R&D areas/s: 02. Health, Safety and Environment (HSE) incl. ice throw and noise, 10. De-/anti-icing including new technologies, ice detection & control incl. standards

Optimizing Windturbine heaters with blade based ice detection Systems

Nils Lesmann, Phoenix Contact, GER

Nils Lesmann

Phoenix Contact Blade Intelligence System ist capable to detect ice thicknesses and temperatures direct on the rotorblade. The sensors detection ice thicknesses <1mm to detect ice build up. The sensor itseld is working self-sufficent on the rotorblade, equipped with a PV module and batteries to ensure 1000h dark operation time. The sensors are applied to the blade surface communicating wireless with the base stations PLC.
In combination with the new Phoenix Contact PLC generation it is possible to detect ice build up on the blade and let those collected data running on the PLC. The PLC is capable to run the Matlab Model from the heater system to ensure a gigh efficient use of the heater system itself.
At some experimental turbine there has been a significant correspondence between light ice build and the power curve. Aim of the presentation should be to show those values and the Phoenix Contact solutions to solve those.
In addition to the ice measurement the Blade Intelligence can be equipped with an Lightning Monitoring and a Load Monitoring System to collect all relevant WTG Data in one system.

Web site:

Short biography: Working for 11 years as Phoenix Contact, 7 in the wind business now as Project Manager for the Blade Intelligence System

R&D areas/s: 01. O&M experiences incl. performance optimization, production losses

Evaluation of Vestas De-icing System

Alexander Stökl, Energiewerkstatt e.V.

Alexander Stökl (Energiewerkstatt, AT)

The presentation focuses on the evaluation and the assessment of the Vestas de-icing system based on operational records from two heated wind turbines of the type Vestas V112 – 3.3 MW on a site in the northern part of Upper Austria. Six wind turbines of the type Vestas V90 – 2 MW without blade heating are situated in the immediate vicinity and serve as a base-line for comparison.

The selected site is, in several ways, well-suited for the evaluation of the Vestas de-icing system. First, it shows a comparatively high number of icing events (corresponding to IEA icing class 3) placing high demands on the performance of the blade heating and allowing for meaningful statistics. And, second, the wind farms in this area also contain a number of turbines without a de-icing system. This comparison among a larger number of wind turbines – two with, and six without blade heating and sited in immediate vicinity – gives a broad statistical basis and thus allows the deduction of well-based conclusions.

The evaluation of the operational records shows that the blade de-icing system reduces the ice-related turbine downtime for this site by 57%. Regarding production this means a reduction of the ice-induced losses between 44% (conservative estimate) and 51% (best estimate). These numbers already include the energy consumption of the blade heating system. On the other hand, it has been observed that the total number of icing-related turbine stops for turbines with blade de-icing is more than twice as high than for turbines without blade heating.

Besides that, it can be concluded that usually the utilization of the Vestas blade heating system leads to an ice-free rotor blade, even though subsequently new ice may form under continuing meteorological icing conditions. The total energy balance of energy production and energy expended for blade heating is generally clearly positive, also for phases with repeated cycles of de-icing and new ice formation and at moderate wind speeds. Overall for the investigated site, the limited heating capacity of the blade de-icing system represented no serious limitation. For about 87% of the time when icing occurred, wind and temperature conditions were within the specified operational limits (Vestas Wind Systems A/S, 2015) of the de-icing system.

The results of this study, specifically the reduction of icing-losses by about 50%, can also serve as a basis for an economic evaluation of blade de-icing systems. Such an evaluation is, however, only sensible with reference to a specific project, i.e. a particular wind turbine and a particular site.

Web site:

Short biography: Alexander Stökl earned his PhD in astrophysics and has worked in this field for many years, mostly on fluid dynamics and numerical methods, interrupted by a two years stint in the wind energy business at AMSC WindTec. In 2018 he has joined Energiewerkstatt e.V. where he now primarily focuses on wind energy research projects.

R&D areas/s: 09. Environmental Impact Assessments (EIA), 15. National strategies, research programs, grid access, system services and new developments

Storage of electricity in molecules

Finn Daugaard Madsen, Siemens Gamesa Renewable Energy A/S

Finn Daugaard Madsen (Siemens Gamesa)

Abstract for WinterWind Sweden
Speaker: Finn Daugaard Madsen - Innovations manager at Siemens Gamesa Renewable Energy
Title: Storage of electricity in molecules
In a fossil-free world, we only have solar, hydro and wind as carbon free source and we need to be able to store large volumes of energy over days and weeks. Today there is talk of batteries and other types of storage, but if we need large amounts of energy it must be stored in a chemical storage carrier.
To get from electricity to chemical storage you need to produce hydrogen in large quantities and this can be done from electrolysis as you know in the physics room - (two eclectic conductive rods in a glass with water and a little salt) today this is done in electrolysis stacks with capacities of 250 kw and up to megawatts, and in the future we are talking about gigawatt systems.
Hydrogen can support the business case for renewables, by providing an alternative revenue stream that is not dependent on a grid connection (particularly relevant in remote areas), and by being used for load-balancing. As the electrolysis process requires large amounts of cheap electricity, it is most cost-effective when there is much wind power in the grid and power prices are low.
By using water electrolysis and renewable electricity, hydrogen production can be made completely carbon-free and scalable with no limiting scarce resources restraining it. Hydrogen can be burned in a hybrid gas turbine, used directly in hydrogen cars or buses, but it can also function as a building block to create electro fuels such as green ammonia, or methanol or methane, if there is a carbon source connected to the process.
In the mid term, electro fuels can be used for both energy storage and as an alternative to heavy fuel oil powering large vessels. In the long run, it is expected to be the next generation's CO2 neutral fuel.
The audience will gain insights into how the low price levels of wind power combined with recent price drops in electrolysis equipment have the potential to make electro fuel production commercially possible, and how this could fundamentally change both the energy and transportation sector as we know it.

Web site:

Short biography: Finn Daugaard Madsen
Current Position: Innovation Manager, Siemens Gamesa Renewable Energy A/S
Experience and Education
Years of Experience in wind: 10+ years
Years of Experience in Project management 25 + years
Education:
2017 Pasteur Program, Harvard Business School
2006 Diploma of leadership
2005 Diploma in Management
2003Diploma in Engineering Business Administration
2002 International project management
2001 Pathfinder
1985 Mechanical engineer
1982 Auto elektro mekaniker
Employment History

2014 -	Innovation Manager	Siemens Gamesa
2010-2014	Innovation Manager	Siemens Wind Power
2008-2010	Think Tank Manager	Siemens Wind Power
2007-2008	Key Account Manager	Primo Danmark
1985 - 2007	Project director	LEGO System

R&D areas/s: 09. Environmental Impact Assessments (EIA), 15. National strategies, research programs, grid access, system services and new developments

R&D areas/s: 01. O&M experiences incl. performance optimization, production losses, 03. Inspection and repair, 05. Market potential, finance, risk assessment, bankability and mitigation, 07. Forecasting, cloud physics and aerodynamics, 14. Big Data, AI, digitalization and machine learning applied to cold climate challenges

Blade defect forecasting

Anders Røpke, Wind Power LAB

Morten Handberg, (Wind Power LAB, DK), Charlotte Hasager,(DTU Wind, DK), Kristian Pagh Nielsen, (DMI, DK)

Environmental conditions cause blade defects to develop and add downtime during the turbine lifetime. Icing, rain, lightning and wind and turbulence all add to the degradation of the blade surface and structure.
Icing will accelerate surface degradation by causing expansion in surface cavities. If the turbine is allowed to continue operation with icing on the blade in the tip area, additional and often asymmetric loads cause increased fatigue loads.
Repairs are costly and exceed the net-cost of a blade at 1-2 million EUR per blade over the lifetime. New types of wind turbine blades and new repair materials are foreseen but at present no unique solution has had a break-through to eliminate leading edge erosion. Thus, the strategic relevance of continuously monitoring the condition and predicting the repair of the existing fleet of wind turbines will be of utmost importance.
To achieve this, it is necessary to first establish the quantification of how a series of environmental parameters influence blade degradation and defects through artificial intelligence method.
Specific objectives:
• To establish comprehensive environmental parameters database for Europe.
• To utilize the novel insights to develop the forecasting tool on blade degradation defining the specific defects and the need for repair, in a given environment.
• To market the forecasting tool as service including site specific blade design requirements and site specific OPEX blade repair planning for new wind farms and planning future repair campaigns for blades in operation
The project is supported and funded by Innovation Fund Denmark. Wind Power LAB(WPL) insights in wind industry, operator perspective and cost of blade repairs is essential to support the project, together with the technical knowledge at Technical University of Denmark Wind Energy(DTU) and Danish Metrological Services(DMI).
DTU and DMI will lead the first part of the project on gathering environmental condition at predefined geographical areas. DTU will collect the data in a database. DTU will then develop a model of environmental parameters and establish of a sufficient geographic grid. The following work packages will link field data from blade defects to the model.
DTU and WPL will then use the weather model and pair the results with the AI detected blade defects at sites in the selected regions. This will provide a combined AI that can correlate weather and defect data and provide a statistical view of defect development at a local site level.
WPL will then build the blade defects forecasting tool into a web platform and use it as an added service to WPL blade defect assessment service. WPL will then be able to offer defect prediction as a service to the general wind industry, primarily to owners and operators.
The proposed risk mitigation will be supported by the results from the project, as a degradation speed linked to the specific environment of the turbine is considered. From this the client will be able to plan for relevant blade defect repairs, fully motivated by both the current state of the turbine and the degradation rate for similar turbines in similar environments.
After sufficient model development of environmental parameters and establishment of a sufficient geographic grid, the following work packages will link field data from blade defects to the model. This is the first step towards implementing the results from the proposed project.
Project outcome for recipients Developers, Owners and Utilities will be benefit from getting a tool able to generate an OPEX budget based on blade specific defect data and weather forecasting from local site data. The repair industry and its affiliated companies will indirectly benefit from the forecasting tool as it will enable long term planning of defect and give basis for long term contracts on blade repairs.

Web site: https://windpowerlab.com/

R&D areas/s: 01. O&M experiences incl. performance optimization, production losses, 03. Inspection and repair, 05. Market potential, finance, risk assessment, bankability and mitigation, 07. Forecasting, cloud physics and aerodynamics, 14. Big Data, AI, digitalization and machine learning applied to cold climate challenges

Short biography: Mr. Anders Røpke. holds a master´s degree in Geoinformatics and a master´s degree in Environmental Engineering. He specialises in the offshore wind power industry with specific focus on wind farm operation, data analysis, development and implementation of cutting-edge technologies in wind farm management, stakeholder engagement, strategy and business development, and execution of business improvement projects.
Mr. Røpke has practical experience with complex business challenges and improvement potentials within the wind power industry. During his employment with DONG Energy (now Ørsted), Mr. Røpke was the project manager on a large-scale cross-organisational data and business improvement project on wind turbine blade inspection and defect detection with 50+ project participants and stakeholders, spanning back office and multiple wind farm sites. As project manager, he was responsible for scoping and delivering all phases of the project to the operational organisation, including steering committee management.
As Lead Business Developer at DONG Energy, Mr. Røpke was responsible for elaborating and monitoring the implementation of business development strategies, developing technical and business concepts, including roadmaps, and screening and analysing concept offerings.
In 2016, Mr. Røpke established Wind Power LAB ApS with the aim to develop an automated defect detection algorithm to help analyse and assess wind turbine blades, initially. By means of cloud computing and a defect detection algorithm, based on a global data set of wind turbine blades, Wind Power LAB is able to provide customers with a quick, automated and high precision analysis and assessment of wind turbines blades quality assured by a team of experienced and professional blade specialists
Personal interest: Family skiing in Sweden! Thank you for the location!

R&D areas/s: 07. Forecasting, cloud physics and aerodynamics

Improvements to the WRF microphysics

Emilie C. Iversen, Kjeller Vindteknikk

Gregory Thompson (NCAR, USA), Bjørn Egil Nygaard (KVT, NOR)

This presentation will show results from research on improved prediction of melting level and mixed precipitation in the Thompson microphysics scheme in WRF, which will improve predictions of snow-to-rain mixing ratios, precipitation amounts at the surface as well as wet snow icing.
In dry air snow can exist as dry snowflakes for several degrees of positive air temperature, and hence zero degree air temperature is not a good measure of melting level. Given that there is a difference in fall speed of dry- and melting, wet snowflakes, a correct determination of melting level is important for a correct prediction of the amount of precipitation reaching the surface. Below melting level the exchange rate of heath between the air and the snowflake (melting degree) is important for the snowflake fall speed and vice versa, and hence a correct representation of fall speed of melting snow is also important to obtain good predictions from numerical weather prediction (NWP) models.
Melting snow will eventually become sticky, which might be problematic for structures in the way that it adheres to them and creates ice sleeves. Wet snow icing has shown to be particularly problematic for overhead transmission lines, with events causing tower collapses and power outages in many countries. Obtaining precise predictions of wet snow is important to prevent costly damages of infrastructure, as well as for human safety.
It is hence important that the relevant NWP models incorporate a microphysical scheme with a good representation of precipitation in the melting layer, without being too computationally expensive to run in real-time. The Thompson microphysics scheme has been explicitly developed and tested for forecasting winter precipitation as part of the WRF model (Weather Research and Forecast model). The scheme is viewed to be perhaps the best real-time, bulk scheme for icing forecasting due to the specific development towards in-cloud aircraft icing. Less attention has though been devoted to wet snow icing, which most often occur close to the ground. This presentation will show results from research on improving the Thompson microphysics scheme with respect to the representation of melting snow.

Web site:

Short biography: I have a bachelors in Meteorology from Uni. Bergen and a Masters in Climate Change from UCL (London). I have worked at Kjeller Vindteknikk (KVT) as a consultant for about 4 years, mainly with climatic load assessments, with specific focus on icing, research and development. As of August 2018 I am doing a PhD at Uni. Oslo, while still employed at KVT. My PhD is part of a big research project, ICEBOX, initiated by Norway's TSO, Statnett, where the goal is to develop a toolbox for icing measurements, modelling, monitoring and forecasting. In the first quarted of 2019 I spent time at NCAR, Colorado working with developers of the WRF code as part of my project. In the second part of the project I will investigate the effects of climate change on the occurence of icing, and estimate future loads. Personal interests are snowboarding and splitboarding (climbing mountains on a "split board" = skis which you put together to a snowboard to run down), music and travelling.

