

WIND ENERGY IN COLD CLIMATES

IEA TASK 19

Winterwind 2011, Umeå, Sweden
February 9th 2011

Timo Laakso, Pöyry Finland Oy
Lars Tallhaug , Kjeller Vindteknik, Norway
Göran Ronsten, WindREN AB, Sweden
René Cattin, METEOTEST, Switzerland
Ian Baring-Gould, NREL, USA
Antoine Lacroix, Natural Resources Canada, Canada
Esa Peltola, Technical Research Centre of Finland, Finland
Tomas Wallenius, Technical Research Centre of Finland, Finland
Michael Durstewitz, ISET, Germany
Mira Hulkkonen, Pöyry Finland Oy
Andreas Krenn, Energiewerkstatt, Austria

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- ➔ • IEA TASK 19 Introduction
- COLD CLIMATE MARKET What size?
- RESULTS 2001-2008 Done so far
- OBJECTIVES 2009-2012 Ongoing activity
- SUMMARY Near future


INTRODUCTION – IEA TASK 19

- **Collaboration** between countries and organizations in order to collect information in wind power project development, construction and usage at areas where low temperatures and atmospheric icing affects operation of wind turbines
- **Cold Climate:** Sites with either icing events or low temperatures outside standard operational limits of wind turbines
- **Aim:** To reduce the risk that originate from cold climate and thereby reduce the cost of wind electricity produced in cold climates.
- **Means:** development of tools, methods and guidelines, standardisation work, information dissemination
- Started in 2001, present term 2009-2012
- **Participating countries:** Finland, Norway, USA, Switzerland, Canada, Germany, Sweden, Austria
- **Operating agent:** VTT Finland / Pöyry since 2009
- **Webpage:** <http://arcticwind.vtt.fi>



Photo:Pöyry Finland Oy

MEMBER COUNTRIES AND REPRESENTING ORGANIZATIONS

Country	Contracting party	Company	Representative
Finland 	TEKES	Technical research centre of Finland	Esa Peltola / Tomas Wallenius
Norway 	Kjeller Vindteknik	Kjeller Vindteknik	Lars Tallhaug
Sweden 	Energimyndigheten	WindREN AB	Göran Ronsten
Switzerland 	Swiss Federal Office of Energy	Meteotest	René Cattin
USA 	NREL	NREL	Ian Baring-Gould
Canada 	Natural Resources Canada	Natural Resources Canada	Antoine Lacroix
Germany 	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety	Fraunhofer IWES	Michael Durstewitz
Austria 	Austrian Federal Ministry for Transport, Innovation, and Technology	Energiewerkstatt	Andreas Krenn

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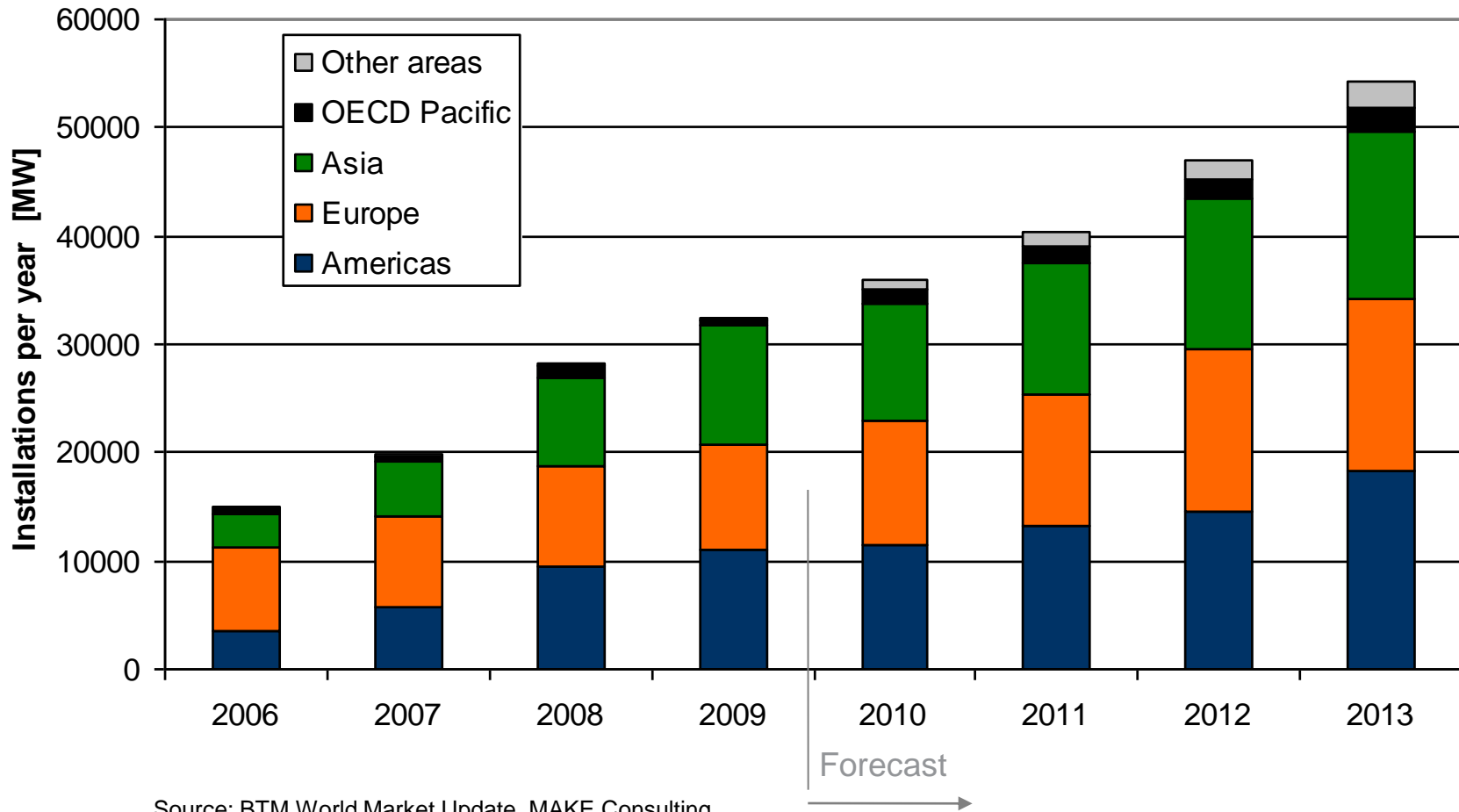
DRIVERS OF COLD CLIMATE WIND POWER

