold climate. Effective ice throw detection and augmenting such detection with the weather condition will lead to improved prediction future ice throw and de-icing systems. This will lead to improved safety in and around wind farms and lower turbine maintenance cost. This work concerns with the design of cost-effective architecture for visual surveillance system for ice throw detection. The objective is to find a cost optimised design for the camera nodes and deployment topology. In this work, we will investigate multi-camera node architecture and evaluate cost-effectiveness based on detection accuracy, real-time performance and coverage volume. Our approach is investigate the optimal camera wavelength for efficient ice throw detection to propose camera node architecture. This will enable night time operations. We will explore the effect of of the camera node architecture on cost, performance and coverage to select the cost effective architecture for ice throw detection.

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

Short biography: Najeem Lawal, has a doctoral degree in electronics from the Mid Sweden University. His active research is the area of embedded configurable platforms for visual measurement system involving scene description and decision making. He is currently investigating design methods with the aim to optimize for low resource usage and real-time performance.

BACK

Abstract #: 1 (Poster), session 7:2:3

R&D areas/s: 07. Inspection and repair

A study of maintenance performance indicators for the European offshore wind farms in cold climate regions

Mahmood Shafiee, Cranfield University, GB,

Dr Mahmood Shafiee (Cranfield University, UK)

Substantial investments have been made in recent years for wind energy development in cold climate regions. A large number of wind turbines are planned to be built in the near future at sites with severe climatic conditions. The European Wind Energy Association (EWEA) has forecasted that between 45 and 50 gigawatts of wind energy will be built in cold climates by 2017 [1]. Even though cold regions have a high wind potential, the installed wind turbines are exposed to low temperatures outside the standard operational limit, leading to icing of structures. Icing phenomena may dramatically shorten the life expectancy of wind turbines and increase the risk of premature failures if sufficient (effective) maintenance is not undertaken within a time period. Therefore, an efficient management of inspection, maintenance and repair programmes for wind energy assets operating in cold climate areas is crucial to maximize reliability, minimize breakdowns, and reduce long-term costs [2].
In this paper, a number of maintenance performance indicators for offshore wind farms in cold climates are defined through survey of experts in the field and the published literature. Some indicators identified include: Mean time between failures (MTBF), Mean time to repair (MTTR), Mean time between repairs (MTBR), number of preventive maintenance work orders divided by corrective maintenance work orders, preventive maintenance labor hours divided by emergency labor hours, spare parts usage, maintenance crew efficiency (work hours completed on schedule per estimated time), work order discipline (part of labor work accounted for on work orders), annual maintenance costs, etc. Then, a quantitative framework is developed to evaluate and monitor the productivity of inspection, maintenance and repair programmes for cold climate wind turbines. The presented framework is applied to several European offshore wind farms built in cold climate areas and their corresponding maintenance performance indicators are calculated. Finally, the results are compared with the productivity of inspection, maintenance and repair programmes for offshore wind farms located in normal climatic conditions. A sensitivity analysis is also conducted to identify the factors having the greatest impact on maintenance productivity of offshore wind farms in cold regions. Our results indicate that the poor accessibility to cold regions, unavailability of means of transportation, and lack of trained technicians are the main factors negatively influencing the maintenance productivity of wind farms in cold climate regions.
Keywords
Wind Energy; Cold Climate Regions; Maintenance Performance Indicator (MPI); Reliability, Availability, Maintainability (RAM); Operating Expenditure (OPEX).
[1] Battisti L. (2015) Wind energy in cold climates. Green Energy and Technology, Springer, Switzerland.
[2] Shafiee M. (2015) Maintenance logistics organization for offshore wind energy: current progress and future perspectives. Renewable Energy 77, 182–193.

Web site: https://www.cranfield.ac.uk/about/people-and-resources/academic-profiles/seea-ac-profile/dr-mahmood-m-shafiee.html

Short biography: Dr. Mahmood Shafiee is a Lecturer in Engineering Risk Analysis at Cranfield University, United Kingdom. His expertise is in the fields of Reliability Engineering, Maintenance Optimisation, Inspection Planning, Residual Life Prediction & Extension, Structural Health Assessment, Aging and Degradation Modelling, Probabilistic Risk Analysis, Risk-based Integrity, Decision Making under Uncertainty, Infrastructure Asset Management, Warranty & Service Reliability, and Maintenance Logistics. Dr Shafiee He has over ten years of experience in the area of Risk and Reliability Engineering within the Oil and Gas, Marine Renewable Energy, Railway, Manufacturing and the Finance industry sectors. He has been extensively involved in a number of research projects aimed at developing new methodologies for Maintenance Modelling and Risk & Reliability Assessment.
Dr Shafiee has so far been awarded with several honours and educational scholarships at the national and international levels. He was recently nominated in Marquis Who's Who which contains biographical information on outstanding achievers worldwide. He has also published more than forty papers in top tier journals, e.g. European Journal of Operational Research, Reliability Engineering and System Safety, Renewable Energy, Journal of Rail and Rapid Transit, Journal of Risk and Reliability, Expert Systems with Applications, International Journal of Advanced Manufacturing Technology, IIE Transactions, as well as

