O2’s wind pilot project – Large-scale cost-effective wind energy development in icing climates, *Göran Ronsten, O2*

O2 VINDKOMPANIET

Swedish Energy Agency

O2’s wind pilot project – Large-scale cost-effective wind energy development in icing climates, *Göran Ronsten, O2*

O2’s wind pilot project – Large-scale cost-effective wind energy development in icing climates, *Göran Ronsten, O2*

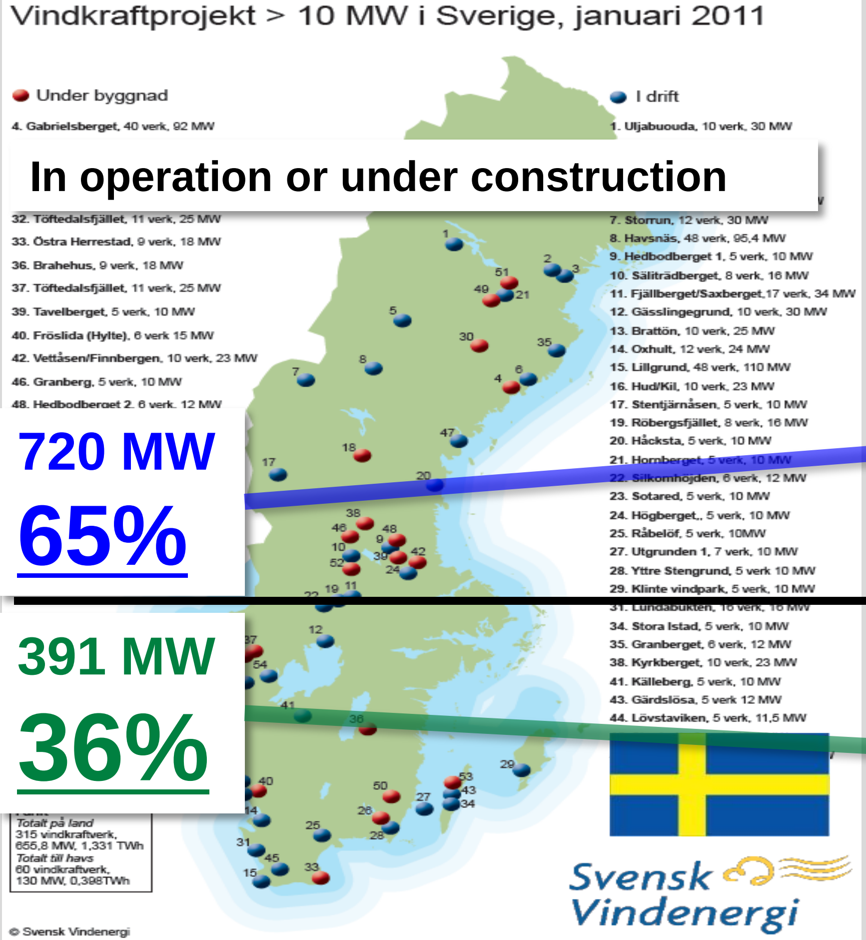
2 0 0 8 – 2 0 1 3

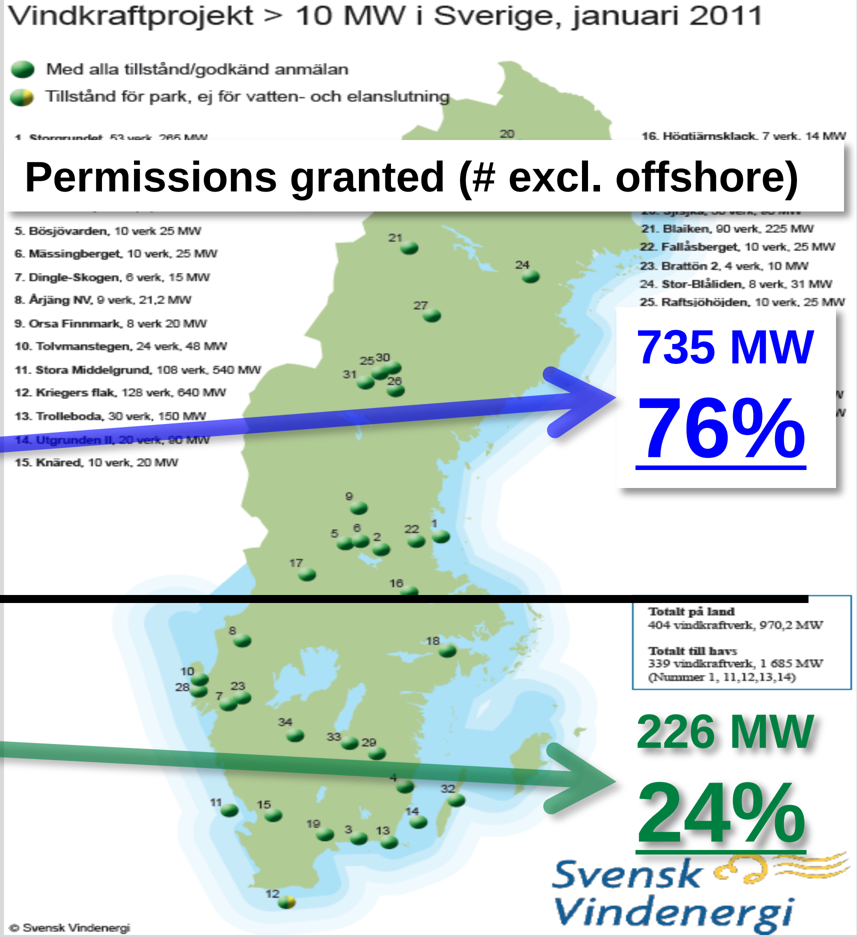
O2’s wind pilot project – Large-scale cost-effective wind energy development in icing climates, *Göran Ronsten, O2*

2 0 0 8 – 2 0 1 3

72.5 MSEK

≈ 8 M€





In operation or under construction

Permissions granted (# excl. offshore)