- National renewable energy targets
- Lack of other energy or renewable energy sources
- Growing importance of security of energy supply
- Increasing volatility of fossil fuel prices
- Overall awareness on environmental issues
- Employment and local development
- Improving cost competitiveness
- Technology development
- Higher cost of offshore wind



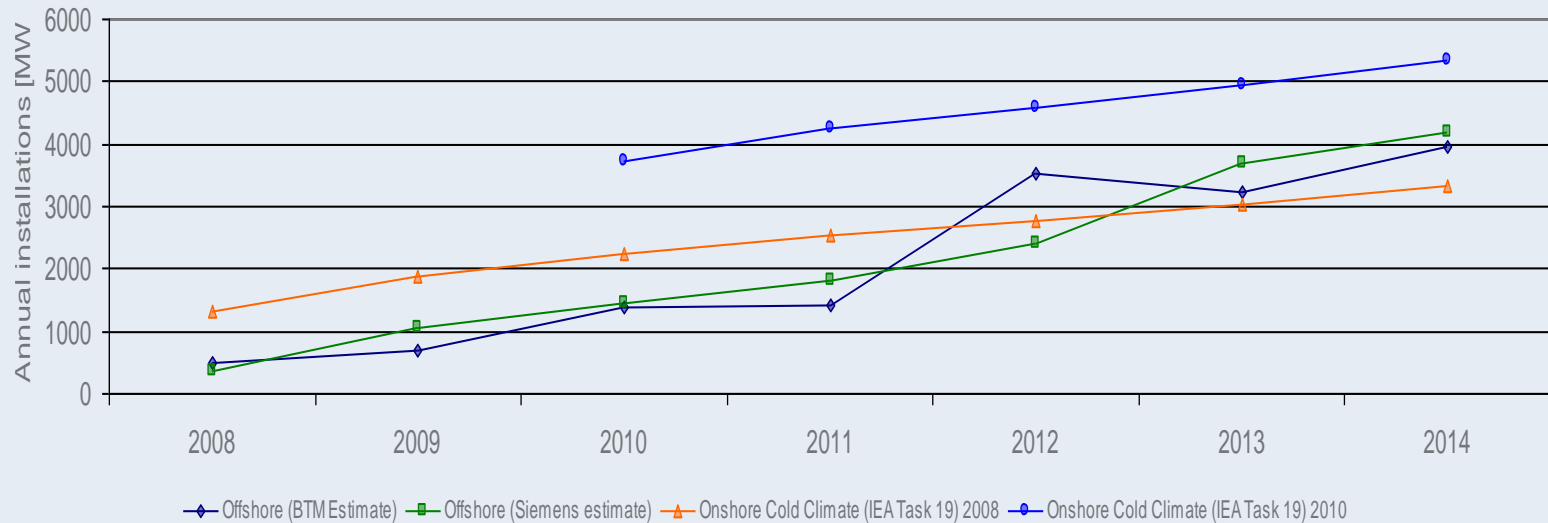
Photo:Pöyry Finland Oy

SHARE OF COLD CLIMATE?



Source: BTM World Market Update, MAKE Consulting

ESTIMATED COLD CLIMATE WIND POWER MARKET



- Turbines are and will be installed to icing and low temperature areas
- The share of cold climate installations annually 5 - 10% of total installations in US, Canada, Europe and China
- Market is segmented to low temperature and icing climate
- Estimated annual installations in cold climate around 5000MW in 2014

PRESENT DAY STATUS

- Cold climate market is still relatively small, but it is growing
- Market is segregated to areas where either low temperature or anti- de-icing or both are needed
- Existing unsolved cold climate specific challenges:
 - Technical: e.g. maturity and commercial viability of ice removal/prevention technologies
 - Economical: e.g. production estimate uncertainties and associated risks
 - Policy related: e.g. project licensing in ice prone areas



