

# IEA WIND TASK 19

## WIND ENERGY IN COLD CLIMATES

### Cold Climate Challenges

EWEA 2011 side event  
Brussels, Belgium  
March 16<sup>th</sup>, 2011

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Göran Ronsten, WindREN AB, Sweden

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Ian Baring-Gould, NREL, USA

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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

## 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

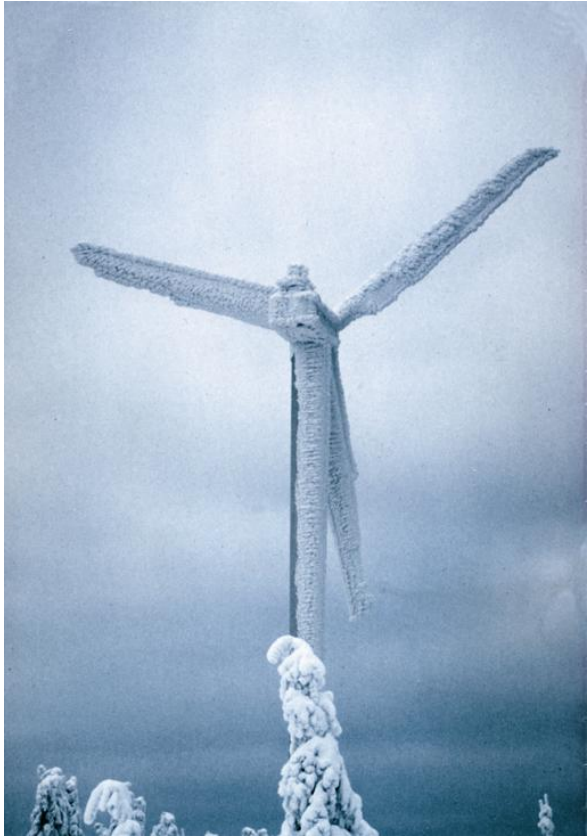
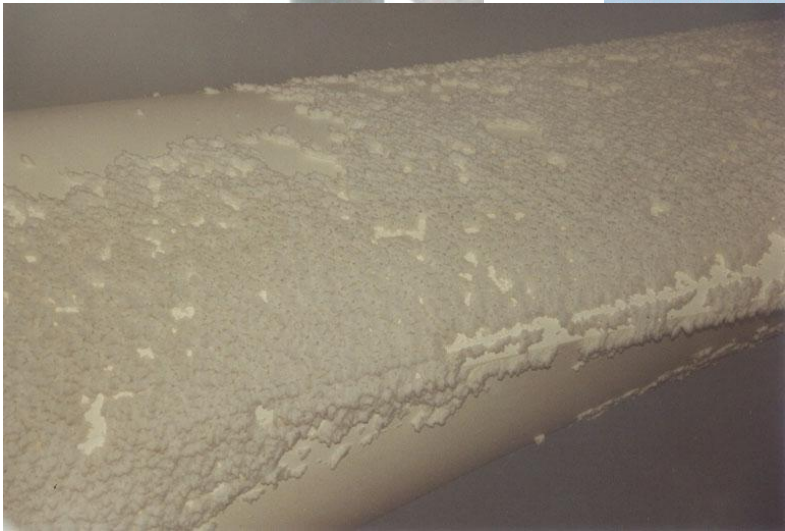
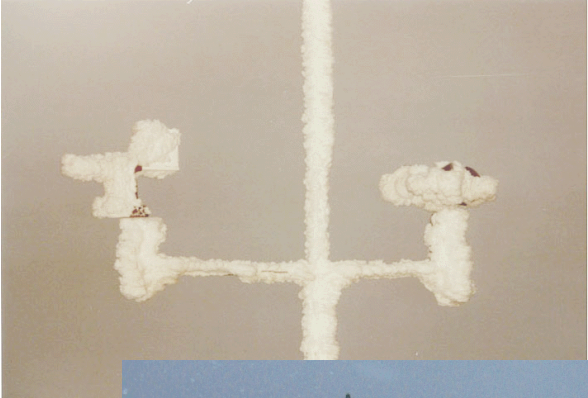
## INTRODUCTION – IEA TASK 19