720 MW
65%

735 MW
76%

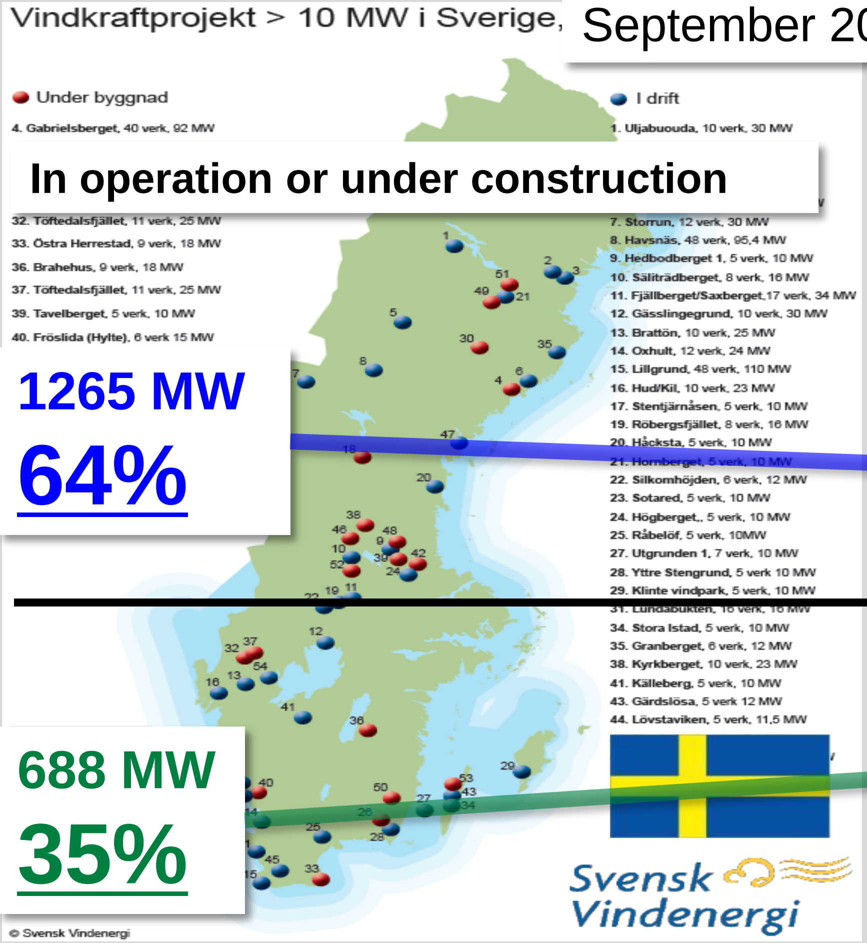
391 MW
36%

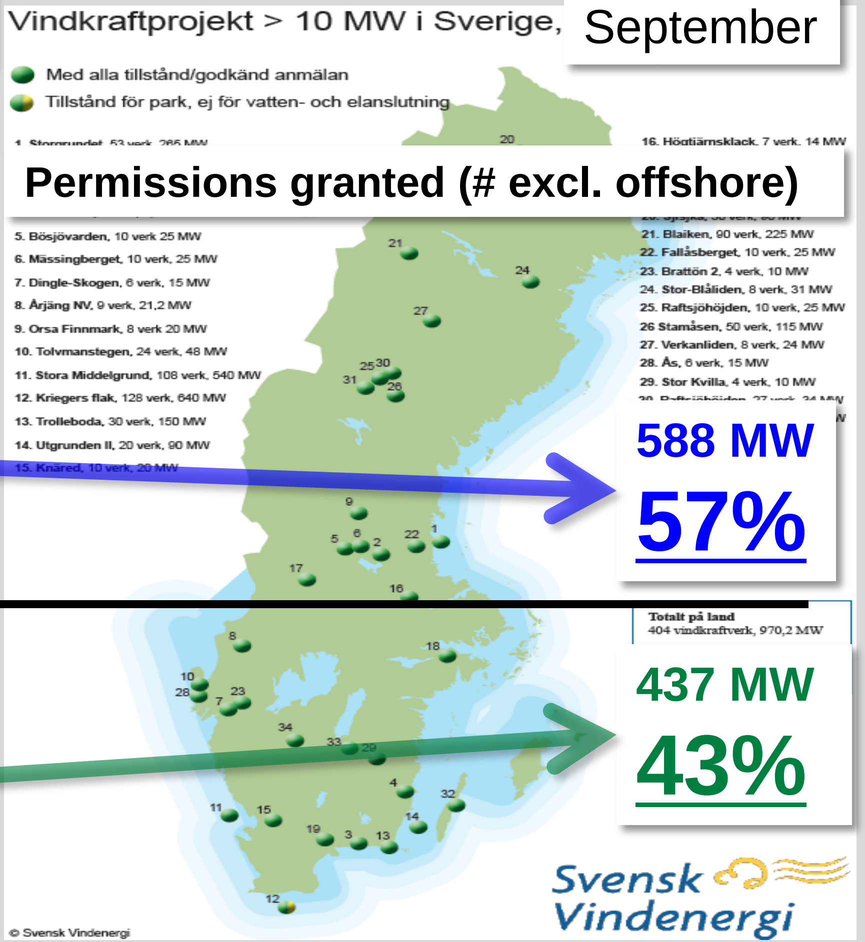
226 MW
24%

September 2011

In operation or under construction

Permissions granted (# excl. offshore)





1265 MW

64%

688 MW

35%

588 MW

57%

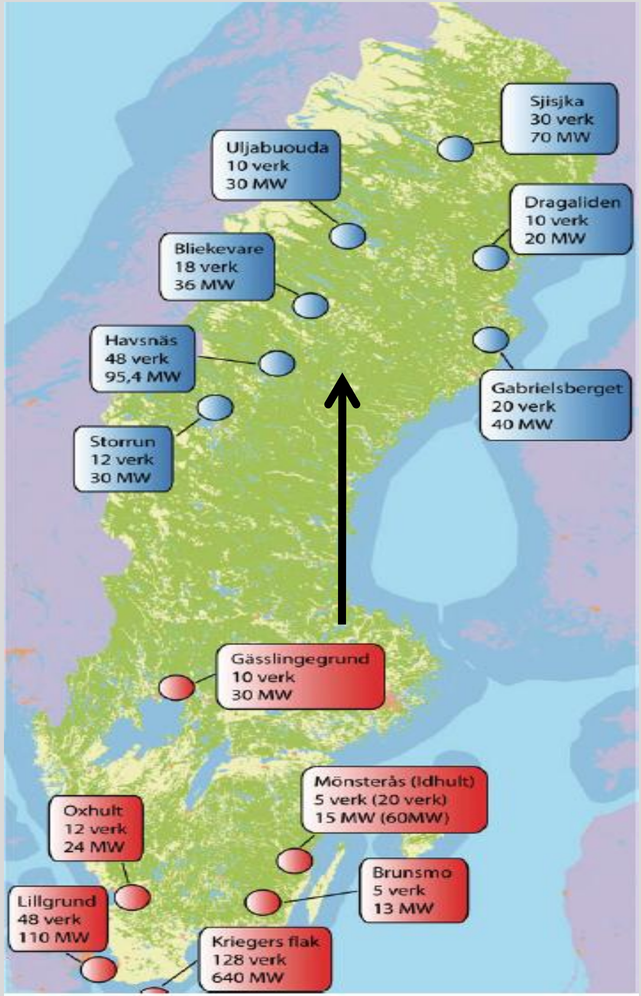
437 MW

43%

Q: A temporary decreasing share of projects in N Sweden due to **grid limitations?**

