April 19th-21st 2022

Winterwind

INTERNATIONAL WIND ENERGY CONFERENCE

Book of Abstracts in session order

Scan the QR-code to watch a video presentation about the Swedish Wind-power Association on YouTube.

Winterwind is an international must-go for everyone working with issues related to wind energy in cold climates. Every year, the world's wind energy professionals meet at Winterwind in Sweden to discuss the challenges and solutions of generating wind power in cold climates.

Organizer

SWEDISH WINDPOWER ASSOCIATION

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Start time	Tuesday April 19	Wednesday April 20		Thursday April 21	
08:00		Exhibition and registration		Exhibition and registration	
08:30				**Keynotes (8) 08:30-09:30** Moderators: Anne Lund Christophersen & Lars Jacobsson Enhancing icing datasets: Lessons learned from the U.S. ice storm, Luke Cunningham, Clir Renewables, CA (5) Business Intelligence Analyst, Simon Grenholm, W3 Energy, SE (24) Using drones for an ice piece collection campaign, Anne Mette Nodeland, Kjeller Vindteknikk part of Norconsult, NO (6)	
09:00		**Ice detection (1)** Chairs: Helena Wänlund & Mark Zagar Accelerated Integration of Joint Ice Load and Damage Detection, Timo Klaas, Wölfel Wind Systems, DE (14) Autonomous calibration and optimization of blade based ice detection systems, Daniel Brenner, Weidmüller Monitoring Systems GmbH, DE (27) Load Monitoring: The way to operate WTG under Ice Conditions?, Nils Lesmann, Deutschland (28)	**Production losses (2)** Chairs: Jenny Longworth & Sven-Erik Thor Validation of icing loss forecasts with SCADA data, Mona Kurppa, Kjeller Vindteknikk part of Norconsult, FI (4) Improvement of ILM calculation by pre-processing of the acquired data, Wakana Igarashi, Kanagawa Institute of Technology, JP (13) A smart algorithm for wind turbine controlling under icing conditions, Franziska Gerber, Meteotest AG (36)		
09:30	Buss pick up at the airport			Break 09:30-10:00	
10:00	Busses depart from The Wood Hotel - Travel to Markbygden	Break		**Validation and offshore (9)** Daniela Roeper & André Bégin-Drolet Addressing the challenges of accurately characterising the impact of cold climate atmospheric conditions for ever larger offshore turbines through a review of operational data, Marie-Anne Cowan, Wood Thilsted, UK (30) Storage of electricity in molecules, Finn Daugaard Madsen, Siemens Gamesa (37) Validation study of modelled icing using met mast data and SCADA data, Marie Cecilie Pedersen, EMD International A/S, DK (15)	**Ice throw (10)** Chairs: Liselotte Aldén & Anne-Mette Nodeland Comparison and validation of ice throw models, Markus Drapalik, University of Natural Resources and Life Sciences, Vienna (BOKU), AT (9) Perceptions of impact-based warning information for ice-throw risk: A Norwegian survey, Rolv Erlend Bredesen, Kjeller Vindteknikk part of Norconsult, NO (for Norwegian Meteorological Institute, NO) (7) Edition 2 of the IEA Wind TCP Task 19 International Recommendations for Ice Fall and Ice Throw Risk Assessment – What's new?, Claas Rittinghaus, Energiewerkstatt Verein, AT (21)
10:30 10:45		**Opening session (3) 10:30-12:00** Moderators: Jeanette Lindeblad & Göran Ronsten Winterwind 2022 - Swedish Windpower Association, Jeanette Lindeblad, Swedish Windpower Association, SE (40) Renewable energy as a growth factor, Stefan Forsgren, Skellefteå Kraft AB, SE (42)			
11:00	Welcome to Markbygden	Wind and Electricity Storage from an European perspective, Johan Söderbom, InnoEnergy, SE (41) Northvolt - Enabling the Future of Energy, Wilhelm Löwenhielm, Northvolt, SE (39)		**Break 11:00-11:30 Poster session 3** Moderator: Linnéa Karlsson Long-term high-efficient Graphene-based anti-/de-icing coating, Jun Chen, Lulea University of Technology, SE (44) ArcticDEM – Next generation elevation model for wind farms in cold climate?, Morten Lybech Thøgersen, EMD International A/S, DK (17) Preliminary Investigation into Shear-Web Behaviors under Thermal Loads from IPS, Dylan Baxter, Borealis Wind Inc., CA (47)	
11:30				**Ice protection systems and repair (11)** Chairs: Marie-Anne Cowan & Konrad Sachse Preventing wind turbines from catching colds, Patrice Roberge, CA (2) Blade repair in artic climate, Greger Nilsson, Blade Solutions, SE (43) Linnovation concept for wind turbines in cold climate – experiences from field operation fall 2021- winter 2022, Lars Tarberg, Linnovation AB, Sweden (19)	**Validation (12)** Chairs: Franziska Gerber & Finn Daugaard Madsen Validation of modelled instrumental icing with mast measurements, Ville Lehtomäki, Kjeller Vindteknikk part of Norconsult, FI (3) Bridging the Gap – Validation of Pre-construction Wind Farm Modelling Against Operational Data, Enrico Sindici, Natural Power, UK (10) A note on ice detection of wind turbine blades by a rotating-cylinder-type ice sensor, Reina Muto, Kanagawa Institute of Technology, JP (12)
12:00		**Lunch 12:00 - 13:30**			
12:30				**Lunch 12:30-13:30**	
13:00	Lunch	**Poster session 1, 13:00-13:25** Moderator: Nils Lesmann A novel model for glaze ice accretion, Robert Szasz, Lund University, SE (26) Cold climate validation testing using a large climate chamber, cold-start-up test bench and large size ice spray array, Bram Cloet, Sirris, BE (18)		**Poster session 4, 13:00-13:25** Moderator: Andreas Wickman An open source ice model running in WRF, Jana Fischereit, DTU Wind and Energy Systems, DK (48) Lifetime extension of main bearings, scientific calculation and practical implementation, Stefan Bill, Rewitec GmbH, DE (35)	
13:30 13:50 14:10	Departure for Skellefteå	**Ice detection (4)** Chairs: Sigrid Carstairs & Timo Klaas Enhancing power production without safety concessions in cold climates – early ice prediction by sensor fusion of surface and high-precision wind data, Michael Moser, eologix sensor technology, AT (22) A thermal based ice detection sensor - from academic research to a commercial product, André Bégin-Drolet, Université Laval and Instrumentation Icetek, CA (20) Marinvent Airfoil Performance Monitor integration to a wind turbine, Dominic Bolduc, Nergica, CA (29)	**Production losses (5)** Chairs: Mona Kurppa & Per Olofsson Validation of Ice-Affected Plant Energy Assessment at a Large OEM, Anne Lund Christophersen, Vestas, DK (16) Nordex advanced Anti-Icing System for N163 wind turbines, Konrad Sachse, Nordex Energy SE & Co. KG (1) Aerodynamics of iced blades: a 2D investigation, Hamid Sarlak, DTU, DK (32)	**Closing session (13) 13:30-15:00** Moderators: Cecilia Dalman Eek & Lars Ydreskog Challenges with Powering the Electrification of the Industry, Daniel Gustafsson, Vattenfall, SE (38) The IEA Wind TCP Task 19: 19 years of cold climate wind research, Timo Karlsson, VTT Technical Research Centre of Finland Ltd, FI (23) Ice Detection Guidelines for Wind Energy Applications by IEA Wind TCP Task19, Charles Godreau, Nergica, CA (33)	
14:30		**Break, Poster session 2** Moderator: Christer Andersson Wind measurment that works in cold climate, Emil Dahl, AQ system AB, SE (45) Drone Based Direct Wind Resource Measurement & Performance Monitoring, Rasmus B. Lajevardi, First Airborne Ltd, IL (46)		**Summary** **THE END**	
15:00 15:20 15:40	Short visit at the Northvolt showroom	**Ice throw forecast (6)** Chairs: Marie Cecilie Pedersen & Gilles Boesch Introducing IceRiskForecast 2.0: Managing icing related risks at wind farms with nowcasts and ensemble forecasts, Sigbjørn Grini, Kjeller Vindteknikk part of Norconsult, NO (11) windThrow 1.0: the aerodynamics ice-throw toolbox, now with a graphical interface, Hamid Sarlak, DTU, DK (31) Calibration icing forecasts using real-time SCADA data, Kristian Ingvaldsen, Kjeller Vindteknikk part of Norconsult, NO (8)	**Third party solutions (7)** *A joint panel with Raphael Janssen (EDF), Daniela Roeper (Borealis), Petteri Antikainen (Wicetec) and André Bégin-Drolet (ULaval)* Third-party solutions for ice mitigation, Dominic Bolduc, Nergica, CA (34)		
16:00	Back at the hotel	Exhibition break			
18:00					
19:00		**Dinner**			

R&D areas/s: B) Technology

Accelerated Integration of Joint Ice Load and Damage Detection

Timo Klaas, Wölfel Wind Systems, DE

Timo Klaas (Wölfel Wind Systems, DE)

Since the efficiency of wind turbine generators (WTG) is primarily reflected in their possibility to produce energy at any time, the down times of WTGs due to structural damages or icing are costly and undesirable for WTG investors.
For this reason Wölfel Wind Systems has developed a wide product line-up with vibration-based structural health monitoring (SHM) systems for damage and ice detection in rotor blades, foundation and tower monitoring (onshore and offshore), to give wind turbine operators the opportunity to reduce the number of WTG inspections and increase availability and potential yield.
Especially the danger of ice throw from rotor blades has to be avoided for personal safety reasons at any time. Furthermore, the ice loads on rotor blades can cause severe damage to the WTG itself. Not only to the rotor blades, but also other parts of the structure, e.g. the gear box and the tower are strongly affected by higher loads and rotor imbalances.
The centerpiece of this presentation covers the latest innovations and developments around SHM systems with the specific focus on the following aspects:

- Smart data processing: How to use advanced data analytics to gain new findings from joint ice load and damage detection
- Advanced insights: Additional blade monitoring features for wind turbines

Web site: https://www.woelfel.de/en/wind-energy.html

Short biography: Bastian Ritter studied mechatronics engineering at Technical University of Darmstadt and obtained his PhD in the field of wind turbine control. He is 37 years old and lives with his family close to Frankfurt am Main. In private, Bastian enjoys to spend time outside in the nature with his children. As product manager at Wölfel Engineering, he is highly committed to the advancement of the structural health and condition monitoring systems for rotor blades, towers and foundations. In his daily work, he is focused on the customer benefit in order to bring added value to the table.

R&D areas/s: B) Technology

Autonomous calibration and optimization of blade based ice detection systems

Daniel Brenner, Weidmüller Monitoring Systems GmbH, DE

Nils Christian Frederiksen (WMS, GER)

Vibrational blade based ice detection systems measure the blades natural vibration to judge if there is critical ice accretion on the blades. In case the measured frequency deviates above a defined threshold value from the expected ice-free frequency an alarm signal is raised to protect the environment of the turbine from dangerous ice throw.
The value of the ice-free frequency is not only depending on the blade type but due to productional tolerances in e.g. blade mass and stiffness also depends on each individual blade.
For the first time this presentation gives an overview of the real blade frequencies measured at more than 300 blades of the same blade type to illustrate the influences of production variations to the audience.
To take such production tolerances into account the ice detection system performs a calibration with measurements of blades free of ice. This is done automatically for various turbine operating conditions (running, standstill, low wind idling). This process can be set to be performed permanently during the whole lifetime of the turbine which then adjusts automatically to steady changes like ageing of the blades.
Besides this calibration process to incorporate productional influences there is an additional need to adapt the ice detection system to site specific operating conditions. Many turbines run at night in defined noise reduced operating modes, which may even vary from turbine to turbine in their maximum rotor speed. Such constraint of the rotor speed may on the one hand lead to unexpected noise effects like tonalities due to the excitation of higher blade frequencies by the drivetrain. This effect is also illustrated in the presentation.
On the other hand these site specific operating conditions can lead to a different behavior of the blades natural vibrations used for ice detection. This makes it necessary to compensate this influence in order to avoid false alarms on the one hand and even more to avoid critical ice throw on the other hand. The presentation shows how an automatic compensation is implemented and demonstrates the benefits for the owners and operators of the turbine.

Web site:

Short biography: As head of Monitoring at Weidmüller Monitoring System GmbH in Dresden, Germany, Dr. Brenner and his team continuously monitor over 3000 turbine rotors of various manufacturers in different regions and climates.
Dr. Brenner studied electrical engineering in Dresden and worked for BMW in Munich during his diploma thesis. He graduated as PhD in mechanical engineering at the University of Magdeburg about the lifetime of wind turbine gearboxes. During the last 12 years he was responsible for the development of condition monitoring methods for wind turbine rotor blades.

R&D areas/s: B) Technology

Load Monitoring: The way to operate WTG under Ice Conditions?

Nils Lesmann, Phoenix Contact, DE

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The Phoenix Contact Blade Intelligence System combines ice detection with load, lightning as well as structural health monitoring in one controller technology.
Phoenix Contact equipped a turbine in eastern Canada with the newest generation of the ice detection system and retrofitted the load monitoring to the turbine. The aim of this presentation should be to point out the WTG behavior on roar frost, light and severe icing on the blades how do those outer effects on the blade effect the power production as well as the loads on the wind power blades.
If the combined system is detecting icing thicknesses as well as blade loads can the WTG operated with ice on the blades without effecting gears, bearings etc.? How to ensure a balanced hub?

Web site: www.phoenixcontact.com

Short biography: Being with Phoenix Contact for 14 years Nils Lesmann is doing working now with ten years most of his business career in the wind sector. Starting as application engineer, he is now in charge for the blade monitoring platform called “Blade Intelligence”
If he doesn’t feel the wind at work he likes to feel the wind while driving his motorbike.