R&D areas/s: 07. Forecasting, cloud physics and aerodynamics, 14. Big Data, AI, digitalization and machine learning applied to cold climate challenges

Improve Wind Project Lifecycle Cost of Energy in Cold Climates

Albert Bosch, VORTEX FdC, SL

Albert Bosch (VORTEX, Spain), Gil Lizcano (VORTEX, Spain), Pau Casso (VORTEX, Spain)

New innovative cold climate indicators have become available for O&M in the wind industry in the last years. One of this indicators is Vortex ICING 10-years time series.
Detailed hourly information will become an essential tool for the wind industry in cold climate regions causing time-collapsed averaged data to become obsolete. Available new technologies as well as computational power increase, make possible the creation of cold climate related variables time series and thus, a deeper analysis can be executed regarding the performance of wind farms on such cold regions.
From mesoscale cold events detection to microscale ice accretion calculation, the generation of long term meteorological icing time series has become now a reality which leads to a new approach when analyzing the project lifecycle, specially regarding the energy cost estimation.
Modelled icing averaged indicators at each turbine location allow to focus on:
- Wind Speed Histograms during Icing Episodes for icing losses,
- Wind Direction Roses during Icing Episodes by sectors,
- Icing hours per year for annual estimation, as other cold climate indicators related to extreme temperature and maximum density events.

Modelled icing time-series at each turbine location allow to deeper analyze:
- Daily profiles analysis,
- Cost of energy evaluation per time slots,
- Service and repair scheduling,
- Long term performance optimization
- Flag indicators testing.

As a conclusion, long-term icing time-series introduction is an open door to other recent technologies like machine learning. Training long-term SCADA data with icing time-series give a huge amount of new information for cold climate wind farms far from a simple matching comparison.

Web site: https://vortexfdc.com/

Short biography: Albert Bosch, Wind Meteorologist at Vortex since 2016.
Skilled in Data Analysis, Communication, Meteorology, Data Science, GIS, mesoscale modeling, project manager and programming. Research professional with a Master of Science - MS focused in Meteorology from Universitat de Barcelona, Spectral energy annalist of wind data, Icing project developer and measured data calibration for models. Part of the Vortex Team on the Global Wind Atlas project by the World Bank Group with Vortex and DTU Wind Energy.
Interested in life outside big cities and camper vans.

R&D areas/s: 06. Wind turbine manufacturers – cold climate solutions, test centres, turbines and components

Nordex advanced Anti-Icing System for N149 wind turbines

Konrad Sachse, Nordex Energy GmbH, DE

Ines Runge (Nordex Energy GmbH), Stefan Magnus (Nordex Energy GmbH), Nils Lehming (Nordex Energy GmbH)

Since 2010 Nordex has been offering an Anti-Icing System (AIS) for its various wind turbines. In 2018 Nordex has done the next step, which was introducing the advanced AIS for the N149/4.0-4.5. This year the system was adapted for the new N149/5.X turbine.
The advanced AIS for the N149/5.X offers very high performance for heavy icing conditions using the new heating element technology that was introduced together with the N149/4.0-4.5. The new technology improves the robustness of the system while reducing the complexity and allowing the system to continue operation in case of local defects.
Maximizing the reliability and achieving highest maintainability were two of the main development goals for the advanced AIS. Nevertheless the key features of the Nordex AIS remained 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 advanced AIS have been intensively tested and qualified regarding the heat distribution as well as the lightning protection system since 2013. A brief overview of test results and field experiences will be presented.

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

Short biography: Mr. Konrad Sachse was born in 1983 and received his Diploma of Physics in 2008. He then worked in the field of nanotechnology research and had the chance to visit research institutes all over the world. Since 2013 he has been working on the Anti-Icing System in the blade engineering department at Nordex Energy. In 2019 he was appointed Expert Engineer for the Nordex Anti-Icing System.
Konrad loves playing the drums and being on stage with his rock bands.

R&D areas/s: 07. Forecasting, cloud physics and aerodynamics, 08. Pre-construction site assessment, measurements, models and standards

How might climate change affect repowering?

Marilys Clément, Nergica

Marilys Clément (Nergica), Nigel Swytink-Binnema (Nergica)

Nergica is halfway through a multi-year project with climate modelling experts Ouranos and multiple Canadian grid operators. We are looking at the effect of climate change on wind energy potential across North America from 1950 until 2100.
Two Representative Concentration Pathways (RCPs) were simulated: RCP 4.5 (global emissions peak in 2040 before declining) and RCP 8.5 (worst-case "business-as-usual" scenario and emissions continue to rise). Within the 150 years simulated, three climate periods have been identified:

- Historical reference period: 1981-2010
- Horizon 1 (short-term / first repowering): 2031-2060
- Horizon 2 (long-term / second repowering): 2061-2090

Simulation results for both Horizons using each RCP will be compared with the Historical period. Focus will be on comparing Horizon 1 to the Historical reference period. This will be the period of most interest as we enter our first repowering efforts in Canada.
The effects of climate change on Annual Energy Production (AEP) will be evaluated by factoring in changes to wind speeds as well as changes to icing. Wind speed effects are evaluated using a power curve, and icing and power losses are modelled using Nergica's model GPEO. In addition, changes to wind direction will be quantified, as this is a significant factor in wind turbine siting.
The presentation will cover a description of the project and methodology but will focus on preliminary results of the simulations. Maps of changes will be shown for key regions within North America. These changes could include the following: annual icing days, severe icing amounts, average wind speeds, dominant wind directions, and AEP. Lastly, future steps will be outlined for the final two years of the project.

Web site:

Short biography: As a specialist in meteorology as it relates to wind power in cold climates, Marilys leverages her know-how in atmospheric physics to skillfully overcome the inherent challenges in wind energy production in cold climates and complex terrain. Although her initial focus area of theoretical climate change research has since evolved to encompass a search for concrete solutions such as renewable energy integration, she remains deeply drawn to climate-related issues.
As a research and innovation project manager, she has had the opportunity to lead and take part in numerous research projects aiming to improve modelling for wind energy. In addition to developing an ice and energy loss model (GPEO), Marilys has also made noteworthy contributions to several projects related to the processing, analysis and evaluation of climatic and meteorological models.
Marilys holds Bachelor's and Master's degrees in atmospheric sciences from the Université du Québec à Montréal.

Abstract #: 9

R&D areas/s: 10. De-/anti-icing including new technologies, ice detection & control incl. standards

Installation of Retrofit Hot Air De-icing Systems

Daniela Roeper, Borealis Wind, Canada

Daniela Roeper (Borealis Wind, Canada)

Describe the process and learnings of installing a Retrofit Hot-Air De-icing System, including adding additional power circuits to the hub, installing the heating system in the blades, and integrating the control system. Details on how to minimize changes to the turbine and without removing the blades of the wind turbine.

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

Short biography: Daniela is a mechanical engineer with a passion for the environment. While still completing her undergraduate degree from the University of British Columbia, Daniela founded Borealis Wind, a startup that provides a blade de-icing retrofit for wind turbines, improving their reliability as well as increasing production. The system has been validated through pilot testing in Canada. The innovative system can be installed up-tower without removing the blades of the turbine, saving significant installation and maintenance costs.

R&D areas/s: 10. De-/anti-icing including new technologies, ice detection & control incl. standards

PhD project on Durable Icephobic coatings on wind turbine blades

Kenth Johansson, RISE, Surface Process and Formulation, SE

Mikael Järn (RISE, SE), Mikael Hedenqvist (KTH, SE), Richard Olsson (KTH, SE)

Ice formation on wind turbines creates serious problems like a reduction in energy production, increased wear of mechanical components and risks for people and animals close to the wind turbines. This makes the use of wind turbines in cold climates less attractive. The deicing systems that are used today are based on heating the wind turbine blades, either by warm air or by electricity. The methods have different drawbacks; high energy demand, high cost, high maintenance costs, issues with lightning etc. The ideal solution would be passive methods, i.e. coatings on the turbine blades that reject the build-up of ice. The aim of this presentation is to introduce a new PhD project on development of new, improved passive anti-icing coatings. An important part of the project will be to increase the understanding of which mechanisms that govern low ice adhesion, and to use the knowledge for development of new, durable coatings. The project will engage a PhD student who will work full time with development, characterization and optimization of surface coatings with super-low ice adhesion and high durability with good adhesion to the substrate. The work will be performed both at RISE Surface Process and Formulation and Department of Fiber and Polymer Technology at KTH. Our approach is to further develop a new type of coating that showed promising results in a pre-study at RISE, where an elastomer-based coating exhibited extremely low ice adhesion values (0.9 kPa), several orders of magnitude lower than ice adhesion values reported for standard blade coatings. The project also possesses an effective infrastructure for development and testing of the coatings. A newly developed icing wind tunnel at RISE with an ice adhesion tester enables short, fast steps between formulation in the lab to tests at relevant conditions. A successful project would in the long run lead to high economic benefits due to a lower demand of today's expensive, energy demanding deicing systems, along with a simple deicing system that can be applied on both new and used wind turbines.

Web site: https://www.ri.se

Short biography: Kenth holds a Master of Science in Chemical Engineering from the Royal Institute of Technology (KTH) in Stockholm and a Licentiate of Engineering from KTH and YKI (Institute for Surface Chemistry). Works as senior project manager in the field of research, development and characterization of functional coatings, e.g. ice- and liquid repelling surfaces. Has worked with both passive and active anti-icing coatings for wind turbine blades. Main free time interests: most types of sports and music.

R&D areas/s: 07. Forecasting, cloud physics and aerodynamics

Large Eddy Simulation of Icing Conditions Impacting Wind Farms in Heterogeneous Land Use

Erik Janzon, Department of Earth Sciences, Uppsala Universitet, Sweden

Heiner Körnich (SMHI, SE), Johan Arnqvist (Uppsala Universitet, SE), Anna Rutgersson (Uppsala Universitet, SE)

Wind turbines located in cold climates and in elevated terrain are often at risk of ice accretion when supercooled water droplets within clouds interact with the surface of the turbine blade structure. The accurate forecast of generation losses during these icing events is necessary for the operation of wind farms. In order to accurately predict wind generation losses, meteorological input is required from numerical weather prediction (NWP) models that are in turn required to resolve the complex interaction between the surface and the atmosphere—more specifically the wind, temperature and clouds within the atmospheric boundary layer. Surface-boundary layer interactions are sub-grid scale processes within operational NWP models and must be parameterized. To further add to the complexity wind farms are often located within regions of heterogeneous land use, which can hinder accurate representation of the surface in the NWP model. The impact of the land-use on the low-level clouds can potentially be important for the forecasting of icing and related power generation losses. This study will explore the validity of the surface model in a Large Eddy Simulation (LES) using the MesoNH research model at 50 m horizontal resolution. Surface-Atmospheric interactions of heat, moisture, and momentum will be analyzed for different patterns of tree cover with the aim of determining the impact of heterogeneous land use on icing conditions.

Web site:

Short biography: Erik Janzon is a meteorology PhD student from the United States in the Department of Earth Sciences at Uppsala Universitet. Erik completed his Bachelor's degree in Meteorology in 2009 at Northern Illinois University and his Master's degree in Atmospheric Science in 2012 at the University of Wisconsin-Madison. Prior to moving to Sweden, Erik worked as a weather forecaster for real-time energy trading at Avangrid Renewables and as a fundamentals meteorologist at Portland General Electric in Portland, Oregon USA. In his spare time, Erik plays the electric guitar.

R&D areas/s: 06. Wind turbine manufacturers – cold climate solutions, test centres, turbines and components, 10. De-/anti-icing including new technologies, ice detection & control incl. standards, 12. Laboratory and full-scale testing, small wind turbines

Climatic chamber testing and verification in cold climate

Mattias Viktorsson, RISE

Mattias Viktorsson

Environmental Engineering environments **-** The potential, and the various challenges with testing and verification in climate chambers with focus on cold climates and icing.

Web site: https://www.sp.se/en/index/services/Climate_simulations/Sidor/default.aspx

Short biography: With 20 years of experience in environmental engineering with a focus on simulation temperature, sun, ice and high humidity. I have combined my expert role at RISE with in recent years also working as a generalist to helping companies to innovate and grow internationally. In my spare time I like to play golf, to be a magician and spending time with my family.

Abstract #: 13

R&D areas/s: 04. Construction of wind farms in cold climates (preparations, foundations and installations)

Pile Foundation Prototype Execution and Applicability for Scandinavia

Miguel Turullols, Nabrawind Technologies SL (Spain)

Arocena, Ion (Nabrawind); Rodriguez, Emilio (Nabrawind); Esparza, Arantxa (Nabrawind); Turullols, Miguel (Nabrawind)

Nabrawind Technologies has developed a new concept for the wind industry foundation. The specific characteristics of the Nabralift tower (with a three leg steel structure) allows the use of a pile or anchor rock foundation. This foundation does not only contribute to reduce the cost of the foundation, but also the quantity of concrete.
Thanks to this, the applicability of these foundations perfectly matches the requirements of cold climates. These techniques only require 80m3 of concrete, so there is a real possibility of heating the concrete when needed. Likewise, as the foundation of each pile requires only 1 hour, these foundations can also be used in autumn and spring, when in some places still freeze during the first hours of the morning but the temperature goes above 0º degrees at midday. All in all, this kind of foundation and tower can help to increase the months of operation for the installation of a windfarm.

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

Short biography: I have worked in the wind industry for the last two years. So I am still kind of a new comer in this sector. Before this I have been linked to the foreign trade world. I worked for almost two years as a Foreign Trade Consultor in the Embassy of Spain in Zagreb (Croatia), helping Spanish companies to enter to the market in the Balkans. Prior to this, I also worked in the Mission of Spain to the United Nations in New York, as a Junior Consultant, for one year.
Before this I work in several media institutions in Spain, as my colleague back ground is Journalism. I also have a Master degree in International Relationship by the Diplomatic School of Spain and an MBA.
As for Nabrawind, I entered in the Marketing and Sales department in order to reinforce the company in a time where the sales process was beginning.

