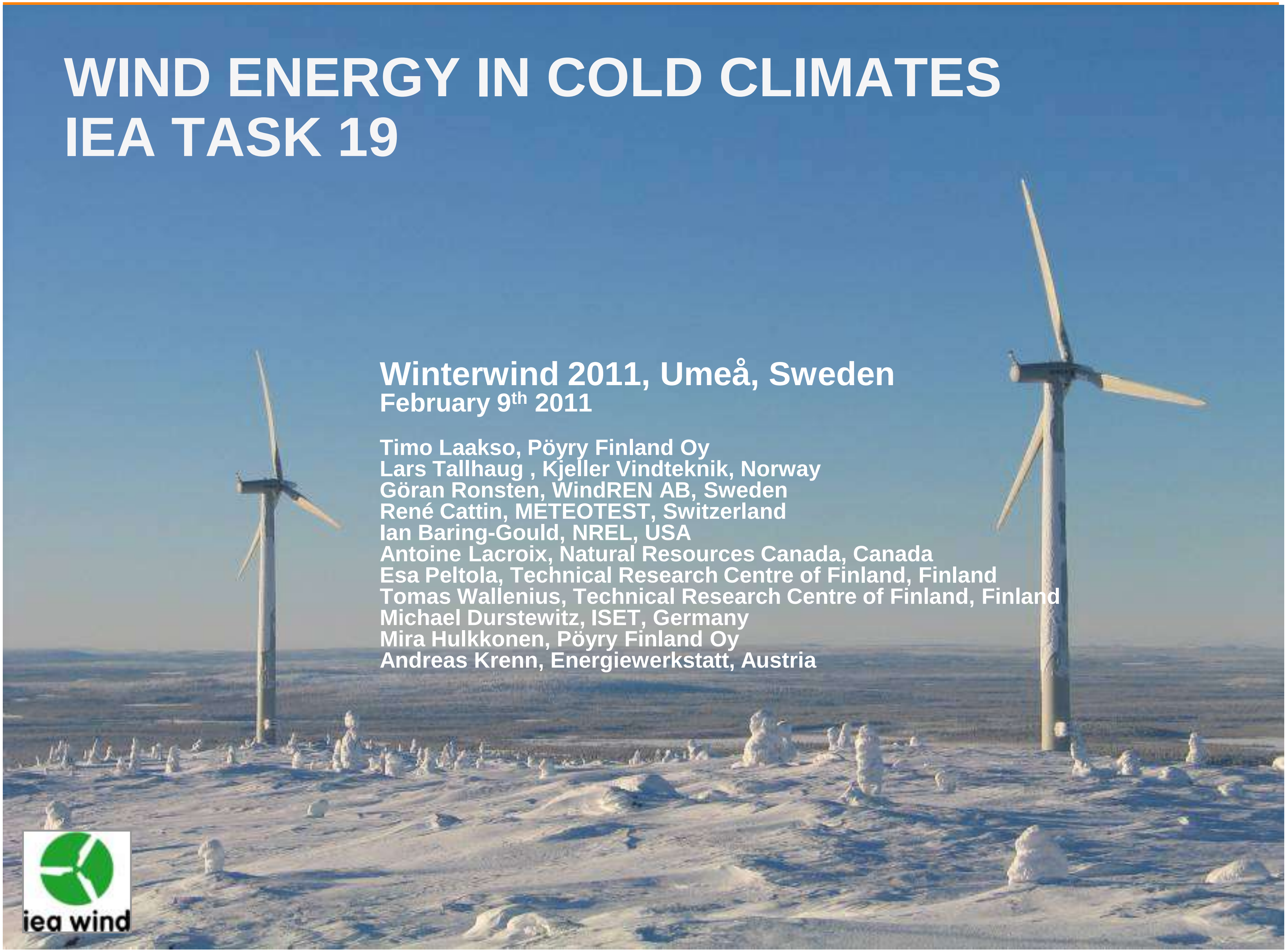
WIND ENERGY IN COLD CLIMATES
IEA TASK 19