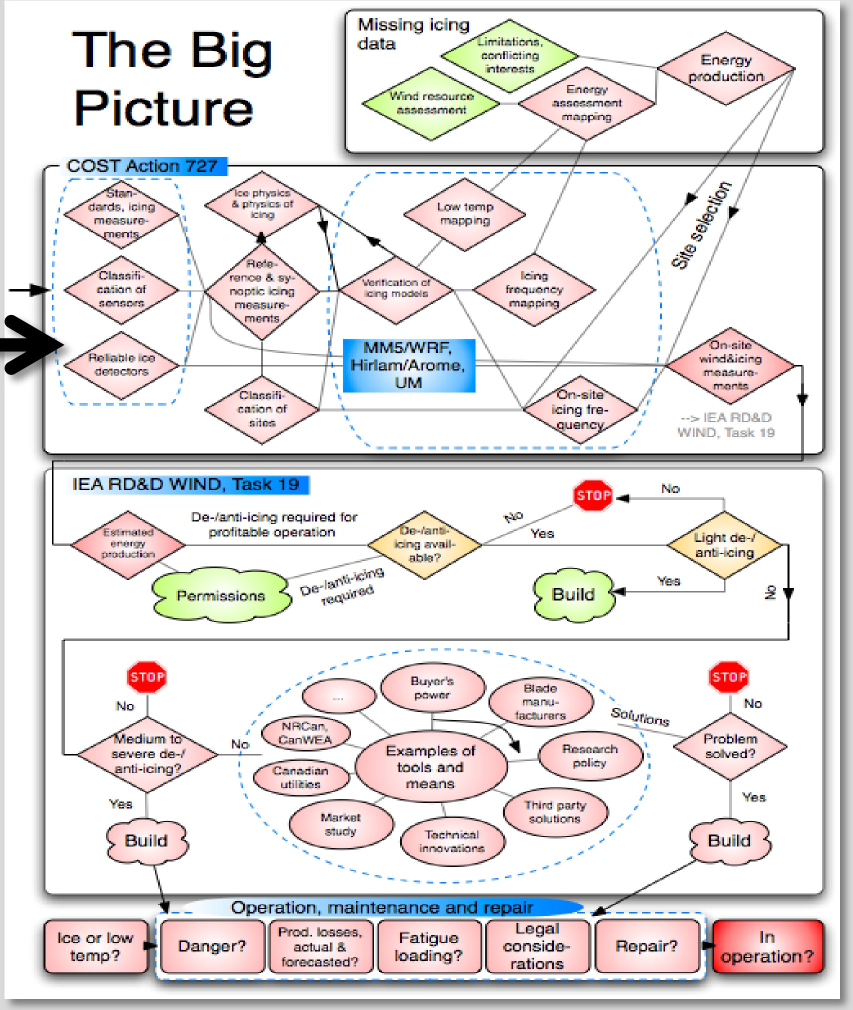
Wind pilot projects: 70 M€ over 10 years

From offshore to cold climate and forests



The main challenge in Sweden is icing, not low temperatures

A plan to keep WT in icing climates in operation



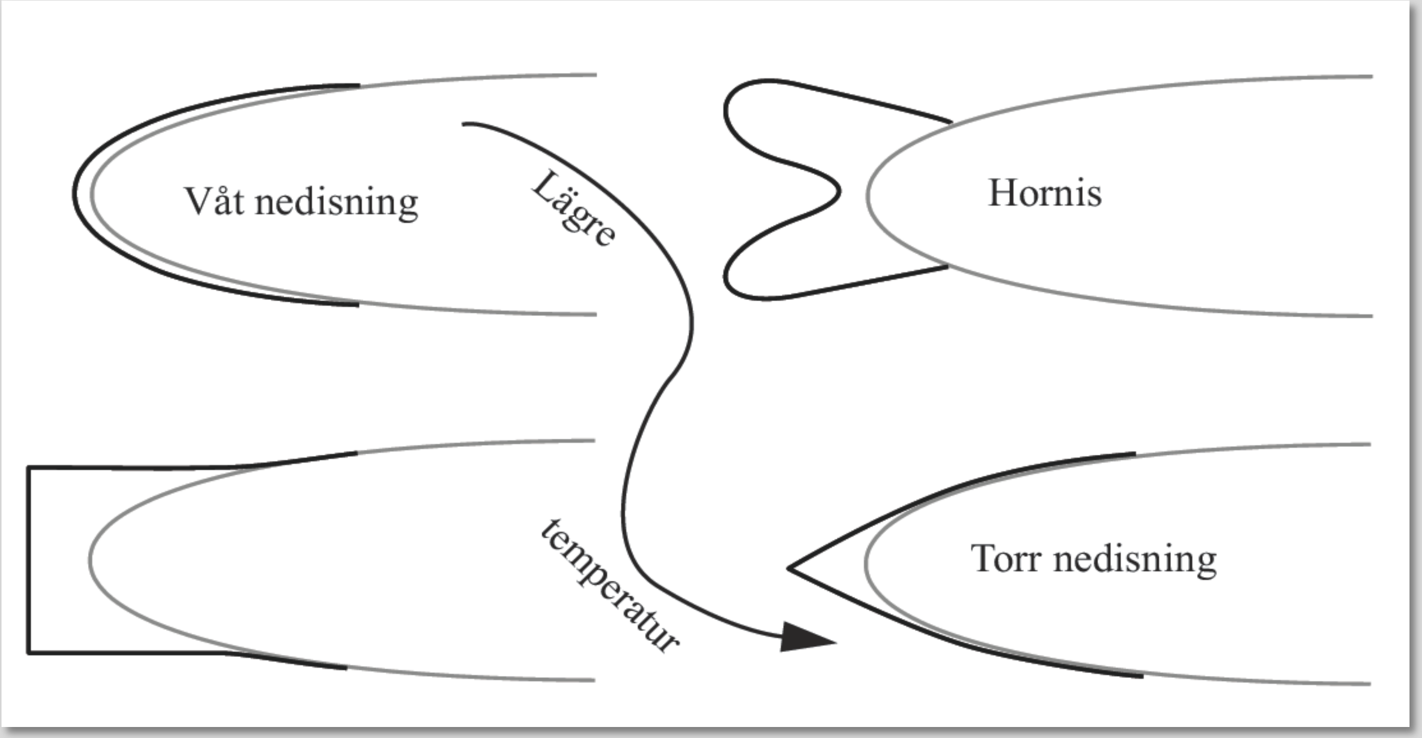
Planning
Standards
Sensors
Models
Measurements