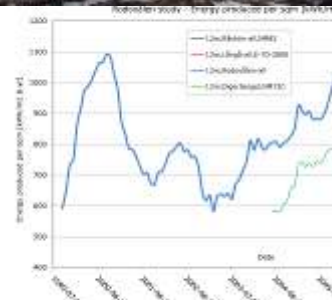
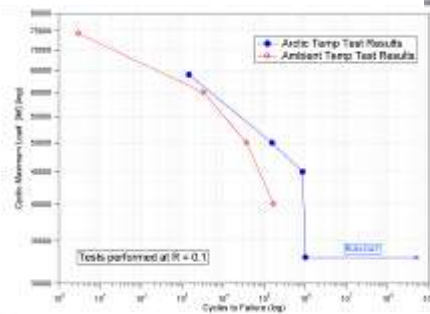
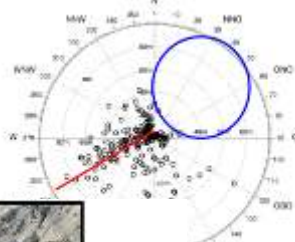
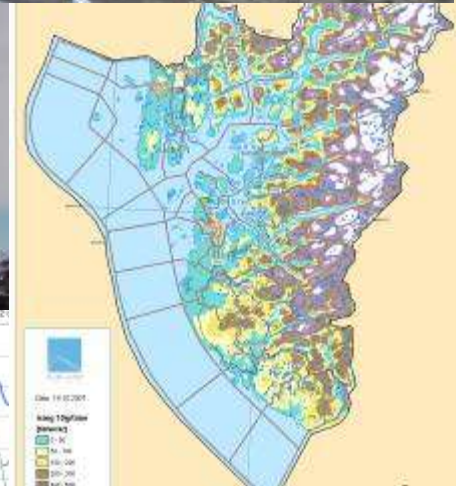
- Thus, various R&D projects which aim at lowering the costs of cold climate wind energy deployments are ongoing in IEA Task 19 participant countries
- The common aim of those projects is to reduce the risk and thereby the cost of wind electricity produced in cold climates:
 - More reliable production estimates to lower the investor risk
 - New technology solutions for anti- and de-icing
 - Statistical information on operation of cold climate wind turbines
 - Market information for the cold climate technology

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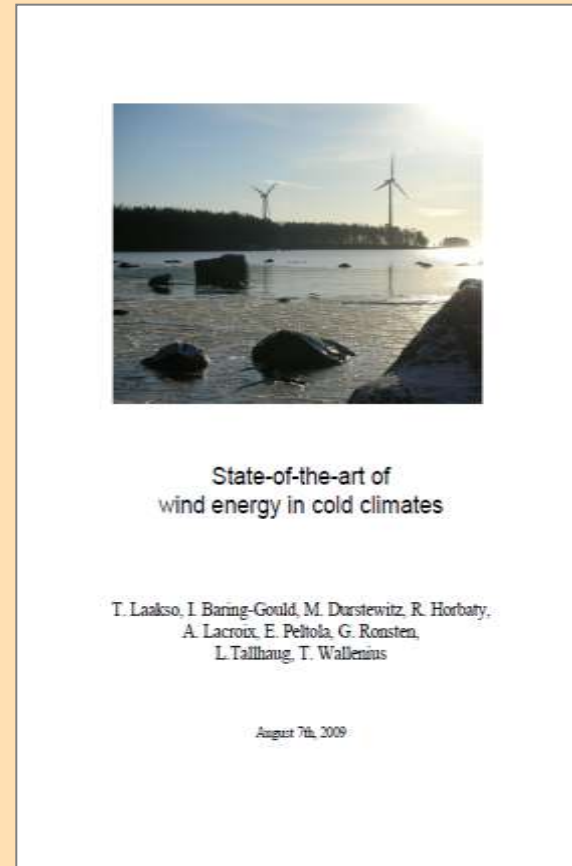
ACTIVITIES IN TASK 19 MEMBER COUNTRIES 2001-2008

- Material testing
- Site measurements
- Ice mapping
- Anti- and de-icing equipment development
- Turbine testing
- Ice throw studies
- Follow-up measurements
- Sensor development
- Icing wind tunnel testing



REPORT: State-of-the-art of cold climate technology

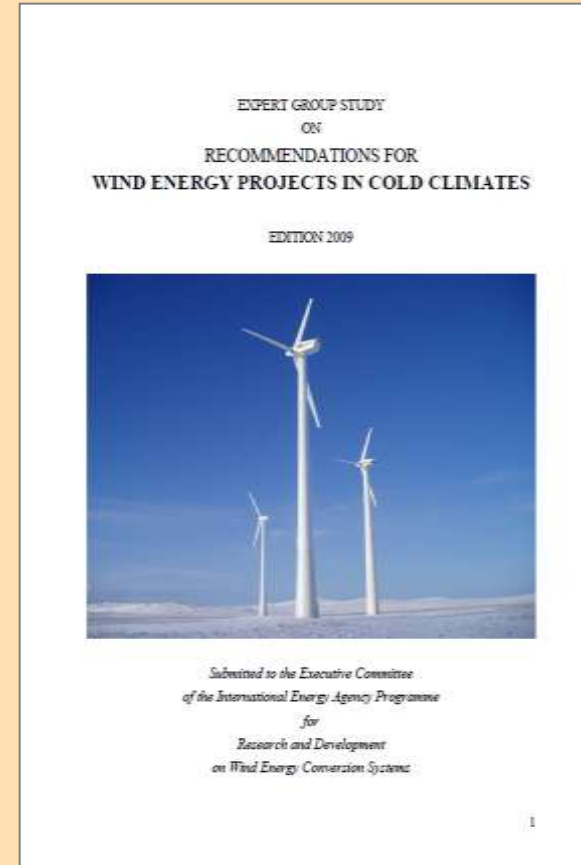
- State-of-the-art technology – report
 - Was published in Fall 2009
- IS commercially available:
 - Heated wind sensors for project development
 - Turbines for low temperatures
 - Ice mapping services e.g. local icing maps
 - Models for calculation of ice accretions
 - De-icing for mild icing climate
- NOT available commercially
 - Long term icing statistics e.g. through national met services
 - Reliable and calibrated ice detectors
 - Models and methods for calculation of ice loads and ice induced loading on wind turbines
 - Verified method for the estimation of the effects of atmospheric icing on energy production
- Question marks
 - Wind turbine technology for severe icing climate