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

iea wind

CONTENTS

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

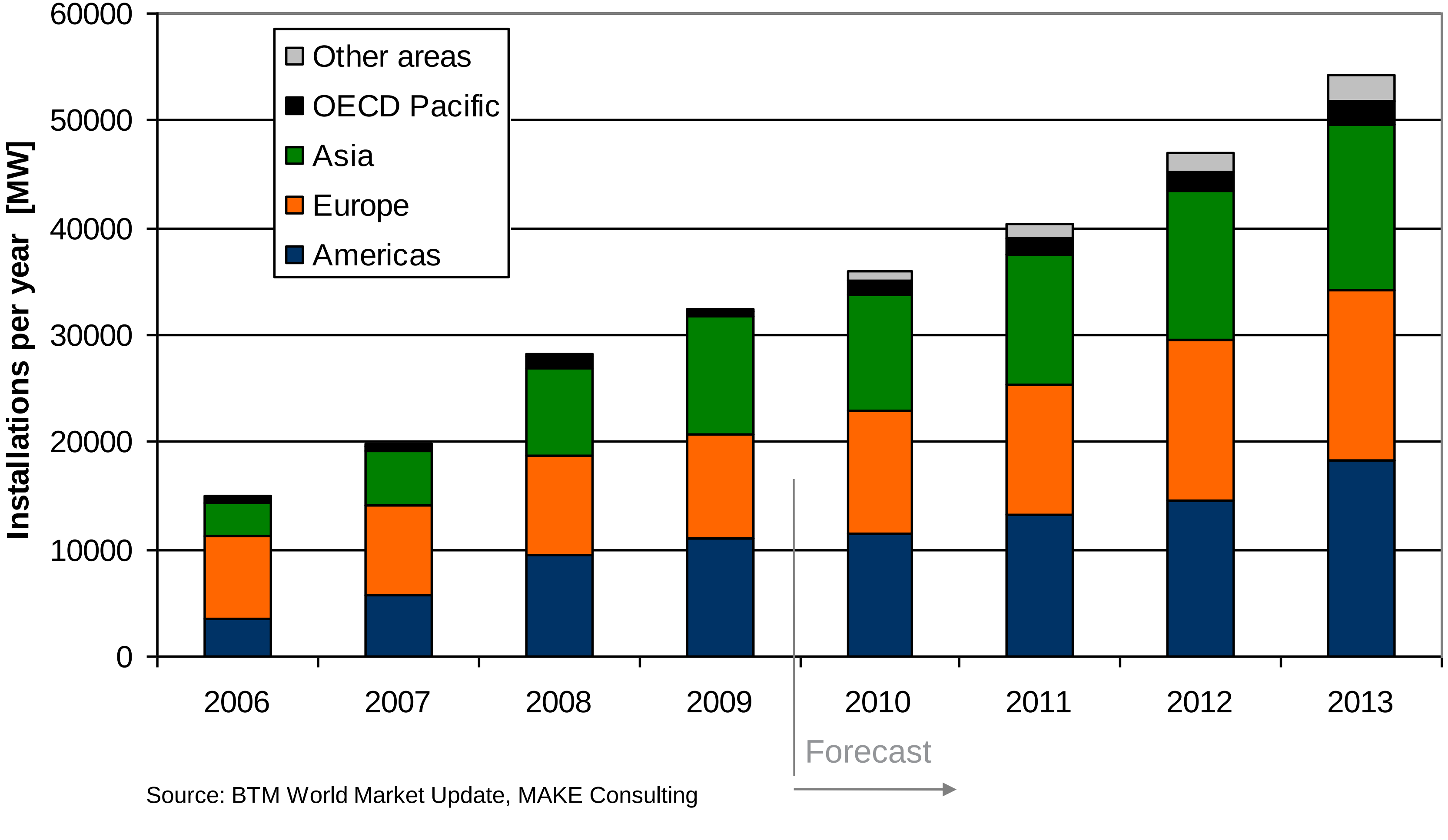
CONTENTS

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

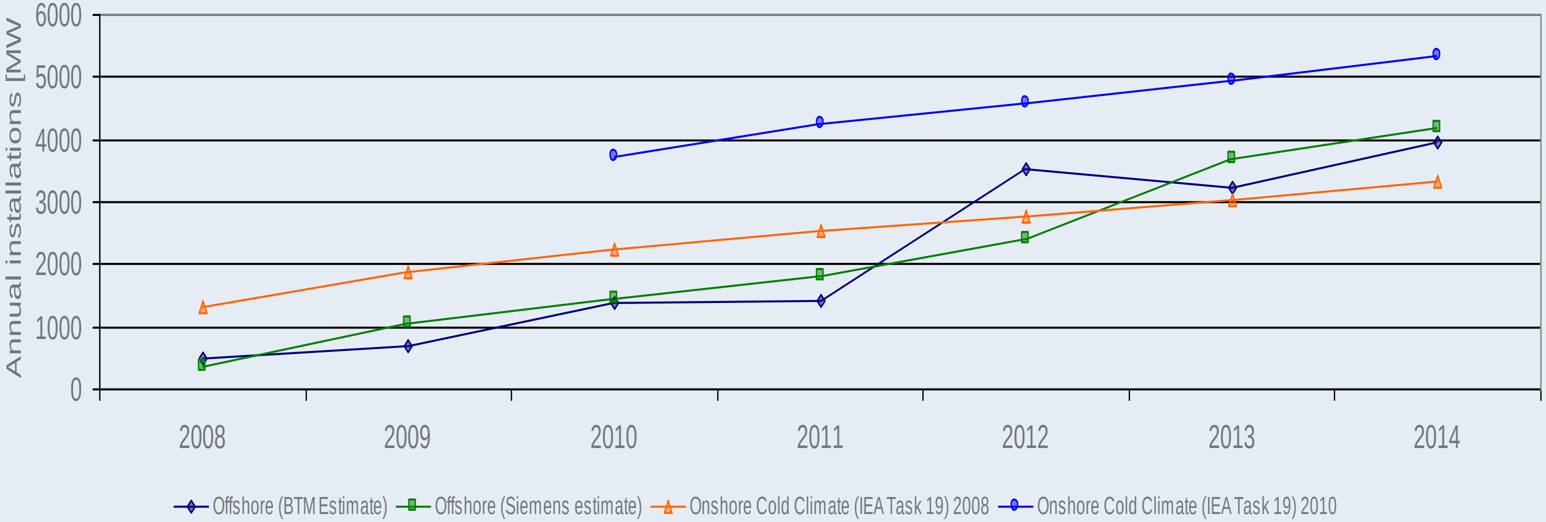
Photo:Pöyry Finland Oy

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

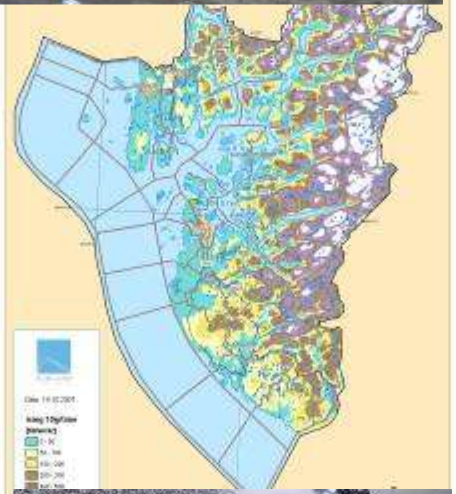
↓ ↓ ↓ ↓

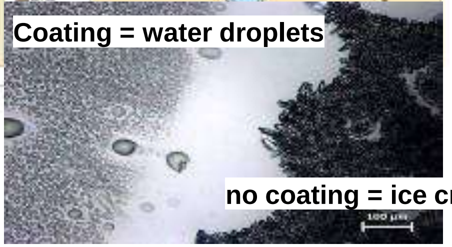
- Thus, various R&D projects which aim at lowering the costs of cold climate wind energy deployments are ongoing in IEA Task 19 participant countries
- The common aim of those projects is to reduce the risk and thereby the cost of wind electricity produced in cold climates:
  - More reliable production 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