Abstract #: 1 (Poster), session 7:2:3

R&D areas/s: 07. Inspection and repair

many Conference Proceedings. He has been plenary speaker and program committee member of around twenty international workshops and conferences.

BACK

Abstract #: 43 (Poster), session 7:3:1

R&D areas/s: 02. De-/anti-icing including ice detection & control

Ice detection via advanced infrared image analysis

Mikko Tiihonen, VTT, FI,

V. Lehtomäki (VTT, FI), P. Suopajärvi (VTT, FI)

For wind power, ice accretion of turbine blades causes many unwanted challenges:
1) production losses due to reduced aerodynamic efficiency
2) safety hazard from blade ice throw
3) increased turbine loading due to rotor ice imbalances and
4) increased noise emission due to increased surface roughness of blades.
Thus for safety and efficient wind power production, it is important to know the ice situation at all times. No ice detector has so far reached sufficient reliability in varying icing conditions. The most reliable method for detecting ice where it matters the most (on wind turbine blade) has been webcam pictures, but going through them is labour intensive and cannot happen in real time. The webcam pictures are also many times very hard to interpret due to varying lighting conditions. As a solution, VTT has taken the most reliable ice detector (web camera) and made it even better through advanced image analysis.
The advanced image analysis is carried out by processing multiple infrared images taken with different illumination concepts. The method enhances the visibility of the ice and hence makes it possible to automate the ice detection. Imaging method also gives possibility to record and study the size and shape of ice formations. Infrared imaging is independent from lighting conditions and can also be carried out in complete darkness without disturbing people with light emissions. Same IR imaging method can be used in both wind turbine blade and stationary installations.
IR imaging method has already been proven effective in VTT icing wind tunnel. Field tests with prototype device at two sites will take place in Northern Finland and Norway during winter 2015 – 2016. The aim is to automate image processing so that the device can report ice thickness and icing rate automatically. Imaging device is light, compact, and robust. This device is very affordable due to use of low cost standard electronic components and open source software.

Web site: http://www.vttresearch.com/services/low-carbon-energy/wind-energy

Short biography: Mr Tiihonen has 15 years of experience with atmospheric measurements both from research and industry. At VTT he is responsible for Olos test wind farm atmospheric measurements and measurements performed at VTT Icing Wind Tunnel. After work, he is a HiFi enthusiast.

BACK

Abstract #: 25 (Poster), session 7:3:2

R&D areas/s: 02. De-/anti-icing including ice detection & control

Monitoring systems for harsh climate

Patrik Jonsson, Combitech AB, SE,

Patrik Jonsson (Combitech, SE)
Björn Ollars (Combitech, SE)

In our close research cooperation with the Mid Sweden University a novel camera for ice detection has been developed. This system is based on reflections in the Near Infra Red spectrum and the technology makes it possible to differentiate between ice, water and snow on a surface. Ongoing research involves investigating the possibility to use this technology to detect ice and frost on wind turbine blades.
Combitech has developed an advanced computer field computer unit that is designed for future sensor applications. This computer unit, called Odin, is the core of the monitoring system that is possible to handle any analogue or digital sensor, any serial or Ethernet based sensor including camera systems. Image analysis software is integrated into the Odin software. The Odin platform is also capable of using any communication method that is available at remote sites. A system solution based on the Odin platform is thus very suitable for wind power applications.
Combitech AB is a well known supplier of robust measurement systems for harsh climate. Our experience involves applications within road transport, airports, power transmission, power generation, high masts and wind power applications.
The expertise within Combitech AB involves electronics, physical properties of sensors, advanced data loggers, reliable field monitoring systems, data communication methods, data collection, data storage, data distribution and presentation of data.
Cooperating with Combitech ensures that the best competence and highest level of technology on the market is included in new projects.

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

Short biography: Patrik has worked at Combitech since 1996 with different monitoring systems. He has been responsible for the R&D work regarding monitoring systems and in May 2015 he took his PhD in electronics while still employed at Combitech. His personal interests involve outdoor activities such as hunting.