R&D areas/s: E) Operation and forecasting

Validation of icing loss forecasts with SCADA data

Mona Kurppa, Kjeller Vindteknikk part of Norconsult, FI

Simo Rissanen (KVT, FI), Øyvind Byrkjedal (KVT, NO), Ville Lehtomäki (KVT, FI)

The share of wind farms in NordPool electricity markets is increasing fast and the impacts of wind power on electricity prices and system dynamics is growing. Reliable wind power forecasts are needed for different horizons, day-ahead being one important forecasting horizon for electricity marketing pricing. All this connected with the technology trend of building bigger wind turbines closer to low level clouds in wintertime means that icing losses will start playing a big role to the demand for accurate forecasts for high production, windy winter season.
Kjeller Vindteknikk has developed for years a mesoscale weather model WRF (Weather Research and Forecasting) based icing loss tool, IceLoss2. Historically the IceLoss2 model has been used extensively in the Nordics to assess the long-term average icing losses for wind farms in pre-construction phase. However, the IceLoss2 model can also be used for operational forecasting of icing losses in short-term 0-72 h horizons.
This presentation focuses on comparing operational SCADA data from 4 wind farms in Finland with forecasted icing losses using the IceLoss2 model. The focus of the forecasts is on extreme icing events: shutdowns due to icing where the produced versus modelled errors are typically largest. Finally, statistics are derived to quantify the uncertainty of the modelled icing stop. Future model improvement plans are discussed.

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

Short biography: Ms Kurppa works as Advisor at the science-based consultancy company Kjeller Vindteknikk Oy (Finnish office). After earning her Doctoral degree in Atmospheric Sciences from the University of Helsinki in 2020, she entered the renewable energy field to explore her passion for wind and green energy. Her technical work focuses on wind energy topics such as energy yield assessments, icing loss evaluations and wind measurement analyses. In her spare time, she enjoys outdoors by running, biking, and skiing.

R&D areas/s: B) Technology

Improvement of ILM calculation by pre-processing of the acquired data

Wakana Igarashi, Kanagawa Institute of Technology, JP

Reina MUTO (Kanagawa Institute of technology, Japan)
Daiki KURIHARA (Notre Dame university, USA)
Masafumi YAMAZAKI (Notre Dame university, USA)
Ken'ichi IWAI (KOMAIHALTEC Inc, Japan)
Hirotaka SAKAUE (Notre Dame university, USA)
Muhammad S. Virk(UiT Norway)
Shigeo KIMURA (Kanagawa Institute of technology, Japan)

The data between April 2019 to March 2020 from the wind turbine site in Tiksi, Russian Federation were analyzed by the Ice Loss Method (ILM) proposed by the IEA Task-19 to evaluate the icing effect on the turbine in terms of the duration of icing and the loss of the energy yield. One of 3 wind turbine at the site was equipped with an ice detector (Labkotec LID-3300IP) and two types of heated anemometers (Mita-Teknik Ultrasonic Anemometer 2D Compact and Mita-Teknik Wind Transmitter Compact) on the nacelle. The icing duration and power loss were also determined from the different methods of the ice detector data analysis and the difference between the two anemometer measurements. It was found that the Ice Loss Method analysis using the original wind turbine data underestimated the results of the aforementioned methods for both power loss and icing duration. The ILM determines the threshold for the icing duration by processing the power data during the warm season. The pre-processing to remove the incompatible from the warm season data set was implemented.
As a result, the accuracy of the ILM analysis was increased.

Web site:

Short biography: Wakana is currently doing her master's degree in mechanical engineering at Kanagawa Institute of Technology in Kimura's lab. She has been working on estimating the loss production of wind turbine due to icing. Her hobby is making accessories by beads.

R&D areas/s: E) Operation and forecasting

A smart algorithm for wind turbine controlling under icing conditions

Franziska Gerber, Meteotest, AG

Franziska Gerber (Meteotest AG, Switzerland), Paul Froidevaux (Meteotest AG, Switzerland), Michael Sedlmayer (Data Science @ Uni Vienna, University of Vienna, Austria), Radu Bot (Data Science @ Uni Vienna, University of Vienna, Austria), David Gruber (AIT Austrian Institute of Technology GmbH, Austria), Tobias Glück (AIT Austrian Institute of Technology GmbH, Austria), Thomas Burchhart (VERBUND Green Power GmbH, Austria), Simon Kloiber (VERBUND Green Power GmbH, Austria)

In cold climate regions, icing of wind turbines is a common issue that affects production and turbine lifetime. Icing also generates ice throw risk that must be managed and mitigated. In this context, optimizing turbine control is crucial to maximize production, while keeping the wind turbines healthy and the surroundings safe.
The recently started project "Smart Operation of Wind Turbines under Icing Conditions" (SOWINDIC) aims at controlling wind turbines in a smart way under icing conditions by making the best usage of available information from turbine data, in-situ meteorological measurements, observations of blade icing, as well as weather forecasts including icing forecasts.
An automated algorithm will process this information in real time to determine the best timing for turbine stops and restarts, and to identify the best timing for blade heating cycles. Two approaches will be compared to develop the smart algorithm, a physically-based and machine-learning-based approach. To this end, three wind turbines were equipped with webcams, temperature and humidity sensors to develop the algorithm and validate the results. The algorithm will finally be implemented to allow real-time turbine control.

Web site:

Short biography: Franziska Gerber finished her master in Atmospheric and Climate Science at ETH Zürich in 2013. She was always interested in snow and ice, which was part of her work throughout the years. While working on snow distributions and corresponding small-scale wind fields in complex terrain during her PhD at EPFL Lausanne and the WSL Institute for Snow and Avalanche Research SLF (Davos), she continued her work there on blowing snow over Antarctica as a PostDoc. In April 2021 she joined the wind and ice team at Meteotest AG, where she extends her horizon of snow and ice to icing of wind turbines. When not at work she can be found on skis in winter, hiking or cycling in summer or on the badminton court chasing shuttle throughout the year.

R&D areas/s: A) Policy and Market

Winterwind 2022 - Swedish Windpower Association

Jeanette Lindeblad, Swedish Windpower Association, SE

Jeanette Lindeblad, Swedish Windpower Association (SE)

The need for more renewable electricity production has become even more obvious to all of us. We see a fast progress for technology development and investments for wind energy production in harsh climates. The international Winterwind conference has after 14 years evolved into a shared experience arena where industry and science meet to improve utilization of wind energy in cold climates.
#Winterwind2022 challenges the industry to put main focus on validation, and we have a record number of exhibitors.
The conference takes place in Skellefteå, and this is where to be when it comes to the new industrialization with massive investments in electrification, hydrogen production, battery production, fossil-free steel and more.
We hope all of you will have a great experience; take the opportunity to get new contacts, new knowledge and new business opportunities!

Web site: https://svenskvindkraft.com/

Short biography: Jeanette Lindeblad is the chair of the Swedish Windpower Association
Swedish Windpower Association
Swedish Wind Power was founded in 1986 and is an industry organisation for wind energy producers, with approximately 800 members, ranging from smaller wind power owners to large-scale energy companies. With more than 35 years experience we are an established referral body and stakeholder in the Swedish wind energy sector, working to promote efficient development and economic conditions for wind power in Sweden.
One of the areas that define Swedish Wind Power is the exchange of knowledge, both as a referral body and provider of courses, seminars, and conferences. The seminars and conferences work as meeting points for the wind industry in Sweden. Being a member of Swedish Wind Power has several advantages and we are continuously working to develop new membership benefits to find attractive solutions that provide real and practical value to our members.
Every year we arrange international conferences like Winterwind and RE-Scandinavia. We offer a wide range of attractive benefits! More about members benefits and the association at:
www.svenskvindkraft.com

R&D areas/s: A) Policy and Market

Renewable energy as a growth factor

Stefan Forsgren, Skellefteå Kraft AB, SE

Stefan Forsgren Skellefteå Kraft (SE)

Sweden has a chance. If we choose the right path forward, it can create the conditions for a completely new growth where access to renewable electricity will determine whether we are winners or losers. Wind power is an important resource that can contribute to increased electrification to meet the climate challenge.

Web site: www.skekraft.se

Short biography: Joachim Nordin är vd och koncernchef vid Skellefteå Kraft, landets femte största energibolag med en omfattande produktion av förnybar energi från vatten, vind och bioenergi. Han har tidigare haft ledande positioner inom Scania i Sverige och Brasilien, Ferruform och Franke. Joachim är en prestigelös lagspelare som styr koncernen mot 100 procent förnybart genom tillitsfullt ledarskap och tron på att det hållbara är det lönsamma och kostnadseffektiva.
Joachim kopplar av med träning och ses både i löparspåret, på curlingisar och padelbanor.

R&D areas/s: A) Policy and Market

Wind and Electricity Storage from an European perspective

Johan Söderbom, InnoEnergy, SE

Johan Söderbom, InnoEnergy (SE)

Energy storage is developing in an ever increasing tempo both in terms of technology development but also from a commercial perspective. A majority of the push is coming from the rapid transition of the mobility to electric drivetrains which has resulted in a massive build-up of the battery industry globally. The development, that has up until 2017 been mainly an industrial boom in Asia, has in just 5 years turned into a very European business. The European commission, European industry and the member states has been done a tremendous, concerted effort and turned Europe into first a fast follower and then to a leader in several aspects. This can be seen by huge investments in most parts of the Li ion battery value chain as well as reinforced research and innovation efforts all across Europe. Now we see that this also has an impact in the storage related to the renewable sector, not the least in wind, and the opportunity to apply the rapid development for storage also to grid firming and energy storage applications. Energy storage with different technologies and characteristics is being deployed for various purposes in the electrical grids. We also see regulatory discussions aiming at removing hurdles for deploying energy storage at gride scale. The presentation will cover the above and also look into the near future.

Web site: innoenergy.com

Short biography: Johan Söderbom has been active in the energy sector for 25 years mainly working with R&D for the electricity system. Between 1995 and 2014 Johan worked at Vattenfall AB in various positions in R&D. From 2014 to 2019 Johan was heading a section at RISE (Research Institutes of Sweden) responsible electrical and optical measurement technology and he now holds the position of thematic leader for Smart Grids and Energy Storage at EIT InnoEnergy

R&D areas/s: A) Policy and Market

Northvolt - Enabling the Future of Energy

Wilhelm Löwenhielm, Northvolt, SE

Wilhelm Löwenhielm, Northvolt (SE)

The move towards renewable energy sources, including wind and solar PV, is forcing an unprecedented transformation of global power systems. Stationary Battery Energy Storage Systems (ESS) are projected to play a vital role in supporting this transformation. Northvolt aims to become a leading partner of the ESS industry and set a new benchmark for connectivity, sustainable sourcing, and CO2 footprint. At the same time, Northvolt is growing into a leading supplier of European EV OEMs and transforming not only the industry but also the communities where it establishes its Gigafactories.

Web site: www.northvolt.com

Short biography: Wilhelm Löwenhielm is the Director of the Energy Storage Systems Business Area at Northvolt, overseeing strategy, customers, and product portfolio. Prior to joining Northvolt, Mr. Löwenhielm served as co-founder of Alight, a Sweden-based solar PV corporate Power Purchase Agreement developer and asset manager. He started off his career in renewable energy as a consultant at the Boston Consulting Group in Stockholm and Boston. Mr Löwenhielm holds a MSc in International Economics from the Stockholm School of Economics and the Wharton School of the University of Pennsylvania. He serves on the board of the Swedish Solar Energy Association since 2017.

R&D areas/s: B) Technology

Enhancing power production without safety concessions in cold climates – early ice prediction by sensor fusion of surface and high-precision wind data

Michael Moser, eologix sensor technology, AT

Theresa Loss (eologix sensor technology, AT), Katrin Ritter (Romo Wind A/S, DK), Michael Moser (eologix sensor technology, AT)

In cold climates, thin layers of icing on the blades can decrease the aerodynamic performance and lead to stall. As a result, a significant reduction of a wind turbine's power production can be observed. As an example, especially during periods in which temperatures fluctuate around 0°C, those unexpected losses may lead to significant deviations from the expected power output of a wind farm.
Even though a variety of approaches exists to prevent safety hazards due to icing (e.g. see [1,2]), the detection of early-stage ice events is still challenging. Meteorological data are often not accurate enough to predict icing on the blades, and vibration-based systems require a minimum mass of ice on the blades [2]. Consequently, measurements of early-stage icing as an intermittent stage between pre-icing and operational icing (as defined in [3]) are needed to close the gap between meteorological methods and commercialised ice detection methods on the market.
Hence, we propose early-stage ice measurements by means of distributed sensors on the outside of the blades. These sensors are successfully used in the market to detect safety-critical icing and are now advanced to provide a measure for early-stage icing (MESI).
In our approach, we combine high-precision wind field measurements with turbine data such as power output and pitch angle. Thereby, even slight deviations from the turbine's power curve can be detected and related to early-stage icing by measuring on the blade surface at the same time. By conducting those wind measurements at the spinner, even turbulence intensities can be taken into account.
The advantages of our method are three-fold: First, in case of temperatures fluctuating around 0°C, power losses can be related to early-stage icing and blade heating can be optimised to increase power production. Second, in case of early-stage icing being followed by severe icing, a safety stop due to severe icing can be prevented by prematurely starting the heating system. Third, our approach can be used to separate power losses due to early-stage icing from other causes such as mechanical faults, and can thereby increase the precision of power curves.
In the full paper, we will deliver an analysis of measurement data from early-stage ice events and resulting power curve deviations on a turbine in a location affected by icing in central Europe. We will present a measure for early-stage icing (MESI) and highlight results based on field data in cold climates. Finally, the potential to enhance power production in cold climates based on this study will be estimated.