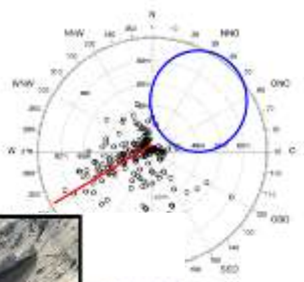
CONTENTS

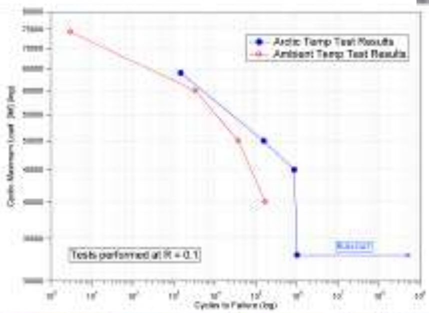
ACTIVITIES IN TASK 19 MEMBER COUNTRIES 2001-2008

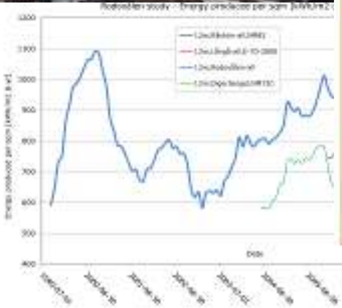
- Material testing
- Site measurements
- Ice mapping
- Anti- and de-icing equipment development
- Turbine testing
- Ice throw studies
- Follow-up measurements
- Sensor development
- Icing wind tunnel testing





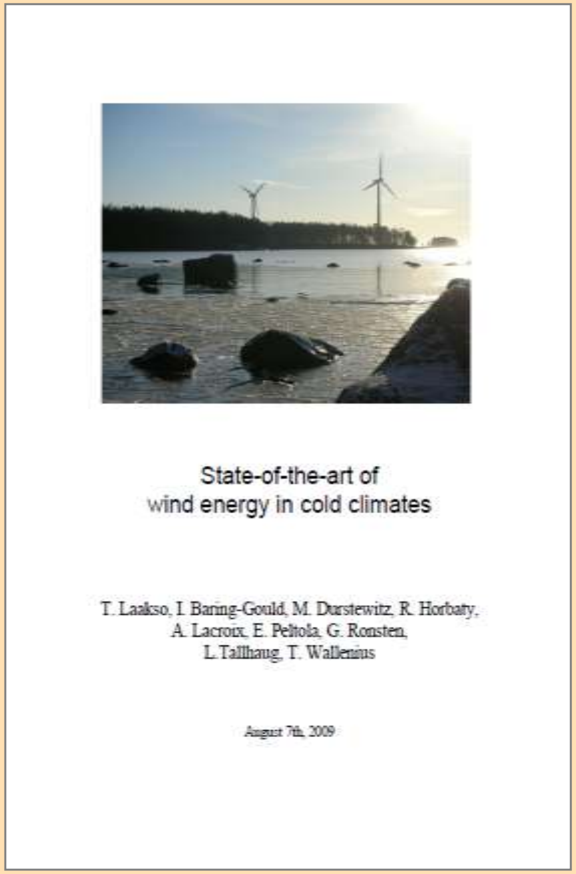






REPORT: State-of-the-art of cold climate technology

- 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


State-of-the-art of
wind energy in cold climates

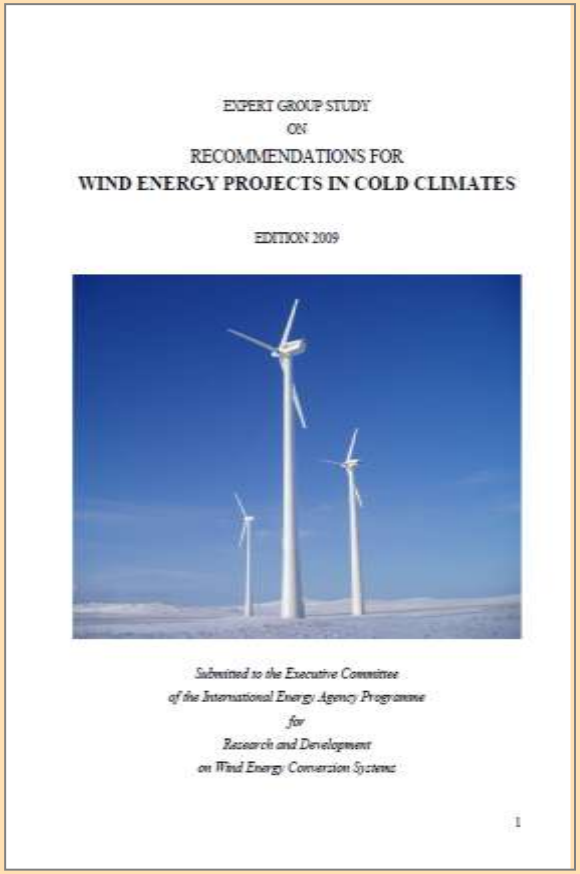
T. Laakso, I. Baring-Gould, M. Durstewitz, R. Horbaty,
A. Lacroix, E. Peltola, G. Ronsten,
L. Tallhaug, T. Wallenius