R&D areas/s: 15. National strategies, research programs, grid access, system services and new developments

Circular streams from GFRP composite waste

Richard Sott, RISE

Richard Sott, Cecilia Mattsson, Magdalena Juntikka and Tanja Tränkle (RISE)

GFRP waste is a growing global environmental problem since the waste from wind, boat, automotive and construction industries go to landfill or incineration. Our project aim is to take a larger perspective on the problem: End-of-Life and manufacturing GFRP waste should be recycled through solvolysis/HTL in order to generate new circular material flows. To lay the grounds for future implementation of the solvolysis technology in a circular value chain, material flows from industries such as wind power, boat and construction industries need to be mapped and future recycled products and value chains will be evaluated regarding their profitability and impact on the environment.
Today, the more valuable carbon fiber composites are recycled by chemical recycling and pyrolysis, where the plastic parts of the composite are utilized for generating energy to the process. However, it’s not possible to use same process conditions for GFRP recycling since the glass fiber are more sensitive to chemicals and heat. In addition the cost of virgin glass fibres is low and therefore no incentive for profitable recycling exits. Our aim is to modify the solvolysis process condition and use lower temperatures (250-400 ºC) and utilizing catalysts for achieving separation between fiber and plastic part in the thermoset linked three-dimensional composite structure. In order to create circular high-quality product streams from both glass fibres and the plastic components, the goal is to produce fine chemicals or plastic building blocks that can be used for repolymerization, and glass fibres that can be reused in new composite materials.
To lay the grounds for future implementation of the technology in a circular value chain, material flows from industries such as wind power, boat and construction industries needs to be mapped, and possible future recycled products and value chains will be evaluated regarding their profitability and impact on the environment. An interdisciplinary perspective must be taken to tackle this GFRP recycling problem, where composite manufacturers and users, recycling industry and potential new players must meet and generate new innovative circular streams from GFRP composite.

Web site: https://www.ri.se/sv/richard-sott

Short biography: Researcher at RISE - Chemistry and Materials with current focus on recycling of composite materials from windmill turbine blades. Background from pharmaceutical industry and research in organic synthesis. Interested in anything that concerns replacement of fossil based materials to biobased plastics, analytical chemistry and recycling of plastics. Personal interest in any possible outdoor Winter sport.

R&D areas/s: 01. O&M experiences incl. performance optimization, production losses

Task19 - Ice Loss Tool

Timo Karlsson, VTT

Timo Karlsson (VTT, FI)

When installing and operating wind turbines in cold climates, the turbine blades can be affected by icing. Icing has an impact on blade aerodynamics and causes production losses. The magnitude of production losses varies depending on the site and the turbine model.
There is no real standard definition what kind of impact in production constitutes an icing event. Task 19 has proposed one way to standardize this. In 2015 a software implementation of this method was published for the first time. The software uses a standard statistical definition of an icing event and can be used to estimate the magnitude of icing losses posthumously from production data.
The method for detecting icing is based on computing an acceptable variance from summer time production and using this as lower limit for ice detection. The tool is using the turbine rotor as an ice detector and calculates specific limits for each turbine every time its run.
The tool has been recently updated to include some new features and at the same time the development and release process has been changed. The development is now more open and welcoming to outside contributions and instead of making big release every now and then, the new development process allows continuous improvement of the tool in an open and collaborative way. [1]
The new additions allow new kind of analysis, including analysis of heated turbines and estimation of effectiveness of ice detection.
Originally, when the tool was developed there were three goals:

1. Have a tool to compare site to each other
2. Validate the IEA ice classification
3. Compare the effectiveness of blade heating systems to non-heated turbines on cold climate sites

The presentation looks into how well these goals have been achieved and what still needs to be done.
Experiences from the first few years of the tools availability will be shared in the presentation, what went right, what went wrong, what was achieved, what could be improved.
Some usage tips and best practices for the usage of the tool will be presented and the future evolution of the tool will be discussed.
[1] https://github.com/IEAWind-Task19/T19IceLossMethod

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

Short biography: My background in industrial automation and I have M.Sc. degree from Aalto University School of electrical engineering. I've been at VTT since 2011 working as a research scientist focusing in wind power and cold climate issues. During this time at I've been working on numerous R&D projects in wide variety of topics including ice detection method development, ice assessment, production data analysis and ice prevention system development.
Currently I'm also the operating agent of IEA Wind Task 19.

R&D areas/s: 11. Onshore turbines, aerodynamics, loads and control

Predicting production loss due to ice accretion

Johan Revstedt, Dept. of Energy Sciences, Lund University, SE

Johan Revstedt (Lund University, SE), Robert Szasz (Lund University, SE), Stefan Ivanell (Uppsala University, SE)

The power output from wind turbines in cold climate is in winter time affected by ice accretion on the turbine. Accounting for this when estimating the potential power output at a prospective new site is important. This can be done in several ways. One method is to make estimates based on wind measurements with anemometers and the number of hours these are affected by ice. One can make empirical estimates based on the connection between terrain height and production losses.
However, these methods are often limited in both space and time to the area and time span of data collection. More advanced methods utilize mesoscale atmospheric models together with, for example the Makkonen [1] model for the ice build-up.
The model we are developing for predicting production losses is based on a modelling chain from mesoscale simulation of the atmospheric conditions via CFD simulations of the ice accretion to CFD of the full iced turbine, in the latter case using the actuator line model.
In the present state of this project we are collecting aerodynamics data for a wind turbine blade from a certain icing event. This includes detailed flow simulations during ice accretion at several sections of the turbine blade. From these sections we extrapolate aerodynamic data to the whole blade. As a model turbine we use the NREL 5 MW turbine.
We will present data from how the blade of this turbine is affected by icing for at least one icing event. Up to now we have only considered rime ice but results from our recently developed glaze ice model will also be presented. Furthermore, using a CFD based technique for ice accretion one will have to address the large separation in time scales between the ice accretion process and the flow. Hence, to get results in a reasonable time one has to scale the time of the accretion process.
Our results indicate that decreasing the time scale of ice accretion by a factor of 1000 still gives reasonable results in terms of ice load and ice distribution on the blade. Future work will present results bridging the gap from mesoscale simulations, i.e., give model input to ice accretion modelling, all the way to rotor simulations including load assessment.
Acknowledgements: This work is financed by the Swedish Energy Agency, project no. 47053-1. Computational resources are provided by SNIC (Swedish National Infrastructure for Computing).
References:
1. Makkonen, L., 2000, “Models for the growth of rime, glaze, icicles and wet snow on structures”, Philosophical Transactions of The Royal Society London A 2000 358, pp. 2913-2939.

Web site: https://www.fm.energy.lth.se

Short biography: Professor Revstedt got his master degree in mechanical engineering in 1996 and a PhD in fluid mechanics in 1999 at Lund University, Sweden. He is since 2011 professor in Fluid Mechanics at the department of Energy Sciences, Lund University. His main research interests are multi-phase flow, fluid-structure interactions and wind turbine aerodynamics. He has been involved in several research projects concerning wind turbine aerodynamics, some including ice accretion and aeroacoustics. Among his extracurricular activities one may mention a keen interest for swimming.

R&D areas/s: 10. De-/anti-icing including new technologies, ice detection & control incl. standards

A simple low-cost optical ice-sensing surface for instrumental icing assessment

Patrice Roberge, Université Laval

Patrice Roberge, Jean Lemay, Jean Ruel, André Bégin-Drolet (Université Laval)

Monitoring precisely icing conditions on a wind turbine is no easy task. Current technology is still evolving and adapting to the many challenges faced. The existent ice detectors can be divided in to separate categories: the direct measurement sensors with a working principle based on the interaction with the icing conditions in the air (i.e. meteorological icing) and the indirect measurement sensors relying on the ice accretion effect (i.e. instrumental icing). Even though they are accurate in most occasions, indirect sensors present a lower sensibility and a higher latency time in addition to be more prone to large ice accretion altering their working principle. On the other hand, direct measurements are vulnerable to non-sticking icing conditions. As observed on several occasions, icing conditions measured by a direct sensor and confirmed by a camera were found to have low adhesion to surfaces. Direct sensors would greatly benefit from being paired with a simple low-cost sensor assessing the state of instrumental icing. In this presentation, a novel optical ice-sensing surface complementary to direct icing measurement sensors is presented. This method relies on the well-known total internal reflection principle and allows a fast and reliable instrumental icing detection. This surface could also be used with indirect sensors to add redundancy or increase sensibility. The variation of the surface signal over time can also give indications of the event type (i.e. rain, freezing rain or in-cloud icing). This process of detecting the event type could also be automatized using machine learning. This technology could be packaged to be installed on wind turbine blades. A prototype of the sensing surface has been installed on a meteorological conditions monitoring station (MCMS), a direct icing sensor, on a wind turbine nacelle. At first, the working principle is described. Then, the controlled environment results and preliminary results gathered over half a winter on a wind turbine nacelle are presented.

Web site:

Short biography: Patrice is currently doing his master's degree in mechanical engineering at Laval University in André Bégin-Drolet's lab. He has been working on the operation of wind turbines in cold climates for 4 years where he had the chance to contribute in the development of an ice detection device. He has authored and co-authored four scientific publications. He completed his bachelor's degree in physical engineering with a distinction mention. He was awarded the prestigious undergraduate student research award form the Natural Sciences and Engineering Research Council of Canada three times, the NSERC Alexander Graham Bell Graduate Scholarship and the FRQNT scholarship for his master's degree as well as the Université Laval's leadership and sustainable development award. He is a very curious person that loves to learn and understand the why and the how of the everyday phenomena. He is passionate about skiing snowshoeing and trekking.

R&D areas/s: 10. De-/anti-icing including new technologies, ice detection & control incl. standards

The impact of liquid water content on thermal ice protection systems efficiency

André Bégin-Drolet, Université Laval

Patrice Roberge (Université Laval, Canada), Jean Ruel (Université Laval, Canada), Jean Lemay (Université Laval, Canada)

In cold climate and especially in eastern Canada where the icing season span roughly from mid-September to early May, ice related losses can reach a substantial percentage of the annual energy production, thus leading to important financial losses for operators. Wind turbine thermal Ice Protection Systems (IPS) are now widely available and are designed to heat a given surface of the blades for the purpose of preventing or removing atmospheric icing. However, it has been observed that wind turbines equipped with IPS still suffer important icing losses. Over the last couple of years, we have developed a semi-empirical model to explain the inefficiency of the IPS under standard meteorological conditions. This model was used to generate what has been called IPS performance envelope, a tool that can be used to characterize the efficiency of IPS. The IPS performance envelope is a concept used to predict the behaviour of a wind turbine and, in its simplest form, relies only on 2 external parameters that are widely available: wind speed and air temperature. Lately, we have observed, during field tests, that the IPS systems are also greatly impacted by the liquid water content (LWC). Hence, even though IPS performance envelopes can be a very useful tool for wind turbine designer as well as for wind energy developers and operators, it is also very important to consider the LWC when trying to assess or predict the behaviour of IPS. In this presentation, we will give a brief overview of the research we are doing in Canada regarding icing detection, characterization of IPS and improvement of wind energy in cold climate as a whole. We will show, using field measurements, the impact that LWC can have on IPS efficiency and the importance of measuring LWC on a given wind test site. Finally, we will also address the importance of establishing partnerships between academia and industry.

Web site: http://www.gmc.ulaval.ca

Short biography: André Bégin-Drolet is a professor of mechanical engineering at Université Laval in Canada. His research, in the wind energy sector, focuses toward improving wind power production in cold climate where atmospheric icing is prevalent. His research led him to the design of a patented smart sensor, the Meteorological Conditions Monitoring Station (MCMS), adapted to measure meteorological conditions in cold and icy environment. Moreover, he is very interested in developing methods to improve the production of wind energy in icing conditions using this novel instrument. Wind is also part of his hobbies as he is an active racing sailor who loves to perform in both inshore and offshore regattas.

R&D areas/s: 10. De-/anti-icing including new technologies, ice detection & control incl. standards

A new type of anti icing system – development/application/demonstration

Sven-Erik Thor, Lindskog Innovation AB

Jonas Sundström (Skellefteå Kraft AB), Kjell Lindskog, Sven-Erik Thor (Lindskog Innovation AB). Sweden.

This presentation will describe the development of a new type of anti-icing system. The presentation will focus on the general characteristics of the system and description of the different subsystems as well as the experiences from operation on a wind turbine.
The goal of the project was as follows:
1. Development of heating modules, including manufacturing technology.
2. Develop methods and models for controlling the heating modules
3. System integration
4. Apply system on a wind turbine
5. Performance test in icing climate on a wind turbine

The system has been installed and been in operation on a wind turbine owned by Skellefteå Kraft AB.
The project has been managed and financed by Lindskog Innovation AB. Financial support from Energimyndigheten and Skellefteå Kraft AB is greatly acknowledged.

Web site:

Short biography: His long career includes; being head of wind RD&D at Vattenfall before his retirement. Participating in a number of EU projects on wind energy. Being a member of EU TpWind Steering Committee and services to the European Commission to evaluate proposals for framework programs. Has been Operating Agent for IEA Task 11.
Presently working with Lindskog Innovation AB regarding the development of de/anti-icing systems.
On his free time, he enjoys woodworking and taking care of the summer house.
https://www.linkedin.com/in/sven-erik-thor-a6124115/

R&D areas/s: 01. O&M experiences incl. performance optimization, production losses, 03. Inspection and repair, 04. Construction of wind farms in cold climates (preparations, foundations and installations), 08. Pre-construction site assessment, measurements, models and standards, 15. National strategies, research programs, grid access, system services and new developments

Control of tower bolt connections and the challenges related to cold climate conditions

Anders Wickström, RISE Research Institutes of Sweden

Magnus Evertsson, Chalmers, Professor in Machine Elements, Head of Division Product Development
Jonas Nilsagård, TensionCam, Inventor

Inaccurate tightening bolt connections is a problem on wind turbine towers. The tightening operation is difficult. The tightening load must not be too low or too high. It is necessary to pay particular attention to the choice of the tightening tool, the process and the control method.
Most often the tightening is conducted with a torque wrench. The real preload, which is applied to the bolt by torque, depends on the friction coefficient in threads and the friction coefficient of the contact surfaces between nut and structure. The ‘‘useful’’ part of the torque is generally only 10–15% of the total torque. Even using a sophisticated wrench tool giving a high precision torque and having low friction coefficients, the accuracy of the final tightening load cannot be better than ±20%.
The pretension might therefore not be equally distributed among the bolts in the same joint. The practical conditions might be different from the hypothesizes at the design stage. The calculations of bolted joints needs to take these uncertainties into account.
There is an ongoing research project within SWPTC. The aim is to develop knowledge and deeper understanding of the tower bolt joints in general and more specifically control of bolt pretension.
The Swedish company TensionCam has invented and developed a concept, where the tightening load is determined by measuring displacements at bolt head or nut by an existing fingerprint sensor. Different locations and patterns have been tested. The resolution, about 1 micrometre, and accuracy have been validated by both FE-calculations and workshop tests at RISE.
This new technology makes it possible to check that the tightening force of each and every bolt is correct both after assembly and over time.
Winter conditions and lack of pretension control had severe impacts on the erection of the V112 turbines at Lemnhult in December 2015. If the pretension of the tower bolt joint would have been accurate, the accident would not have occurred.
There are additional challenges related to winter and cold climate conditions:
 The optimal type of lubricant might differ depending on the ambient temperature.
 Material properties of the foundation might change in extreme coldness.
 The foundation ageing might be affected.
 Ice on contact surfaces during tightening
All of these aspects might have an impact on the bolt pretension over time.
With a simple and rapid technology for checking the pretension, these aspects can be further evaluated. Therefore, involved partners hope to get an extension of this successful SWPTC project in order to also address the cold climate aspects of bolt pretension in towers and foundation.
With hope of getting the opportunity to tell more at the conference.