- **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:** Austria, Canada, **Finland**, Germany, Norway, Switzerland, Sweden, USA,
- **Operating agent:** VTT Finland / Pöyry since 2009
- **Webpage:** <http://arcticwind.vtt.fi>



Photo:Pöyry Finland Oy

# ICING IMPACTS



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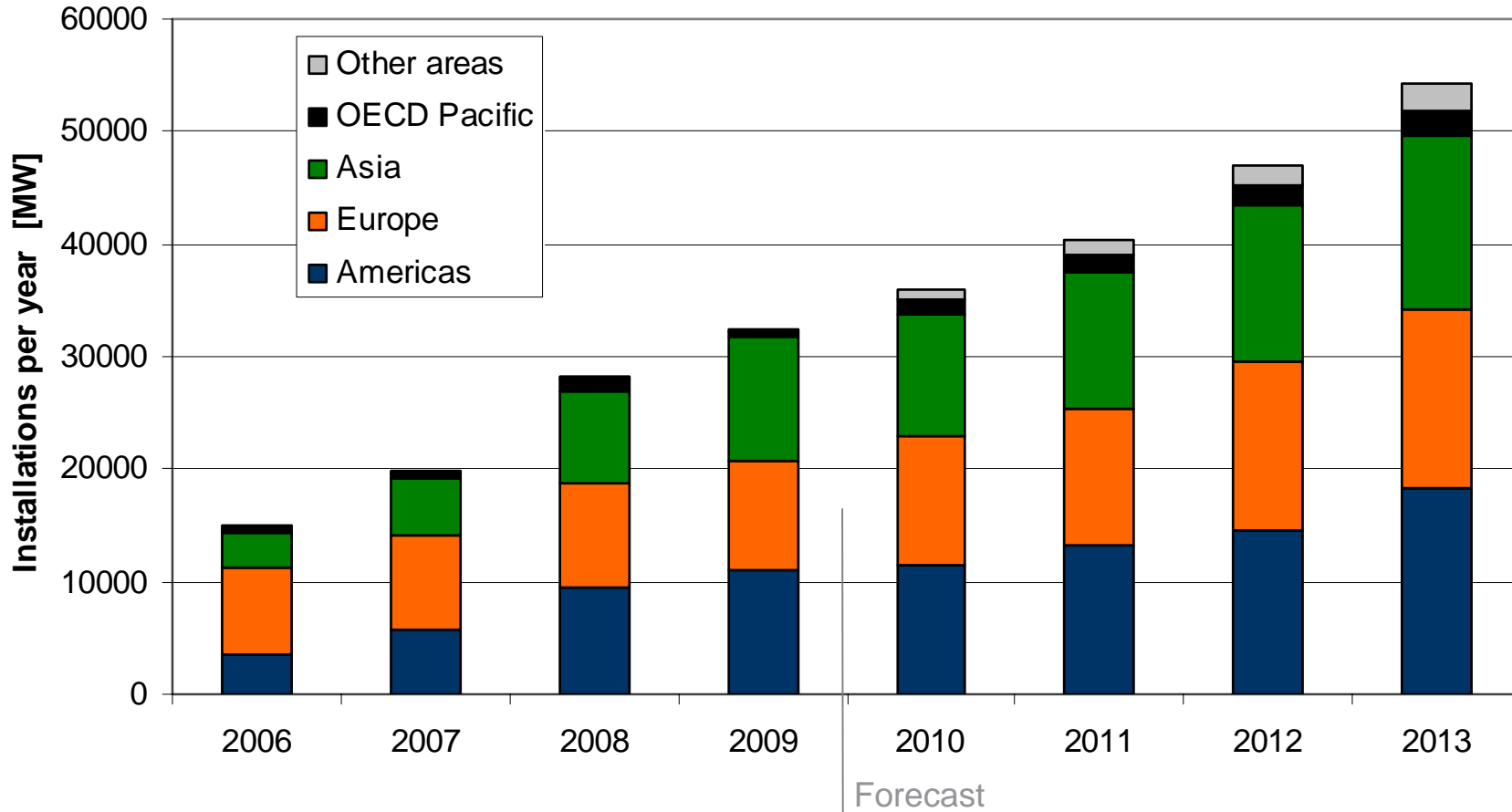
## DRIVERS OF COLD CLIMATE WIND POWER