August 7th, 2009

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


EXPERT GROUP STUDY
ON
RECOMMENDATIONS FOR
WIND ENERGY PROJECTS IN COLD CLIMATES

EDITION 2009

Submitted to the Executive Committee
of the International Energy Agency Programme
for
Research and Development
on Wind Energy Conversion Systems

1

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 **<u>regardless of slow progress in technology development side</u>**

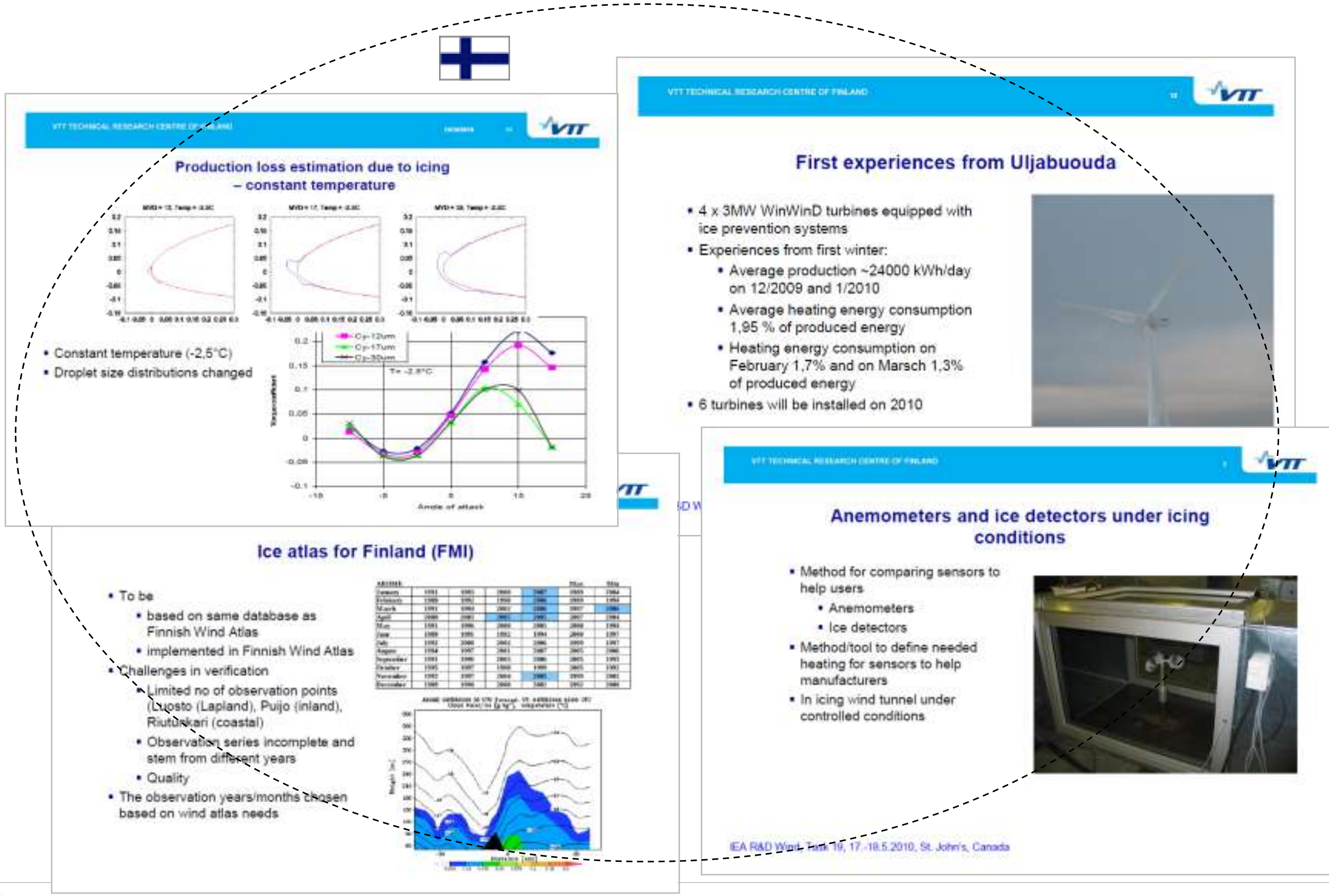
CONTENTS

OBJECTIVES 2009-2012

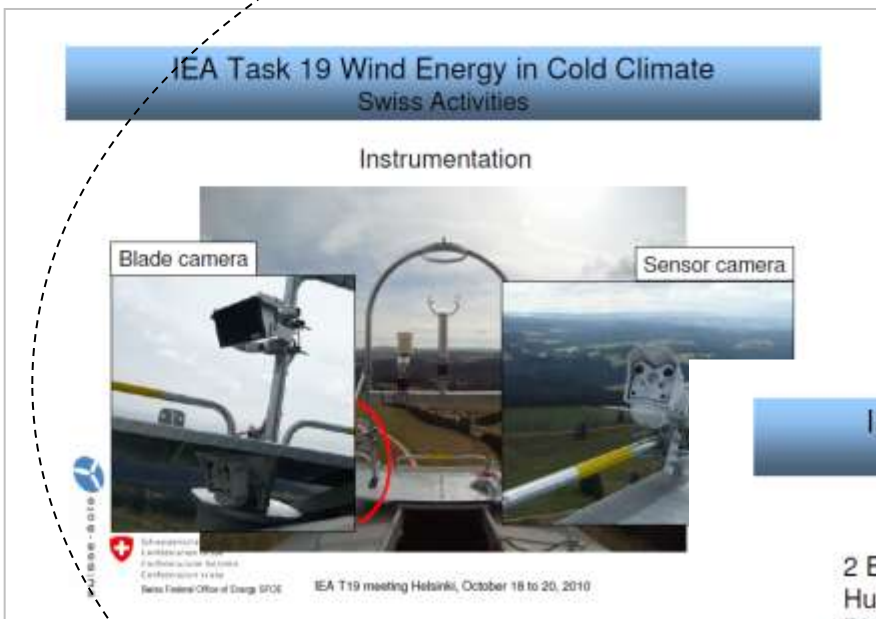
1. To collect information on **ice mapping** to support early phases of project development.
2. To collect experiences related to **icing forecasts** with numerical weather models
3. Find new solutions for **wind resource assessment** in cold climate