Web site: https://tensioncam.com/

Short biography: Wind turbine design since 1988, Kvaerner, ScanWind, GE.
Independent wind turbine consultant at Scandinavian Wind.
Official wind turbine expert at Statens haverikommission and its investigation of the V112 accident in Lemnhult
Since last year, employed at RISE.

R&D areas/s: 01. O&M experiences incl. performance optimization, production losses, 10. De-/anti-icing including new technologies, ice detection & control incl. standards, 14. Big Data, AI, digitalization and machine learning applied to cold climate challenges

The impact of light ice masses on expected wind power production

Florian Rieger, fos4X GmbH

Florian Rieger (fos4X GmbH), Luis Vera-Tudela (fos4X GmbH)

Wind power production in cold climates is affected by the formation of ice on rotor blades. In consequence, efforts in the industry have been focused on its detection. The goal is twofold, first to mitigate the risk of damaging the turbine structure as well as third-parties and, second, to minimize wind power production lost in the process. It is a risk-reward trade-off.

A previous investigation on the performance of various rotor-mounted ice detection systems has shown their overall high technical availability (Nergica, 2019). It has also shown that vibration-based systems limit the occurrence of false detection, as it is the case for fos4X Rotor Ice Control. This is achieved by using a threshold for ice-mass detection. This approach also implies a lower rate of detection when there is light icing. Thus, it is of interest to explicitly relate the amount of ice-mass to the power loss expected.

In this publication we evaluate field measurements to assess the impact of light icing on expected power production. Data sets gathered from fos4X Rotor Ice Control installations include time-series for electrical power produced, ice-mass, ice warnings and ice alarms. We include a statistical expectation for power production in ice-free periods to account for the lost power when there is light icing events. We describe how varying the threshold impacts on the expected power loss.

The utility function serves as baseline to discuss threshold selection in terms of expected power production. Since manufacturers guarantee power curves, this is also relevant to help market participants to find a fair expectation of power production under light icing. Furthermore, varying the threshold implies a change in false detection, which is discussed in qualitative terms to weight the interests of other market participants

Web site: https://www.fos4x.de/

Short biography: Florian is the main data scientist on ice detection at fos4X GmbH. He holds a master in electrical engineering from the Technical University of Munich, where he currently deepens his technical expertise by pursuing a PhD.

R&D areas/s: 01. O&M experiences incl. performance optimization, production losses, 02. Health, Safety and Environment (HSE) incl. ice throw and noise, 03. Inspection and repair

Offshore work in icy conditions

Staffan Martinsson, RWE Wind karehamn AB

Staffan Martinsson (RWE Wind Karehamn AB

To share experience of offshore work in icy condition, such as ice along the coastline, ice on the foundations and ice on the nacelle/blades

Web site:

Short biography: Plant manager for Kårehamn offshore since construction 2012.
Offshore wind experience in colder climate for more than 10 years.
Previous experience on 3 other offshore sites in Sweden.
35 Years old with house, wife, 2 kids and a passion for skiing and Triathlon

R&D areas/s: 02. Health, Safety and Environment (HSE) incl. ice throw and noise, 09. Environmental Impact Assessments (EIA)

windThrow: an open source toolbox for ice throw simulations

Hamid Sarlak, Denmark

Assistant professor, DTU Wind Energy

Latest developments on DTU's ice throw aerodynamic model will be presented. Compared to the original, research based version (see Sarlak, H. and Sørensen, J.N., 2016. Analysis of throw distances of detached objects from horizontal-axis wind turbines. Wind Energy, 19(1), pp.151-166.), the new revision includes a graphical user interface and a Python-based Monte Carlo simulation toolbox is integrated into the aerodynamics module (Fortran) to perform massive simulations with varying input parameters. Latest improvements and challenges in developing the toolbox will also be presented. The code will be released to the research community at the Winter Wind conference.

Web site: https://dk.linkedin.com/in/hamid-sarlak

Short biography: Hamid is an assistant professor of fluid mechanics at the department of wind energy at the Technical University of Denmark. Hamid has a previous background in ocean engineering and his current research involves turbulence modeling, CFD, hydrodynamics, and experimental aerodynamics.

R&D areas/s: 14. Big Data, AI, digitalization and machine learning applied to cold climate challenges

Should I heat or should I not? - Smart operation of wind turbines in Cold Climate

René Cattin, Meteotest, CH

Paul Froidevaux (Meteotest, CH), Ulrich Langnickel (VGB PowerTech, DE)

Today, electricity prices are low. As a result, there is a lot of pressure on wind turbine operators to maximize the production of their wind farms. The focus is on minimizing production losses and standstill times. At the same time, digitalization offers many new opportunities in the field of wind energy. Huge amounts of data from operating wind turbines are available in real time and turbines become more and more connected. In particular, the interaction between wind farms and servers located anywhere becomes more and more a standard.
Wind energy under icing conditions itself has also made a lot of technical progress in the past years: Ice detection has strongly improved and by today, various robust systems for blade based ice detection are available on the market. Ice protection systems (blade heatings) are today being offered by almost all OEMs.
However, the removal of blade icing still remains a technological challenge and the success of a blade heating attempt strongly depends on external conditions such as ambient temperature and wind speed (performance envelope). Moreover, the success of a blade heating event might be pragmatically assessed in terms of net production gain, rather than in terms of ice removal. The production gain depends on the temporal evolution of wind speed and ice cover in the hours or days following a heating event. Typically, all this information is by today not yet taken into account by the control systems.
Ideally, a smart control of the blade heating should consider external conditions for the present and for the near-future, i.e. it should combine real-time data with weather forecasts for efficient nowcasting. Nowadays, weather forecasts for wind speed or ambient temperature, as well as for icing, have reached an accuracy which allows to consider them for turbine control. This includes automatic decision making without the need of human interpretation of the forecasts.
In summary, there are a lot of suitable technologies and information sources available to optimize operation of wind turbines under icing conditions. However, all these advantages are not yet applied in an intelligent manner, a wind turbine operating under icing conditions is to some extent still "stupid". As of today, a blade heating is typically activated immediately when ice is detected at the blades, instead of controlling it in a predictive way by taking into account all available information. In other words, the optimal time to heat the blades depending on the current and forecasted external conditions must be put into focus.

There is a large potential to improve the operation of wind turbines by introducing a smart turbine control. This presentation will be of conceptual nature and outline the current technological state of the art as well as potential benefits and ways forward towards a real-time smart turbine control under icing conditions.

Web site: https://meteotest.ch/

Short biography: René Cattin holds a master degree in Geography. He works at Meteotest for almost 19 years. Since 2018, he is the CEO of Meteotest. He has been active in cold climate and wind energy since more than 15 years and was the Swiss representative of IEA Task 19 from 2009 to 2016. Outside the office, he is husband, father of three kids, a local green politician and always interested in rock music.

R&D areas/s: 01. O&M experiences incl. performance optimization, production losses

Wind turbine operations in northern Siberia

Masafumi Yamazaki, Kanagawa Institute of Technology, Japan

Ken'ichi Iwai(Komaihaltec Inc., Japan), Masao Hosomi(Komaihaltec Inc., Japan), Shigeo Kimura(Kanagawa Inst. of Tech., Japan)

In Tiksi, the Sakha Republic of northern Siberia, three wind turbines were installed. Tiksi is located in the area where the electricity is off the grid and has been depending on diesel power generation for a long time. Diesel power system often faces the high cost of the transportation of fuels. From this point of view, wind turbines are expected to contribute to reducing those costs as well as alleviating the load on the diesel power generator.

Tiksi experiences extremely low temperature climate in witer. All the three wind turbines are manufactured by a Japanese company, Komaihaltec Inc., designed to withstand below -30 degrees in Celsius. In addition to turbine's specification, icing on wind turbines also should be considered in cold climate. This report aims to provide information gathered through operating experiences.

Web site: https://www.linkedin.com/in/masafumi-yamazaki-541076b4/

Short biography: Masafumi Yamazaki is a Master student at Kanagawa Institute of Technology and a trainee at National Institute of Advanced Industrial Science and Technology (AIST). He received Bachelor's degree in Applied Physics from Tokyo University of Science in 2013. He has contributed to icing problems on various kinds of objects internationally. In addition to wind turbines, commercial aircrafts, multi-copters, and anemometers are of those.

R&D areas/s: 10. De-/anti-icing including new technologies, ice detection & control incl. standards

Megaterends in blade heating

Petteri Antikainen, Wicetec, Fi

Lasse Hietikko & Tomas Wallenius, Wicetec

The cold climate wind market has matured to very serious utility scale business, with utility scale requirements. The presentation is describing few trends which are making appropriate ice prevention more important than ever before.
When the turbines are getting bigger and higher, the icing is increasing exponentially due to increased frequency when blade is hitting the clouds. At the same time, the turbines are getting cheaper, requiring light weight structures, which are more sensitive to different disturbances, for example icing. The long blades also introduce different constraints with different heating technologies.
More and more turbines are being built to icing climate, in bigger units, for example Markbyggden with a plan for 4 GW. This introduces a big interest for security of supply in a severe icing periods.
Other economic concerns rise, fulfilling production requirements of PPA's. What is the cost, if you need to buy electricity with the top prices instead of selling?

Web site: https://wicetec.com

Short biography: Petteri has worked 25 years with cold climate wind. 2014 he co-founded Wicetec, a company dedicated to Ice Prevention for wind turbines.
Before Wicetec, he has developed tools and methods for cold climate including standards in National and International standardization committees, SESKO and IEC MT12-1. He has a M. Sc. in Technical Physics at HUT, Finland. Petteri worked as principal scientist at VTT, Technical Research Centre of Finland. He has also been a board member in Finnish Wind Power Assosiation.

R&D areas/s: 10. De-/anti-icing including new technologies, ice detection & control incl. standards

Vestas Cold Climate solutions

Karl Gregory, Vestas Wind Systems A/S, DK

Karl Gregory (Vestas), Brian Daugbjerg Nielsen (Vestas)

Vestas will present the cold climate solutions package available to the market. 1) Low Temperature: Low temperature operational ranges and turbine product adaption. 2) Icing mitigation solutions: A)Vestas turbine in icing conditions - Production impact due to icing and how Vestas Turbines reacts to the icing. B) Anti-icing – moving into mass production, most recent field data and next steps. C) Ice detection solutions – how the operational strategy can be tailored to fit high regulative ice throw sites to less regulative, and what can be combine in order to enable the most optimum operational strategy.

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

Short biography: MSc Aerospace '85-'87 Cranfield University, BEng, Civil Engineering '81-'85 Univerisity of Bradford.
2010 till now, Vestas, Senior specialist 2010 till now. Main focus on cold climate solutions
1997-2010 GKN Aerospace Chief Engineer (propulsion)
1992-1997 Team leader, rolls Royce Deutschland

R&D areas/s: 08. Pre-construction site assessment, measurements, models and standards

Wind farm blockage onshore: what drives the loss?

Till Beckford, DNV GL, UK

Till Beckford (DNV GL, UK), Christiane Montavon (DNV GL, NL

When modelling turbine interactions within arrays, the wind industry typically only considers wake losses, whereby a specific turbine only affects turbines located downstream of its position. In practice, turbine interactions also include lateral as well as up- and downstream interactions, which altogether contribute to the resistance (aka blockage) that the wind farm induces on the background flow, deflecting some of the flow above and around the wind farm. A consequence of this is that the turbines operating on the upstream edge of the wind farm are exposed to wind speeds which are slightly different (usually reduced) from the so-called freestream conditions, as measured by a mast before the wind farm is in operation.
Since the adoption of blockage effects by DNV GL in 2018, further research and the acceptance in the industry, particularly offshore, has increased culminating in the recent (at the time of writing) announcement by Ørsted of their own blockage model and downgrading of their expected long-term production forecast /1/.
Questions however remain over the applicability of blockage effects onshore, and in particular, the influence of forestry and terrain, such as that seen in the Nordic region. Do forestry and terrain effects introduce more mixing in the atmosphere, and thereby mitigate blockage effects? Are these effects negligible in relation to the driving factor in wind farm blockage calculations, turbine density?
In order to answer these question, DNV GL has undertaken CFD simulations of a range of generic wind farms with variable levels of forestry and terrain, in order to represent typical onshore wind farms in the Nordics. Through this, the important relationships between these factors and the turbines are investigated and empirical relationships suggested. These enables improved predictions of turbine interaction blockage effects at typical Nordic wind farm projects to be made.
In addition, the influence of atmospheric stability on the magnitude of blockage effects is considered, along with the height of the boundary layer and the influence this can have on onshore and offshore blockage calculations.
In viewing this presentation, delegates will gain an important understanding of the driving factors for blockage effects at Nordic wind farm projects, along with how this may change when looking offshore. This understanding is vital in empowering industry stakeholders to make well informed decisions and understand the risks in predictions of long-term energy yield.
References
1. https://orsted.com/en/Company-Announcement-List/2019/10/1937002

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

Short biography: Till has been working in the renewable energy sector with DNV GL since 2012. Working in the Renewable Energy Analytics department, Till focuses on undertaking analyses of wind farms throughout their life cycle – from project development through to operational analytics. In his current role, Till leads a team of engineers serving the Nordic & Baltic markets and is the technical lead for DNV GL's pre-construction services. Till has worked on some of the largest wind farms in northern Europe and has extensive experience in Cold Climate projects. Till has a Masters in Mechanical Engineering from the University of Bath. Outside of work you can find Till enjoying music or keeping fit!