De-icing

Rules, O&M

Modern LED obstacle lights need heating to be seen

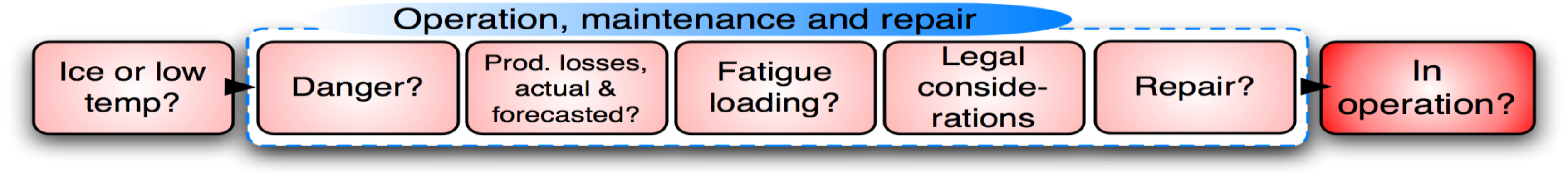
Icing versus temperature




OPA
HEADLR


O2
VINDKOMPANIET
Swedish
Energy Agency

How to deal with practical issues?



Anti-icing (40 WT) and icing measurements (13 stations, 11 sites),

Bliekevare, Brahehus & Glötesvålen and other, 2008-2013, **R&D: 8 MEuro**

O2 VINDKOMPANIET | SIEMENS | Vestas | KELLY AEROSPACE Thermal Systems | EcoTEMP | COMBITECH | IN SITU | …

International participation in O2 Vindkompaniet's wind pilot project

International participation in O2 Vindkompaniet’s wind pilot project

International interest in CC: IEA RD&D Wind, Task 19 meeting in Umeå, Feb 7-8, 2011

Participants from:

Austria
Canada
China (observer)
Denmark (observer)
Finland
Germany
Norway
Sweden
Switzerland
USA

Potential new members

Denmark
China
Italy
Japan

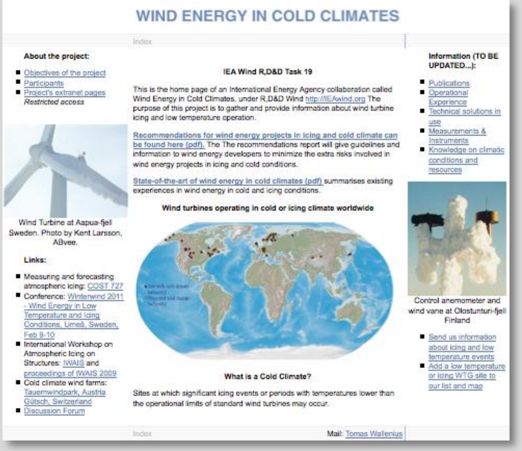
IEA Task 19 home page - http://arcticwind.vtt.fi/

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

EDITION 2011

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

- Recommendations report – today!
- State-of-the-art report - 2012
- Planned continuation 2013 - 2015



WIND ENERGY IN COLD CLIMATES

Index

About the project:

- Objectives of the project
- Participants
- Project's extranet pages *Restricted access*

Wind Turbine at Aapua-fjell Sweden. Photo by Kent Larsson, ABvee.

Links:

- Measuring and forecasting atmospheric icing: COST 727
- Conference: Winterwind 2011 - Wind Energy in Low Temperature and Icing Conditions, Umeå, Sweden, Feb 9-10
- International Workshop on Atmospheric Icing on Structures: IWAIS and proceedings of IWAIS 2009
- Cold climate wind farms: Tauernwindpark, Austria Gütsch, Switzerland
- Discussion Forum

IEA Wind R,D&D Task 19

This is the home page of an International Energy Agency collaboration called Wind Energy in Cold Climates, under R,D&D Wind http://IEAwind.org The purpose of this project is to gather and provide information about wind turbine icing and low temperature operation.

Recommendations for wind energy projects in icing and cold climate can be found here (pdf). The The recommendations report will give guidelines and information to wind energy developers to minimize the extra risks involved in wind energy projects in icing and cold conditions.

State-of-the-art of wind energy in cold climates (pdf) summarises existing experiences in wind energy in cold and icing conditions.

Wind turbines operating in cold or icing climate worldwide

What is a Cold Climate?

Sites at which significant icing events or periods with temperatures lower than the operational limits of standard wind turbines may occur.

Information (TO BE UPDATED...):

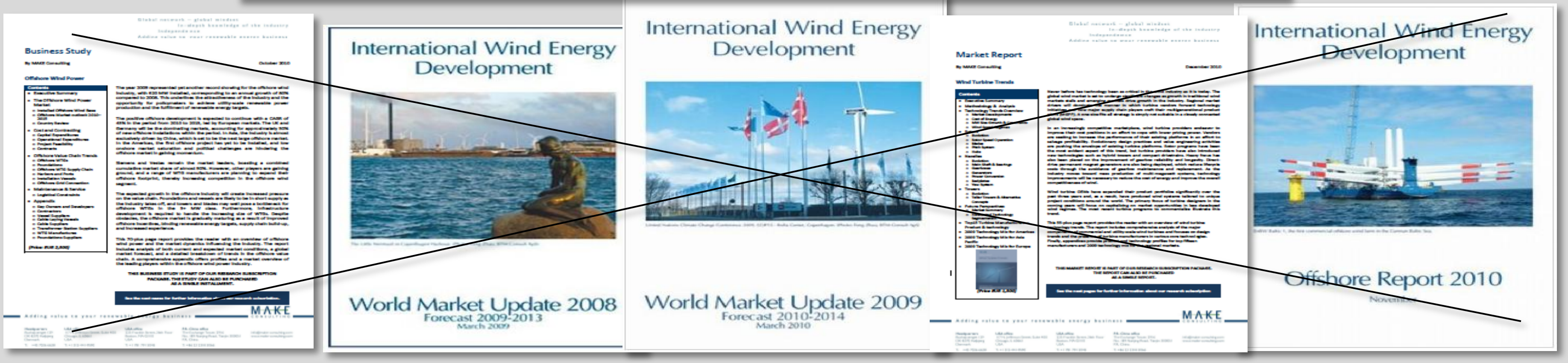
- Publications
- Operational Experience
- Technical solutions in use
- Measurements & Instruments
- Knowledge on climatic conditions and resources