- 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

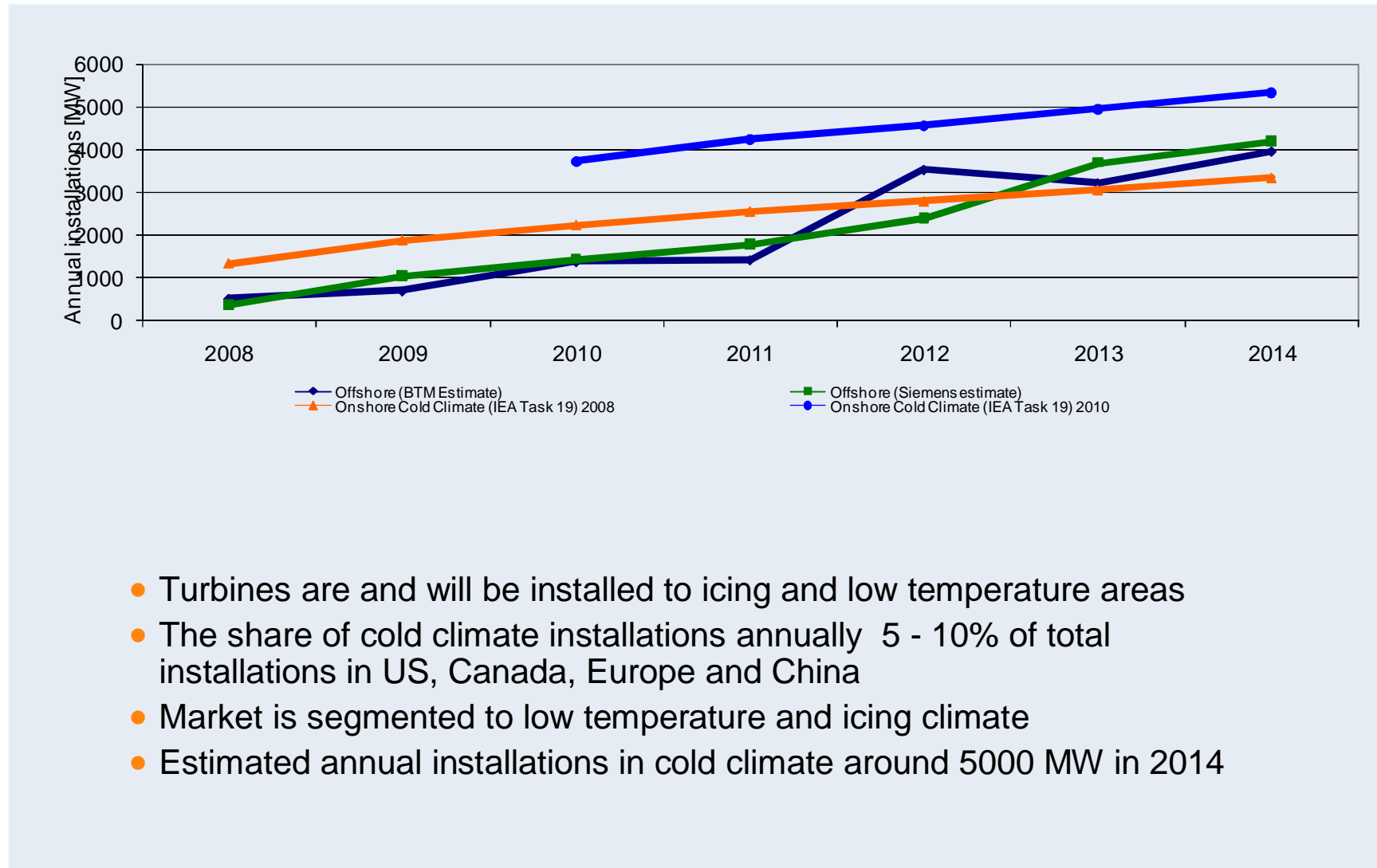
# SHARE OF COLD CLIMATE?