4. Collect information on the **anti- and de-icing 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

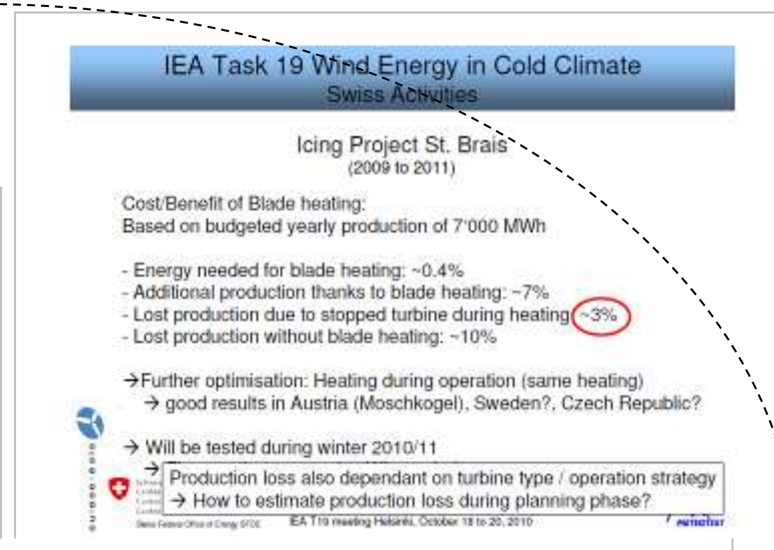
Photo:Pöyry Finland Oy and Kjeller Vindteknikk

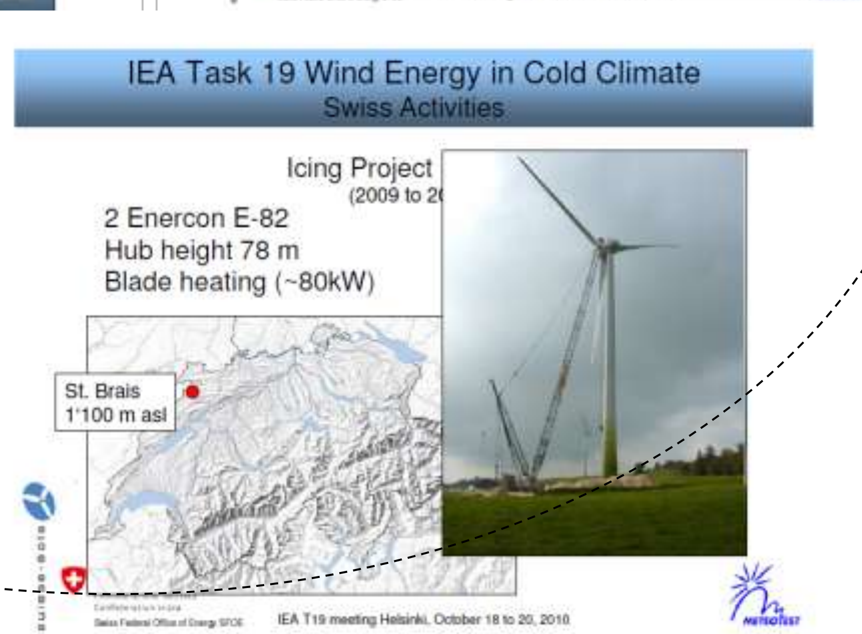
NATIONAL ACTIVITIES: FINLAND



NATIONAL ACTIVITIES: SWITZERLAND







NATIONAL ACTIVITIES: SWEDEN

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

HAVSNÄS - FÖRST AV DE STORA

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 Ronsten — IEA Task 19 project meeting in Helsinki, Oct 18 & 19, 2010

Icing measurements at 11 sites in 13 stations

4 telecom. masts and 5 adjacent actual and potential wind farm sites.

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 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 offhsore issue ??