Control anemometer and wind vane at Olostunturi-fjell Finland

- Send us information about icing and low temperature events
- Add a low temperature or icing WTG site to our list and map

Index Mail: Tomas Wallenius

Technology development for WE in cold climates
Requires market studies **- not available : - (**



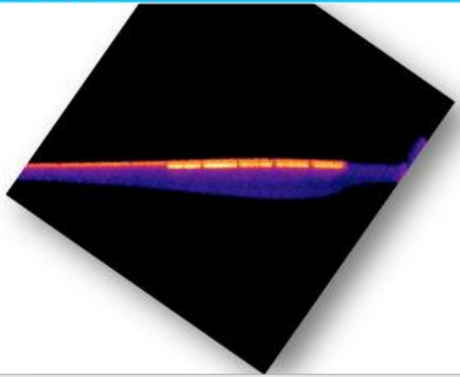
International participation in O2 Vindkompaniet’s wind pilot project

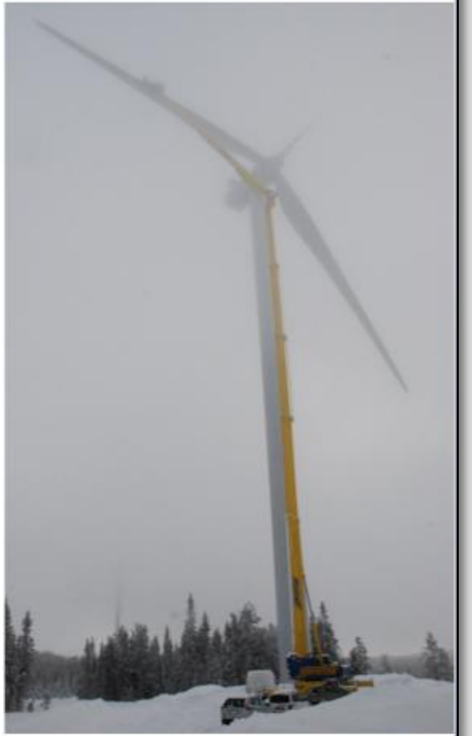
Testing Active: Outside hot panels

Top 5 reasons for not pursuing leading edge heating

- AEP
  - Losses during summer time to large compared to the gain during icing conditions
- O&M cost proved to be to high
- High system costs
  - Component costs and lightning protection
- Lifetime
  - It remains unproven that a reasonable lifetime can be achieved
- Damage from lightning

In terms of ***performance*** it has to be said that the technology didn't receive a full and fair *trial in severe ice conditions*





Vestas De-icing solution

Wind. It means the world to us.™

Vestas

As presented by Vestas at Winterwind 2012 on Feb 7, 2012

Applying external panels isn't a proven technology

International participation in O2 Vindkompaniet's wind pilot project

Swedish Energy Agency

SIEMENS

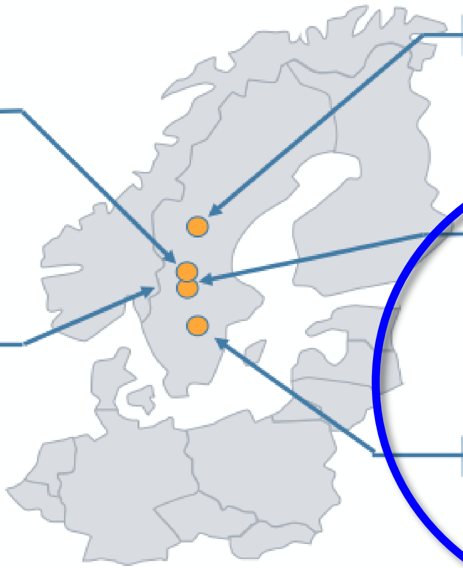
O2 VINDKOMPANIET

Vestas

iea wind

SIEMENS

Turbines installed in Sweden and ongoing testing



Kyrkberget
- 1 SWT-2.3-101
- Customer: Jämtkraft

Raftsjöhöjden
- 4 SWT-2.3-101
- Customer: Höjdvind AB

Korpfället
- 9 SWT-2.3-101
- Customer: O2

New projects in 2012-13
- 4 SWT-2.3-101
- 30 STW-2.3-101
- 37 SWT-2.3-DD-113
- And more to come

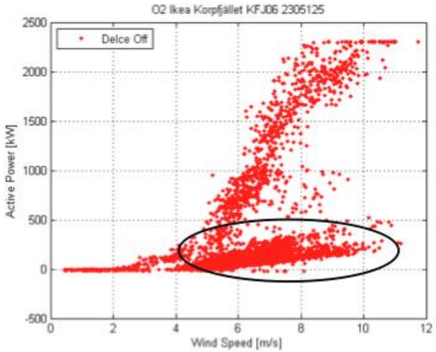
Brahehus
- 1 SWT-2.3-101
- Customer: O2

As presented by Siemens at Winterwind 2012 on Feb 7, 2012

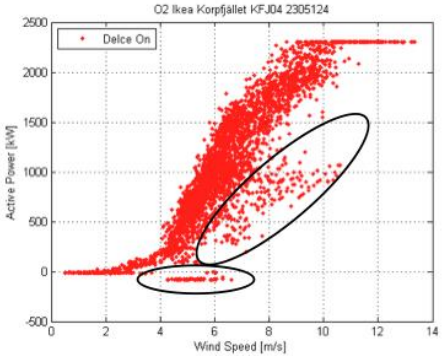
Korpfjället and Brahehus are part of O2's wind pilot project