Document available at IEA Task 19 webpage at <http://arcticwind.vtt.fi>

REPORT: Wind energy projects in cold climate

- Wind energy projects in cold climate – report
 - Was published in Fall 2009
- Be aware of the extra risks and costs involved in CC wind energy production at early stages of the project.
- Employ available best practises to the extent possible,
- Conduct a survey to find solutions for each project understanding that CC circumstances vary greatly between different sites.
- Perform a thorough site assessment measurement of at least one year with measurement devices, including ice measurements.
- There is no standard method for estimating ice-induced production losses. Make the best estimate based on the results of site measurements.
- Insure that in the project planning phase CC-related safety aspects, such as low-temperature working conditions and the risk of ice throw, are addressed.
- Carry out a risk assessment that includes assessment of the quality of the selected turbine and experience of the installation company
- Consider the consequences of increased noise due to operation with iced-up blades
- Select CC solutions carefully as these packages differ by manufacture
- Use anti- and/or de-icing systems if site conditions require and proven technology is available.
- Insure that selected wind turbines are only operated under conditions for which they have been certified



Document available at IEA Task 19 webpage at <http://arcticwind.vtt.fi>

SUMMARY ON KEY FINDINGS

- Requirement number one – **reliable site data** often omitted due to the extra cost. Tools i.e. ice maps and appropriate measurement systems available
- Cold climate solutions especially **anti- and de-icing solutions** for heavy icing conditions and acceptable **ice detection** not yet commercially available in the market
- The economical risks involved in cold climate wind energy projects are not fully taken into account in the project development phase. Methods to estimate the effects of ice on energy production have been developed to assess the risks for investor.
- The ice induced extra loading wind turbines can stem from increased operation in rotor imbalance and increased number of start/stop cycles. **There are no requirements concerning these loads in the present standards.**
- The market for cold climate wind technology, including wind farms, remote grid systems and stand-alone systems is showing growth in Canada, Sweden, Norway and Finland.
- Wind turbines will be build in numbers on areas where cold climate criterions will be met **regardless of slow progress in technology development side**



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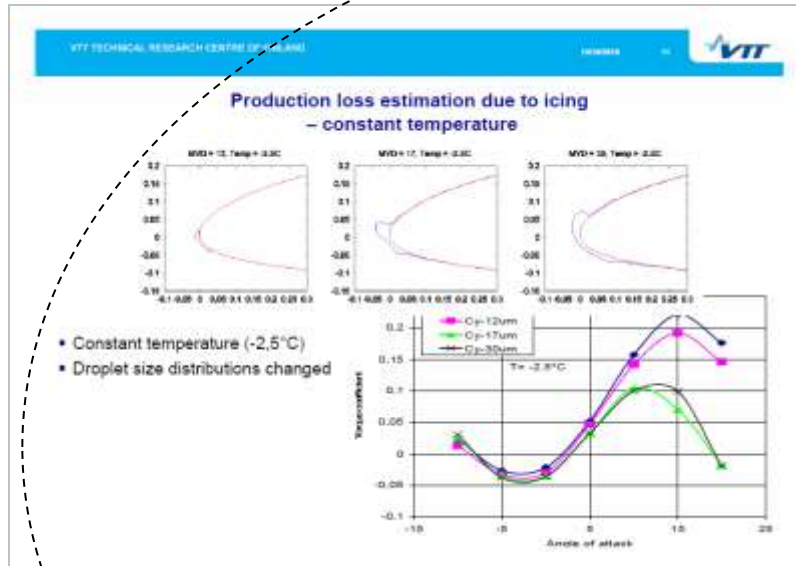
OBJECTIVES 2009-2012

1. To collect information on **ice mapping** to support early phases of project development.
2. To collect experiences related to **icing forecasts** with numerical weather models
3. Find new solutions for **wind resource assessment** in cold climate
4. Collect information on the **anti- and de-icing and coating solutions**
5. Review the **current standards** and recommendations - cold climate perspective
6. Find an improved method for the estimation of the **effects of ice on energy production**
7. Clarify the significance of ice induced extra loading on wind turbine components
8. Initiate a **market survey** for cold climate wind technology
9. Improve the understanding of the risks and the mitigation strategies regarding **ice throw**
10. Reporting



Photo:Pöyry Finland Oy and Kjeller Vindteknikk

NATIONAL ACTIVITIES: FINLAND



VTT TECHNICAL RESEARCH CENTRE OF FINLAND

First experiences from Uljabuouda

- 4 x 3MW WinWind turbines equipped with ice prevention systems
- Experiences from first winter:
 - Average production ~24000 kWh/day on 12/2009 and 1/2010
 - Average heating energy consumption 1,95 % of produced energy
 - Heating energy consumption on February 1,7% and on March 1,3% of produced energy
- 6 turbines will be installed on 2010