1) Wei, K., Yang, Y., Zuo, H., & Zhong, D. (2020). A review on ice detection technology and ice elimination technology for wind turbine. Wind Energy, 23(3), 433-457.
2) René Cattin and Ulla Heikkilä. (2016). Evaluation of ice detection systems for wind turbines. Final report, VGB Research Project No. 392. Meteotest AG.
3) A.G. Kraj, E.L. Bibeau. (2010) Phases of icing on wind turbine blades characterized by ice accumulation, Renew. Energy. 35, 966–972.

Web site:

Short biography: Theresa Loss is working as an R&D engineer at eologix sensor technology. She has more than five years of experience in data analysis, signal processing and algorithm development. She received her M.Sc. degree in electrical engineering and audio engineering from the Technical University of Graz in 2017 and completed her PhD thesis at the Institute of Electronic Sensor Systems in 2021. Her interests include icing of wind turbine blades, blade pitch and damage detection. If time allows, she likes to enjoy the panoramic views of wind farms while bike touring through Europe.

R&D areas/s: B) Technology

A thermal based ice detection sensor - from academic research to a commercial product

André Bégin-Drolet, Université Laval and Instrumentation Icetek, CA

André Bégin-Drolet (Université Laval and Instrumentation Icetek, CAN)

During this presentation, I will share my experience of bringing an academic innovation into the commercial world. A thermal based ice detection sensor, now commercialized by Instrumentation Icetek, took its origin through 15 years of academic research. The long path of wind energy in cold climate innovations through the academic world will be presented. The ice detection concept as well as all the important steps that led to the sensor being commercialized in 2021 will be covered. This presentation will also highlight the different kind of icing that can be observed on wind turbines as well as the important parameters that affects ice formation and their impacts on turbine performances. The presentation will also show some of the field experiments that took place in the last 15 years in my research group and that led to the sensor being commercialized. Some ice modelling simulations will be presented to highlight the fact that nature is sometimes hard to emulate and that sensors are still needed! Finally, the icing definitions (start time, duration, intensity, liquid water content) will also be discussed.

Web site: www.icetek.ca

Short biography: André Bégin-Drolet is a professor of mechanical engineering at Université Laval in Canada and CEO of Instrumentation Icetek a spinoff company launched in November 2020 that commercialize the ice sensor he and his team have developed at Université Laval. 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. He is very interested in developing methods to improve the production of wind energy in cold climates and have done so with many industrial partners. 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: B) Technology

Marinvent Airfoil Performance Monitor integration to a wind turbine

Dominic Bolduc, Nergica, CA

Olivier Paré-Lambert (Nergica, CA), John Maris (Marinvent, CA), Reeve Hicks (Marinvent, CA)

Nergica is a research centre based in Gaspé, Canada, that stimulates innovation in the renewable energy industry through research, technical assistance, technology transfer and technical support for businesses and communities. The aerospace company Marinvent approached Nergica three years ago to evaluate if their airfoil performance monitor (APM) could be integrated to a wind turbine to measure the airflow characteristics around the airfoil of the blades. This technology uses multiple pressure sensors distributed over a small device to calculate the turbulence intensity of the flow on the suction side of the wing. It is compared to a highly sensitive electronic wind tuff. A first preliminary study demonstrated beyond any doubt that this technology could be beneficial to wind industry by detecting disturbances from contaminants as small as 40 grit sand paper.
The ongoing project goal is to install 3 Enhanced APM (EAPM) sensors for a period of 2 years, on the blades of a large 2 MW wind turbine at Negica's test site in order to: 1) validate the performance of the Marinvent Enhanced (EAPM) sensor to detect the presence of frost and erosion of the blades in order to prevent stalls and to optimize energy production; 2) to get as much information as possible from the sensor data by using artificial intelligence (AI) to make links with the operational data of the wind turbine; and 3) to support Marinvent in the search for potential partners for the necessary large-scale trials reaching a higher level of technological maturity.
This presentation will show the progress of the project during the first year. We will present the challenges in installing the EAPM on a wind turbine rotor, record and synchronize the data with the SCADA and the preliminary results of the data acquisition during the winter and summer of 2021. We will focus on the turbulence intensity metric measured by the EAPM compared to the estimated local angle of attack and Reynolds number at the section of the blade where the sensors are installed. The airflow characteristic from a clean surface will be compared to the one produced by icing contamination ranging from very light to medium icing.

Web site: www.nergica.com

Short biography: Expert in wind turbine optimization in cold climate conditions, Dominic boasts indisputable know-how in the operation and performance of turbines sited in harsh climates, as well as the de-icing systems installed on these machines. With several years of experience in the wind sector under his belt, he participates in developing techniques for the detection, measurement and characterization of icing occurrences.
Dominic is also passionate about sail racing. So he understands well the need to have an accurate airflow indication, like wind tuffs, to optimize the performance of an airfoil.

R&D areas/s: B) Technology

Validation of Ice-Affected Plant Energy Assessment at a Large OEM

Anne Lund Christophersen, Vestas, DK

Anne Lund Christophersen (Vestas, DK), Dan Beltoft (Vestas, DK), Mark Zagar (Vestas, DK)

Validation of ice-affected plant energy assessment at a large OEM
A. Lund Christophersen, D. Beltoft, M. Zagar
Plant Modelling & Analytics, Vestas, Aarhus
Examples of model-based products in cold climate include energy assessments of ice-affected wind plants. To increase the confidence of their results, and to enable accurate risk quantification of downstream products, these assessments must be thoroughly validated. In large multifunctional organizations various users have different requirements or are differently affected by the use of the results. It is important that the model is validated according to its purpose and use cases and following best practices described by e.g. IECRE. This in turn means that the performance of one model-based product shall be validated and presented with different relevant metrics and in different ways, depending on the target user.
The complex interplay of aerodynamics, mechanics, and control systems results makes the wind turbine react to icing in ways that are not possible to predict from a simple parameter like number of icing hours. Therefore the validation does not necessarily only concern the prediction models, but also the performance of wind turbines and relevant cold climate options like de-icing and anti-icing systems.
We show how the plant energy assessments in cold climate are validated against the available meteorological and turbine production data. The results are aggregated along space and time dimensions in various ways and we demonstrate a number of typical use scenarios. For the validation of ice loss prediction models, the wind turbines' production loss due to icing is calculated using the IEA T19 algorithm to enable objective comparison across the industry. Both the park-average, and individual turbine's production impact of icing is analyzed.
When validating the energy assessment models it is important to be able to distinguish between the individual contributions of the long-term correction, flow modelling, wake modelling, ice loss modelling, etc. Our validation tools natively support these kinds of analyses and we present the results of the validation of above mentioned parameters on a selection of cold climate wind farms.

Web site:

Short biography: TBA, https://www.linkedin.com/in/mark-zagar-7733593/

R&D areas/s: B) Technology

Nordex advanced Anti-Icing System for N163 wind turbines

Konrad Sachse, Nordex Energy SE & Co. KG

Ines Runge (Nordex Energy SE & Co. KG)

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. During the last years the system was adapted for the N163/5.X and the new N163/6.X turbines.
The advanced AIS for the N163 offers very high performance for heavy icing conditions using the latest heating element technology that was introduced together with the N149/4.0-4.5. The 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: B) Technology

Aerodynamics of iced blades: a 2D investigation

Hamid Sarlak, DTU, DK

Hamid Sarlak (DTU, DK)

Wind tunnel experiments are carried out to investigate the effect of leading edge icing roughness on the aerodynamics of wind turbine blades. Tests are performed on two families of airfoils: a NREL S826 as well as DU 06-W-200 and similar behavior for horn ice on both NREL S826 and DU 06-W-200 is observed. It is observed that ice geometries can cause significant changes in aerodynamic performance. For example, horn ice can cause earlier stall and therefore reduced performance. Icing is found to typically decrease the lift force by around 20% and increase the drag 10 fold. Contrary to the common belief, glaze ice caused an increase in lift for lower Reynolds numbers of up to 20%.
The study can be used for benchmarking CFD studies.

Web site:

Short biography: Hamid Sarlak is an associate professor of aerodynamics and CFD at the Technical University of Denmark. He has been involved in wind energy in cold climates activities since 2015 and is currently a member of the IEA Task 19 Denmark.

R&D areas/s: E) Operation and forecasting

Introducing IceRiskForecast 2.0: Managing icing related risks at wind farms with nowcasts and ensemble forecasts

Sigbjørn Grini, Kjeller Vindteknikk part of Norconsult, NO

Sigbjørn Grini (KVT, NO), Kristian Ingvalsen (KVT, NO)

A new state-of-the-art forecasting system, IceRiskForecast 2.0, has been developed within an R&D project. The system provides the users with insight into the current and upcoming icing events and allows them to make optimal decisions to manage the risk of ice throw and ice fall. The IceRiskForecast 2.0 combines the forecast from Kjeller Vindteknikks adept in-house WRF forecast simulations with ensemble forecasts from the MetCoOp Ensemble Prediction System (MEPS). In addition real time SCADA data from the wind farms is used to now-cast the current icing situation in the wind farms. The IceRiskForcast 2.0 was released for the first wind farms on October 1st 2021. For the current winter a total of 15 windfarms will supply these forecasts to the public.

The target user for the IceRiskForcast 2.0 is the public. To reduce the risk of accidents from ice fall or ice throw from the turbines the IceRiskForcast aims to provide visitors to the wind farm with valuable information on the current risks associated with entering the wind farm during the winter months.

The risk related to icing in the wind farm concerns both rime ice forming on the wind turbine blade, but also situations with wet snow that can accrete on the nacelle roof and turbine tower. The snow on the nacelle roof can fall down as larger ice chunks or melt and form large icicles. IceRiskForecast 2.0 include forecasts for both rime ice and wet snow.

While there is plentiful information available from the models used and SCADA, the forecast presentation for the public is simplified using a “traffic light” and six-hour time windows. This is done to prevent “information overload” for the user. Here the versatility of the ensemble forecasting allows a wide window of tuning the relative operating characteristics. For Norwegian wind farms the focus for the tuning of the forecasts has been to limit the number of missed icing events, leading to a conservative forecast.

IceRiskForecast 2.0 has been developed in the R&D project “Wind Energy in Icing Climate” and would not have been possible without the funding from The Research Council of Norway and its sponsors, Fosen Wind, Zephyr, Fortum, Fred Olsen Renewables and Hydro.

Web site: www.vindteknikk.com

Short biography: Sigbjørn Grini works as an advisor at the science-based consultancy department Kjeller Vindteknikk in Norconsult AS being responsible for operational services. He holds a Master’s degree in Environmental Physics and Renewable Energy specializing in quality control of measurement data and a PhD in Solar Energy. Having a profound interest in programming and data, he seeks to apply an extensive use of quality data to enable more successful Wind and Solar projects in cold climates. On his spare time, he is an avid tennis player.

R&D areas/s: B) Technology

windThrow 1.0: the aerodynamics ice-throw toolbox, now with a graphical interface

Hamid Sarlak, DTU, DK

Hamid Sarlak and Franck Bertagnolio (DTU, DK)

We will present the latest developments in our toolbox for calculation of ice throw from turbines in operational as well as standstill operation. The code solves aerodynamics of 6 DoF motions of ice fragments using an inertial as well as a body-fixed reference frame. New features include the effect of surface roughness and ability to perform massive calculations of ice throw using a Monte Carlo technique to account for risks of fatal injuries etc.

Web site:

Short biography: Hamid Sarlak is an associate professor of aerodynamics and CFD at the Technical University of Denmark. He has been involved in wind energy in cold climates activities since 2015 and is currently a member of the IEA Task 19 Denmark.

R&D areas/s: E) Operation and forecasting

Calibration icing forecasts using real-time SCADA data

Kristian Ingvaldsen, Kjeller Vindteknikk part of Norconsult, NO

Sigbjørn Grini (KVT, NO)

Safe operation of wind turbines in icing climates requires knowledge about present as well as imminent risks of ice throw. Reliable icing forecasts also help to increase the predictability of the wind farm's power production. However, forecasting atmospheric ice accretion on structures is challenging due to the high sensitivity to meteorological variables such as wind speed, wind direction, cloud water content, droplet size distribution, temperature etc. Consequently, the Wind Energy in Icing Climates (WEIC) research project has put focus on increasing the skill and reliability of icing forecasts by combining numerical weather prediction model ensembles with real-time icing signals derived from SCADA data. The WEIC project was initiated by Kjeller Vindteknikk in collaboration with the Norwegian Meteorological institute as well as key wind farm operators in Norway and Sweden. The concept has been adapted from the ongoing Icebox project on monitoring of ice accumulation on overhead power lines.
The addition of real-time SCADA data provides both an overview of the current icing conditions (i.e. a "nowcast") as well as initial conditions to the ice accretion model (i.e. the forecast). Although natural ice removal mechanisms such as melting and sublimation may be modeled using physical equations, other ice removal mechanisms such as stochastic shedding (i.e. ice throw) are inherently difficult to predict. The SCADA data's ability to serve as initial conditions to the ice accretion model is therefore a key factor in determining when the wind farm area is once again safe following an icing event, which also helps to reduce the number of false alarms issued by the forecast system. More importantly, initial conditions derived from SCADA data help to reduce the number of false negative ice risk forecasts.
Real-time SCADA has been integrated as a part of the public forecasting of ice risk for 13 wind farms in Norway and Sweden for the 2021-2022 winter season.