VINDKOMPANIET

Power curve from reference turbine



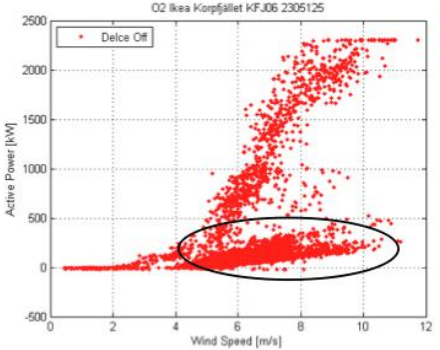
Power curve from turbine with de-icing



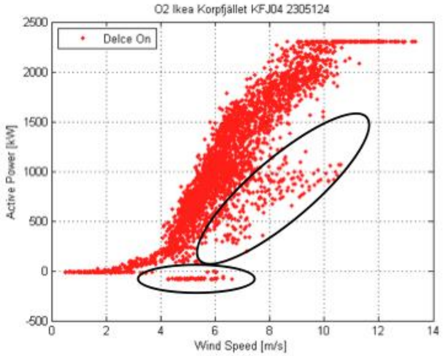
Turbines keep operating in spite of icing conditions

SIEMENS

Power curve from reference turbine

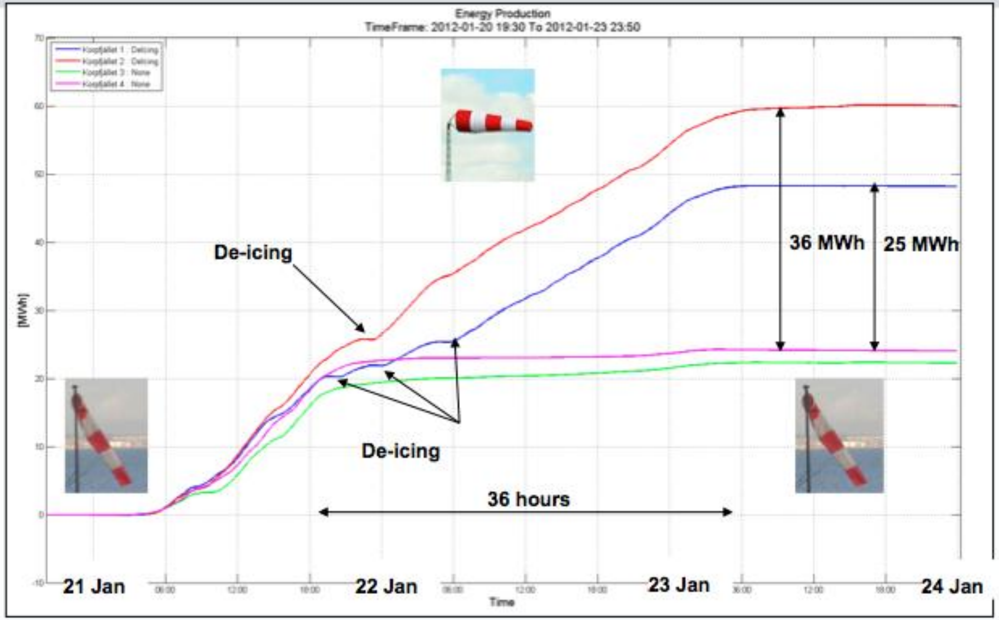


Power curve from turbine with de-icing

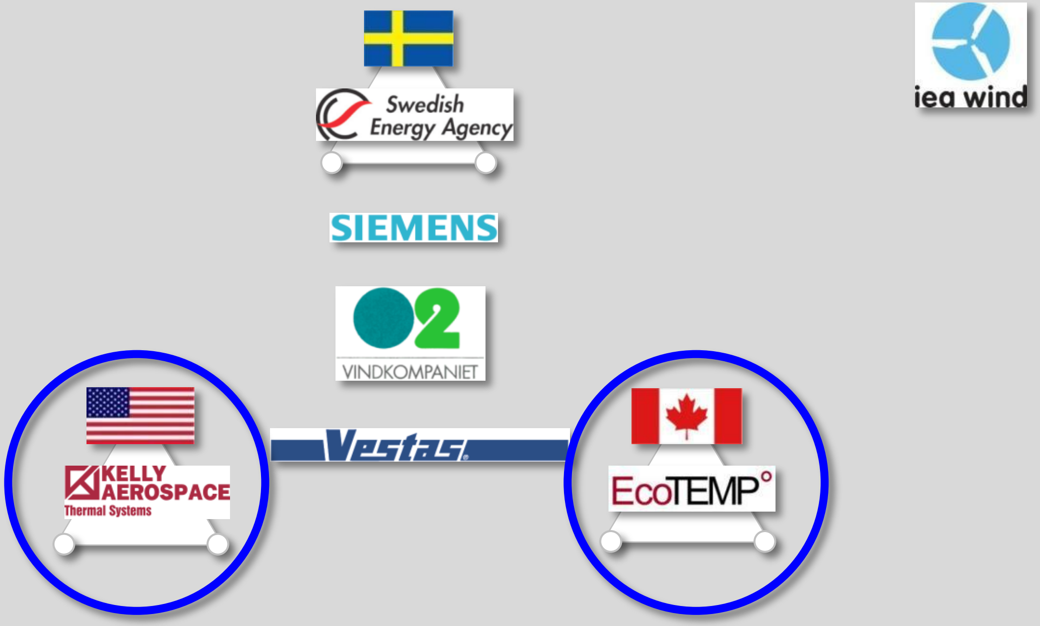


SIEMENS

Power production in icy conditions



International participation in O2 Vindkompaniet’s wind pilot project



EcoTEMP°


ARBETSMILJÖ
VERKET

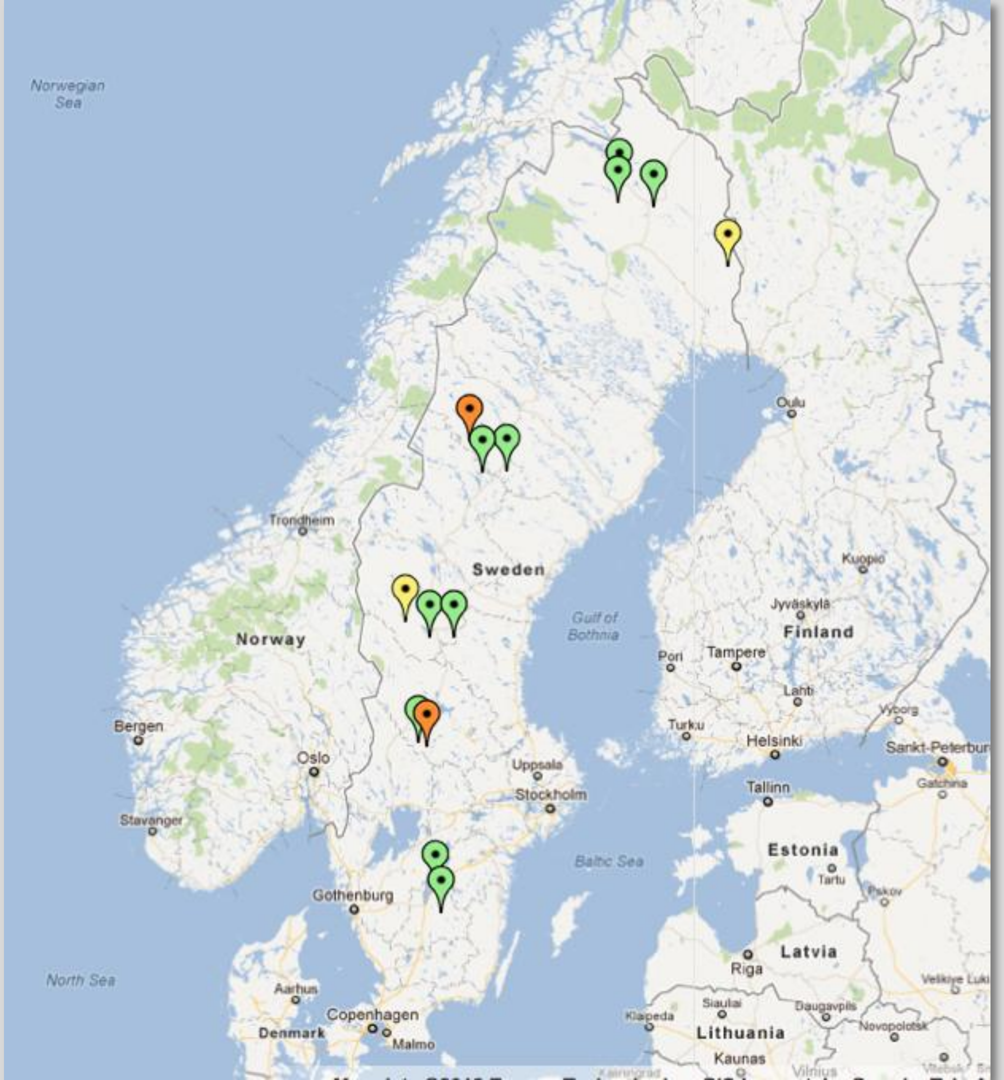

EcoTEMP°

KELLY AEROSPACE

KELLY AEROSPACE
Thermal Systems


KELLY AEROSPACE

Mapping of icing requires verification



Icing measurements **are ongoing**

International participation in O2 Vindkompaniet’s wind pilot project

SIEMENS

Metrology installation on the nacelle

Metrology test station mounted at Korpfället and Brahehus together with O2, IKEA and Gören Ronsten (Project manager on behalf of O2)

To learning and adjust the turbine controller for operating more efficient to improve energy production in cold climate

Equipment used on WT

Ice detector, ice load, met sensor

Long boom for WS

COMBITECH

& in the masts (13 stations)

International participation in O2 Vindkompaniet’s wind pilot project

UPPSALA UNIVERSITET

WeatherTech

KJELLER

Swedish Energy Agency

SIEMENS

COMBITECH

O2 VINDKOMPANIET

iea wind

LEADING EDGE ATMOSPHERICS, LLC

FINNISH METEOROLOGICAL INSTITUTE

IN SITU

SMHI

KELLY AEROSPACE Thermal Systems