IEA Task 19 meeting / May 17-18, 2010 / St. Johns, Canada

Fraunhofer IWES

RESEARCH FOCI
simulation and assesment of wind turbines

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

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

Fraunhofer

RESEARCH FOCI
Tools for wind energy integration

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

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

Fraunhofer IWES

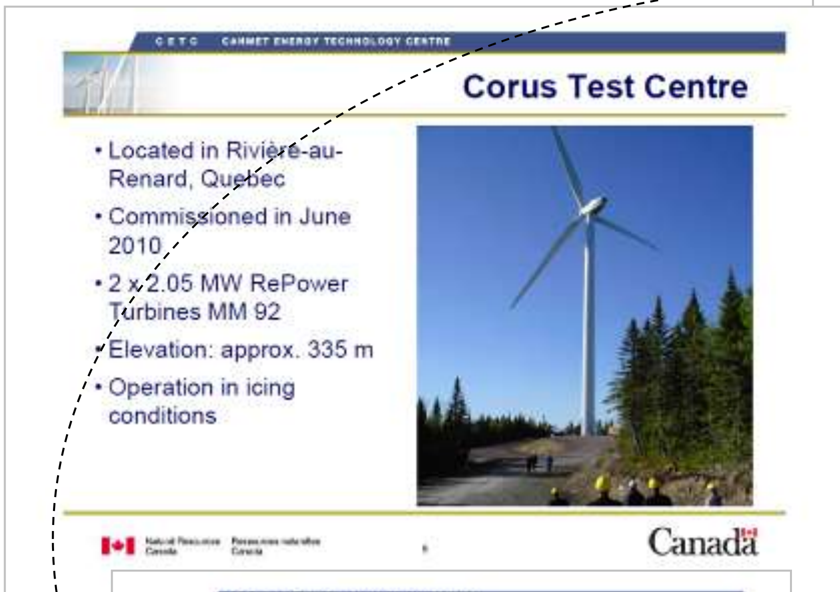
RESEARCH FOCI
rotor blade competence center

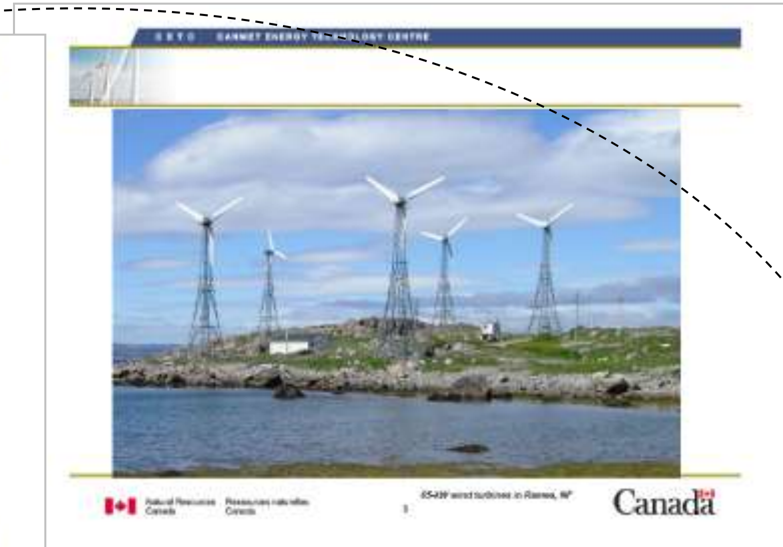
- Rotor blade, component and material testing
- New concepts for rotor blades
- Development of test methods

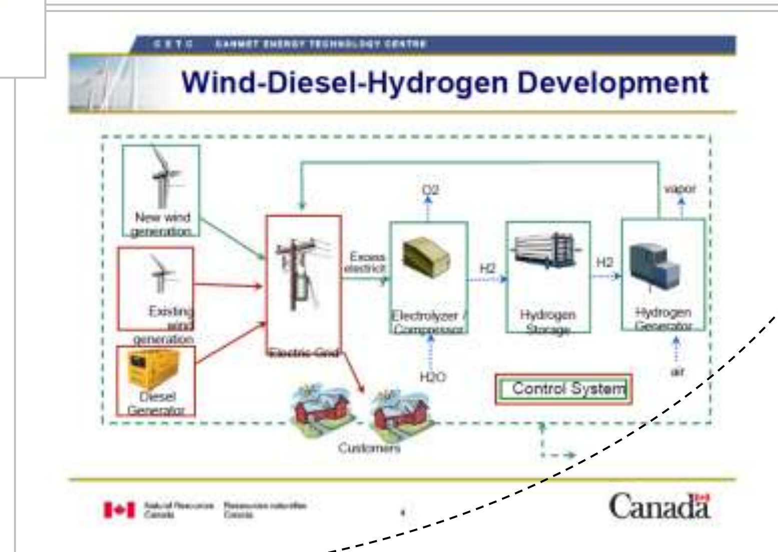
IEA Task 19 meeting / Dec. 3-4, 2009 / Vienna, Austria