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 5000 MW in 2014

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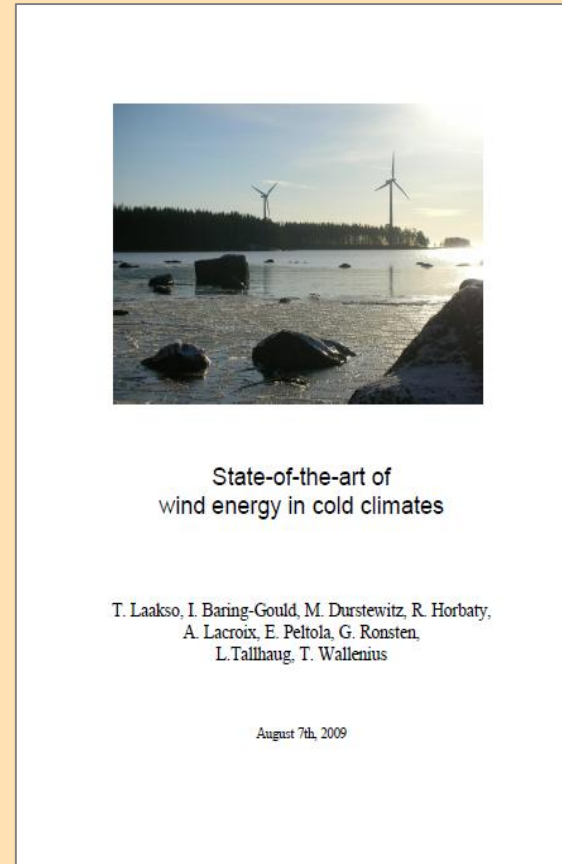
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## REPORT: State-of-the-art of cold climate technology

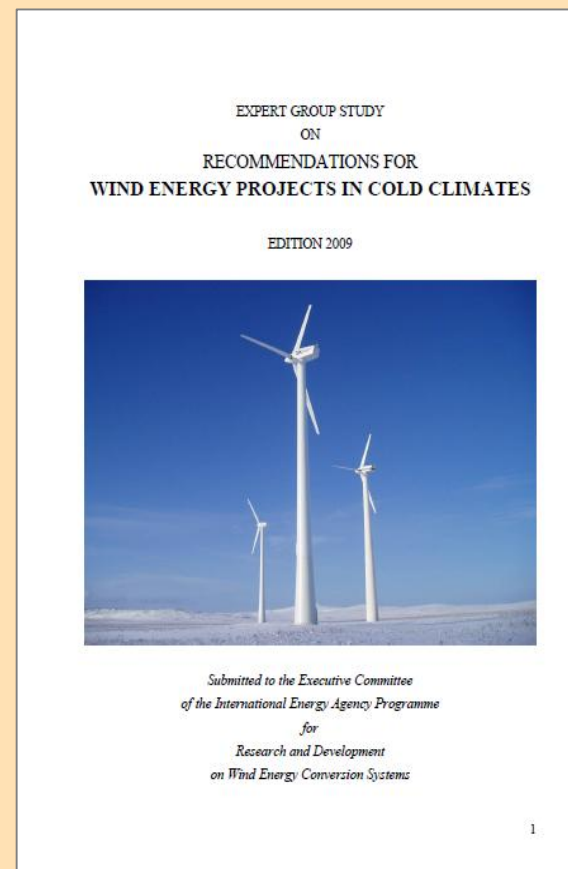
- State-of-the-art technology – report
  - Was published in Fall 2009
- IS commercially available:
  - Heated wind sensors for project development
  - Turbines for low temperatures
  - Ice mapping services e.g. local icing maps
  - Models for calculation of ice accretions
  - De-icing for mild icing 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>**