R&D areas/s: 05. Market potential, finance, risk assessment, bankability and mitigation

Cost of uncertainty in project development

Jenny Longworth, Kjeller Vindteknikk AB

Ville Lehtomäki

This presentation will show how uncertainty in wind measurements and the resulting uncertainty in expected wind farm annual energy production (AEP) impacts the wind farm purchase price near financial close. The purchase price analysis was done by a big equity investor based on a statistical analysis of historical wind farm transactions. A cost-benefit analysis is performed by Kjeller Vindteknikk on how to mitigate the wind measurement uncertainty by different methods and solutions. Solutions to mitigate uncertainties before and after wind measurements are presented.
It is recommended that project developers make AEP uncertainty reduction a #1 priority in project development as this proves to be cost effective. Active, early intervention including corrective measures during wind measurement campaigns are financially viable ways to reduce AEP uncertainties.

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

Short biography: Jenny Longworth has been working in the wind industry since 2005 at a number of different wind energy consultancies and project developers such as Sgurrenergy, SSE and Vattenfall with wind energy analysis as well as wind turbine procurement. She joined Kjeller Vindteknikk AB as Managing Director in September this year. Jenny has a master's in mechanical engineering from Luleå University of Technology and a MSc in Renewable Energy Systems Technology from Loughborough University and she is also active in the research centre Stand Up for Wind.

R&D areas/s: 03. Inspection and repair

Siemens Gamesa effective blade repair solution at cold temperatures

Mert Satir, Siemens Gamesa Renewabe Energy, Ireland

Mert Satir (Siemens Gamesa Renewable Energy, IE), Maria Azzurra Riezzo (Siemens Gamesa Renewable Energy, DK)

Siemens Gamesa has a long history and vast experience in servicing turbines in cold climates around the world and has been a pioneer in developing innovative solutions to improve the performance and serviceability of turbines in cold climates. Cold weather makes blade repair a challenge both technically and logistically. Ordinary lamination solutions like wet lamination are just not up to the task. Not suitable for winter – or humid – conditions, these can only be applied in temperatures over 15°C, and carry the risk of an incorrect mixing ratio, and have a long curing cycle – even up to 5 hours. To overcome these challenges, Siemens Gamesa has introduced the innovative Siemens Gamesa UV Curing Laminate Repair System. An efficient, proven concept that responds directly to the inefficiencies of other blade repair lamination solutions, thanks to its UV lamp curing solution allowing the repairs to be done at lower temperatures and higher humidity conditions. Greatly simplified lamination with less operator dependency results in substantial reduction in processing time and simplified logistic set-up. This ensures a repair cost reduction by 20-30%. This presentation explains this innovative, cost and time-efficient repair solution that helps to keep the turbine blades operating optimally.

Web site: https://www.siemensgamesa.com/en-int

Short biography: Mert Satir is the Product Marketing Manager in Siemens Gamesa Renewable Energy, covering North, Central and East Europe and Middle East region. He has a BSc degree on Naval Architecture and Marine Engineering and a MSc degree on Sustainable Energy and Green Technologies. Prior to his current work, he worked at various roles in Wind Energy in Project Management and Sales Bid Management at locations such as Denmark, USA, Germany and Ireland. Currently based in Dublin, Ireland, he is working to help shape the product portfolio.

R&D areas/s: 08. Pre-construction site assessment, measurements, models and standards

Validation of turbine specific modelled ice losses

Stefan Söderberg, DNV GL, SE

Till Beckford (DNV GL, GB), Carla Ribeiro (DNV GL), Alan Derrick, (RES Ltd, GB), Min Zhu (RES Ltd, GB)

In recent years technical innovations and improved understanding of challenges in cold climate areas has allowed the development of large wind farm projects in regions where severe icing conditions can be expected. One of the challenges has been, and still is, to accurately predict the expected energy loss due to icing.
The tool DNV GL use to estimate production losses due to icing is called WICE [1,2,3,4]. WICE includes a site-specific mesoscale modelling study using the state-of-the-art mesoscale model WRF [5], modelling of ice accretion on a turbine blade, a machine learning model to predict production losses due to icing and methods to long term correct the model results. The model chain has previously been validated in an internal study [4].
Recently DNV GL undertook a blind test for RES. RES is the world's largest independent renewable energy company with a portfolio of over 16 GW. In the study, 6 wind farm projects were included. The projects were located in different parts of Sweden, providing a good geographical spread within the country. Icing loss estimates were generated using WICE. Timeseries with hourly data for each individual turbine was provided by DNV GL and then compared to the observed losses in the operational data by RES. In the analysis an overall good agreement between WICE and SCADA derived losses was found.
As the performance of icing loss modelling continues to improve, the possibility presents itself for the use of icing modelling in the optimisation of wind farm designs, as opposed to limiting icing modelling to the estimation of energy losses. This optimisation may entail the specification of Ice Protection Systems only at the more severely effected locations, or the placement of turbines themselves.
To this end, the work presented here, includes an in-depth analysis of the turbine by turbine icing loss predictions in the blind test, and is augmented by the analysis of turbine specific losses from previous internal DNV GL WICE validations. From this it is shown that WICE performs well in capturing icing loss variation within wind farms, offering the potential for better wind farm designs. The presentation shall discuss where WICE does well, where there is room for improvement, and what the next steps are to enable developers of wind farms in Icing Climates to optimise their projects.
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[1] Söderberg, S., M. Baltscheffsky, and H. Bergström, 2013: Estimation of production losses due to icing - a combined field experiment and numerical modelling effort. EWEA 2013, Wien, Austria.
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[3] Söderberg, S. and M. Baltscheffsky, 2014: A novel model approach to test de-icing strategies and de-icing efficiency. Winterwind 2014, Sundsvall, Sweden.
[4] Söderberg, S, J. Collins, T. Beckford, and C. Ribeiro, 2019: WICE 2.0 – The new generation of ice loss models. Winterwind 2019, Umeå, Sweden.
[5] Skamarock, W. C.; J. B. Klemp; J. Dudhia; D. M. Gill; M. Duda; X.-Y. Huang; W. Wang; and J. G. Powers (2008): A Description of the Advanced Research WRF Version 3. NCAR Technical Note.

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

Short biography: Stefan has worked in the wind industry since 2006. In DNV GL Stefan is and expert in numerical mesoscale modelling and icing climate studies. Prior to DNV GL, Stefan founded and worked in WeatherTech Scandinavia developing services based mesoscale model data such as wind resource mapping and estimates of production losses due to icing.
In the Renewable Energy Analytics Team, Stefan is Technical Lead responsible for the development and application of mesoscale modelling techniques in wind and solar resource assessment, working together with DNV GL's global pool of specific energy assessement challenges affecting the NEMEA (North Europe, Middle Easts and Africa) region, such as production losses due to icing, wind flow modelling and wakes offshore, among others.

Abstract #: 31

R&D areas/s: 08. Pre-construction site assessment, measurements, models and standards

R&D areas/s: 07. Forecasting, cloud physics and aerodynamics, 10. De-/anti-icing including new technologies, ice detection & control incl. standards, 15. National strategies, research programs, grid access, system services and new developments

Ice and snow management innovations for critical infrastructure

Ville Kaikkonen, University of Oulu

Ville A. Kaikkonen (University of Oulu, FI), Eero O. Molkoselkä (University of Oulu, FI), Harri J. Juttula (University of Oulu, FI), Katri M. Kukkola (University of Oulu, FI), Mikko Rintala (Lapland University of Applied Sciences, FI), Yijun Shi (Luleå Un

The Ice Proof Arctic - Innovations for ice and snow management –project aims to increase the number of actors involved in innovation activities in the Interreg North Program area by developing and validating solutions to reduce damages caused by ice and snow loads on various structures. The project aims for new innovations for reliable and cost effective risk management of snow and ice for critical infrastructure such as power grids, wind power production and large-scale buildings. The project includes the field test validations of multiple new innovations originating from both the commercial partners and the research units in the fields of cold climate wind power production, icing condition detection and measurement, power line ice load de-icing, and rooftop snow load monitoring and management systems. The project increases the cross-border co-operation between the companies and research institutes located in the northern parts of Norway, Sweden and Finland through cross-linked actions and public workshop events. This 3-year project started in October 2019 and is done in close collaboration with companies Rajakiiri Oy, Statnett FS, Global Boiler Works Oy, Dimense Oy, Koillis Mittaus Oy, Kjeller Vindteknikk AS, Wind Controller JV Oy, Nordic Cai Project Consulting AB and by four research groups from the University of Oulu, the Lapland University of Applied Sciences, the Luleå University of Technology and the Arctic University of Norway.

Web site:

Short biography: M.Sc.(tech.) degree in electronics, currently finalizing PhD work in the field of photonics on image based rain and snow measurements. Past research activities on different kind of optical environmental measurements. Spend my free time with my family and double basses playing jazzy and classical music.

R&D areas/s: 01. O&M experiences incl. performance optimization, production losses, 06. Wind turbine manufacturers – cold climate solutions, test centres, turbines and components, 08. Pre-construction site assessment, measurements, models and standards, 10. De-/anti-icing including new technologies, ice detection & control incl. standards

Performance Maps for Ice Mitigation Operational Strategies

Dimitar Stoyanov, Coventry University

Jonathan Nixon(CU,UK)

The study looks at determining how a wind turbine should perform for three alternative operational ice mitigation strategies during extreme and harsh in-cloud icing. Complete shutdown, anti-icing and tip-speed-ratio derating are evaluated for two icing events with ambient temperatures ranging between -30 and -5°C. Two anti-icing approaches are investigated; protecting the whole surface of the blade section and impingement zone protection only. The effectiveness of the ice mitigation strategies is evaluated by means of performance maps, which display what the reduction of the produced energy over a period of time would be depending on the choice of ice mitigation strategy. The considered time of operation is 24 hours, while the chosen wind turbine is NREL 5MW reference wind turbine. The ice simulations are completed using lewINT ice accretion software to generate the ice shapes for the extreme and harsh icing case with durations of 1 and 4 hours. The reduced aerodynamic performance is obtained using the predictive capabilities of XFoil and blade element momentum theory.

Tips-speed ratio derating was estimated to reduce the maximum possible ice induced energy losses by 35% during the extreme icing condition in comparison to the reference operational strategy, while the estimated reduction for the harsh icing conditions was 70% at an ambient temperature of -5°C, which reduced with lower temperatures.

Keeping the whole surface of the blade at 5ºC was found to require 0.5-2.6% of the daily energy production for the extreme icing case, while the maximum icing losses vary from 2.6-8.4% over the temperature region. During the harsh icing event, the ani-icing of the whole blade was found to be effective for ambient temperature between -10 and -5°C, leading to less than a 4% reduction of the daily energy generation, while the maximum losses from not utilising any strategy ranged from 12–15.5%. The anti-icing of the impingement region was found to be the optimal solution for both icing events, requiring less than 0.5% of the daily energy generation. The margin between maximum achievable losses and the energy required to heat the protected area can be used to establish design limits for the second anti-icing approach, which will allow wider protected zone and/or increase of blade surface temperature.

The operational shutdown reduced the daily energy loss by 30% during the harsh icing event at an ambient temperature of -5°C, while assuming wind turbine operational recovery 1-hour post-icing event. For the rest of the operational conditions, the alternative strategies are suggested.

The study shows also the importance of modelling ice melting, shedding and abrasion from wind as the expected reduction of the energy was estimated to vary between 0.5 to 4% of the daily energy production for 1-hour long extreme icing event, while for a 4-hour harsh icing event the variation was between 15.5% to 1.7%.

The results outline a framework for evaluating different ice mitigation strategies and set out to establish design limits for anti-icing systems. It was shown that the current approach visualise the potential effect of each ice mitigation strategy and its advantage is that it allows for the comparison of various possible ice mitigation techniques providing their ice mitigation properties are translated to reduction in the daily/annual energy losses. By investigating a potential wind site using this approach, it will be possible to select a combination of optimal operational strategies ensuring improved energy generation during the icing periods. The proposed framework will be beneficial for manufacturers in identifying regions of interest for high fidelity analysis on ice mitigation systems and techniques. In addition, the choice of suitable cold climate packages and wind turbine operational set of sequences would be eased for wind turbine operators when wind energy projects are being developed for Cold Climate regions.

Web site: https://www.researchgate.net/profile/Dimitar_Stoyanov4

Short biography: Dimitar Stoyanov is a third year PhD candidate in Coventry University, UK. After finishing his MSc in Aerospace Engineering in Coventry University, he started a PhD project on Wind Turbine Operation in Icing Conditions. The project aims to establish a method, which can help wind

R&D areas/s: 01. O&M experiences incl. performance optimization, production losses, 06. Wind turbine manufacturers – cold climate solutions, test centres, turbines and components, 08. Pre-construction site assessment, measurements, models and standards, 10. De-/anti-icing including new technologies, ice detection & control incl. standards

turbine operators to choose which is the best ice mitigation strategy or set of ice mitigation strategies for a specific Cold Climate location and wind turbine.
Following a journal article in Renewable Energy journal and a book chapter in Renewable Energy and Sustainable Buildings book, the project is set out to finish in the next four months when the complete output will be available to the research community.
Personal interest to Dimitar Stoyanov are CFD, aerodynamic, MATLAB programming routines and numerical analysis.

R&D areas/s: 01. O&M experiences incl. performance optimization, production losses, 14. Big Data, AI, digitalization and machine learning applied to cold climate challenges

Advanced operational analytics with machine learning

Sarah Barber, DNV GL, UK

Sarah Barber (DNV GL, UK), Thomas van Delft (DNV GL, UK)

The operational management of renewable energy assets is an area for optimisation and opportunity; where improved practices can bring significant financial benefits for projects. This trend is driven by the increased consolidation of operators and the growing size of portfolios, both in terms of numbers and geographic spread. Advanced machine learning techniques, in collaboration with large high quality SCADA datasets, has enabled DNV GL to develop new tools for the analysis of operational data which improves both the accuracy and efficiency of analytics.

In the past year, DNV GL has been developing two tools using machine learning techniques and this presentation shall demonstrate these and the expected improvements available to operators of wind farms in the Nordics.

The first application of these techniques is power curve performance analysis, where the benefits of human experience and automation are combined into a single model. The presentation shall demonstrate the ability of the model to capture abnormal turbine performance, including icing conditions. This allows for the robust and efficient quantification of icing losses, which has been demonstrated to be variable with existing tools and is an essential component in performance management, in particular when undertaking Ice Protection Systems warranty tests.

Furthermore, through the development and training of the model, DNV GL has amassed a large database of operational turbine data, derived from the over 65 GW of wind farm operational data analysed by DNV GL. Through the analysis of this, interesting findings comparing the operation of different turbine types in cold climate conditions are revealed. This offers a greater understanding of turbine operations, from which smarter decisions can be made.