Fraunhofer IWES

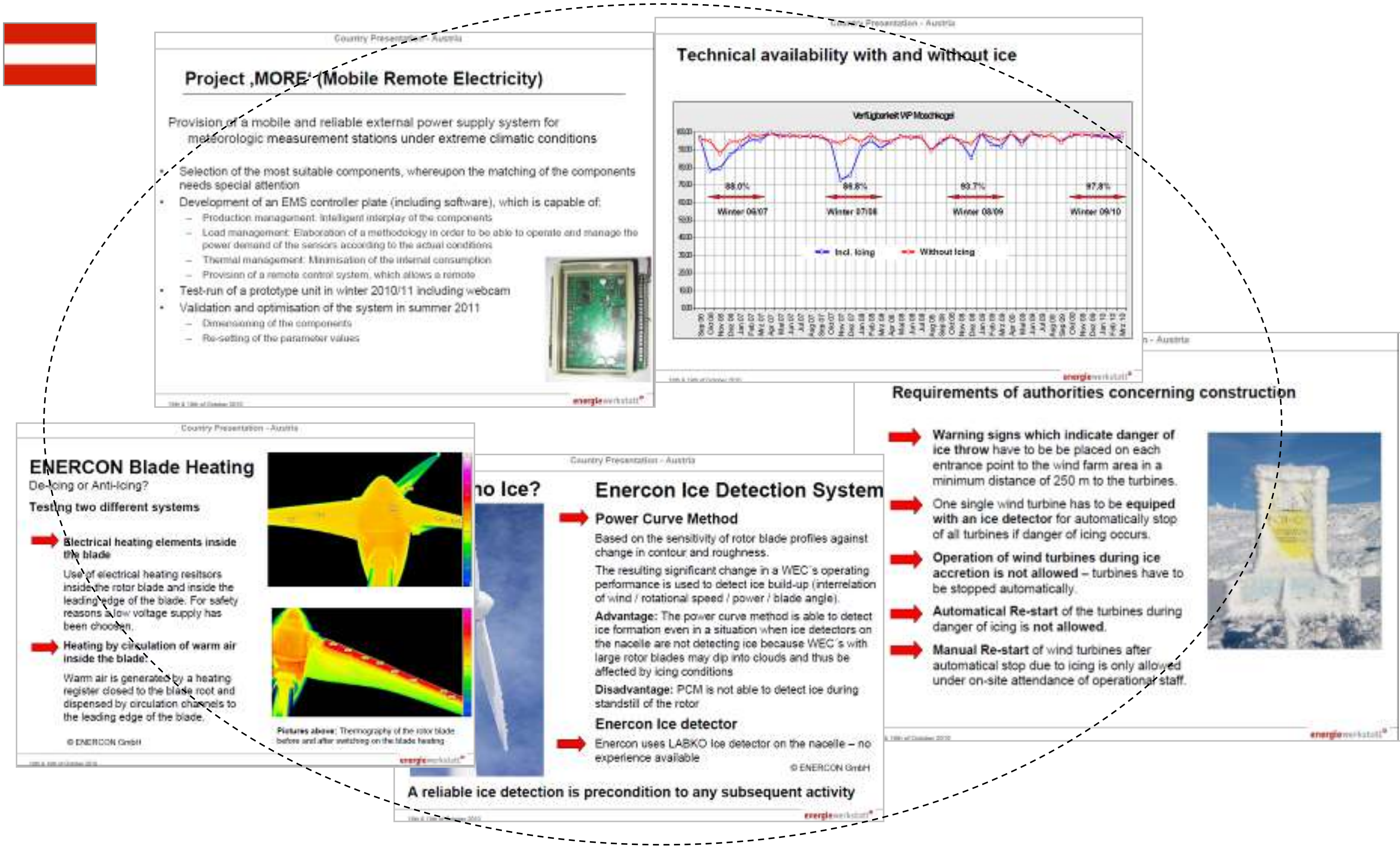
NATIONAL ACTIVITIES: CANADA





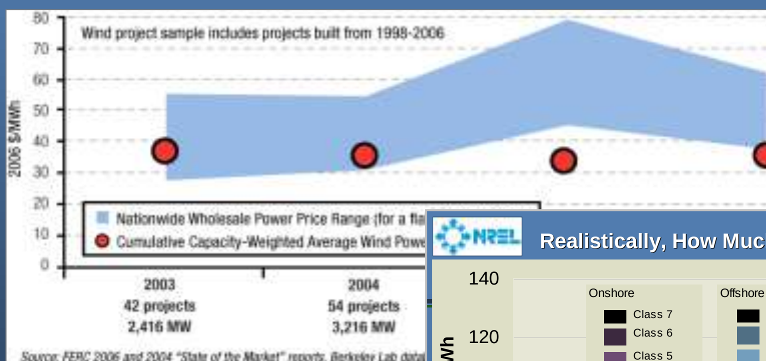


NATIONAL ACTIVITIES: AUSTRIA



NATIONAL ACTIVITIES: US

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



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

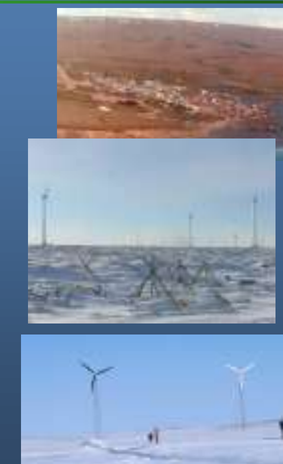
- Small community in western Alaska
- Installation of 3 NW100kW turbines
- Just over 20% average wind penetration with much higher instantaneous penetration
- Average Net Capacity Factor of 23.3% from 06 to Aug 07
- First year turbine availability of 92.4%
- Permafrost foundations a large problem (Martina)