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## 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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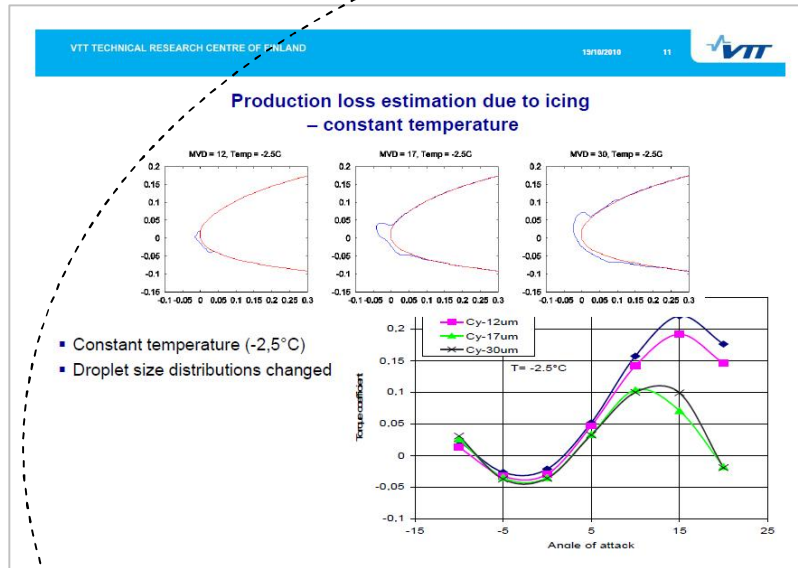
## OBJECTIVES 2009-2012

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 Marsch 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), Riutunhari (coastal))
  - Observation series incomplete and stem from different years
  - Quality
- The observation years/months chosen based on wind atlas needs

AROME	1991	1993	2000	2007	1989	2004
January	1991	1993	2000	2007	1989	2004
February	1989	1992	1998	2006	1989	1994
March	1991	1994	2002	2006	1997	2006
April	2000	2003	2005	2005	2007	2004
May	1991	1996	2000	2005	2000	1994
June	1989	1991	1992	1994	2000	1997
July	1992	2000	2002	2006	1999	1997
August	1994	1997	2001	2007	2005	2006
September	1991	1996	2003	2006	2005	1993
October	1995	1997	1998	1999	2005	1992
November	1992	1997	2004	2005	1999	2002
December	1989	1990	2000	2002	1992	2000

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 R&D Wind Task 19, 17.-18.5.2010, St. John's, Canada

# NATIONAL ACTIVITIES: SWITZERLAND



## IEA Task 19 Wind Energy in Cold Climate Swiss Activities

### Instrumentation



Schweizerische  
Confederazione 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)

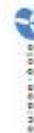
Cost/Benefit of Blade heating:  
Based on budgeted yearly production of 7'000 MWh

- 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?



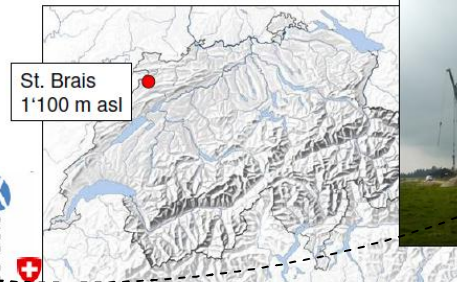
Swiss Federal Office of Energy SFOE IEA T19 meeting Helsinki, October 18 to 20, 2010



## IEA Task 19 Wind Energy in Cold Climate Swiss Activities

### Icing Project (2009 to 2011)

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



Confederaziun svizra  
Swiss Federal Office of Energy SFOE

IEA T19 meeting Helsinki, October 18 to 20, 2010



# NATIONAL ACTIVITIES: SWEDEN



Havsnäs is Sweden's largest onshore wind farm – no official experience of icing yet



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 Silkohöjden.
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 Ronsten

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	3 310
Swedish University of Agricultural Sciences, Reindeer	2 332
Wind in forests, Uppsala University, 2009-2012	10 000
<b>Total: 29.3 MEuro, 27.7 MEuro excl. forest and reindeer</b>	<b>293 000</b>

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

Swedish cold climate wind energy activities, Göran Ronsten


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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## RESEARCH FOCI