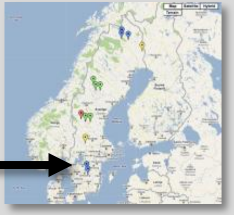
Vestas

EcoTEMP°

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	33	40	26	10	0	0	0	0	0	0	0	53
2001	61	29	27	13	0	0	0	0	0	0	11	80
2002	26	39	23	3	0	0	0	0	2	20	62	86
2003	32	57	5	24	0	0	0	0	0	24	66	60
2004	68	28	10	4	0	0	0	0	0	3	75	21
2005	22	64	27	0	0	0	0	0	0	0	13	41
2006	59	42	32	4	0	0	0	0	0	0	7	4
2007	21	33	22	7	0	0	0	0	0	0	34	40
2008	24	18	34	7	0	0	0	0	0	5	5	46
2009	32	12	56	0	0	0	0	0	0	1	4	39
										0	0	6
2010	83	71	28	0	0	0	0	0	0	1	79	25
	66	41	35	1	0	0	0	0	0	0	7	7

Table 55: Monthly number of hours with icing intensity $\frac{dM}{dt} > 10\frac{g}{hr}$ for Nässjö (black = 5x5km data set, red = 1x1km data set).

Example:
Number of hours of icing intensity >10g/h, Nässjö



WeatherTech

Site	max ice load kg/m	act icing hours no
Brahehus	0.7	167
Nässjö	0.9	184
Kiruna	0.7	154
Luongastunturi	1,2	357
Sjisjka	0.7	120
Bliekevare	1.2	240
Tåsjö	1.3	211
Sveg	0,9	244
Glötesvålen	3,1	619
Aapua	2.7	902
Röberg	2.5	640

Example:
Sum of monthly values, 201009-201104 Act icing hours: No of hours with icing intensity > 10g/m/h

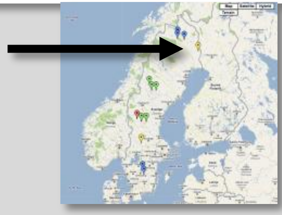
Example: Calculated and observed energy production in Dec 2011 on Aapua

LEADING EDGE ATMOSPHERICS, LLC

FINNISH METEOROLOGICAL INSTITUTE

Site	T_{mean}	T_{min}	T_{max}	U_{mean}	U_{max}	$Load_{avg}$	$Load_{min}$	$Load_{max}$	Rate>10	PwrPot PwrCln	PwrObs PwrIced	%LossObs %LossCln
AAPUA[1]	-	-	-	7.6	19.1	-	-	-	-	506	652	22.4%
671	-4.8	-16.5	0.9	8.1	18	2	0	7.7	279(42%)	729	593	18.7%

Table 3a: Subset of Table 2 for AAPUA.