Ice atlas for Finland (FMI)

- To be
 - based on same database as Finnish Wind Atlas
 - implemented in Finnish Wind Atlas
- Challenges in verification
 - Limited no. of observation points (Luosto (Lapland), Puijo (inland), Riutukari (coastal))
 - Observation series incomplete and stem from different years
 - Quality
 - The observation years/months chosen based on wind atlas needs

AR1998	1991	1992	1993	1997	2000	2001	2002
January	1991	1992	1993	1997	1999	2001	2002
February	1991	1992	1993	1997	1999	2001	2002
March	1991	1992	1993	1997	1999	2001	2002
April	1991	1992	1993	1997	1999	2001	2002
May	1991	1992	1993	1997	1999	2001	2002
June	1991	1992	1993	1997	1999	2001	2002
July	1991	1992	1993	1997	1999	2001	2002
August	1991	1992	1993	1997	1999	2001	2002
September	1991	1992	1993	1997	1999	2001	2002
October	1991	1992	1993	1997	1999	2001	2002
November	1991	1992	1993	1997	1999	2001	2002
December	1991	1992	1993	1997	1999	2001	2002

VTT TECHNICAL RESEARCH CENTRE OF FINLAND

Anemometers and ice detectors under icing conditions

- Method for comparing sensors to help users
 - Anemometers
 - Ice detectors
- Method/tool to define needed heating for sensors to help manufacturers
- In icing wind tunnel under controlled conditions

IEA RAO Workshop, 16-18.5.2010, St. John's, Canada

NATIONAL ACTIVITIES: SWITZERLAND



IEA Task 19 Wind Energy in Cold Climate Swiss Activities

Instrumentation




 Schweizerische Eidgenossenschaft
 Confédération suisse
 Confederaziun svizra
 Confederaziun svizra
 Swiss Federal Office of Energy SFOE

IEA T19 meeting Helsinki, October 18 to 20, 2010

IEA Task 19 Wind Energy in Cold Climate Swiss Activities

Icing Project St. Brais (2009 to 2011)

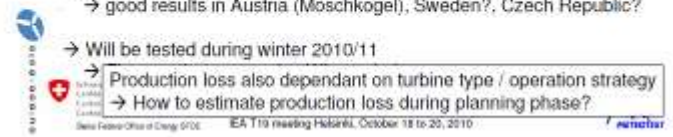
Cost/Benefit of Blade heating:
Based on budgeted yearly production of 7'000 MWh

- Energy needed for blade heating: ~0.4%
- Additional production thanks to blade heating: ~7%
- Lost production due to stopped turbine during heating: ~3%
- Lost production without blade heating: ~10%

→ Further optimisation: Heating during operation (same heating)
→ good results in Austria (Moschkogel), Sweden?, Czech Republic?

→ Will be tested during winter 2010/11

→ Production loss also dependant on turbine type / operation strategy
→ How to estimate production loss during planning phase?



IEA Task 19 Wind Energy in Cold Climate Swiss Activities

Icing Project (2009 to 2011)

2 Enercon E-82
Hub height 78 m
Blade heating (~80kW)




 Schweizerische Eidgenossenschaft
 Confédération suisse
 Confederaziun svizra
 Confederaziun svizra
 Swiss Federal Office of Energy SFOE



IEA T19 meeting Helsinki, October 18 to 20, 2010



NATIONAL ACTIVITIES: SWEDEN



Icing measurements at 11 sites in 13 stations
4 telecom. masts and 5 adjacent actual and potential wind farm sites.

WindREN AB

De-/anti-icing systems

1. Black blades - Not sufficient in low solar radiation conditions
2. WindWind/Skellefteå Kraft - A developed JE-system, same as previously used on some 20 Bonus turbines (225 kW-1 MW)? Carbon fibre layer beneath the gelcoat.
3. Enercon/Svevind - Hot air based de-icing system. Official list price: 20 kEuro for 3 fans (20 kW). Will test de-icing during operation at Dragaliden and Silkomhöjden.
4. Nordex/LM/Dong Energy - Hydrophobic coatings and control system development to avoid ice build up.
5. EcoTEMP/o2VK/Vestas - Foil based anti-icing system
6. Kelly/MW-Innovation/o2VK/Vestas - Foil based anti-icing system
7. Goodrich - Foil based anti-icing system, yet to be deployed?