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

Short biography: Kristian Ingvaldsen has a background in meteorology with a Master's degree from the University of Oslo. He currently works at Kjeller Vindteknikk (part of Norconsult) mainly with modeling of ice accretion on overhead power lines and wind turbines for both extreme value analysis and forecasting applications. He has previously presented icing related topics on international conferences such as IWAIS and WindEurope Technology Workshop. His non-icing related interests include music, ice hockey and hiking.

R&D areas/s: B) Technology

Third-party solutions for ice mitigation

Dominic Bolduc, Nergica, CA

André Bégin-Drolet (Université Laval, CA), Daniel Roeper (Borealis Wind, CA), Petteri Antikainen (Wicetec, FI), Raphael Janssen (EDF Renewables North America, Canada

Over the last 5 years, several third-party ice protection systems have been installed as retrofits to tackle the icing challenge in Eastern Canada. These installations involved EDF Renewables as the wind farm operator, Borealis Wind and Wicetec as IPS manufacturers as well as Université Laval and Nergica as research institutions.
Both IPS manufacturers were able to provide a solution to the icing problem faced by EDF, but this came with some challenges. One of them is the uptower installation of such retrofit IPS systems. With Borealis being based on hot air technology and Wicetec on electrothermal, each approach is different while having to face similar constraints.
Another challenge is to conduct an unbiased performance evaluation of the IPS, knowing that they are independent systems from the wind turbine itself. This is applicable for IPS suppliers for wind turbine OEMs as well as for retrofit IPS suppliers for wind farm owners. Some new approaches have been tested to overcome this limitation and all participants are now ready to share their recommendations.
To cover these topics over one session, the authors propose a panel format. This 90 minutes panel discussion would be split into 5 sections:
1- Introduction - 5 minutes
2- Icing problem and actions taken (EDF), Solution proposed (Borealis, Wicetec, ULaval) - 25 minutes
3- Installation challenges: Borealis - Installation inside the blade, ULaval - R&D project related to installation, Wicetec - Uptower installation - 25 minutes
4- Performance validation: Icing time definition (Wicetec, ULaval), Recommendations for third party IPS performance evaluation (supplier, operator, OEM) (All) - 25 minutes
5- Wrap-up and questions (10 minutes)

Web site: https://www.linkedin.com/in/charles-godreau/

Short biography: André Bégin-Drolet is a professor of mechanical engineering at Université Laval in Canada and CEO of Instrumentation Icetek a spinoff company that commercialize the ice sensor he and his team have developed at Université Laval. His research, in the wind energy sector, focuses toward improving wind power production in cold climate where atmospheric icing is prevalent.
Charles Godreau specializes in wind turbine performance assessments in cold climates and icing detection/protection systems. He possesses strong skills in data analysis for operational turbines as well as for developing, planning and implementing research project. He notably represents Canada in the International Energy Agency's Task 19 working group on wind energy in cold climates and is an active member of Winterwind's program committee.
Daniela Roeper founded Borealis Wind, a startup that provides a blade de-icing retrofit for wind turbines, improving their reliability as well as increasing production. The innovative system can be installed up-tower without removing the blades of the turbine, saving significant installation and maintenance costs. Daniela leads the company in her role as CEO, taking part in the technical and business development.
Petteri Antikainen has worked 25 years with cold climate wind. In 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. Petteri worked as principal scientist at VTT, Technical Research Centre of Finland. He has also been a board member in the Finnish Wind Power Association.
Raphael Janssen is an Associate Asset Manager at EDF Renewables North America. In his role, he oversees the operation of wind farms and monitors their performance. He was involved in the deployment of several ice protections systems on wind farms in Eastern Canada.

R&D areas/s: E) Operation and forecasting

Enhancing icing datasets: Lessons learned from the U.S. ice storm

Luke Cunningham, Clir Renewables, CA

Luke Cunningham (Clir Renewables, CA)

When an unprecedented ice storm hit the South Central region of the United States in February 2021, wind farms, turbines, owners and operators were paralyzed. Although some farms had OEM-provided icing packages, the sheer severity of the storm meant that many turbines still could not withstand the unusual weather patterns and low temperatures. The outages caused by major icing events also impacted data quality. SCADA and OEM provided status codes were not robust or precise enough to track and understand the outages, nor to quantify the lost energy associated with the storm. This impacted reporting and budgets, and skewed wind production estimates.

In helping clients recover from the storm, Clir Renewables noticed that there were significant gaps in data used to explain and quantify icing events. Although OEMs report ice detection from low torque or adapted operation, turbines frequently fail to register that they are not operating at full performance due to icing. Unexplained outages, power curve deviation and being unable to reach rated power are statuses that are sometimes missing from regular turbine data sets, but that can be attributed to icing if weather patterns are tracked alongside observed power. At the same time, extreme weather patterns can severely convolute ingested data, leading to messy, unstandardized data sets. Without the ability to update or reconcile data, wind farm owners are unable to understand the true impact of icing events, whether mild or severe.

Using two case studies located in south-central United States, the presentation will examine the knowledge gaps created by relying solely on OEM-provided status codes. First, it will look at de-icing systems and cold climate package implementation and the issue with missing status codes. When validating an OEM-provided icing package that a client had tested on three turbines on its 66 turbine wind farm, it discovered that the package generated significant additional energy. Unfortunately, OEM provided status codes only identified 1021.5 MWh of additional energy. By using AI to detect additional icing events and performance issues, Clir was able to find 181.7 MWh of additional energy generated by implementing the icing package. This allowed the client to accurately quantify the benefits of icing packages on turbine performance and understand the need to implement the icing package site-wide to reduce losses.

Next, the presentation will look at how the 2021 wind storm led to poor data quality. With an OEM icing software upgrade installed at a wind farm impacted by the February storms, turbines were inaccurately logging their availability throughout the storm. Since the turbines reported that they were available yet were not generating power, reporting showed huge losses. With the ability to edit, add and review status codes and events to override OEM data, the client was able to see a more accurate picture of availability during the storm, leading to more accurate reporting and budgeting.

These case studies show the need for more robust icing data, including synthetic or user-created event codes to ensure an accurate reflection of periods of icing and benefits of icing software upgrades. The presentation will examine the adverse impacts of incomplete and inaccurate icing data on icing package validation, as well as reporting and budgeting. Enhanced and high-quality icing data can provide improved visibility into wind farm performance. Improved icing data can also support visibility into potentially adverse icing events, allowing operators to perform derating strategies to reduce risk and blade loading, and increase the longevity of turbine components.

Web site: https://clir.eco/

Short biography: Luke Cunningham is a data analyst at Clir, joining the company in early 2020. Luke has performed performance analytics on over 1.5 GW of wind assets. Luke previously worked for a reputable wind resource assessment consultancy in Ireland and holds a Master's degree in Civil, Structural, and Environmental Engineering from Trinity College Dublin, where he developed expertise in aero-elastic modelling of wind turbines and the design of floating foundations for use in the wind energy industry.

R&D areas/s: B) Technology

Business Intelligence Analyst

Simon Grenholm, W3 Energy, SE

Simon Grenholm

Abstract - W3 Energy - Winterwind 2022
Visual stacked monitoring methods for surveillance and optimization of large wind farms in cold climate
Monitoring large wind farms in winter conditions is a challenge. The large number of wind turbines, each with its unique local condition and ongoing concerns, makes monitoring time consuming and messy. However, the large number of units can also be turned into and advantage, an opportunity to find patterns, compare driving forces, highlight repeated faults, fine tune settings or adjust control systems.
W3 Energy has the privilege of monitoring large wind farms in cold conditions; but has also, as an independent asset manager, the opportunity to bring together manufacturers and customers in collaborative working groups, to focus on tasks, ideas and solutions that are valuable to all parties.
Creative discussions require overview and well substantiated data analyses. For this matter W3 Energy is using a combination of aggregated farm or sub farm views, together with stacked views showing key events and/or time series data for each single unit in a compressed format.
A visual view, with a stacked format, is especially powerful when it comes to understanding the impacts of icing events and the wind turbines´ ice mitigation systems response to icy conditions. If only looking at one wind turbine, one may not even know what one is looking for. But from a visual view of multiple units, unexpected patterns can be seen. A common view creates a bases for a fast way of working, especially in early stages of newly constructed wind farms with many open issues, where many parties need to work together to achieve common goals.
PLEASE NOTE: A presentation of this abstract requires an approval from the owners of the data to be used in the presentation. Therefor - if such approval not will be reached the presentation/abstract can not be presented.

Web site: www.w3e.se

Short biography: Short biography: Simon Grenholm is business intelligence analyst at W3 Energy, with a specialisation on ice mitigation systems, software development and data analyses. He has a Master of Science in Environmental Engineering with a focus on renewable energy sources. He also has a long-time experience as a software developer for the construction industry.

R&D areas/s: E) Operation and forecasting

Using drones for an ice piece collection campaign

Anne Mette Nodeland, Kjeller Vindteknikk part of Norconsult, NO

Anne Mette Nodeland (Norconsult, NO), Rolv Erlend Bredesen (Norconsult, NO)

In our research project "Wind Energy in Icing Climates", one of the goals was to get information about the landing positions of ice pieces around wind turbines to validate our model for ice throw. To achieve this goal, we used drones to take pictures of the ground beneath the turbines after an icing event. The high-quality pictures from the drone allowed us to identify the ice pieces on the ground and get information about the number of ice pieces and their location and size. The presentation will show statistics from the registration of 800 ice pieces around two turbines.
The turbines studied are located in Storheia wind farm in the coast of mid-Norway, close to Trondheim. The campaign was carried together with Fosen Vind. The drones are owned and operated by aersea, who delivered great quality photos. The research project is led by Kjeller Vindteknikk and Norconsult, in collaboration with Fosen Vind, the Norwegian Meteorological Institute, Zephyr, Fortum, Fred Olsen Renewables and Hydro, with funding from the research council of Norway.

Web site: www.vindteknikk.com

Short biography: Anne Mette Nodeland works as an advisor at the science-based consultancy department Kjeller Vindteknikk in Norconsult AS. After an engineering education in Norway, she moved to work for a turbine manufacturer in Germany, working mainly with site assessment and different icing related topics. At Kjeller Vindteknikk she continues on this path, working with pre- and post-assessment of wind farms with a special focus on production loss due to icing and the risk of ice throw.

R&D areas/s: C) Development and financing

Addressing the challenges of accurately characterising the impact of cold climate atmospheric conditions for ever larger offshore turbines through a review of operational data

Marie-Anne Cowan, Wood Thilsted, UK

Jon Collins (WT, UK), Carla Ribeiro (WT, UK)

Offshore wind farm development in cold climates, particularly with the scale of turbine technology that is forecast for the coming decade, will present interesting challenges for characterising the wind conditions. Future turbine technology is forecast to reach turbine rotor diameters of up to 300 m, requiring top tip heights of up to 380 m, so well in to the atmospheric boundary layer. Such large rotor tip heights and rotor swept areas require an accurate understanding of the wind conditions, not just for the estimation of energy yield production and potential losses, but also as an input to the design basis of offshore foundations.

In cold climates, stable atmospheric conditions tend to dominate, which have associated with them very different wind regime characteristic compared to neutral or unstable atmospheric conditions. To date, the majority of offshore wind farms have been developed in areas with predominantly neutral or unstable atmospheric conditions, and with smaller turbines than are available now. The increasing size of turbines also necessitates a greater understanding of complex wind flow events such as low level jets which are likely to impact the rotor at these higher heights.

Whilst investigations in to turbine performance under cold weather driven stable atmospheric conditions have previously been undertaken onshore [1], very little research has been presented for the same conditions offshore. Under stable atmospheric conditions onshore, turbulence levels are typically low (< 10%). Thus low turbulence is seen as a proxy for stable conditions. However, this proxy does not apply as easily for offshore sites, where the ambient turbulence levels are already very low (<6%).

Historically there has been very little public evidence presented within the industry to confirm that offshore turbines are achieving their claimed performance within the conditions assumed due to the commercial sensitivity of such findings. However, some industry evidence has previously been presented based on nacelle mounted Lidar campaigns to indicate that 'off design' low turbulence site conditions at offshore wind farms have a negative impact on performance [2].

The authors seek to further build on this limited evidence to date, and inform a position on potential turbine performance losses that might be expected from offshore wind farms operating in cold climate conditions, by performing an analysis of the publicly available Levenmouth Demonstration Test site datasets in Fife, Scotland. This includes concurrent data from January 2017 from a 110m meteorological mast and SCADA production data from a 7MW Samsung wind turbine (110 m hub height and 170 m rotor diameter).

These datasets provide a unique combination of robust meteorological measurements, to allow for a classification of the atmospheric stability to be undertaken, and detailed turbine production data, to allow for an investigation of turbine performance. The authors are also currently exploring the potential of extending the study to include other datasets, if deemed relevant.

The goal of this study is to identify and characterise turbine underperformance attributed to cold climate atmospheric conditions, which can be used to inform likely impact on turbine performance losses. The authors shall also highlight opportunities for improvements to this study and recommendations for further measurement campaigns that would support offshore wind development activities in cold climates. Particular consideration is given to the importance of reliable meteorological measurements to inform accurate metocean conditions assessment to feed in to offshore turbine foundation design.

[1] C Ribeiro, S Cox, S Lindahl, "An investigation into turbine performance under cold weather driven stable atmospheric conditions in Scandinavia", WinterWind 2013.

[2] F Ettrup Brink, N G Nygaard, "Measurements of the wind turbine induction zone", 21st meeting of the Power Curve Working Groups 2016.