Example: Calculated and observed energy production in Dec 2011 on Aapua

SMHI

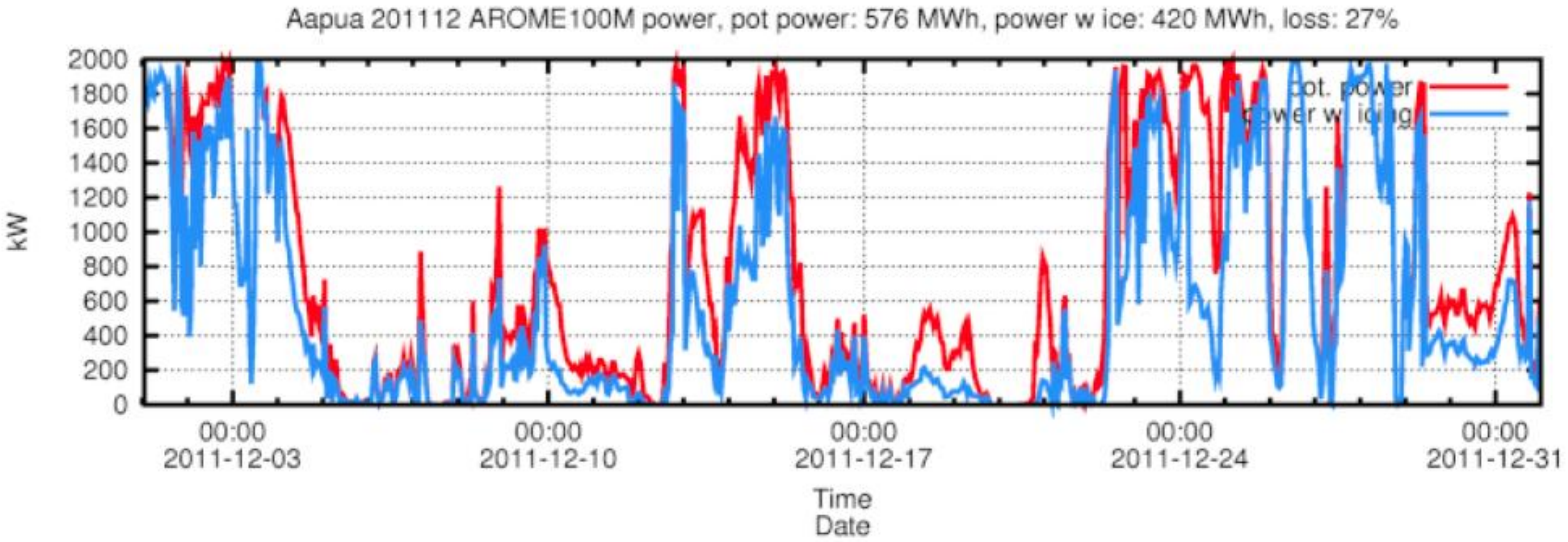


Figure 77. Ideal power production (red) and power production with ice (blue) (kW) at Aapua.

International participation in O2 Vindkompaniet's wind pilot project

Reference group Meteorology:
Greg Thompson, NCAR
René Cattin, Meteotest
Bjørn Egil Nygaard, NMO

International participation in O2 Vindkompaniet's wind pilot project

Uppsala Universitet

WeatherTech

Kjeller Vindteknikk

Swedish Energy Agency

Siemens

Combitech

O2 Vindkompaniet

iea wind

Leading Edge Atmospherics, LLC

Finnish Meteorological Institute

In Situ

SMHI

Kelly Aerospace Thermal Systems

Vestas

EcoTEMP°

Luleå Tekniska Universitet

SWECO

Luleå Tekniska Universitet

Teknikgruppen AB

Prefabricated gravity foundation using high strength steel cellular reinforcement

Aim: Shorten the construction period

Teknikgruppen AB

Prefabricated gravity foundation using high strength steel cellular reinforcement

Aim: **Shorten the construction period**

Structural dynamics and fatigue loads of iced up WT using current CMS-systems

Aim: **Input for update of IEC 61400-1**

Teknikgruppen AB

Prefabricated gravity foundation using high strength steel cellular reinforcement

Aim: Shorten the construction period

Structural dynamics and fatigue loads of iced up WT using current CMS-systems

Aim: Input for update of IEC 61400-1

Independent evaluation of performance of de-icing systems

Aim: Verification of performance of de-icing systems

Large Scale, Cost Effective Wind Energy Deployment in Icing Climates

Welcome to O2's wind pilot project seminar

Sep 16, 2011, Elite Hotel Marina Tower, Stockholm

Swedish Energy Agency

O2

Recap and kick-off 2011

09:00-09:30	Welcome, participants, background	Göran Ronsten
	O2's current activities	Sónia Liléo, Kristina Lindgren
09:30-10:00	The foundation	Sten Forsström, SWECO
10:00-10:15	Ice measurement systems, portal	Mikael Töyrä, Jenny Ericson, Combitech
10:15-10:30	Ice measurement systems	Bengt Norén, Björn Östberg, In Situ
10:30-10:45	**Coffee**	
10:45-11:15	Weathertech	Stefan Söderberg
11:15-11:45	Kjeller Vindteknikk	Erik Nordborg
11:45-12:15	Siemens de-icing	Finn D. Madsen
12:15-13:15	**Lunch ...**	

Wind energy aerodynamics - icing and de-icing of WT blades

Swedish Energy Agency

Wind energy aerodynamics - icing and de-icing of WT blades

09:00-10:00 Cross-pollination of aircraft icing and wind turbine icing technologies,
Prof. Wagdi Habashi, *Director, CFD Lab, Department of Mechanical Engineering, McGill University*
NSERC-J-Armand Bombardier-Bell Helicopter-CAE Industrial Research Chair of Multidisciplinary CFD
Pratt&Whitney Canada Research Fellow, Editor-in-Chief, International Journal of CFD
10:00-10:20 Challenges using composites in large rotor blades in arctic environment, **Sören Nilsson**, Swerea SICOMP AB
10:20-10:40 CFD in icing and deicing of WT, risk assessment of ice throw, increased noise due to iced up blades and cylindrical sound propagation, **Prof. Laszlo Fuchs**, KTH
10:40-11:00 Pause
11:00-11:20 Detailed national mapping of icing, influence from icing on wind energy production and the benefits of forecasting of icing to improve profitability
Øyvind Byrkjedal, Kjeller Vindteknikk …

http://www.chalmers.se/ee/swptc-en/events/previous-events/wind-energy-aerodynamics

Thank you!