BACK

Abstract #: 46 (Commercial Poster), session 7:3:3

R&D areas/s: 02. De-/anti-icing including ice detection & control

Recent development on blade mounted and nacelle mounted ice detectors

Tatu Muukkonen, Labkotec, FI,

Tatu Muukkonen (Labkotec, FI), Jarkko Latonen (Labkotec, FI)

Together with the commercial nacelle mounted ice detector Labkotec is developing an ice detector for the blades. One of Labkotec's first blade mounted ice detector prototype was installed to a wind turbine blade in 1994. The detector was integrated to optimize blade heating and to minimize ice accumulation on the blade. That knowledge has been a baseline to intensive development for new generation blade mounted ice detector where ice is detected directly on the blade surface. Field tests show correlation between blade mounted and nacelle mounted ice detectors.Recent development will be presented together with test results in laboratory, wind turbine and met-mast.
Development on nacelle mounted ice detector LID-3300IP has been focusing on several small improvements. They include among others in-depth functional safety analysis and enclosure design with hinges and warning sign. The design is based on responses from the customers to make installation and maintenance easier. Also a log file with accurate time stamps has been introduced in the latest software version. The log file shows history of user entries, parameter changes and improves diagnostics and troubleshooting.
Functional safety analysis has been carried out according to standard ISO 13849-1. Functional safety characteristics like Diagnostic coverage (DC), Mean time to failure (MTTF), Mean time to dangerous failure (MTTFD) has been calculated. Included Proven in use analysis shows this technology has millions of hours of operating time. Intensive tests have been carried out in an icing wind tunnel to verify the ice detection capability of the nacelle mounted sensor. Performance of the sensor in different type of icing conditions has been analyzed and a simulation has been made to correlate the results with the conditions on a turbine blade.

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

Short biography: Working on ice detection R&D and applications for about five years as Project Manager and about one year as Product Manager.

BACK

Abstract #: 8 (Poster), session 7:4:1

R&D areas/s: 12. Permission and legal challenges

Decommissioning of wind farms – ensuring low environmental impact

Liselotte Aldén, Uppsala University, SE,

Andrew Barney, Uppsala University, Sweden

Decommissioning of wind farms – ensuring low environmental impact
The installed capacity of wind power has increased substantially in the last few years. In 2014 over 50 GW were added bringing the total capacity to 370 GW, this is remarkable when considering that total capacity was just 14 GW in 1999. As wind turbines have lifetimes between 15 to 25 years the demand for decommissioning will grow in a similar way to the increase of installed capacity, meaning a time lag of 15 to 25 years. It is becoming clear this will be a challenge.
Decommissioning already is happening on a large scale in countries that were front runners in using wind power such as Denmark and Germany. A primary challenge when decommissioning wind farms is ensuring as small environmental impact as possible. To address this challenge extensive knowledge and practice is required.
In many countries a security bond is required during the permitting of wind farms. This security bond is intended to ensure that the wind farm will be decommissioned and the location be restored.
This article will discuss and recommend how wind farms can be decommissioned with low environment impact and compare the practices in several of countries. Wind power decommissioning laws, regulations, permits, history, activity costs and the disposal and restoration options in Sweden and around the world will be analysed and compared.
Special focus will be placed on the amount of financial security required, the degree of restoration and its environmental impact and cost implications.

Web site: http://www.geo.uu.se/?languageId=1

Short biography: With a background in chemical engineering at KTH, Stockholm and further studies in energy technology, I work today in education and projects in renewable energy particularly wind power. I teach sustainable energy, wind resources, energy policy and planning issues at Uppsala University.
I have been working in the Network for wind utilization (Nätverket för vindbruk) since the start in 2008. Uppsala University and formerly Gotland University is the node with responsibility for education and competency questions in the network.
In my leisure time I enjoy swimming and outdoor life.

BACK

Abstract #: 4 (Poster), session 7:4:2

R&D areas/s: 03. Resource assessment, measurements and models

Doing a meso-scale re-analysis using the WRF-model – does it matter for the resulting icing climatology which version of WRF you use?