Swedish cold climate wind energy activities, Göran Roester | IEA Task 19 project meeting in Helsinki, Oct 18 & 19, 2010

WindREN AB

Sweden, funding has been granted for the following cold climate projects [kSEK]

Mapping of Icing, Uppsala University, 2009-2012	8 000
Skellefteå Kraft - Anti-icing, 2007-2011	35 000
o2 Vindkompaniet - Icing meas., anti-icing, 2008-2012	72 500
Svevind - 2 cold climate sites, investment subsidy, 2009-	115 000
Dong Energy - orography, coating and control, 2009-	26 000
Nordisk Vindkraft - Havsnäs, icing, foundation, 2009-	20 000
IEA Task 19 - Wind Energy in Cold Climates, 2009-2012	800
VindREN - Wind/Reindeer, 2009-2011	3 340
Swedish University of Agricultural Sciences, Reindeer	2 332
Wind in forests, Uppsala University, 2009-2012	10 000
Total: 29.3 MEuro, 27.7 MEuro excl. forest and reindeer	293 000

* not including work in kind, 1 Euro = 10 SEK

Swedish cold climate wind energy activities, Göran Roester | IEA Task 19 project meeting in Helsinki, Oct 18 & 19, 2010

NATIONAL ACTIVITIES: GERMANY



OVERVIEW OF IWES COLD CLIMATE ACTIVITIES

- participant to IEA Task 19 on behalf of BMU
- Providing information to administration and public (on demand)
- project „utilisation of inland wind energy“
 - partial instrumentation for measuring icing conditions (planning stage)
- Influence of icing events to wind power forecast accuracy
- Is CC an offshore issue ??



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IEA Task 19 meeting / May 17-18, 2010 / St. John's, Canada



RESEARCH FOCI

simulation and assesment of wind turbines

- local calculation with ADCoS Offshore
- Software development for simulation
- Consulting with regard to structural design



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IEA Task 19 meeting / Dec. 3-4, 2009 / Vienna, Austria



RESEARCH FOCI

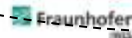
Tools for wind energy integration

- Optimization of generators
- Development of test methods
- Synergistic effects with aviation



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IEA Task 19 meeting / Dec. 3-4, 2009 / Vienna, Austria



RESEARCH FOCI

rotor blade competence center

- Rotor blade, component and material testing
- New concepts for rotor blades
- Development of test methods



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IEA Task 19 meeting / Dec. 3-4, 2009 / Vienna, Austria




NATIONAL ACTIVITIES: CANADA




C E T C CANMET ENERGY TECHNOLOGY CENTRE

Corus Test Centre


- Located in Rivière-au-Renard, Québec
- Commissioned in June 2010
- 2 x 2.05 MW RePower Turbines MM 92
- Elevation: approx. 335 m
- Operation in icing conditions



Natural Resources Canada Ressources naturelles Canada




C E T C CANMET ENERGY TECHNOLOGY CENTRE



0549P wind turbines in Rivard, QC

Natural Resources Canada Ressources naturelles Canada



C E T C CANMET ENERGY TECHNOLOGY CENTRE

Severe Icing

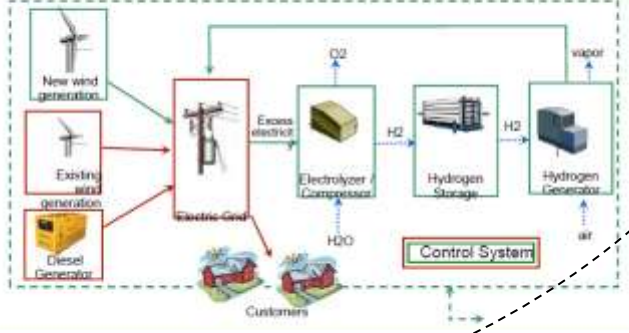


Natural Resources Canada Ressources naturelles Canada




C E T C CANMET ENERGY TECHNOLOGY CENTRE

Wind-Diesel-Hydrogen Development



Natural Resources Canada Ressources naturelles Canada



NATIONAL ACTIVITIES: AUSTRIA



Country Presentation - Austria

Project 'MORE' (Mobile Remote Electricity)

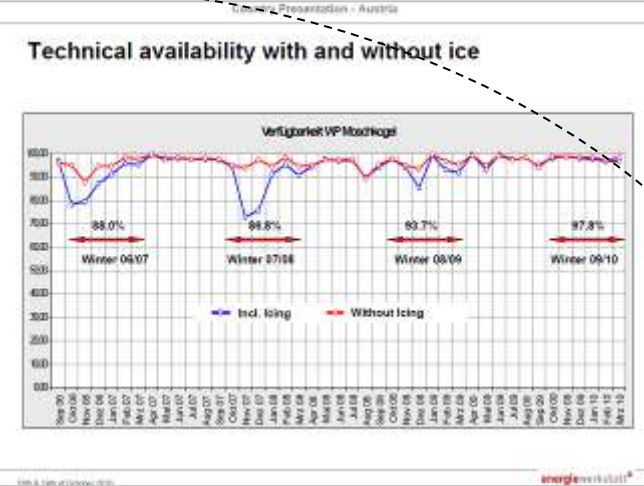
Provision of a mobile and reliable external power supply system for meteorologic measurement stations under extreme climatic conditions

Selection of the most suitable components, whereupon the matching of the components needs special attention

- Development of an EMS controller plate (including software), which is capable of:
 - Production management: Intelligent interplay of the components
 - Load management: Elaboration of a methodology in order to be able to operate and manage the power demand of the sensors according to the actual conditions
 - Thermal management: Minimisation of the internal consumption
 - Provision of a remote control system, which allows a remote
- Test-run of a prototype unit in winter 2010/11 including webcam
- Validation and optimisation of the system in summer 2011
 - Dimensioning of the components
 - Re-setting of the parameter values



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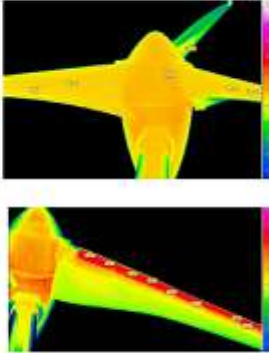
Country Presentation - Austria

ENERCON Blade Heating

De-icing or Anti-icing?