The second application of machine learning is in drivetrain condition monitoring. Here, DNV GL has applied machine leaning techniques to turbine SCADA data to develop a model predicting impending component failures. The presentation shall show the driving factors in the model and the implications of operating in cold climate environments.

In conclusion, from this presentation delegates shall gain an understanding of the uses of machine learning in operational analytics, along with an appreciation of the benefits in using large high-quality turbine SCADA datasets. This shall engender further discussion in the industry about what these datasets can show and be used for, and where machine learning can be intelligently used to improved turbine operations in cold climates and worldwide.

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

Short biography: Sarah Barber is DNV GL's Global Service Line Leader for Asset Operations and Management, focusing on advisory services for operational solar and wind plants. Sarah joined DNV GL in 2008 and has worked in renewable energy technical advisory for nearly 17 years. Her experience includes both solar and wind energy, from single projects to global portfolios. Examples of her current and past work include: advising renewable asset owners in transactions and strategy decisions, monitoring for wind and solar farms, long-term energy production assessments, developing operational energy analytics, and project management of due diligence for large operational renewable portfolios. She has experience in many roles including as a Team Lead, Technical Lead, and Key Account Manager. She has degrees in Chemistry and Renewable Energy Systems. Outside of work, Sarah is an enthusiastic cyclist and also enjoys hiking and camping.

R&D areas/s: 06. Wind turbine manufacturers – cold climate solutions, test centres, turbines and components

Siemens Gamesa ice accretion modelling and its impact on the aerodynamic performance and AEP

Esteban Belmonte, Siemens Gamesa Renewable Energy, SP

Esteban Belmonte, Gabriel Ovejero, Marta Barreras

Siemens Gamesa Renewable Energy (SGRE) has more than 20 years of experience with wind turbines working under Cold Climate conditions around the world. Our cold climate expertise ensures that we understand the impact of operating the turbines on icing climate conditions and we overcome the challenges associated with ice accretion.
The presentation will show the blade airfoils modification based on different ice accretion models and their deteriorated aerodynamic performance based on CFD analysis. Various ice conditions and wind speeds are taken into account for the development of such models covering different blade sections.
The information provided by the ice accretion models are used to predict AEP losses of SGRE wind turbines at a specific site. Load simulations allow SGRE to analyze which loads/components are affected by ice formation and to achieve an optimal operation of the turbine during icing by use of advanced control strategies. Main benefits are the recovery of AEP losses and the extension of operating range in ice events.

Web site:

Short biography: Esteban Belmonte de Udaondo is currently working at Siemens Gamesa Renewable Energy in Onshore Technology Development department as the Project Manager for the cold climate solutions. Since graduated as a Mechanical Engineer he has been working in wind power industry for more than 15 years in different areas such as R&D and certification and he has been involved in broad range of areas from technical tasks to group and project management. He has supplemented his education with Project Management Professional granted by the Project Management Institute (PMI).

R&D areas/s: 08. Pre-construction site assessment, measurements, models and standards

Validation of, and findings from, the IceLoss 2.0-project

Johannes Lindvall, Kjeller Vindteknikk, SE

Johannes Lindvall (KVT, SE), Leon Lee (KVT, SE), Øyvind Byrkjedal (KVT/Norconsult, NO)

IceLoss 2.0 is a research project partly funded by the Swedish Energy Agency that has been running since 2018 and that will be delivered in spring 2020. The overall goal with the project is to increase the knowledge of production losses due to icing and to develop a next generation IceLoss model, which will be able to provide wind power project developers, investors and banks with better estimates of the production losses due to icing on the turbine blades.

Wind farm owners have contributed with SCADA data to the project and a database with historical icing losses from about 400 WTGs from 24 wind farms (~2000 WTG years) spread over Sweden, Norway and Finland has been created. This database is used to calibrate and validate the IceLoss 2.0 model but also to compare losses from different wind farms and different turbine types when subject to similar icing conditions.

In this presentation the focus will be on the calibration and validation processes of the IceLoss 2.0 model. Parts of the SCADA icing loss database will be dedicated to optimizing the modelled icing loss on turbine level to get as close match as possible to the historical losses. The simulated variables used in the calibration process are wind speed, accumulated ice load on a rotating blade cylinder and the icing intensity. SCADA data independent from the calibration process, are then used for the validation of the IceLoss model. The presentation will discuss the challenges of the calibration process and show the results of the validation study.

The presentation will also display the benefits of the IceLoss 2.0 model for estimating a long-term icing loss for a wind farm in operation by applying the optimization methodology to the historical SCADA data of a single wind farm.

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

Short biography: Johannes holds a PhD in atmosperic sciences from Stockholm University and continued with research on boundary layer clouds at NASA Jet Propulsion Laboratory and Stockholm University before joining Kjeller Vindteknikk in 2013. At Kjeller Vindteknikk, Johannes works with commercial and R&D-projects. At the moment, the majority of his hours are put into the IceLoss 2 research project, which aims to develop Kjeller Vindteknikk next model for predicting production losses due to icing. Johannes is also a United States champion in floorball, which means nothing.

R&D areas/s: 07. Forecasting, cloud physics and aerodynamics

A CFD benchmark study of ice accretion on a wind turbine blade and a comparison to the ice accretion of a rotating blade cylinder model

Johannes Lindvall, Kjeller vindteknikk, SE

Leon Lee (KVT, SE), Ville Lehtomäki (KVT, FI), Johannes Lindvall (KVT, SE), Richard Hann (NTNU, NO), Johan Revstedt (LTH, SE), Muhammad S. Virk (UiT, NO)

This presentation will show results from a Computational Fluid Dynamic (CFD) benchmark study that has been done as part of the research project IceLoss 2.0, partly funded by the Swedish Energy Agency. IceLoss 2.0 is an upgraded version of Kjeller Vindteknikk's (KVT) IceLoss algorithm, which is used to analytically predict long-term and short-term production loss estimates due to ice on wind turbines using modeled weather data.
Five different CFD model setups has been used to simulate ice accretion on the 3.4 MW onshore research turbine developed within IEA Task 37. The simulations were done for three pre-defined meteorological cases and performed in co-operation with the Arctic University of Norway (UiT), Lund University (LTH) and Norwegian University of Science and Technology (NTNU). A total of 30 different simulation runs was performed.
The Makkonen standard cylinder ice accretion model, originally developed for estimating ice loads on power lines, has proved to be useful within the wind industry on estimating icing losses. Although widely used, the model is limited to the fact that it models ice on a cylinder with the mean wind speed fed in as droplet collision velocity. In a study by Davis et al. (2014), the inputs to the Makkonen model was modified to better represent a rotating turbine blade and it was shown to have a better skill score than the standard cylinder model. KVT has developed a Blade Cylinder model based on this as part of the IceLoss 2.0 project and has performed calculations equivalent to the benchmark CFD simulations to make it comparable in this study.
It is seen that all CFD models give approximately the same amount of ice mass, although the ice shapes have some differences, especially for the more extreme meteorological cases. The chosen droplet distribution also has a significant impact on the estimated ice loads. Although the simulated ice loads of the KVT Blade Cylinder model is of the same magnitude as the CFD models, it shows buildup of larger ice loads in general. Due to a reduction in accretion coefficient (alpha3) in the blade cylinder model, the icing intensity remains the same although the collision speed increases for the different blade sections. This is not the case for the CFD calculations where an increase is seen for the outer blade sections also under the extreme icing case.

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

Short biography: Johannes holds a PhD in atmosperic sciences from Stockholm University and continued with research on boundary layer clouds at NASA Jet Propulsion Laboratory and Stockholm University before joining Kjeller Vindteknikk in 2013. At Kjeller Vindteknikk, Johannes works with commercial and R&D-projects. At the moment, the majority of his hours are put into the IceLoss 2 research project, which aims to develop Kjeller Vindteknikk next model for predicting production losses due to icing. Johannes is also a United States champion in floorball, which means nothing.

R&D areas/s: 02. Health, Safety and Environment (HSE) incl. ice throw and noise, 07. Forecasting, cloud physics and aerodynamics

Forecasting of icing for wind energy applications

Øyvind Byrkjedal, Kjeller Vindteknikk, NO

Johannes Lindvall (KVT, SE), Rolv Bredesen (KVT, NO)

Operational short-term icing forecasts have been carried out for 22 wind farms in the Nordic countries for the last 2-3 winter seasons. This presentation will show the results from the validation of the icing forecasts for these wind farms.
Better knowledge combined with the possibility to forecast turbine icing events has the potential to improve on the safety for the personnel working in the cold climate wind farms and can be used for the planning of service and maintenance in the wind farm. In addition it can be used to inform other parties about when it is safe to visit the wind farm area. Short term forecasting of turbine icing can also be beneficial for power forecasting and potentially as a supplementary signal for the operation of blade heating systems.
Kjeller Vindteknikk's operational forecasts consist of the WRF model using GFS forecasts as input source. The forecasts are run for a 48 hour period 4 times daily. The horizontal resolution of the WRF model is 4 km x 4 km. In three of the wind farms in the Fosen project in Trøndelag, Norway, these forecasts are now publicly available through Fosen Vinds home page (fosenvind.no).
To validate the forecasts a study has been carried out where the operational icing forecast was compared to period where icing was found to influence the energy production at 22 wind farms. The observed icing periods was found using the IEA Wind Task 19 method for calculating icing losses from SCADA data. The results show that the for the most exposed wind farms the forecasts correctly predict 70-90 % of the icing situations detected from the SCADA data.
Since there is also some uncertainty in identifying icing by the use of power data from SCADA we also illustrate this uncertainty by choosing one of the turbines in the wind farm as a predictor of icing for the rest of the turbines. The results show that typically 70-90% of the icing episodes in the wind farm are captured using the one turbine as a predictor. This is on the same level as was found for the icing forecasts. However, with a lower false alarm rate compared to the icing forecasts.
For one of the wind farms two different ice detection instruments located at the turbine nacelle was also available and showed that not all icing events found from SCADA was captured by the instruments. The instruments also detected several episodes that was found not to influence the energy production in the wind turbine. The operational icing forecasts was found to better predict icing on the rotor compared to icing on the instruments.

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

Short biography: Øyvind has a background from meteorology with a PhD from the University of Bergen, Norway. He has been a consultant in Kjeller Vindteknikk for the past 13 years and developed the tools used for icing loss assessment at Kjeller Vindteknikk today.
He currently has the position of R&D manager of Kjeller Vindteknikk and has been in charge of several research projects within wind energy and within icing climate.

R&D areas/s: 10. De-/anti-icing including new technologies, ice detection & control incl. standards

Ice protection systems and retrofits: Performance and experiences

Charles Godreau, Nergica, CA

On behalf of IEA Wind Task19

This presentation from IEA Wind TCP Task 19 (T19) will consist of a review of the publically available performance results from various ice protection systems (IPS) and retrofits. The collection of results will highlight the range of performance results, the metrics used and the scope of the studies published and push the discussion on how can IPS performance be compared from one system to the other. The presentation will also include the results of an industry survey conducted by T19 aimed at collecting and sharing experiences and operational knowledge of IPS and retrofits.

Web site: https://nergica.com/

Short biography: As a specialist in assessing wind turbine performance in cold climates as well as icing detection/protection systems, Charles possesses strong skills in data analysis for operational turbines as well as for developing, planning and implementing research projects. He has participated in a number of conferences and represents Canada in the International Energy Agency's Task 19 working group on wind energy in cold climates. In his free time, he enjoys white water canoe, splitboarding and improv theater.

R&D areas/s: 08. Pre-construction site assessment, measurements, models and standards

Improved flow modelling at cold climate sites through novel land-surface data from satellite sources

Morten Lybech Thøgersen, EMD International A/S, DK

Merete Badger (DTU, DK), Henning Skriver (DTU, DK), Rogier Floors (DTU, DK), Ebba Delwik (DTU, DK), Lasse Sveningsen (EMD, DK), Kenneth Grogan (DHI-GRAS, DK), Yavor V. Hristov (VESTAS, DK), Mark Žagar (VESTAS, DK), Anders Sommer (VATTENFALL, DK)

Setup and calibration of a land-surface model are the important first steps by wind-analysts to simulate the flow over a wind farm site. Accurate land-surface data play a key role and includes land-cover characteristics such as terrain roughness, elevation as well as tree heights and leaf-area density. These are the main inputs to modern flow models to derive accurate predictions of the energy-yields over the whole modelling domain for the potential wind farm area. Cold climate sites are often located in forested areas with semi-complex or complex orography and establishing the land-surface models at the required accuracy may prove a challenge, as maps and aerial imagery are not up-to-date or the full site may be inaccessible during site-inspections. An additional complication for cold-climate sites is the significant variation of land-cover characteristics over the seasons. A consequence is inaccurate and incomplete land-surface models which result in errors propagating down the full flow model chain resulting in non-optimum/erroneous results.
A solution to this issue result from the recently deployed Sentinel satellites and their raw data which are distributed via the Copernicus joint European Union infrastructure project. Here hundreds of petabytes of raw data with Earth observations are available at a resolution down-to 10-meters - with most locations on the globe being revisited once every few days. These data – and other national and international data services enable the development of unique sets of novel land-surface products describing the land-surface conditions in high temporal and spatial resolution with unprecedented accuracy and are fully up-to date.
A major achievement has been to develop a model that can derive leaf area-index, tree-type and tree height from the available Sentinel satellite data sources – along with the possibility to calibrate with LiDAR data to achieve best
possible accuracy. This product has been evaluated at 10 sites around the globe. Preliminary investigations promise improved predictions and reduced uncertainty. This is achieved both via a physical parameterization within the flow modelling and with the new data sources. When combined with a time-varying flow modelling approach it is possible include also the seasonal land-surface variation to model the seasonal variations at cold-climate sites with unprecedented accuracy in time and space.
The work presented is supported through the InnoWind project – an R&D project with partners from the industry and academia: Vattenfall, Vestas, DHI-Gras, EMD International and the Technical University of Denmark. Innovation Fund Denmark has co-funded the project.