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Wind turbines in cold climate regions are likely to be affected by atmospheric icing. This may affect production and loads, and may due to ice throw also be a risk to people being in the neighbourhood of the turbines.
One of the goals of the project 'Modelling of icing and production losses', financed by the Swedish Wind Energy Agency's research programme for wind energy in cold climates, is to refine the meteorological methods for calculating icing losses and to quantify uncertainties of ice calculations.
The term climatology in meteorology usually means statistics over 30 years of data and usually in the form of direct or indirect measurements. Or in the absence of long-time measurements such is the case of ice loads, by modelling 30 years of icing which when using 1 km2 resolutions would need huge computer resources.
An icing climatology is a complex property as icing is a derived quantity from several variables that are generally not all measured, except maybe in some special research masts. Thus icing is a function of air temperature, total moisture content (vapour, liquid water content and solid to some extent), and wind speed in the height range of interest. In the case of wind energy usually the range that the turbine blades sweep through centred around 100 m height above ground.
Since there will never be any complete or comprehensive measurements of these variables they have to be model generated from sophisticated meteorological prediction models. The models are used to transfer the information derived at measurement sites in space and in time to construct the best possible climatology over say the last 30 years. This way of using models has rather successfully been applied for many other applications like winds, temperatures and precipitation. The models provide an internally multi-variate consistent regularly spaced atmospheric state of the variables involved.
The most complete measurements possible have been collected and have been re-analysed using several types of consistent analyses and model system, as NCEP/NCAR, ERA40, and ERA-Interim. Many climatological and other diagnostic studies have been carried out from such re-analysis data. The re-analyses are however at fairly coarse resolution (50-150 km roughly). For our purposes we need to downscale these fields to the km scale of the wind power parks. This has here been done using the WRF-model (Weather Research and Forecasting). The coarse resolution re-analyses data are then downscaled to a higher resolution using higher terrain resolution data together with actually modelled high resolution weather results. Basically the meso-scale model is first downscaled from the global re-analysis data in several steps to the three desired resolutions 9 and 1 km which are presented here. Making a 30 year icing climatology on a 9 km resolution is quite feasible to do, and several such climatologies have been calculated.
Here results using different large-scale re-analyses forcing have been compared together with the effects of choosing different WRF model schemes, such as schemes governing the planetary boundary layer (PBL) parameterization and the microphysics (condensation schemes). The results show that the choice of both PBL and microphysics definitely makes a difference to the results, as do the choice of forcing re-analysis data. Looking e.g. at the annual average number of hours with active icing this differs within about ±200 hours. As no reliable observations of this exist today there are no real means to find out which icing climatology that fits reality best.

Web site: http://www.geo.uu.se/research/luval/disciplines/Meteorology/ongoing-research/wind-energy/

Short biography: Ph.D in Meteorology at Uppsala University in 1988.
Working as a researcher since then at Uppsala University with main focus on boundary-layer meteorology in general, and specially on wind energy related meteorology. Experiences both in experimental meteorology and atmospheric modelling.
Enjoys spending time outdoors picking berries and mushrooms in the forest. Specially interested in growing things at the summer house, especially apples.

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R&D areas/s: 02. De-/anti-icing including ice detection & control, 03. Resource assessment, measurements and models, 05. DOM (Deployment, Operations and Maintenance)

Determination of the actual ice mass on wind turbine blades; Measurements and methods for avoiding excessive icing loads and threads

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Ice formation on rotor blades of wind turbines poses a problem for stable energy production and also a thread to the health of the turbine and may even endanger the environment due to ice throw.
Avoiding the accumulation of excessive ice loads on the turbine blades requires experienced strategies or where possible an active de-icing system. However, no matter what the method is they all rely on a close evaluation of the actual ice mass on the blades and its current growth rate.
With over 1000 active rotor blade condition monitoring systems out in the field Bosch Rexroth has gathered a large amount of data and experience on icing events, the detection of ice on the rotor blades as well as the quantitative assessment of the ice loads.
The objective of the proposed presentation is to provide field examples of icing events with actual mass indications and share best practice methods applied in the field to keep ice accumulation at a minimum.
Another topic will cover the actual ice loads and resulting turbine imbalances which can also be caused by ice throw events.
Finally, it is desired to fuel and trigger an expert discussion on the best possible ice prevention and reduction strategies and the underlying methods and requirements. What is already possible today and what will be feasible in the future.

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

Short biography: As head of Monitoring at Bosch Rexroth Monitoring System GmbH in Dresden, Germany, Dr. Brenner and his team continuously monitor over 1000 turbine rotors of various manufacturers in different regions and climates.
Dr. Brenner studied electrical engineering in Dresden and worked for BMW in Munich during his diploma thesis. He graduated as PhD in mechanical engineering at the University of Magdeburg about the lifetime of wind turbine gearboxes. During the last 6 years he was responsible for the development of condition monitoring methods for wind turbine rotor blades.