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

Short biography: Marie-Anne is a senior renewable energy expert with 15 years of experience in the wind industry. She began her career with Garrad Hassan (subsequently DNV), rising to the role of global technical lead for offshore wind resource and energy yield assessment. She is now a Lead Wind Engineer at Wood Thilsted. Over the course of her career, Marie-Anne has provided independent, technical advisory services to onshore and offshore wind farms at various stages of development across a range of markets

R&D areas/s: C) Development and financing

both onshore and offshore. Marie-Anne has been involved in the delivery wind resource and energy yield related analyses for several tens of GW of offshore wind farms in Northern Europe, many of which are now operational, and in the US and Asia. She has also managed industry leading projects with the Crown Estate and Carbon Trust, improving industry understanding of offshore wind resource and reducing LCoE of offshore wind projects. Marie-Anne has a specific interest in the role of floating Lidar technology in supporting offshore wind farm development; she led the consortium of authors of the Carbon Trust OWA Floating Lidar Roadmap update in 2018 and is currently actively involved in the IEC 61400-50-4 draft for floating Lidar measurements.

R&D areas/s: Power to X - and storage of Energy

Storage of electricity in molecules

Finn Daugaard Madsen, Siemens Gamesa, DK

Finn D Madsen, Siemens Gamesa (DK)

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 electric conductive rods in a glass with water and a little salt) today this is done in electrolysis stacks with capacities of 500 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.
There will also be shown firsthand experience from our first hydrogen test facility in Brande Denmark – where we are producing H2 for taxies in Copenhagen.
https://www.linkedin.com/posts/greenhydrogen.dk_greenhydrogen-activity-6867064566400983040-BgoL/

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

Short biography: Innovation Manager with extensive knowledge in Project management, Leadership, Networking, Innovation, Technology, Roadmap, Manufacturing equipment, Sales and Business management.
Mechanical engineer with a Diploma degree in leadership and a lot of hands-on training.
With more than 30 years of experiences from major international companies, I have learned best practices in; Project Management, Innovation, R&D, Process optimization and many other topics.
Experience:
My experience as Innovation Manager, Project Director, Think Tank Manager (developed a deicing system for Siemens Gamesa) , Key Account Manager, and now Innovation and Project Manager and heeding a group named Hybrid, Storage and conversion.
And my latest "build" a test center for power to x next to a turbine where SGRE are producing H2 production for taxies and store electricity in batteries of different kinds.
Personal interest - Owner of forest - and therefore hunter and has built / worked with Lego for over 20 years.

R&D areas/s: C) Development and financing

Validation study of modelled icing using met mast data and SCADA data

Marie Cecilie Pedersen, EMD International A/S, DK

Tobias Ahsbahs (EMD International A/S, Denmark), Morten Thøgersen (EMD International A/S, Denmark), Jan Coelingh (Vattenfall, NL)

Modelling icing to assess production loss for wind power pre-construction is still a challenge. At EMD, the modelling chain to estimate production losses consist of three steps. First a site-specific meteorological model is created using an "icing" configuration of the EMD WRF On-Demand service [1]. An ice accretion model is then applied using the standard icing model described in [2] and [3], and finally the production losses are estimated using the IEA classification system [4]. Uncertainties are present throughout the modelling chain all the way from the choice and settings of the meteorological model to the ice growth model and finally at the modelling approach for obtaining a production loss estimate. Therefore, validation of each step of the modelling chain is crucial to conclude the final performance of the model.
An essential step to estimate the production loss is to identify periods of instrumental icing and meteorological icing from the modelled ice load and ice accretion rate, respectively. A validation has therefore been carried out using a unique dataset consisting of measurements from 25 meteorological masts from northern Europe and production data from 6 wind farms in Sweden and Norway. The focus was to validate the identified instrumental and meteorological icing as well as analysing the sensitivity towards the used standard thresholds of 0.01 kg [3] and 10 g/h [5] respectively. The validation study carries two parts:
Part 1: Validation of modelled instrumental icing using instrumental icing records obtained by filtering standard meteorological mast data in windPRO. The filtering was performed by identifying abnormalities in the measured wind direction, wind speed and temperature (if available), and by identifying periods of disagreement between pairs of heated and unheated anemometers (i.e., double anemometry). The validation was carried out by comparing the total number of hours of instrumental icing within one season. Furthermore, the hourly modelled ice load and identified instrumental icing was compared to ice load measurements from two met masts.
Part 2: Validation of total modelled icing (instrumental and meteorological) using icing related production losses from the SCADA data in accordance with the T19 Ice Loss Method defined by the IEA Task19 [6]. The total production loss due to icing from the T19 Ice Loss Method was compared to the modelled instrumental icing using different thresholds. And by identified icing events - the hourly agreement between modelled icing parameters and the production losses from the T19 Ice Loss Model was evaluated. Finally, the modelled productions losses obtained by using the IEA classification system was validated against the results obtained from the T19 Ice Loss Method.
In the presentation, results from both parts of the validation study will be shown and put into the context of how they can improve the modelling chain of production losses due to icing. Relevant uncertainties in the modelling chain will be highlighted, and their impact on the estimated production loss will be considered.

[1] https://help.emd.dk/mediawiki/index.php?title=EMD-WRF_On-Demand_and_Custom-Area
[2] L. Makkonen, "Models for the Growth of Rime Glaze Icicles and Wet Snow on Structures," Royal Society, vol. 1776, no. Ice and Snow Accretion on Structures, pp. 2913 - 2939, 2000.
[3] ISO, "DS/ISO 12494:2017 Atmospheric icing on structures," Danish Standard Association, København, 2017.
[4] I. Baring-Gould, R. Cattin, M. Durstewitz, M. Hulkkonen, A. Krenn, T. Laakso, A. Lacroix, E. Peltola, G. Ronsten, L. Tallhaug and W. T., "13 Wind Energy Projects in Cold Climate," IEA Wind, http://ieawind.org, 2011.
[5] K. Hämäläinen and S. Niemelä, "Production of a Numerical Icing Atlas for Finland," Wind Energy, vol. 20, pp. 171-189, 2017.
[6] https://iea-wind.org/task19/t19icelossmethod/

Web site: https://www.emd-international.com/

Short biography: Marie Cecilie Pedersen is a wind energy R&D specialist at EMD International A/S in Denmark. She started working with wind power in cold climates in 2014 during her Industrial PhD. studies. Her competences stretch from micro-scale modelling of icing accretion on structures using

R&D areas/s: C) Development and financing

Computational Fluid Dynamics (CFD) to preconstruction production loss assessment for wind power in cold climates.
Marie is interested in flow modelling for wind power applications, data analysis and the “green energy transition”. Marie holds a PhD. (2018) and a M.Sc. in Energy Technology from Aalborg University.

R&D areas/s: A) Policy and Market, Safety and Environment (HSE)

Comparison and validation of ice throw models

Markus Drapalik, University of Natural Resources and Life Sciences, Vienna (BOKU), AT

Markus Drapalik (BOKU, AT), Sebastian Purker (BOKU, AT), Larissa Zajicek (BOKU, AT)

Ballistic Models are routinely used for ice throw risk assessments. For obvious reasons, these models are usually validated against observed ice throw distances. While these data are very convincing, since comparison is made to the actual problem, the efficacy of these observational data for validation purposes is limited. Most observation campaigns necessarily focus on collection of ice pieces some time after the actual icing event, which severely limits the knowledge about environmental conditions during the throw of an individual ice fragment. This demands for large data sets and introduces additional uncertainty, which has to be respected in the validation results. This again is reflected by larger safety distances in assessments.
Apart from the obvious disadvantages, this lack of knowledge may lead to underestimation of the risk near the turbine, since larger distances may distribute the total risk over a larger area. Lack of knowledge about wind or nacelle direction during an individual throw may even lead to distorted spatial risk distributions.
In order to create more detailed data for validation, experiments with artificial ice fragments were conducted, dropping or throwing them under semi-controlled conditions. The results from these experiments contain in addition to the impact locations high resolution wind measurements and reconstructions of the throw trajectories.
Comparison with simulated results from the Biswas model show unsatisfactory results. Thus, a new six-degree-of-freedom model was implemented, for the complete representation of all possibilities of translation and rotation. Data for forces and moments acting on an ice fragment were pre-calculated using CFD simulations. Using these lookup-tables, Monte-Carlo simulation of ice throw in acceptable time is possible.
For validation of this new model, the 90% confidence intervals of the respective values were chosen as a measure for the comparison of the simulation results and the experimental values. In this validation attempt significant improvement compared to the state of the art was found.

Web site: risk.boku.ac.at

Short biography: Markus Drapalik is a physicist at the Institute of Safety and Risk Research (ISR) at the University of Natural Resources and Life Sciences, Vienna. He has been working on wind turbine icing for the last seven years and received his Ph.D. for working on the risk of ice shed from turbines.
Following his preferences for hands-on experiences, his main interest is in experimental investigation of ice shed and ice throw, which covers large and small turbines alike. For this, he maintains a small monitoring program for ice shed, which provides the necessary input and validation.
Since the ISR is focusing on technology assessment, his work is expanding towards a systemic view on wind energy in particular and energy transition in general, integrating view points ranging from natural protection to societal impacts.
His personal time is mostly spent with his family and horses.

R&D areas/s: E) Operation and forecasting, Research and service delivery

Perceptions of impact-based warning information for ice-throw risk: A Norwegian survey

Rolv Erlend Bredesen, Kjeller Vindteknikk part of Norconsult, NO (for Norwegian Meteorological Institute, NO)

Jelmer Jeuring (Norwegian Meteorological Institute), Anders Sivle (Norwegian Meteorological Institute)

Risk management for wind farms has become more standardized in terms of calculating acceptable risk criteria, but so far the communication of possible risks and their consequences for societal actors has not evolved into a validated set of best practices. The current state of knowledge about best practices for ice throw/fall risk communication is still in an exploratory phase, and empirical research on this is fragmented. The main attempt toward a consolidation of best practices in ice throw/fall risk communication has been part of the IEA Wind TCP Task 19 work. Its mandate is to provide international guidelines for ice risk assessment. A report that was published in 2018 (Krenn et al., 2018) is currently being updated. The work reported in this presentation is part of the project 'Wind Energy in Icing Climates', funded by the Norwegian Research Council and wind farm operators in Norway. The Norwegian Meteorological Institute has executed a national survey with the specific aim to develop recommendations for communication of the risk of ice throw from turbines in Norwegian wind farms.
The survey aimed at getting insight into perceptions of the general public in Norway about ice-throw risk, and the perceived value of different communication tools and formats of ice-throw risk information for Norwegian wind farms. We discuss findings on a range of topics, including people's familiarity with wind turbine parks, their weather risk information seeking patterns, people's understanding of impact-based warnings for ice-throw risk, and their behavioural capacity to mitigate possible negative impacts emerging from ice throw risks. Based on the survey findings, we provide a systematic set of recommendations regarding communication and formatting of ice throw risk warning information.
References
Krenn, A., Stökl, A., Weber, N., Barup, S., Weidl, T., Hoffmann, A., ... & Lautenschlager, F. (2018). International Recommendations for Ice-Fall and Ice-Throw Risk Assessments. Wind Energy in Cold Climates. Available online at https://iea-wind.org/wp-content/uploads/2021/09/Task19_Recommendations_ice_throw_2018.pdf

Web site: https://www.researchgate.net/profile/Jelmer-Jeuring

Short biography: Jelmer Jeuring is a researcher at the Norwegian Meteorological Institute in Bergen, Norway. He has a background in social psychology and cultural geography. His research has mostly an interdisciplinary nature. It focuses on the societal contexts in which weather information is being used, and how people include weather information in their decision making and protective actions. Within MET Norway a key aim of this research is to contribute to improved service delivery for both the general public and expert audiences, and facilitate dialogues between users and producers of prediction services. Jelmer has an unresolved plan to take his stand-up paddleboard into the Norwegian fjords.

R&D areas/s: A) Policy and Market

Edition 2 of the IEA Wind TCP Task 19 International Recommendations for Ice Fall and Ice Throw Risk Assessment – What's new?

Claas Rittinghaus, Energiewerkstatt Verein, AT

Andreas Krenn (Energiewerkstatt Verein, AT)

Project developers and consultants as well as manufacturers and operators in the wind turbine industry eagerly anticipated the publication of the first edition of the International Recommendations for Ice Fall and Ice Throw Risk Assessment in 2018. It has since been adopted in many countries as a de-facto standard for risk assessment of icing phenomena in the approval processes for wind energy projects. The second edition of the recommendations, to be published in mid-2022, incorporates latest scientific findings as well as field-experience and offers new and revised guidelines for in-depth risk analysis and assessment of wind turbine icing.
One of the new additions is a more differentiated treatment of icing with respect to operating modes of the turbine in conjunction with a potential blade heating system. Ice protection systems in the form of blade heating systems are the currently most-adopted approach in limiting power losses due to icing. Depending on the operating modes of the turbines and blade heating systems, these systems directly affect the processes of ice accretion and ablation. It is therefore essential to incorporate these effects in ice fall and ice throw risk assessments.
Another focus lies on a more detailed risk assessment process for high-level roads, such as federal roads and highways and the infrastructure connected to them. In most cases, a project-specific approach needs to be adopted, as local and country-specific regulations and statistics have to be taken into account. Nonetheless, basic guidelines can be provided, to be adhered to in the absence of further information, for instance in early project planning stages.
A central part of the overall risk assessment process is mitigating risks by introducing risk-reducing measures. The new edition of the recommendations broadens the focus to the assessment of the technical/factual effectiveness of risk reducing measures as well as the jurisdictional effects.
The second edition of the International Recommendations for Ice Fall and Ice Throw Risk Assessment meets the state-of-the-art in wind turbine technology as well as the regulatory framework. They enable users to assess the project-specific risks of wind turbine icing, and thereby help to further advance and fully realize the potential of wind energy generation in icing climates.