Web site: http://www.innowind.dk

Short biography: Morten Lybech Thøgersen is the head of the Wind R&D Department at EMD International A/S – and is currently leading a team of 5 R&D specialists - along with being the project manager for a number of external and internal R&D projects. He has specialist knowledge within topics like MCP, wakes, turbulence, IEC classification and probabilistic methods. Morten oversees the high-performance computing efforts at EMD and its links to the windPRO software. Morten came to EMD in early 2001 and he has been working with software development, consultancy services and R&D. Prior to that, Morten was employed as a scientist at Risø National Laboratory (now DTU Wind Energy). His interests are within probabilistic methods and wind modelling as well as project management using Agile methods. At home, he enjoys the time with his family - and to sail, scuba-dive and snowboard.

R&D areas/s: 01. O&M experiences incl. performance optimization, production losses

Highlights from CanWEA's operations and maintenance summit 2020

Charles Godreau, Nergica, CA

In collaboration with the Canadian Wind Energy Association (CanWEA)

CanWEA's Operations & Maintenance (O&M) Summit is the largest annual wind operations event in Canada. With an expected attendance of over 300 wind energy professionals from across Canada and the United States, the CanWEA O&M Summit serves as a critical meeting ground where key stakeholders come together to learn from one another and discuss the latest opportunities and challenges facing this rapidly growing sector. As wind fleets expand and age, the sector's knowledge base advances and strengthens resulting in an array of new options and support services for operators to strategize and improve their business.

The Canadian wind industry is intensely focused on leading edge innovation at sites across the country. For this reason, the 2020 O&M Summit theme will be "Solutions Focused". The program will center on topics that have clear linkages to improved wind energy operations within the diversity of Canadian wind sites. Facing challenges head on, speakers will target solutions that work and serve a direct purpose. With health and safety running as an integrated element to all content, sessions will be as local and technically sound as possible.

The technical topics covered during the conference will be: Advanced control strategies, multi-technology, advanced inspections, approaching end of financed life and forces of nature.

With the cold climate focus in mind, Charles Godreau, will present the highlights from the conference held the week just before Winterwind. Fresh O&M innovations from across the pond!

Web site: https://canwea.ca/events/canwea-operations-and-maintenance-summit-2020/

Short biography: As a specialist in assessing wind turbine performance in cold climates as well as icing detection/protection systems, Charles possesses strong skills in data analysis for operational turbines as well as for developing, planning and implementing research projects. He has participated in a number of conferences and represents Canada in the International Energy Agency's Task 19 working group on wind energy in cold climate. Charles has been contributing to CanWEA's activities as a member of the O&M Caucus' Cold Climate Health & Safety committee and as an active member of the O&M Summit program committee. In his free time, he enjoys white water canoe, splitboarding and improv theater.

R&D areas/s: 01. O&M experiences incl. performance optimization, production losses, 10. De-/anti-icing including new technologies, ice detection & control incl. standards

Towards tracing a rotor surface's 3D trajectory over time

Michael Moser, eologix sensor technology gmbh

Theresa Loss (Graz University of Technology, AT), Michael Moser (eologix, AT), Thomas Schlegl (eologix, AT)

While in cold climates icing has still one of the biggest negative impacts on the energy yield of wind turbines, wind fields over complex terrains and forests - typical locations for wind power in cold climates such as Alpine regions or northern Scandinavia - also contribute to significant uncertainties and losses, not only during winter time.
Research is being carried out to extend our blade-based icing and temperature measurement technology with 6 degrees-of-freedom acceleration sensing units. Using measurement data obtained from integrated micro-electro-mechanical systems (MEMS) and given the exact location of the sensing units on the blade's surface, the 3D trajectory of each sensing unit in space can be derived. By means of a mesh of sensing units, this allows for tracking the surface in 3D over time without the necessity to collect data from the turbine's SCADA system.
In combination with the mechanical model of the blades, this information can be useful for detecting and assessing various scenarios which have in common the effect of a decreased production as well as an impact on the turbine components' lifetimes. At the end of the day, 3D motion tracking also allows for estimating loads and mechanical strain over each blade.
Applications include but are not limited to detection and measurement of both pitch and yaw angle misalignment (including shear winds), excessive blade vibration and blade integrity issues.
In the full paper, we will present pitch angle estimations which have been recorded under load (i.e., during production) obtained from enhanced sensors retrofitted to the blade surface.

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

Short biography: Michael Moser studied Electrical Engineering and Sound Engineering at University of Music and Performing Arts Graz and Graz University of Technology. Between 2007 and 2013, he was a research assistant at the latter, where in 2013 he completed his PhD thesis focusing on energy harvesting and icing detection on electrical power transmission lines. Since 2014, he is managing director of eologix sensor technology. When he finds time, he still likes to play the piano.

R&D areas/s: 10. De-/anti-icing including new technologies, ice detection & control incl. standards

Icing intensity and ice removal algorithms for automatic turbine restart

Jarkko Latonen, Labkotec Oy, FI

Tatu Muukkonen (Labkotec, FI)

This presentation will describe solutions to estimate icing intensity and ice removal time based on ice detector measurement data. Intelligent algorithms have been developed by analyzing several years of icing and weather measurements from wind turbines and the Icing Wind Tunnel at VTT.
Icing intensity detection can be used to categorize icing events and to estimate the actual amount of ice on wind turbine blades during icing conditions. This feature allows for improved control of blade heating systems as well as operation of iced wind turbines.
Ice removal algorithm of Labkotec Ice Detector will estimate the time needed for ice ablation from wind turbine blades, taking the prevailing weather conditions into account. This will enable efficient windfarm operations regarding de-icing and safety actions related to ice-throw. An automatic restart of a wind turbine after an icing event, thus reducing the need for site visits and blade inspection.

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

Short biography: Jarkko Latonen studied at the Tampere University of Technology and holds a master's degree in electrical engineering. He has worked 17 years for Labkotec, being actively involved in wind industry and ice detection for about 15 years. Currently he's responsible for R&D and product management as the CTO of Labkotec.
Jarkko used to coach ice hockey for junior teams of hockey club Tappara. Nowadays he's more into jogging and cross-country skiing.

R&D areas/s: 02. Health, Safety and Environment (HSE) incl. ice throw and noise

On the communication of the ice throw hazard to the public

Rolv Erlend Bredesen, Kjeller Vindteknikk, NO

Øyvind Byrkjedal (KVT, NO)

With regards to the ice throw hazard surrounding wind farms in cold climate there has been a standardization on how to describe and evaluate the risk [0]. The current community knowledge regarding the risk has been described [1] and the Norwegian guideline [1][2] gave easily understood advice on typical measures.
However there are still inherent uncertainties in the analyses [3] and there is a challenge in finding the suitable measures for site specific decisions made under uncertainty. This is can be a challenge when communicating the risk further.
The talk touches on the topics of what to do after a risk assessment is carried out, what does the risk assessment not tell you, and what are the limitations of risk assessments. (IPS systems etc.).
Examples on how to establish and maintain the dialogue with relevant stakeholders for a wind farm (e.g. service personell, forrest workers, reindeer herders, local community and those opposed to local wind farms) is given together with presentation of relevant information campaigns [4][5] and alert systems for the task of informing the public [6].

[0] International Recommendations for Ice Fall and Ice Throw Risk Assessments (2018. IEA Wind RD&D Task 19.https://community.ieawind.org/task19/viewdocument/international-recommendations-for-i?CommunityKey=b1ba65c9-bf79-4b55-98cd-cf324c26f76f&tab=librarydocuments
[1] Bredesen et al. (2017). Understanding and Acknowledging the icethrow hazard. Journal of Physics. https://iopscience.iop.org/article/10.1088/1742-6596/926/1/012001/pdf
[2] National Norwegian Guidelines: Ice-throw hazard (2018)
https://windren.se/WW2018/03_2_24_Bredesen_Norwegian_guidelines_regarding_the_risk_of_icethrow_for_the_public_Pub_v2_draft.pdf.
Norwegian guideline:
https://www.nve.no/nytt-fra-nve/nyheter-konsesjon/nyveileder-for-handtering-av-faren-for-iskast-fra-vindturbiner/
Norwegian Framework for wind power, report on icethrow: https://www.nve.no/Media/6951/iskast.pdf
[3] An ongoing cross comparison of the Icethrower database with 10 years of SCADA and meteorological forecast data.
https://windren.se/WW2019/05_01_Bredesen_A_cross-comparison_of_the_IceThrower_database_with_10_years_of_SCADA_and_meteorological_forecast_data_-_What_can_we_learn_pub_v2.pdf
[4] Application of Risk Management and Barrier Management for Structures in Cold Climate. IWAIS 2019, Iceland. https://iwais2019.is/papers
https://iwais2019.is/images/Papers/063_IWAIS_Paper_LR_KVT_rev2.pdf
[5] https://austri.no/sikkerhetsavstand-til-vindturbiner/
[6] https://www.fosenvind.no/vindparkene/iskastvarsel/

Web site: http://vindteknikk.com

Short biography: Rolv Bredesen is Kjeller Vindteknikk's expert on IceRisk assessments and the current Norwegian representative in IEA Wind Task 19 - expert group on wind energy in cold climates. His considered safe hobbies are speed-riding, hang-gliding, motorcycling as well as rock climbing.

Abstract #: 45

R&D areas/s: 07. Forecasting, cloud physics and aerodynamics

Parametric analysis of wind turbine icing in cold regions

Ifrah Mussa, Kingston University, United Kingdom

Ifrah Mussa (Kingston University, UK), Prof. Jian Wang (Kingston University, UK), Dr. Yujing Lin (Kingston University, UK)

Ice accretion on wind turbine is one of the core challenges for renewable wind energy development in cold climates. Therefore, in order to continue exploiting these cold regions for clean energy growth, it is important to understand the icing process on wind turbine blades. Research conducted on aircraft icing can be very beneficial in this respect. However, even though a substantial amount of knowledge and understanding can be employed from aircraft icing investigations, it cannot completely represent icing on wind turbine blades. There are a range of parameters which can influence wind turbine ice shape and size. Some of these parameters are site dependent climatic variables including ambient temperature, wind speed and icing time; while others are meteorological variables such as Liquid Water Content (LWC), Median Volumetric Diameter (MVD) and humidity. Since all of these parameters collectively play a significant role in the icing process, it is vital to investigate their individual effect on wind turbine blade icing by conducting a parametric analysis which can help better understand the underlying physics of the ice formation process for different types and densities of ice, the amount of heat required to de-ice the blades and the to design an effective operational strategy to get the maximum power output.

This study uses numerical techniques to investigate the effects of different parameters on wind turbine blade icing by monitoring some of the main characteristics of ice including: ice shape, mass, thickness and location. The method employed to conduct this study is as follows. First, NREL Phase VI wind turbine blade was selected for the analysis which is composed of S809 aerofoil from root to tip. The icing parameters investigated were: angle of attack, wind speed, temperature, LWC, MVD and icing time. The icing conditions selected for this study were based on a wind farm site in Smóla. Prior to starting the flow and icing simulations, an optimized code for Blade Element Momentum Theory (BEMT) was established on Matlab with tip and root loss corrections. This was important to determine the relative velocity and local angle of attack for a range of cross sections along the blade length. Following this, five cross sectional locations were selected for the parametric analysis which best represented the wind turbine blade. The parametric analysis was then conducted starting with ANSYS Fluent flow simulations followed by ANSYS FENSAP-ICE simulations for ice prediction using single shot technique.

Results proved that BEMT plays a significant role in conducting a quasi-3D numerical analysis on wind turbine blade icing and reducing the computational time. Ice profiles obtained from parametric study revealed that the ice shape, mass, thickness and location is highly influenced by the icing variables tested. The effects of each variable must be taken into consideration while designing an anti-/de-icing system for wind turbine blades. A linear growth in ice accumulation was observed from the blade root to blade tip which further highlighted the critical area of the blade that has the most degrading effect.

The current paper presents early phase of parametric study with single shot. Future work includes a comprehensive study with additional variables that were beyond the scope of current research. It would further include multi-shot simulation results, which is a time iterative icing process on FENSAP to predict icing. A three dimensional wind turbine blade icing simulations would also be presented.

Web site:

Short biography: Ifrah is a third year PhD student at Kingston University. She completed her undergraduate degree in Aerospace Engineering (MEng) from Kingston University in 2017. She recently completed a six months PhD placement in China where she observed icing experiments. Personal interest: travelling

R&D areas/s: 11. Onshore turbines, aerodynamics, loads and control

Effect of heavy rotor blade icing to lifetime consumption of tower and foundation

Carsten Ebert, Woelfel Wind Systems

Manuel Eckstein (Wölfel Engineering GmbH + Co. KG, Germany)

Wind turbine towers are exposed to various loads such as high wind, additional loads due to imbalances due to heavy blade icing or pitch angle errors and incorrect operational modes. These loads affect the operating costs as well as the lifetime of the components. Nevertheless, the majority of all existing wind turbines have normally large – but unknown – reserves with respect to their lifetime.
With an efficient and intelligent monitoring concept, these loads can easily be recorded and analyzed with respect to operational mode, lifetime and predictive maintenance. An accelerometer at tower top supplemented by an inclination sensor in the tower base combined with a numerical model is used to measure the vibrations and to derive the loads in any segment of the tower.
In this presentation, we would like to focus on the effects of rotor blade icing and show how different mass distributions and aerodynamic effects increase the stresses of the tower. It can be shown that the fatigue loads differ from ice-free operating modes. The effects to lifetime consumption are illustrated.
Operators can use these efficient load measurements to record the real actions and to objectively evaluate and assess the structural condition of their asset. It is possible at any time to compare the real loads with the loads from the design and from the certification as well as to forecast the remaining service life.
In a validation survey, the presented concept has been investigated with respect to validity and precision. With additionally installed strain gauges, the mathematically derived loads are compared and evaluated with respect to the loads measured by the strain gauges directly. It is shown that the concept is very suitable for lifetime prediction and various load analyses (e.g. influence of retrofitted components).
In this context, the following will be presented: sensor and monitoring concept; insight in mathematical method; calculation of ice loads and influence to tower vibrations; lifetime consumption depending on degree of icing and lifetime prediction

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

Short biography: Carsten Ebert is civil engineer (Dr.-Ing.) and 43 years old. He has been working for Wölfel Wind Systems since 2008 and is CTO of the company. He has an extensive knowledge in structural dynamics, especially in the field of structural health monitoring based on vibration measurements. At Wölfel, he is responsible for the development of products for the structural monitoring of rotor blades, towers and foundations. Since 2013, he is a member on advisory board of VDI-Guideline 4551, a German guideline for the condition monitoring of offshore wind foundation structures.