Testing two different systems

- Electrical heating elements inside the blade**
Use of electrical heating resistors inside the rotor blade and inside the leading edge of the blade. For safety reasons a low voltage supply has been chosen.
- Heating by circulation of warm air inside the blade.**
Warm air is generated by a heating register closed to the blade root and dispensed by circulation channels to the leading edge of the blade.



Pictures above: Thermography of the rotor blade before and after switching on the blade heating

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Country Presentation - Austria

no Ice? Enercon Ice Detection System

- Power Curve Method**
Based on the sensitivity of rotor blade profiles against change in contour and roughness. The resulting significant change in a WEC's operating performance is used to detect ice build-up (interrelation of wind / rotational speed / power / blade angle).
Advantage: The power curve method is able to detect ice formation even in a situation when ice detectors on the nacelle are not detecting ice because WEC's with large rotor blades may dip into clouds and thus be affected by icing conditions.
Disadvantage: PCM is not able to detect ice during standstill of the rotor.
- Enercon Ice detector**
Enercon uses LABKO ice detector on the nacelle – no experience available


A reliable ice detection is precondition to any subsequent activity

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Requirements of authorities concerning construction

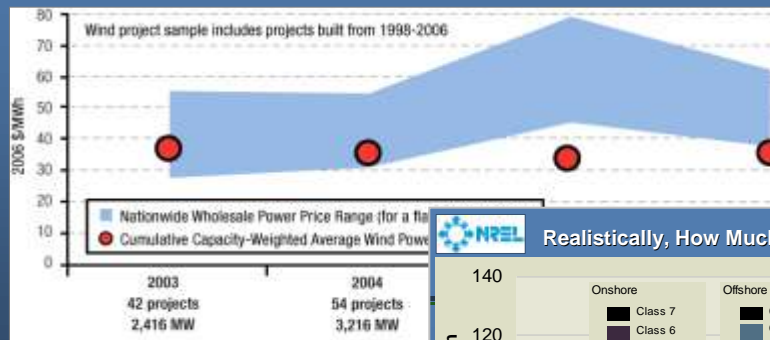
- Warning signs which indicate danger of ice throw have to be placed on each entrance point to the wind farm area in a minimum distance of 250 m to the turbines.
- One single wind turbine has to be equipped with an ice detector for automatic stop of all turbines if danger of icing occurs.
- Operation of wind turbines during ice accretion is not allowed – turbines have to be stopped automatically.
- Automatical Re-start of the turbines during danger of icing is not allowed.
- Manual Re-start of wind turbines after automatic stop due to icing is only allowed under on-site attendance of operational staff.



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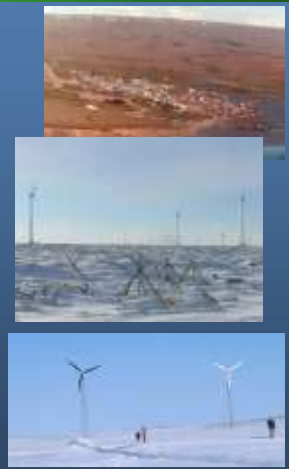
NATIONAL ACTIVITIES: US

Nationally, Wind Has Been Competitive with Wholesale Power Prices in Recent Years

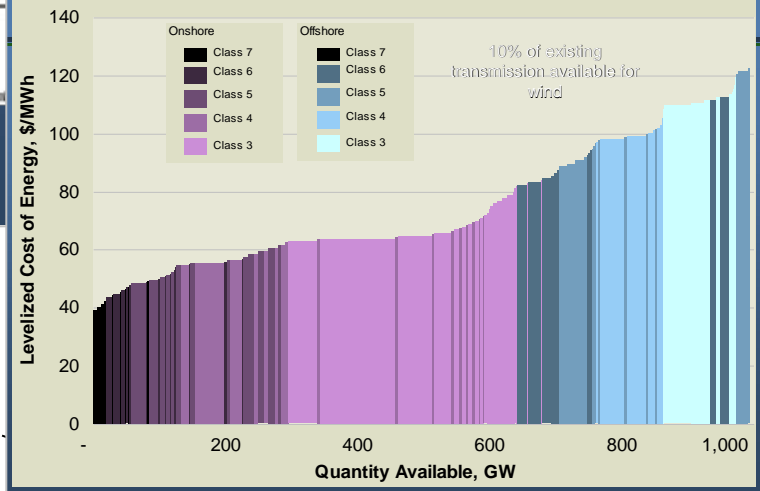


Alaska Activities - Update

- Expanding need for wind in rural areas
 - Fuel prices up to \$7/gal w/ over 100 communities
- Current Status
 - 5 wind/diesel systems operating
 - 5 currently under active development
 - Several being planned
- Toksook Bay - Example W/D System
 - Small community in western Alaska
 - Installation of 3 NW100kW turbines
 - Just over 20% average wind penetration with much higher instantaneous penetration
 - Average Net Capacity Factor of 23.3% from 06 to Aug 07
 - First year turbine availability of 92.4%
 - Permafrost foundations a large problem (Martina)
- Other Projects
 - Kotzebue – opportunity for side by side comparisons due to new SCADA system
- Other work
 - Some limited research activities in icing starting in Colorado
 - More projects experiencing icing related down time – but getting data has been very difficult



Realistically, How Much Wind Is Available in the U.S.?