Other Projects

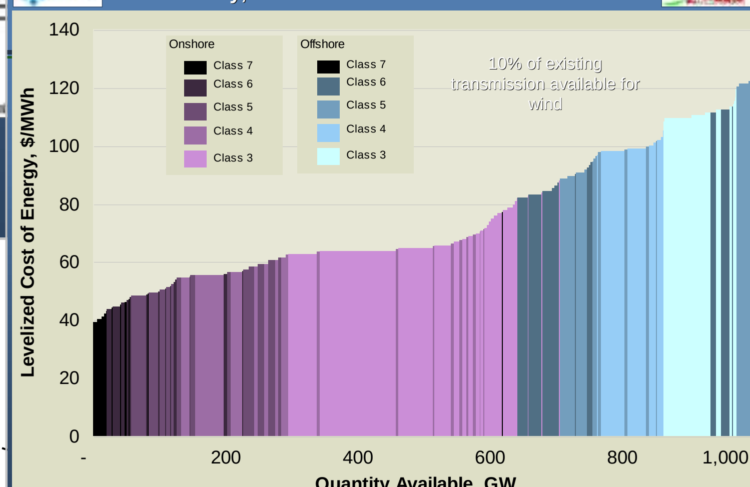
- Kotzebue – opportunity for side by side comparisons due to new SCADA system

Other work

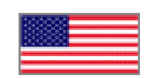
- Some limited research activities in icing starting in Colorado
- More projects experiencing icing related down time – but getting data has been very difficult



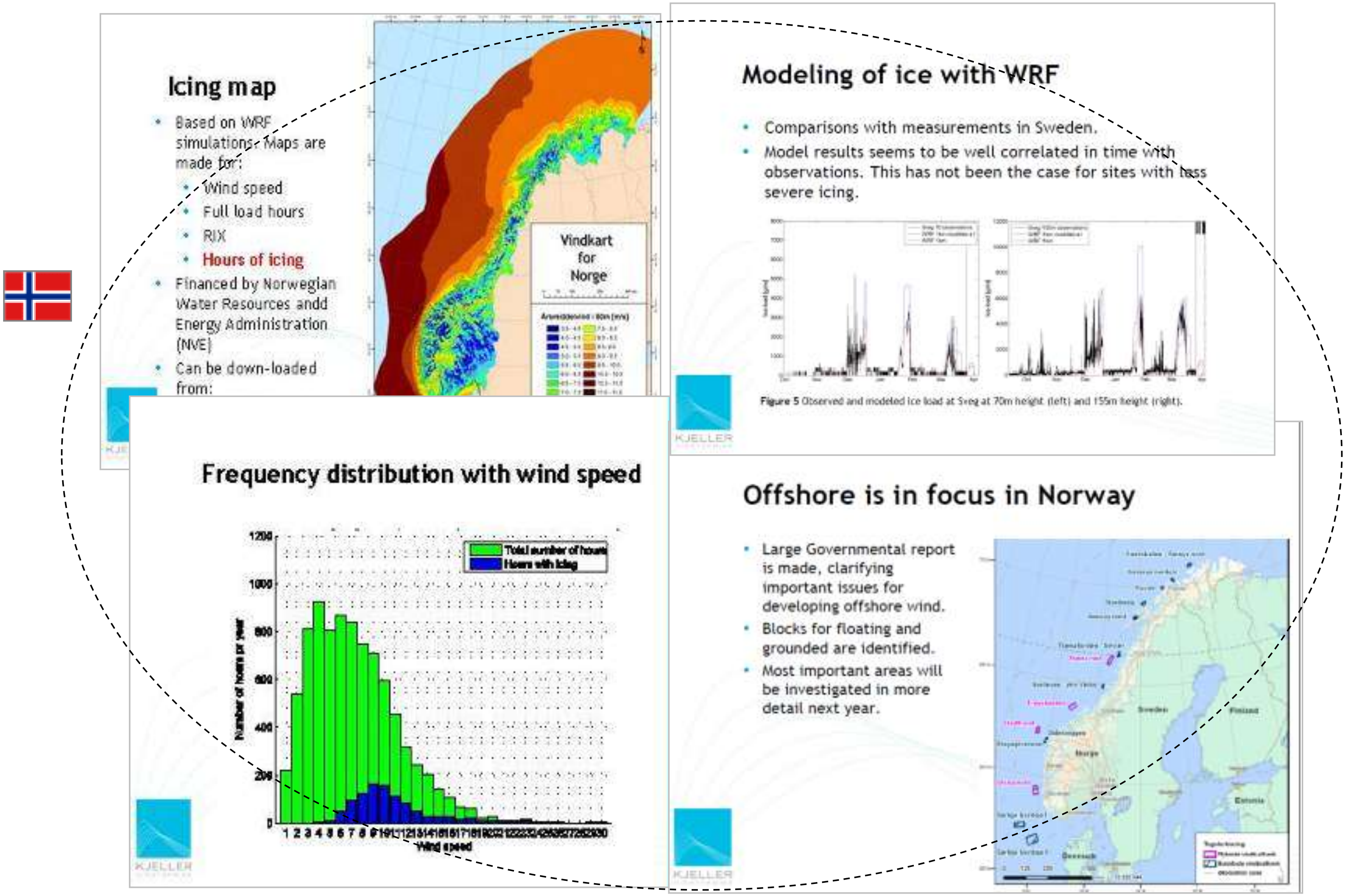
Realistically, How Much Wind Is Available in the U.S.?



2010 Costs w/ PTC, $1,600/MW-mile, w/o Integration costs Source: Black & Veatch/NREL



NATIONAL ACTIVITIES: NORWAY



DISSEMINATION OF INFORMATION

2009:

- Oral presentation, IWAIS 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: 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

CONTENTS

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