### simulation and assesment of wind turbines

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

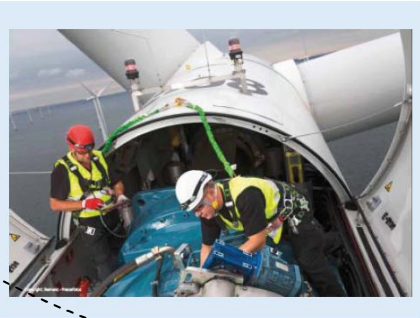


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## RESEARCH FOCI

### Tools for wind energy integration

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




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## 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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# 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

Canada

C E T C CANMET ENERGY TECHNOLOGY CENTRE


## Severe Icing



Natural Resources Canada / Ressources naturelles Canada

Canada

C E T C CANMET ENERGY TECHNOLOGY CENTRE



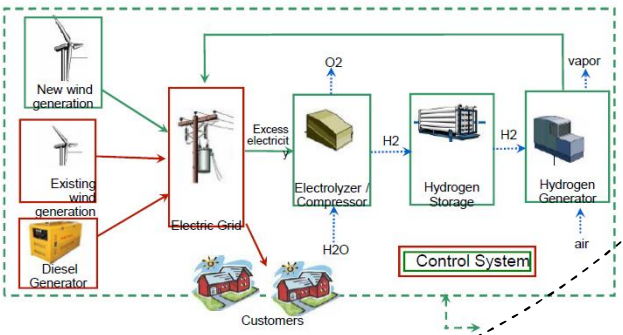
65-kW wind turbines in Ramoth, NF

Natural Resources Canada / Ressources naturelles Canada

Canada

C E T C CANMET ENERGY TECHNOLOGY CENTRE

## Wind-Diesel-Hydrogen Development



Natural Resources Canada / Ressources naturelles Canada

Canada



# NATIONAL ACTIVITIES: AUSTRIA




Country Presentation - Austria

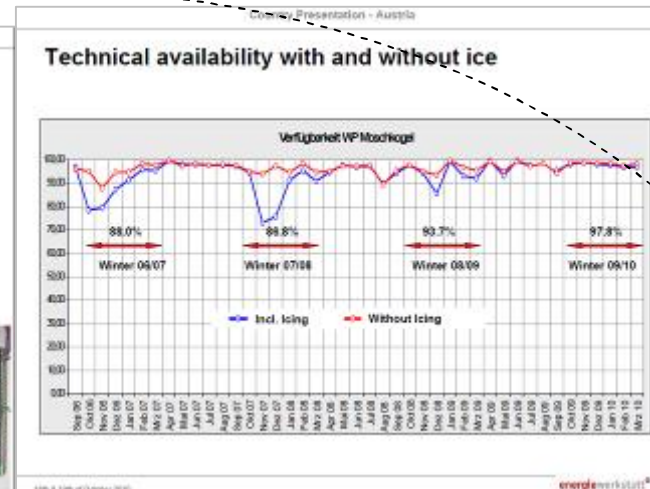
## Project 'MORE' (Mobile Remote Electricity)

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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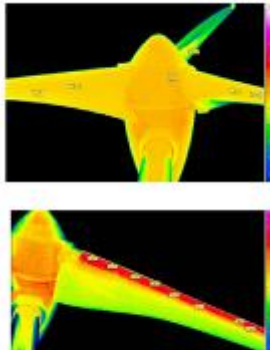
Country Presentation - Austria

## 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.



© ENERCON GmbH

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


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A reliable ice detection is precondition to any subsequent activity

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## Requirements of authorities concerning construction

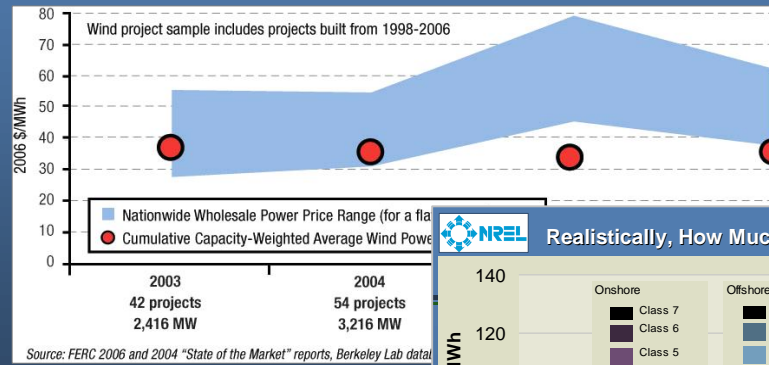
- Warning signs which indicate danger of ice throw have to be placed on each entrance point to the wind farm area in a minimum distance of 250 m to the turbines.
- One single wind turbine has to be equipped with an ice detector for automatically stop of all turbines if danger of icing occurs.
- Operation 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 automatical 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