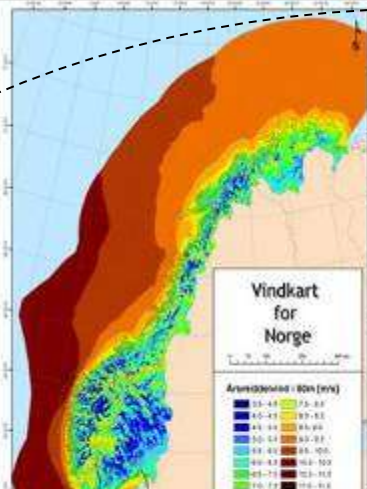


NATIONAL ACTIVITIES: NORWAY



Icing map

- Based on WRF simulations. Maps are made for:
 - Wind speed
 - Full load hours
 - RIX
 - **Hours of icing**
- Financed by Norwegian Water Resources and Energy Administration (NVE)
- Can be down-loaded from:



Modeling of ice with WRF

- Comparisons with measurements in Sweden.
- Model results seems to be well correlated in time with observations. This has not been the case for sites with less severe icing.

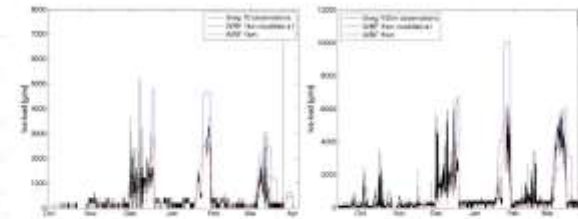
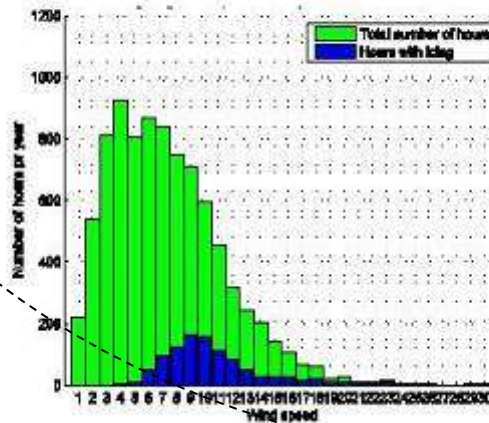


Figure 5 Observed and modeled ice load at Sveq at 70m height (left) and 155m height (right).

Frequency distribution with wind speed



Offshore is in focus in Norway

- Large Governmental report is made, clarifying important issues for developing offshore wind.
- Blocks for floating and grounded are identified.
- Most important areas will be investigated in more detail next year.



DISSEMINATION OF INFORMATION

2009:

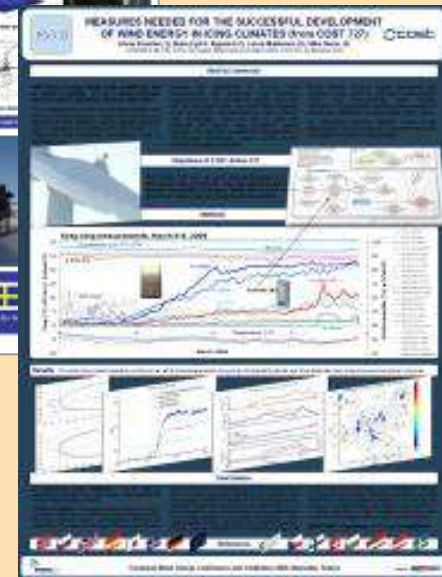
- Oral presentation, IWAS 2009, Andermatt, Switzerland
- Poster presentation EWEC 2009, Marseille, France

2010:

- Poster presentation, EWEC2010 Poland, April 20th – 23rd
- Key-note speaker Ice and Rocks III - Croatia - Zadar May 2010
- Poster presentation, DEWEK, Bremen, Germany, November 2010

2011:

- Oral presentation: Winterwind 2011, Umeå, Sweden, February 2011
- Oral presentation: IWAS 2011, Chongqing, China, May 2011



1. IEA Recommended practices report – Wind energy in cold climates
2. State-of-the-art of Cold climate wind energy - report

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SUMMARY

- International collaboration IEA Task 19 has gathered and disseminated information on cold climate wind energy since 2001
- Wide range of R&D activities underway in participant countries which are likely to produce new solutions that will reduce the present additional risks involved in cold climate wind power projects
- The economical risks involved in cold climate wind energy projects are not fully taken into account in the project development phase. Methods to estimate the effects of ice on production have been developed to assess the risks for investor.
- Solutions especially anti- and de-icing solutions for severe icing conditions and certified/classified ice detection require further development
- The market for cold climate wind technology, including wind farms, remote grid systems and stand-alone systems is still modest but showing growth in Canada, China, US, Sweden, Norway and Finland.
- State-of-the-art report and Guidelines for cold climate wind energy activities has been produced based on the experience gained.
- **Wind turbines will be build in numbers on areas where cold climate criterions will be met regardless of the progress in technology development side**

CONTACT:

IEA Task 19

Timo Laakso

Pöyry Finland Oy

Senior Vice President, Wind power

Telephone: +358 10 3311

email: timo.laakso@poyry.com