R&D areas/s: 10. De-/anti-icing including new technologies, ice detection & control incl. standards

Blade based ice detection IDD.Blade – efficient operation in cold climate

Timo Klaas, Wölfel Wind Systems GmbH

Timo Klaas (Wölfel), Carsten Ebert (Wölfel)

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.
Especially the danger of ice throw from rotor Blades has to be avoided for personal safety reasons. Furthermore, the ice on rotor blades can cause severe damage to the wind turbine itself. Not only to the rotor blades, but also other parts of the structure, e.g. gear box and the tower are more affected by higher loads and imbalances.
For this reason 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 latest innovations and developments around SHM systems:
In this context the following will be presented:

- The importance of ice and damage detection on rotor blades
- New hardware concept: Have a look into the future
- Additional blade monitoring features such as damage detection, rotor blade imbalance and pitch angle monitoring
- Increase of energy output: summer vs winter operation
- Smart data: How to use advanced data analytics to gain new findings

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

Short biography: Timo Klaas is educated as an industrial engineer (B. Eng), 32 years old and lives in Hamburg. He is working for Wölfel Engineering and is leading the sales department for all systems related to wind energy.

R&D areas/s: 10. De-/anti-icing including new technologies, ice detection & control incl. standards

Experimental investigation of an infrared de-icing system for wind power application in cold climate

Sofia Sollén, Luleå University of Technology

Sofia Sollén (Luleå University of Technology), Jennifer Pettersson (Vattenfall AB).
Lavan Kumar Eppanapelli (Luleå University of Technology), Johan Casselgren (Luleå University of Technology), Jan Ukonsaari (Vattenfall AB), Pär Attermo (Vattenfall AB).

Icing of wind turbine blades poses a great challenge for wind farms in cold climate and this challenge is addressed using various traditional de-icing practices, which require significant cost to operate. Thus alternative and potential solutions are needed to improve wind power production in cold climate. The present study is focused on an experimental method to investigate the effectiveness of a new de-icing system that consists of infrared heaters. Two types of heaters were selected based on wavelength, input power and investment cost. Due to experimental limitations, test blades covered with soft rime ice were prepared using snow machines in a controlled indoor testing facility. Individual heaters and combinations of the heaters were tested with respect to distance from a section of a real wind turbine blade and ambient temperature.
This presentation is focused to the experimental methods used during the experiments simulating ice accumulation at wind turbine blades together with results showing the possibilities to implement an infrared de-icing system. The project was initially proposed by Vattenfall AB and were performed in a collaboration with Luleå University of Technology in the spring of 2019.

Web site:

Short biography: Sofia Sollén and Jennifer Pettersson graduated as sustainable energy engineers at Luleå University of Technology in 2019. Their specialization is wind and hydro power and together they performed their master thesis including an experimental investigation of a new de-icing system for wind turbine applications. Today Jennifer is working as a research engineer at Vattenfall R&D focusing on wind turbines in cold climate and Sofia has just started as a PhD student in experimental mechanics at Luleå University of Technology. Both Jennifer and Sofia enjoys the nature and spends a lot of time outside hiking or skiing.

R&D areas/s: 10. De-/anti-icing including new technologies, ice detection & control incl. standards

Task 19: Performance warranty guidelines for wind turbines in icing climates workshop at Winterwind 2020

Helena Wickman, Vattenfall

Charles Godreau (Nergica), Timo Karlsson (VTT) and Stefan Söderberg (DNVGL)

There are a number of different Ice Protection Systems and other turbine operational strategies available on the market today for mitigating icing effects on wind turbines. Wind farm development in cold climates is becoming more mature, but there is still work to be done. Further developed performance warranties plays an important role in ensuring that icing risks can be quantified and handled.
The IEA Wind Task 19 will therefore host a workshop on performance warranty guidelines for wind turbines in icing climates. The workshop will be held at the Winterwind conference in Åre, Sweden on February 3rd, 2020 from 14:00 to 17:30.
The main objectives of the workshop are:
- To establish a common language for wind turbines in Icing Climate;
- To establish an outline for Performance Warranties;
- To discuss test methods for Performance Warranties in Icing Climate and move towards fewer and standardized warranty options and test methods;
- To discuss the benefit of having a warranty in pre-construction energy and risk assessments;
- To share experiences on both icing and ice mitigations;
- To align Cold Climate industry expectations on the above.
The results from the workshop will be used in the update of the Task 19 "Performance Warranty Guidelines for Wind Turbines in Icing Climates" report to be published in Q4:2020. The workshop will be chaired by Helena Wickman (Vattenfall), Charles Godreau (Nergica), Timo Karlsson (VTT) and Stefan Söderberg (DNVGL) representing IEA Task 19 subtask on "Performance warranty guidelines for wind turbines in icing climates ".
This will be an invitation only or by request workshop, targeting cold climate experts working across Northern Europe and North America.
Please complete the following questions via the link below
https://forms.gle/4iXGREGjcngDVzAf7
by 17th of January 2020 if you are interested in attending the workshop, so that Task 19 can get in touch with you. Due to limited seats in the workshop, Task19 will select attendees based on their potential contribution to the workshop and remaining seats.

Web site: https://community.ieawind.org/task19/home

Short biography: Helena Wickman (Vattenfall), Charles Godreau (Nergica), Timo Karlsson (VTT) and Stefan Söderberg (DNVGL) representing IEA Task 19 subtask on "Performance warranty guidelines for wind turbines in icing climates "

R&D areas/s: Open Innovation

Open Innovation Contest

Tanja Tränkle, RISE

Tanja Tränkle

Winterwind's arena for new ideas within research and product development! You pitch your very own idea and will get instant feedback from the community as well as the possibility to network with the market players you need to get on board. We'll make sure you'll meet a fair-minded jury and have the chance of being rewarded with more than just honour.

Web site: https://www.ri.se/sv/richard-sott

Short biography: Researcher at RISE

Abstract #: 51

R&D areas/s: Keynote

A European Outlook on the prospect of Onshore Wind - Global importance with regional benefits

Sandra Grauers, Vattenfall

Sandra Grauers

Onshore wind is one of the main pillars of the decarbonisation of society. Electricfication is the key tool for the transformation of the Industry and Transport sectors, which will drive a highly increasing demand for renewable electricity moving forwards. Sweden is currently the Onshore market in Europe with the largest volume of projects in construction. What is making Nordic countries attractive now and in the future?
Vattenfall is a key Onshore player in Northern Europe, with 1 GW in construction and a development pipeline of around 5 GW. Stakeholder management and local acceptance is evermore important. In the presentation I will share some reflections and best practice examples around the regional benefits and potential of windfarm projects.

Web site: http://vattenfall.com/

Short biography: Sandra Grauers

R&D areas/s: 15. National strategies, research programs, grid access, system services and new developments

Slowly, slowly, we'll reach our goal!

Sébastien Trudel, EDF Renewables, Canada

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For many years, the industry has been working towards improving the operation of wind turbines in cold climate and icing environments. Along the way, obstacles, challenges and unexpected outcomes have paved the way to the development of new technologies such as de-icing systems, and of new products such as anti-icing coatings or better ice detectors. In many ways, our common path on this adventure is similar to leaving for a Himalayan expedition to climb one of the highest peaks on the planet.
The magnitude of the endeavor looking from the starting point can be overwhelming, and the overarching goal can only be reached by setting smaller, intermediate objectives. The path to the end might be clear for some of us, but it will likely be foggy, hesitant and uncertain for the rest of us. But, we have to keep moving forward, one step at the time, knowing that challenges and obstacles will appear on the way, and that with confidence we will overcome them.
In this presentation, we will see how climbing mount Manaslu in Nepal, the 8th highest summit on the planet, can be a reflection on how we can approach challenges in our personal and professional life.

Web site:

Short biography: Sébastien Trudel graduated as a civil engineer in 1998. After a few years in the industrial waste management business, he went back to school to complete a Master's degree in Environmental sciences. His thesis assessed renewable energy potential worldwide. For now more than 15 years, he has been involved in the development of onshore wind projects in North America, working as a resource assessment analyst, and then manager. With EDF Renewables since 2009, he has been specifically involved in the assessment of pre-construction icing losses, and the assessment and testing of various anti-icing and de-icing technologies on turbines operating in eastern Canada. As of last year, he was promoted to manager of offshore wind and metocean analysis, involved in the offshore measurement campaigns and layout optimisation work.
In his personal life, Sébastien is an avid hiker, trekker and mountaineer, going out to the mountains whenever possible. He has climbed mountains everywhere from Alaska to Argentina, Europe, India and Nepal. His latest significant achievement was reaching the summit of Manaslu at 8163m last September.

R&D areas/s: 01. O&M experiences incl. performance optimization, production losses, 03. Inspection and repair

Case study; Controlled environment in up-tower blade repairs

Ville Karkkolainen, Bladefence, FI

Ville Karkkolainen (Bladefence, FI)

Rotor blade repairs have traditionally been very difficult, sometimes even impossible, in cold climate areas, especially during winter time. Often repairs require a summer like conditions, as conventional blade repair systems generally require an ambient temperature of more than +15 Celsius and a maximum RH of 60% to work properly. In the case of more significant issues, a de-mounting of the blade might be needed for on-ground repairs under controlled weather environment.
We present a novel approach, developed in co-operation with a major OEM during the 2018 repair season, where a rapid and safe skylift access is combined with a controlled environment for blade repairs. This controlled environment, or a habitat, will enable the usage of conventional blade repairs materials in conditions which typically have completely prevented blade repairs. Although habitats have been used in the industry before, this is the first of its kind where the flexibility and speed of skylift access is combined with a controlled blade repair environment.
Experiences and data gathered during actual on-site repair operations shows that the usage of a controlled environment significantly reduces weather related downtime, lowers costs, increases repair quality and expands the works scope that can be completed during a repair season. Controlled environment also enables permanent repairs to be carried out during cold climate season, reducing the number of temporary repairs which should then be repaired again during the summer season.

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

Short biography: Ville Karkkolainen is the CEO of Bladefence North America. Prior to this position, for six years, he was the co-founder and managing director of Bladefence Ltd., based in Helsinki Finland. During this period the company grew to become one of the leading independent blade service providers in Europe. Ville has been an active speaker in dozens of industry events and a promoter of advanced blade repair procedures and pre-emptive blade maintenance programs. Outside of wind energy he is an enthusiastic Harley-Davidson rider.

Abstract #: 54

R&D areas/s: 13. Offshore and near offshore – access, foundations incl. artificial islands

Offshore wind farm at icy conditions – Tahkoluoto

Jaakko Kleemola, Suomen Hyötytuuli Oy, FI

Jaako Kleemola

The presentation is describing the Tahkoluoto offshore wind farm technology and conditions at Pori, Finland. Cold climate and frozen sea makes offshore wind energy production challenging. Winter time construction, service and operation has severe disadvantages. Location offers also benefits like Kokemäki river, ports, grid connections, positive local attitude sea bottom properties and wind conditions. The foundation design is presented. The monopile was not possible to use at Tahkoluoto because of the hard sea bottom. The icing loads was necessary to take account in load calculations. The main information from construction phase and the project management is described. The site has been operating now two and half year. Information how the service is carried out and possible risks are shared.

Web site:

Short biography: Jaakko Kleemola, Doctor of Science (Tech.), is Director of Technology at Suomen Hyötytuuli Oy. Since 2009 he has been working at wind energy sector in many different roles starting from Group Manager of wind turbine gearbox manufacturer to his current role as Technology Director at wind turbine owner. Prior to this, working at university and industrial side has given him a very strong and broad technical background starting from individual EHL contacts to largest power train systems. His current responsibilities include to improve production capabilities and tools for example by offering better productions energy forecasts or developing predictive maintenance algorithm for monitoring. His doctoral theses is from Tampere University of Technology (2010).

R&D areas/s: 09. Environmental Impact Assessments (EIA)

Riskminimera med egen strategi för biologisk mångfald

Åsa Abel, Ecogain, Sverige

Åsa Abel, Ecogain, SWE

FN:s vetenskapliga panel IPBES har gjort det tydligt att förlusterna av biologisk mångfald är lika allvarliga för mänskligheten som klimatförändringarna. En följd är att lagstiftarens och myndigheternas kravställning kring arter och ekosystem kommer fortsätta att ökar, och att de gröna riskerna för företagen förändras.
”De som inte börjat jobba med biologisk mångfald har stora utmaningar”. Det var en av slutsatserna vid OECD:s branschkonferens om gruv- och miljöfrågor i Skellefteå i juni. Steget mellan mineraler och energi är inte långt.
På det här seminariet får du insikter och goda exempel från andra företag på hur du kan ligga i framkant för att möta framtida risker och möjligheter som rör FN:s globala mål 14 och 15. Seminariet kommer visa hur ditt företag kan sätta en strategi som adresserar en avgörande samhällsfråga, stödjer ditt företags kommunikation och framtidssäkrar dina affärer.”

Web site: https://www.ecogain.se/

Short biography: Åsa är affärsområdeschef för Ecogain. Med utgångspunkt i FN:s globala mål för hållbar utveckling tar hon ett samlat grepp om företagens behov och utmaningar kopplade till ansvarsfull markanvändning och biologisk mångfald.
Åsa har lång erfarenhet av strategiskt och lösningsfokuserat arbete på ledningsnivå, inom både privata företag och politiskt styrda organisationer. Ecogains kunder uppskattar hennes förmåga att styra mot satta mål, identifiera risker och ta fram åtgärder på ett sätt som leder mot hållbar utveckling och som stärker deras varumärke.
I grunden är Åsa ekolog från Linköpings universitet, vilket hon kombinerat med utbildning i företagsekonomi och vindkraftprojektering.
Åsa har läst en masterutbildning i vindkraftprojektering, vid vindkraftteknikutbildningen på Gotland. Hennes examensarbete handlade om hur turbulens, (vakar), ökar underhållsbehovet ojämnt fördelat i vindparken. Turbulens och biologisk mångfald i alla dess former fascinerar henne.

Abstract #: 56

R&D areas/s: 08. Pre-construction site assessment, measurements, models and standards

Blockage - a review

Jan-Åke Dahlberg, Jan-Åke Dahlberg

Jan-Åke Dahlberg, SE

Blockage is ...

Web site:

Short biography: Mr. Jan-Åke Dahlberg has been ...

Abstract #: 57

R&D areas/s: 08. Pre-construction site assessment, measurements, models and standards

Swedish Windpower Association and RISE - Workshop on blockage

Martin de Maré, RISE Research Institutes of Sweden

Martin de Maré and Tanja Tränkle (RISE, SE)

Blockage is ...

Web site: http://rise.se/

Short biography: Mr. Maré has been ...