Web site: www.energiewerkstatt.org

Short biography: I earned my diploma in physics at the University of Bielefeld, Germany. After 10 years of working as a product manager for Phoenix Contact in Blomberg, Germany, I have recently joined Energiewerkstatt Verein in Friedburg, Austria, as a project manager focussing on research projects and consultancy services.
I am a mountain enthusiast, in summer as in winter, which is another reason for my move to Austria. I enjoy hiking, climbing, bouldering, downhill skiing and ski touring. This winter season I plan to try out cross-country skiing.

R&D areas/s: B) Technology

Preventing wind turbines from catching colds

Patrice Roberge, Université Laval, CA

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

The wind energy market in cold climate is bursting with new solutions for its specific challenges. A good example of these new technologies is the development of ice protection systems (IPS). Even though the first IPS appeared in the 90s, the technology is evolving rapidly and we have few evaluations of their performances. The offer in IPS is growing with even more OEM and retrofits coming to the market to answer to the demand of wind farm owners trying to prevent significant icing losses. Recently, IEA task 19 provided general guidelines on how to evaluate the performance of IPS for the implementation of warranties. Although this work is a step in the right direction, there is a lot of work still to be done. As we would do with new drugs coming to the market, new IPS technologies should go through experimental trials to assess their performance before being deployed large scale. In this presentation, the different strategies to evaluate IPS performance in the past are reviewed underlying their strengths and weaknesses. Based on the shortcomings of the previous studies, new solutions are then proposed. A clear methodology on how to apply the different tools is presented inspired by the other spheres of science. We strongly believe that, as pharmaceuticals are bound to, IPS providers should share their standardized trial results to their clients to help them make an informed choice.

Web site:

Short biography: Patrice is currently doing his Ph.D. in mechanical engineering at Université Laval in André Bégin-Drolet's lab. He has been working on the operation of wind turbines in cold climates for nearly 6 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 engineering physics with a distinction mention. He also completed a master's degree in mechanical engineering. He was awarded the undergraduate student research award form NSERC three times, the FRQNT scholarship for his master's degree, the NSERC Alexander Graham Bell Graduate Scholarship (for both his masters and Ph. D.). He is a very inquisitive 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: Repair, Materials

Blade repair in artic climate

Greger Nilsson, Blade Solutions, SE

Philippe Christou (Huntsman Advanced Materials)

Blade Solutions has together with Huntsman advanced materials developed a thermoset adhesive that can used below zero degree Celsius. The adhesive is suitable to use in artic climate for smaller blade repairs and has been selected as one of three competitors in the JEC innovation award, in the category Renewable Energy 2022.
For larger structural repair has Blade Solutions developed the Resistive Vacuum Infusion method (RVI). In RVI the repair patch is also the heating layer. This new solution gives possibilities to perform structural blade repair year around in temperatures below zero degree Celsius.
A structural blade repair is best carried out in the same environment as the in the blade factory. Controlled humidity and temperature. Therefore, the RVI aims to replicate the blade factory environment's conditions at the wind turbine site in the repair patch and the blade interface. The complete lamination repair can be performed down to temperature of -20°C without any problems, including vacuum infusion, curing and post curing. The conductive layer between the blade surface and the repair patch is also the heating layer. The surface temperature can be precisely adjusted both during the infusion and cure phases. The fine temperature control is that the interface, between blade and repair path, is that the heating layer and the warmest part. At the infusion, the temperature is adjusted to the desired resin viscosity. The temperature is also adjusted during the curing process according to the chosen cure cycle.
RVI is primally developed for blade fibre wrinkle crack repairs but can be used in other repairs as well. Dangerous cracks can be repaired all year round in excellent quality.

Web site: bladesolutions.se

Short biography: Extensive background as a composite researcher at RISE/Sicomp. Intrested in down hill skiing and catamaran sailing.

R&D areas/s: B) Technology

Linnovation concept for wind turbines in cold climate – experiences from field operation fall 2021-winter 2022

Lars Tarberg, Linnovation AB, SE

Kjell Lindskog, Lars Tarberg and Sven-Erik Thor, (Linnovation AB, Sweden)

The main challenges operating windturbines in cold climates are as follows:

- Production losses due to icing
- Damages on blades due to falling ice
- Health and Safety Issues

The Linnovation concept for anti-icing addresses all three topics above. This presentation will give information about the latest development and experiences of the new and innovative anti-icing system. It is a system for retrofitting existing blades as well as to be incorporated in initial production of blades. The project has contributed to the development of the different sub-systems and interaction between them. The system is planned to meet TRL level 8, at least, in Q2 2023.

Experiences from operation in Jokkmokksliden of the next improved generation antiicing system will be presented. Comparisons with two other windturbines (without IPS) in the windfarm will be presented and discussed in detail, mainly with focus on production losses/gains and availability.

In addition to that, information will be presented related to the Linnovation concepts for service and repair of different components in wind power plants operated in cold climate.

Examples are:

- Presentation of the newly developed service platform. This platform will facilitate blade service in harsh environments.
- Repair and strengthening of blades. Severe damages on blades from falling ice is a challenge for operators of wind power plants. The new platform is an essential part of the concept.
- Nacelle and spinner anti-icing, uses the same technology as used on the anti-icing on the blades.
- A possibility to use the developed heating panels as a new type of ice sensor.

The proposed presentation will be given by the recently appointed managing director Lars Tarberg.

Support from the Swedish Energy Agency and Skellefteå Kraft is greatly acknowledged.

Web site: www.linnovation.se

Short biography: Lars Tarberg has a background in developent, service and production during the last 20 years at StrongPoint/SQS. The anticing system is a spin off from a technology used in that company.

R&D areas/s: C) Development and financing

Validation of modelled instrumental icing with mast measurements

Ville Lehtomäki, Kjeller Vindteknikk part of Norconsult, FI

Øyvind Byrkjedal (KVT, NO)

Every wind farm needs reliable wind measurements to evaluate the planned project's financial feasibility and to ensure bankability. In addition to a wind resource assessment from site measurements, icing losses have been one of the driving forces in Nordics kick-starting the WinterWind conferences in 2009 and much of the conference's program revolved around icing losses still in 2021.
Kjeller Vindteknikk has developed for years a mesoscale weather model WRF (Weather Research and Forecasting) based icing loss tool, IceLoss2. One key part of the IceLoss2 tool is it´s ability not only to model icing losses (as presented in WinterWind 2020) and meteorological icing but also to model instrumental icing: ice present on wind sensors on a met mast.
This presentation focuses on comparing multiple mast measurement campaigns conducted in Northern Europe with measured instrumental icing to modelled instrumental using the in-house WRF model for ice accretion. Use of different sensors (pair of heated and unheated anemometers or wind vanes) to detect instrumental icing is discussed. Finally, statistics are derived to quantify the uncertainty of the modelled instrumental icing durations of the WRF model setup. Implications to uncertainty of icing loss assessments is discussed.

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

Short biography: Mr Lehtomäki works as Managing Director at the science-based consultancy company Kjeller Vindteknikk Oy (Finnish office). In addition to managing the Finnish office's commercial operations, his technical work today focuses on wind energy topics such as energy yield assessments, icing loss evaluations and wind measurement analyses. From 2009-2018, he worked at VTT Technical Research Centre of Finland Ltd in Wind Power team having extensive international wind energy experience, coordinating and developing new projects and creating new technology innovations mainly in the field of wind energy. He is a retired Operating Agent of IEA Wind Task 19.
Mr Lehtomäki has a Master's degree in mechanical engineering (product development) from Helsinki University of Technology.
In his spare time, he runs around badminton and floorball arenas and prefers downhill over cross-county skiing.
He is on a mission to help unlock the full potential of wind energy in Finland.

R&D areas/s: C) Development and financing

Bridging the Gap – Validation of Pre-construction Wind Farm Modelling Against Operational Data

Enrico Sindici, Natural Power, UK

Iain Dinwoodie (NP), Enrico Sindici (NP), Daniel Marmander (NP), Peter Denholm (NP), Christian Jonsson (NP), Graeme Watson (NP)

Pre-construction modelling of wind farm operations strives for accuracy and realism, however estimates may differ from post-construction assessments based on measured operational data. The differences may generally lie in the complex nature of wind power generating systems, however some of the contributing factors can be unravelled when comparing pre-construction and post-construction models on a time series basis.
We present a case study of an operational wind farm in cold climate and compare a number of pre-construction estimates to the observed data, with a focus on icing, availability, and production. The detection of icing on operational wind turbines can be challenging, and is tackled in our approach by using a combination of meteorological data, the wind farm's own alarm system and the analysis of operational power curves.
In frequency-based assessments availability is modelled as a flat loss, however in real wind farms it is a dynamic effect affected by a number of complex variables such as mechanical deterioration and extreme weather events. Due to this, a deterministic approach at modelling turbine downtime in time is not feasible, but can be tackled as a stochastic process. We show how operational turbine availability data can be used to generate a long-term stochastic availability timeseries which preserves the key statistics of the observed data. The method can be applied to pre-construction availability assessments without available operational data, and is validated against a database of over 100 operational sites.
Furthermore, comparing the per-turbine pattern of production on a timeseries basis resulting from a pre-construction versus an operational model allows to compare the predictive power of different spatial extrapolation and wake models.
Our approach illustrates the possible benefits of reviewing operational data against time series modelling, focussing on validating assumptions related to downtime in cold climate wind farms. The methodology can be applied on a large scale as a validation tool for pre-construction modelling assumptions.

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

Short biography: As graduate from the University of Strathclyde, with a PhD in Theoretical Quantum Physics, Enrico has worked on resource estimation and optimization in quantum mechanical systems. His research interests cover a broad spectrum of topics, including solid-state physics, optics, atomic and mathematical physics. Enrico has academic expertise in the mathematical modelling and numerical simulation of complex physical systems, with focus on statistical methods and matrix analysis. His long-standing interest in renewable energy generation and environmental issues has led him to work for Natural Power, where he is employed as an Energy Analyst, working within the Analytics team to provide state of the art assessments throughout the lifecycle of renewable energy projects. Key areas of focus include both pre-construction and operational energy yield assessments of onshore wind farms, wind resource estimation and wind farm performance engineering. He also holds a Master's and Bachelor degree in Physics at the University of Trieste. His personal interests revolve around live music and travel.

R&D areas/s: B) Technology

A note on ice detection of wind turbine blades by a rotating-cylinder-type ice sensor

Reina Muto, Kanagawa Institute of Technology, JP

Wakana Igarashi (Kanagawa Institute of Technology, JAPAN), Daiki Kurihara (The University of Notre Dame, USA), Masafumi Yamazaki (The University of Notre Dame, USA), Kenichi Iwai (KOMAIHALTEC Inc., JAPAN), Hirotaka Sakaue (The University of Notre Dame, USA), Muhammad S. Virk (UiT, Norway), Shigeo Kimura (Kanagawa Institute of Technology, JAPAN)

For wind turbines in cold climate, icing on blades induce adverse effects such as the production loss, ice throw and shortened lifetime. To mitigate those effects, blade heating by heaters and rotor rotation control (suspending and/or moderate operation) have been proposed. In economical perspective, those mitigation schemes should be optimized to maximize the power production yet to minimize the adverse effect. One such way is for the countermeasure to kick in right after the icing on blades is detected. Although researchers have devoted to developing such detection method, successful method which can detect the blade icing in real-time has not been achieved. In this study, employing a simplified method in order to relate ice accretion on a rotating-cylinder-type ice sensor installed on a wind turbine nacelle to an ice mass or thickness on the blade, we make a suggestion of requirements for the ice sensor to correctly indicate an ice deposit on a specified position of the turbine blade.

Web site:

Short biography: Reina Muto received Bachelor's degree from Kanagawa Institute of Technology. She is currently pursuing Master's degree in mechanical engineering at the same university. Her research interest is wind turbine operation in cold climate. She has been working on the development of the blade icing detection algorism. In her free time, she enjoys playing the ukulele.

R&D areas/s: A) Policy and Market

Challenges with Powering the Electrification of the Industry

Daniel Gustafsson, Vattenfall, SE

Daniel Gustafsson, Vattenfall (SE)

We are facing a new industrial revolution based on the growing fossil-free economy. The key is electrification and the forecasts of future electricity demand grows as ambitions for the climate increase. A doubling of electricity use by 2045 is no longer seen as unreasonable but as a prerequisite for Sweden to succeed in reaching climate goals with strengthened competitiveness. But this positive development also arouses natural questions. Will we be able to supply sufficient electricity?
The requirement for large investments in wind power in the north of Sweden are a corner stone in supplying the energy for the transformation. But for this to be possible laws, regulation and prioritization needs to improve considerably for this to be possible. What changes is needed to make this shift possible? We must prioritize wisely and the goal must be clear; to reach net zero emissions of greenhouse gases 2045, in balance with other important interests. As much as we need brave politicians and wise priorities, we need to work fast.

Web site:

Short biography: Daniel Gustafsson has been working with Wind Power development for the last 13 years and is currently acting Head of Development for Vattenfall's Onshore portfolio.

R&D areas/s: B) Technology

The IEA Wind TCP Task 19: 19 years of cold climate wind research

Timo Karlsson, VTT Technical Research Centre of Finland Ltd, FI

Timo Karlsson, VTT, FI

The IEA Wind TCP (International Energy Agency Wind technology collaboration platform) set up the research Task 19 on cold climate wind in 2002. In 2002 the landscape for cold climate wind was very different. In 2022 Task 19 is looking at another term to continue it's work into 2025. The roadmap of the new term and future efforts of Task 19 are now set and are presented along with a look back on previous efforts under this umbrella.

Over its existence Task 19 has been involved in development of a lot of cold climate wind standards, practices vocabulary and technology. This work has been quite visible also at Winterwind conferences in the past.