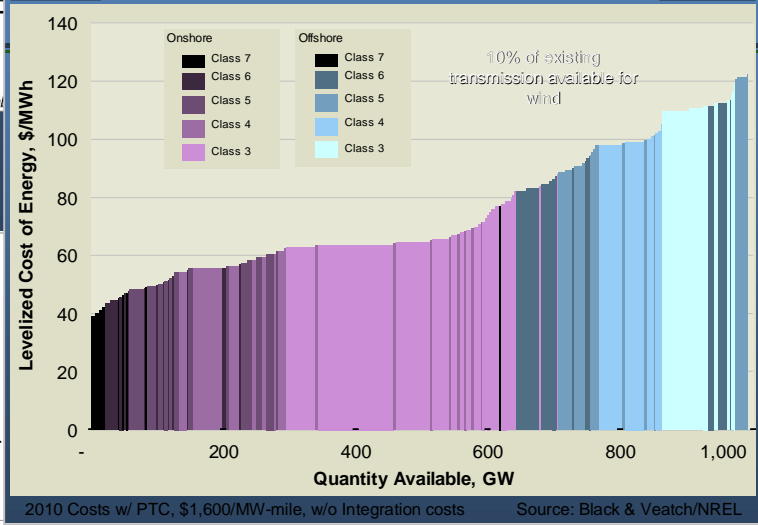


## Alaska Activities - Update

- 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 NW 100kW 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