The mission of Task 19 is to make large scale deployment of cold climate wind possible in a safe and economically feasible manner. At it's core IEA Wind TCP Task 19 is a collaboration platform where members from different countries work together to gather and disseminate information and research results related to cold climate wind. Based on this state-of-the-art information the Task then produces recommendations and reports on different relevant topics.

The long history of the Task allows for a retrospective on the impact this work has had and Task 19 has become an important forum for pushing forward common practices and terminology related to cold climate wind. Many Task 19 efforts have been adopted over the years as de facto industry standards and have become commonly accepted definitions and methods that have seen widespread adaptation. Examples of these are:

- EA Wind Ice classification; classification of sites based on icing climate conditions. Used widely to present the severity of icing
- Task 19 IceLossMethod: originally released as a software tool for estimating production losses due to icing. Since the icing event definition used in the software has seen wide adaptation.
- Task 19 Ice throw and ice fall risk evaluation guidelines: Developed in collaboration with industry, these guidelines serve as a baseline for evaluating risk associated with icing conditions.

In addition to these, Task 19 has been instrumental in introducing cold climate concerns into IEC standards governing wind turbines: both IEC 61400-1, IEC 61400-12-1, and upcoming IEC 61400-15 which now include cold climate and icing effects in the standard language as a direct result of the work done in Task 19. Pushing cold climate issues into standards has been made possible by the long runtime of the task.

The impact of Task 19 has been largest when offering practical actionable solutions to problems identified by industry stakeholders and it would be important to allow this work to continue.

When Task 19 started cold climate wind was quite niche even compared to the size of then quite small wind power sector as it was. Today, Task 19 has estimated cold climate wind capacity to be roughly 156 GW or ~20 % of the global wind power market. This capacity is mainly located North America, Scandinavia and Central Europe and the installed cold climate fleet is still estimated to grow at a rate of 13.5 GW/year. (Karlsson, 2021)

A retrospective on the growth and evolution of Task 19 is presented along with future plans and a roadmap for the coming years.

Rerefences:

Karlsson, T. (2021). IEA Wind Task 19: Climate wind market study 2020-2025. Winterwind 2021.

Web site: https://iea-wind.org/task19/

Short biography: Timo received his M.Sc. degree form Aalto University in 2012, from the School of electrical engineering, with speciality in automation and control engineering. He has been employed at VTT since 2011 working as a research scientist in VTT Wind power technologies group. During his time at VTT Timo has been working on numerous R&D projects related especially to wind power technology development. These projects have covered developing signal processing tools for wind turbine performance assessment and automatic ice detection, control system design for blade heating system,

R&D areas/s: B) Technology

embedded system development, and development of GIS tools for icing risk assessment for wind power applications. He's been the operating agent of Task 19 since 2018.

R&D areas/s: B) Technology

Ice Detection Guidelines for Wind Energy Applications by IEA Wind TCP Task19

Charles Godreau, Nergica, CA

Yanick Paquet (Nergica,CA), Paul Froidevaux (Meteotest, CH), Andreas Krenn (Energiewerkstatt, AT), Helena Wickman (Vattenfall, SE)

In icing climates, ice detection is fundamental to the optimization of wind turbine operations. Specifically, ice detection is used in a wide variety of wind turbine applications, e.g. controlling a rotor blade heating system, ensuring safe operation with respect to ice throw, preventing structural damage to the wind turbine due to the presence of ice, predicting production losses for the coming days, quantifying icing-related production losses during the previous winter season, or quantifying the average share of annual production that a future wind turbine will lose due to icing.
Each of the applications listed above requires an ice detection method tailored to its specific needs. For example:

- Some applications require accurate detection of light icing and early accretion, while others need to accurately differentiate between different severe icing loads.
- For some applications, adequate quantification of ice loads is most important, while for others, correct identification of ice growth periods is more relevant.
- Safety-related applications require particularly high reliability and availability, while simplicity and price are important in other cases.
- Some applications require detection of rotor icing, while in other cases instrumental icing is sufficient or even more appropriate.

Due to the wide variety of ice detection methods and applications mentioned above, prospective users often struggle to determine which ice detection method or system best suits their needs.
The wide variety of existing ice detection methods also makes it difficult to compare them with each other, which prevents a good synchronization of the behaviour of different ice detection systems.
Over the last two years, the IEA Wind TCP Task 19 has defined guidelines for ice detection methods developed for wind energy applications.
This presentation will provide an overview of the complete report: background information on ice detection and its practical applications in wind energy, a classification of available methods and specific requirements for several wind energy applications. The objective of these guidelines is to pave the way for the optimization, standardization and synchronization of ice detection as it is performed by different methods and systems.

Web site: https://www.linkedin.com/in/charles-godreau/

Short biography: As Project Manager, Research and Innovation, Charles Godreau specializes in wind turbine performance assessments in cold climates and icing detection/protection systems. Besides possessing strong skills in data analysis for operational turbines as well as developing, planning and implementing research projects, he has also participated in a number of conferences. He notably represents Canada in the International Energy Agency's Task 19 working group on wind energy in cold climates and is an active member of Winterwind's program committee. In his free time, he enjoys backcountry snowboarding, stand-up paddle surfing and improv.

R&D areas/s: E) Operation and forecasting

A novel model for glaze ice accretion

Robert Szasz, Lund University, SE

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

In glaze ice conditions the incoming droplets do not freeze instantaneously upon impact on solid surfaces. Instead, a water film is developed on the surface which freezes at locations further downstream. As a result, in order to accurately model glaze ice conditions, one needs to use a multitude of interacting models to describe the impact of the droplets, the formation of the water film and the heat transfer between the air, the water film and the solid surfaces. The large number of required models renders the CFD computations heavy both directly, by increasing the computational time needed to evaluate the models, and indirectly due to slower convergence as a result of the large number of degrees of freedom. The goal of this work is to develop a simpler and more efficient model to account for glaze conditions. The increased efficiency compared to classical models is achieved by reducing the number of physical phenomena explicitly accounted, however, it will be less general and validation is needed for certain icing conditions.

The main idea is to base the development on a model for rime ice conditions but not allowing the droplets to freeze instantaneously. Instead allowing them to slide along the surface during an a priori defined freezing time, ft, thus, mimicking the cooling and eventual freezing of the droplet as it comes in contact with the cold surface. During sensitivity studies of the model we work with setting the time delay as well as the droplet elasticity factor, e, which is the ratio between the wall normal and wall parallel velocity components. The latter is used to adjust the wall boundary condition of the droplet to account for the effect of surface tension which tries to prevent the droplet from rebounding off the surface. Below we will vary ft and e to see their respective influence on the ice accretion. It should be noted that the freezing time of a droplet could be estimated from solving the time dependant conduction equation for a spherical droplet with knowledge of the initial and exterior temperatures.

We chose to compare our model against the experiments reported in Hochart et al [1] and we chose to focus on cases corresponding to mild and severe glaze ice conditions. Considering the accreted ice mass, we observe only a minor influence from ft and e and we also note an overprediction of the total mass by 24% and 58% for the mild and severe cases, respectively, which is somewhat higher than what we found previously for rime ice cases. However, we see a slight difference in the distribution of ice on the aerofoil. One can observe that even allowing a relatively long freezing time, the shape of the ice does not change significantly if the parameter, e, controlling the elasticity of the droplet collision with the surface was set to zero. Hence, the impacting droplet parcels are trapped in the low velocity region in the proximity of the wall, leading to very small displacements even for long freezing times. Varying the elasticity parameter leads to better agreement of the ice shape with the experimentally observed contour from Hochart et al [1] in the leading edge region and to slightly increased amount of ice accreted in the trailing edge region.

This work is an effort to implement a fast ice accretion model applicable for glaze ice conditions. Considering the fact that the amount of physical models is significantly reduced we deem that the accuracy of the model is reasonable for mild icing conditions. Further development will include finding a stronger coupling between the model parameters and the meteorological conditions, which will improve the applicability.

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[1] Hochart C., Fortin, G. and Perron, J. Wind Turbine Performance under Icing Conditions, Wind Energ. 2008; 11:319-333, DOI: 10.1002/we.258

Web site:

Short biography: R.Szasz received his PhD at Lund University in 2004. Since 2004 he is working at the Department of Energy Sciences, Lund University, currently as researcher, the main topics of interest being isothermal and reacting swirling flows, acoustics and flows related to wind turbines.

R&D areas/s: A) Policy and Market, B) Technology, C) Development and financing, E) Operation and forecasting

Cold climate validation testing using a large climate chamber, cold-start-up test bench and large size ice spray array

Bram Cloet, Sirris, BE

Daniele Brandolisio (Sirris, BE), Ozlem Ceyhan Yilmaz (Sirris, BE), Pieter Jan Jordaens (Sirris, BE)

1. General summary
Wind turbines are more frequently installed in remote areas, where often profitable wind conditions makes such sites attractive to implement wind farms. On the other hand, such locations have to deal with extreme inhospitable climatic conditions: extreme cold or hot temperatures, strong winds, gusts, high humidity, atmospheric or splash icing, snow, or salty conditions depending on the site. In cold climate markets wind turbines need to be capable of operating below -30°C and need to be capable of surviving -40°C conditions. These events form a challenge for the machine itself and maintenance works. Some repairs even have to be postponed due to safety and thereby affect the turbine availability and business case. OEM's and component suppliers develop specific cold climate package solutions for these markets to increase the reliability and robustness of the turbine. Dedicated cold-start procedures, the use other materials, lubrication or di-electric fluids and all kind of monitoring and mitigation solutions when dealing with icing are developed nowadays. In order to learn and validate how these solutions perform in a real cold climate event, and to investigate the reliability of such adaptations in real scale, dedicated testing infrastructures are needed to help the industry. We will share 8 years of experience of validation testing in one of Europe's largest climatic test chambers with specific attention to cold climate testing of turbine components. Also a new icing test array feature will be explained that can be used to investigate specific ice related issues.
2. Method
In 2010 a large climate chamber was built-up in Belgium to support the design validation testing of large wind turbine components. The climate chamber was foreseen with the ability to recreate -60°C to +60°C environments in a 560m^3 test room. In order to perform system testing of gearboxes to evaluate cold start torque, warm-up times and the functioning of lubrication units a no-load test rig was developed. In order to test liquid filled transformers for cold start functioning, an electrical test concept was built in the same climate chamber. Recently a new feature was set-up, an icing test array, that will be used to evaluate anti-ice coatings, ice detection and de-icing strategies as alternative to climatic wind tunnels which are more costly.
3. Results
The failure of small parts such as a lubrication pump, heater or a sensor that is tested as individual part can still cause unforeseen failures in a system test approach during tests. Most suppliers know the added value of system testing and they put effort in developing dedicated cold climate packages. On the other hand we see that there is room for improvement to research cold climate fatigue issues. For liquid filled transformers, the tank-pressures due to temperature fluctuations can be tested more cost-effective in an accelerated way by using an hydraulic test-bench than using a climate chamber. In respect to the ice spray testing we believe that alternative ice adhesion test approaches can be promising to bench test anti-icing coatings as done nowadays.
4. Conclusions
The experience obtained in the climatic test campaigns has learned us that design validation testing at system level apart from material coupon testing, sub -and component testing tends to be very valuable to ensure elimination of design flaws at early stage. The experience obtained by working together with leading suppliers has shown us that special attention is made for tackling potential cold climate issues and the adaptations tend to be effective. A new approach was investigated to deal with ice testing as alternative to climatic wind tunnels. This approach will be used in the future to bench test the performance of anti-ice coatings. An alternative ice adhesion test approach tends to be promising in such testing large scale test approach.

Web site: https://www.linkedin.com/in/bramcloet/

Short biography: I've been working in the energy sector since 2007. I'm currently Senior Engineer Onshore and Offshore Wind Energy Industry at Sirris. Previously I was working on long term operation

R&D areas/s: A) Policy and Market, B) Technology, C) Development and financing, E) Operation and forecasting

projects for the Belgian nuclear power plants (Tractebel/Syngenia). Therefore I was teamleader at the Global Product Design Group of CG Power Systems (formerly Pauwels Trafo) for managing R&D projects related to the development and improvement of high voltage distribution transformers. In 2007 I got my master degree in Mechanical Electrical Engineering (option electrical energy) at the KULeuven in Leuven, Belgium.

R&D areas/s: E) Operation and forecasting

Wind measurment that works in cold climate

Emil Dahl, AQ system AB, SE

Jan Åke Wallin, Vattenfall Service nordic AB (SE)

”Wind measurement in harsh winter climates can present difficulties. Choosing the right measurement equipment is crucial to collect usable data. Data from five Vattenfall measurement projects of a combined time of 13 years where five AQ510 Cold winters were used in challenging climates show the reliability and robustness of the AQ510. Presenting an average uptime of 98%, data availability at 100 meters of 97% and measurement consistency of <1% ranging over three calibrations per unit. The measurements in the study have been in climates spanning from the polar circle to the middle of Sweden. Between every project the sodars have been calibrated against a 100m mast for verification and the results shows the accuracy of the AQ510. Robust technology, no moving parts and sophisticated snow and ice melting solutions allow the AQ510 CW to measure in the coldest of climates. A comment about the AQ510 from Jan-Åke from Vattenfall service Nordic
“The main issue with the new generation is that failures are so rare that this prevents the engineers from getting experienced”

Web site: www.aqs.se

Short biography: Pelle Hurtig has over 20 years of International sales and marketing experience. Almost 15 years of his career have been spent in the renewable energy industry. He came to AQSystem 2005 and before that working for multinational companies with key roles, including, Marketing, Sales and Technical support Manager.
His technical background and education as mechanical designer have also been very important for the growth of AQSystem for the past years.