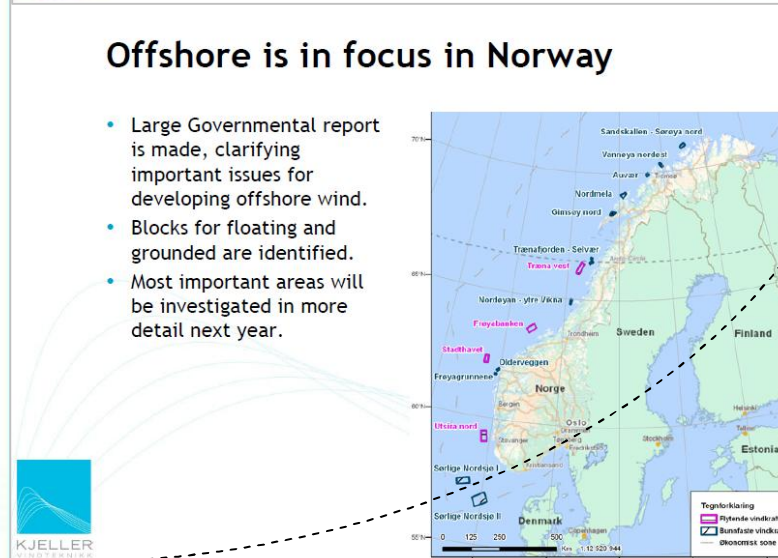
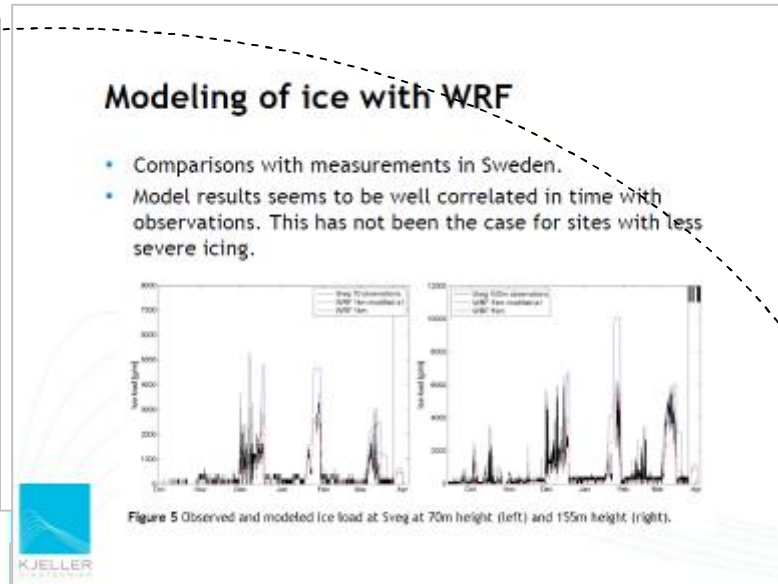
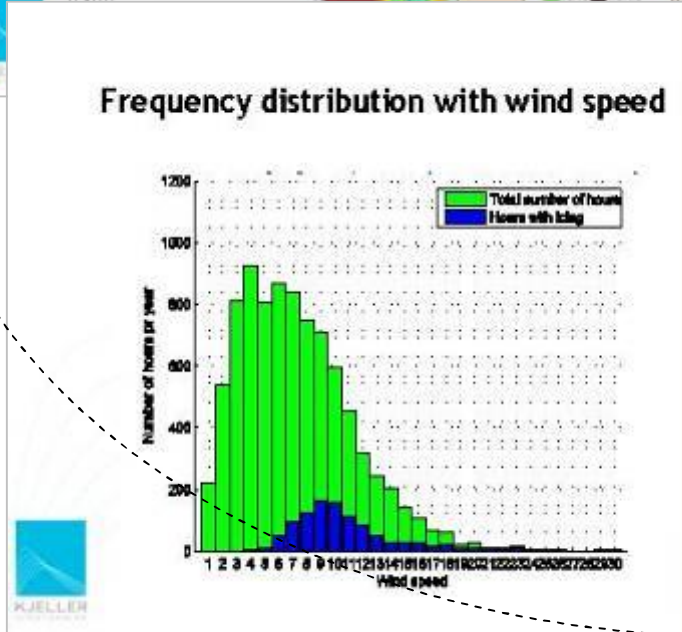
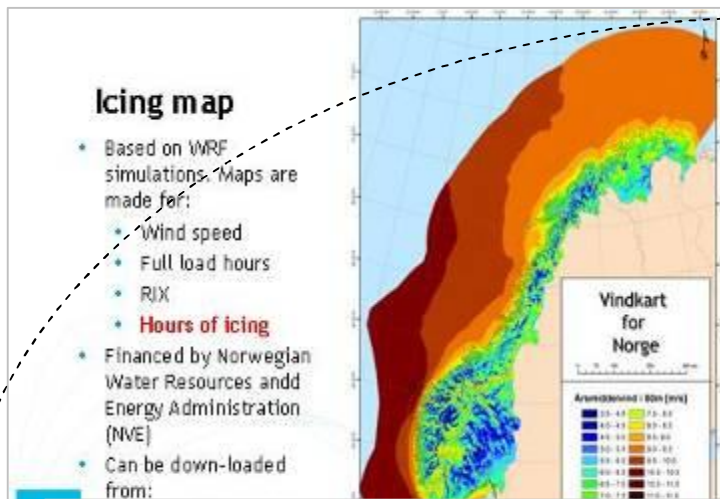


## Realistically, How Much Wind Is Available in the U.S.?





# NATIONAL ACTIVITIES: NORWAY



# DISSEMINATION OF INFORMATION

2009:

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

2010:

- Poster presentation, EWEC 2010 Warsaw, Poland
- Key-note speaker Ice and Rocks III - Croatia - Zadar May 2010
- Poster presentation, DEWEK 2010 Bremen, Germany

2011:

- Oral presentation: Winterwind 2011, Umeå, Sweden
- Oral presentation: EWEA 2011 side event Brussels, Belgium
- Oral presentation: IWAIS 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:**

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Photo: Lars Tallhaug, Kjeller Vindteknikk, Site Fermeuse wind farm in St John's New Founland, Canada