R&D areas/s: B) Technology

Drone Based Direct Wind Resource Measurement & Performance Monitoring

Rasmus B. Lajevardi, First Airborne Ltd, IL

Rasmus B. Lajevardi (DK)

Problem
The simple truth is that when the energetic value of the harvested raw material - in our case the wind resource, is not directly measured - it is by definition impossible to accurately determine whether production levels are consistent with required WTG power-curves.
This is the incentive for the deployment of external wind measurement/performance monitoring technologies in operating wind farms – the most common of these technologies being LiDAR devices. However LiDARs have an exceedingly low penetration in the wind-power OPEX market - mainly due to their cost and extensive logistics: They have to be moved from one WTG to the next, calibrated, carried, and even craned if nacelle based. This results in a miniscule number of turbines which are constantly monitored for performance issues - examples of which originate in phenomena such as nacelle misalignment, sector-based power reduction, software-induced power reduction and different control /sensor drifts.
In short, stationary devices which require manned labor fall short when it comes to constant farm-wide performance monitoring and therefore significant income recovery potential remains untapped. Enter the era of unmanned & resident robotics.
Solution
Wind turbines are remote, unmanned and very tall, and therefore naturally well complimented by resident (permanently on site) airborne robotics for various use cases – inspection for example. In the case at hand, the positioning of an aircraft which can accurately measure upwind of any and all WTGs in a wind farm, and while doing so automatically adjusts its position to the prevailing wind sector, leads to constant, farm-wide WTG performance monitoring and analysis, which in turn leads to significant income recovery.
Considerations:
1. The system at hand must be resident, automatic and unmanned to efficiently render services
2. It would be most useful should such a system consist of additional important services such as automated blade inspection. When the wind is up: performance monitoring, when down: inspection.
3. Accuracy & Precision validation: A rotor-based aircraft creates its own climate and wakes – these must be isolated and eliminated as is the case of Windborne - First Airborne's globally, patented, aircraft-deployed wind measurement instrument.
4. Campaign duration: The mobile nature of such a system is where it outperforms its stationary rivals many times over. By "hopping" from one turbine to the next, assessing WTG performance vis-à-vis the measured incoming wind, it can efficiently collect a predetermined sample amount per wind-bin and/or wind-sector. Once it has accumulated the required quota it will automatically seek to fulfil the quota required for other turbines in the windfarm. Experience shows that resident solutions generate 3-5 performance campaigns yearly for every single WTG within a windfarm of 60 WTGs.
5. Customer policies: customers should be able to remotely apply service policies and parameters to the wind farm and to selected turbines
6. Integration: For best results the system should be interconnected with WF SCADA to quickly deliver performance insights.
7. Technology: resident robotics require advanced technology and architecture: Autonomous navigation, proximity-sensing, redundancy, battery charging, SCADA connectivity and accurate landing are but a few examples.

Web site: www.firstairborne.com

Short biography: https://www.linkedin.com/in/boaz-peled-37ab622/

R&D areas/s: B) Technology

Long-term high-efficient Graphene-based anti-/de-icing coating

Jun Chen, Lulea University of Technology, SE

Jun Chen (LTU, SE), Marcus Björling (LTU, SE), Pär Marklund (LTU, SE), Yijun Shi (LTU, SE)

Ice build-up is a ubiquitous phenomenon in nature, which can pose a serious catastrophic impact on a wide range of systems. Wind turbine blades work has been seriously affected. In this study, we developed a green hydrophobic graphene-based anti-/de-icing coating. To avoid the unfriendly environmental problems, we adapted the graphene water slurry to fill the poly(vinyl) alcohol-water solution and in situ polymerized the siloxane urea crosslinked polymer inside the coating. The graphene ensured high electric conductivity and great photo-thermal behavior, crosslinked polymer network provide enough strength and hydrophobic property. We successfully achieved high conductivity and hydrophobic in a composite coating at the same time, rather than a multi-layer structure. This sustainable composite coating shows excellent anti-/de-icing behavior with solar power and under 48V safety voltage in real weather conditions.

Web site: www.ltu.se/staff/j/junche-1.201338?l=en

Short biography: Jun Chen is currently a Ph.D. student at Lulea university of technology. He obtained his master's degree from Nanjing Forestry University in Nanjing City in 2019. His research interest includes the Nano-modified polyurethane and multi-function self-healing polymers, and their application in organic coatings and engineer materials.

R&D areas/s: C) Development and financing

ArcticDEM – Next generation elevation model for wind farms in cold climate?

Morten Lybech Thøgersen, EMD International A/S, DK

Marie Cecilie Pedersen (EMD, DK), Lasse Svenningsen (EMD, DK), Tobias Ahsbahs (EMD, DK)

ArcticDEM is a high-resolution digital surface elevation model (DSM) recently made available from the Polar Geospatial Center (PGC) of the University of Minnesota, USA. The model has a very high grid resolution, down to two meters, and covers all territory north of 60oN along with the full territory of the arctic regions of Greenland, Alaska, and Kamchatka peninsula. The ArcticDEM model has the potential to become the default choice of elevation model when developing wind farms at high latitudes. However, it takes time and effort to build experience and trust in a new elevation dataset, learning it's inherent qualities and potential pitfalls.
Establishing a reliable model of terrain elevations and understanding it's limitations is an important and integral part of wind resource assessment and microscale flow modelling [1]. Typical practice is using digital elevation models (DEM) from national, regional or global data sources. The two most prominent widely used global models are the Shuttle Radar Topographic Mission (SRTM) and CopernicusDEM [2].
This study analyses the performance of the ArcticDEM, SRTM and CopernicusDEM by utilizing different ground-control-points (GCPs) relevant for wind energy applications. We calculate statistics of the vertical accuracy for each elevation model and focus selected GCPs on locations that are representative of wind energy sites, including complex sites with steep terrain and/or forest. The vertical error for the ArcticDEM model is analyzed at 1000+ existing wind turbine locations and compared to the error for the well-established and trusted DEMs SRTM and CopernicusDEM.
In addition to the existing wind turbine locations where the GCP elevations are established from high-quality national elevation models (typically obtained from aerial LiDAR campaigns), we also include two other sources of GCPs where the vertical coordinate is known accurately: ground point samples from the ICESAT2 satellite mission and aerial runway endpoints.
The results are presented for different land-cover (LC) types, e.g. inside or outside forest. Classification of LC is determined from the most recent global databases: the Copernicus LC-100m and the recent World-Cover 10m datasets.
References:
[1] Thøgersen, Svenningsen & Sørensen: High Fidelity Elevation Models - What is the Value in Microscale Modelling?, Resource Assessment Workshop 2019, WindEurope, 2019, Brussels.
[2] Thøgersen et al: windPRO online data: Digital Elevation Models.
Available at: https://tinyurl.com/emd-dems

Web site: https://www.emd-international.com/

Short biography: Morten Lybech Thøgersen is a wind-energy senior technical specialist at EMD in Aalborg, Denmark, the developers of the windPRO software. His specific research interests are within applied methods and include: data analysis, probabilistic methods and loads, global reanalysis data, GIS and land-surface data, machine-learning, big-data and high-performance computing. Morten enjoys software development - with focus on creating end-user value by integrating data and models into the windPRO toolchain. Prior to joining EMD, Morten was a scientist at Risø National Laboratory (now DTU Wind Energy).

R&D areas/s: B) Technology

Preliminary Investigation into Shear-Web Behaviors under Thermal Loads from IPS

Dylan Baxter, Borealis Wind Inc., CA

Dylan Baxter (Borealis Wind, CA), Marie-Laure Dano (Universite Laval, CA)

Borealis Wind Inc. has created an Ice Protection System (IPS) which circulates hot-air inside wind turbine blades to prevent and remove ice accumulation. During operation, air temperatures inside the blade typically reach +40C when the IPS is on, then drop back to ambient temperatures, typically -20C, when the IPS is off. Borealis contracted M^3C Laboratories at the University of Laval to subject polyester-balsa shear-web samples up to 1400 thermal cycles which mimic IPS operations, inspected the samples under microscopes for voids and micro-cracks, and completed ASTM C393/C393M-20 three-point bending tests on the samples inside a heated chamber until failure was observed. This presentation will outline the methods used during testing, the preliminary results, and discuss the potential presence of relationships between the number of thermal cycles, the temperature at which the shear-web is stressed, and the magnitude of the failure load. This presentation will close outlining how Borealis Wind Inc. utilizes this information to ensure safe heating techniques.

Web site: www.borealiswind.com

Short biography: Dylan is the Sr. Mechanical Engineering and Operations Manager at Borealis Wind Inc. He holds a B.A.Sc. in Mechanical Engineering from the University of British Columbia and is a member of Professional Engineers Ontario. He first entered the wind industry in 2016 and has completed research for universities in Canada and Germany. He is interested in all forms of renewable energy, sustainable practices, and anything related to skiing.

R&D areas/s: C) Development and financing, E) Operation and forecasting

An open source ice model running in WRF

Jana Fischereit, DTU Wind and Energy Systems, DK

Marc C. Kelly (DTU Wind and Energy Systems, DK), Neil Davis (DTU Wind and Energy Systems, DK)

In cold climates, icing of the turbine blades can be a major issue when designing a wind farm. Ice growth on turbine blades can lead to production losses and increased noise, with the potential for ice throw causing risks to nearby persons and property. Turbine manufacturers have developed ice prevention systems to help reduce these factors, but there is still an open question of when to purchase such systems, and for what turbines. Additionally, ice forecasts combined with careful management of turbines can reduce the impact of icing in affected areas.
IceBlade aims to fill this gap by estimating the amount of icing that a turbine will experience at pad level, in terms of icing-related production loss, using meteorological modeling. The iceBlade model represents the turbine airfoil as a static cylinder, and accounts for both ice accretion and ice ablation. It has been used and validated in previous studies (Davis et al. 2014, Davis et al. 2016).
The source code of iceBlade incoorperated in the mesoscale model WRF is now released on DTU's gitlab server. Accompanying that release, for the first time a case study comparison with measurements was performed. The measurements were made in the project ICE CONTROL (2016-2019) conducted by the Zentralanstalt fuer Meteorologie und Geodynamik (ZAMG), the University of Vienna, VERBUND Green Power GmbH, and Meteotest AB, whom kindly provided the data. The measurements have been published graphically in Strauss et al. (2020). In our presentation, the verification results for this case study will be shown.
To investigate its performance and potential impact, we also undertake a comparison between icing prediction from iceBlade with predictions using combined temperature and humidity according to the emerging IEC uncertainty standard. To do so we use simulations for Northern Scandinavia from the New European Wind Atlas (NEWA, https://map.neweuropeanwindatlas.eu/). Preliminary results of this comparison, and relevant statistics, will be presented.

Neil Davis, Andrea N. Hahmann, Niels-Erik Clausen, and Mark Žagar. Forecast of icing events at a wind farm in Sweden. Journal of Applied Meteorology and Climatology, 53(2):262 – 281, 01 Feb. 2014. doi:10.1175/JAMC-D-13-09.1.
Neil N. Davis, Pierre Pinson, Andrea N. Hahmann, Niels-Erik Clausen, and Mark Žagar. Identifying and characterizing the impact of turbine icing on wind farm power generation. Wind Energy, 19(8):1503–1518, 2016. doi:https://doi.org/10.1002/we.1933.
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Web site: https://windenergy.dtu.dk/english/research/research-sections/ram

Short biography: Jana Fischereit has a background in meteorology and a PhD in Earth System Sciences from Hamburg University. Since 2019 she has been working at DTU Wind and Energy Systems in the section on Resource Assessment and Meteorology focusing mostly on coupled mesoscale modelling of the atmosphere. She is part of the Danish representative team in the IEA Task 19. In her free time she enjoys to be outside both in summer and winter.

R&D areas/s: B) Technology

Lifetime extension of main bearings, scientific calculation and practical implementation

Stefan Bill, Rewitec GmbH, DE

Vanessa Bill (Rewitec GmbH, DE)

REWITEC, as a part of Croda International Plc, is a developer and manufacturer of an innovative particle-based surface treatment Phyllosilicate-technology for increasing the reliability and lifetime of wind turbine gears and bearings. The active particles are compatible to all common oils and greases and use lubricants as a carrier to build through their adsorption a protective and repairing phyllosilicate-based coating on the surface. The modified surface has a significantly lower surface roughness, which ensures a better load distribution, lower local pressure and lower tribological stress. Additionally, due to the special layered material structure the particles can be sheared in the tribological contact, which leads to a reduction in friction.
Wind turbine maintenance and component failure is costly, with bearings and gearboxes contributing significantly to downtime and repair costs.The Phyllosilicate-Additive technology helps to significantly reduce or even prevent the damage, whereby an application is recommended for both new and already damaged systems. The technology is an innovative lubricant additive with a protective and repairing effect, which mainly consists of phyllosilicates in the form of micro and nanoparticles. After the application of the innovative technology, the new, modified surface is optimized and protected from a tribological point of view, so that surface roughness, friction, wear, and temperature in the system are reduced. This leads to a significant improvement in efficiency and lifespan.
All in all, when applying the products systems can run better with reduced friction, wear, surface roughness and temperature. These effects lead to great reliability and longer lifetime and reduce costs. In this presentation we would like to show our new scientific study about the lifetime calculation of a grease-lubricated wind turbine bearing (1.5 MW) with and without the technology application.

Web site: https://www.crodaenergytechnologies.com/en-gb/applications/wind-turbine-lubricants

Short biography: Stefan Bill is Business Director at Croda GmbH and Managing Director at REWITEC GmbH. He is the inventor of the REWITEC technology, applied the relevant international patents for it in 2012 and has now been active in the lubricant and additive business for 17 years. Stefan studied electrical engineering with a focus on electrical drives. He has held various management roles at ABB and other drives business companies.