OX2's wind pilot project

Large-scale, cost-effective wind energy development in icing climates,

Göran Ronsten

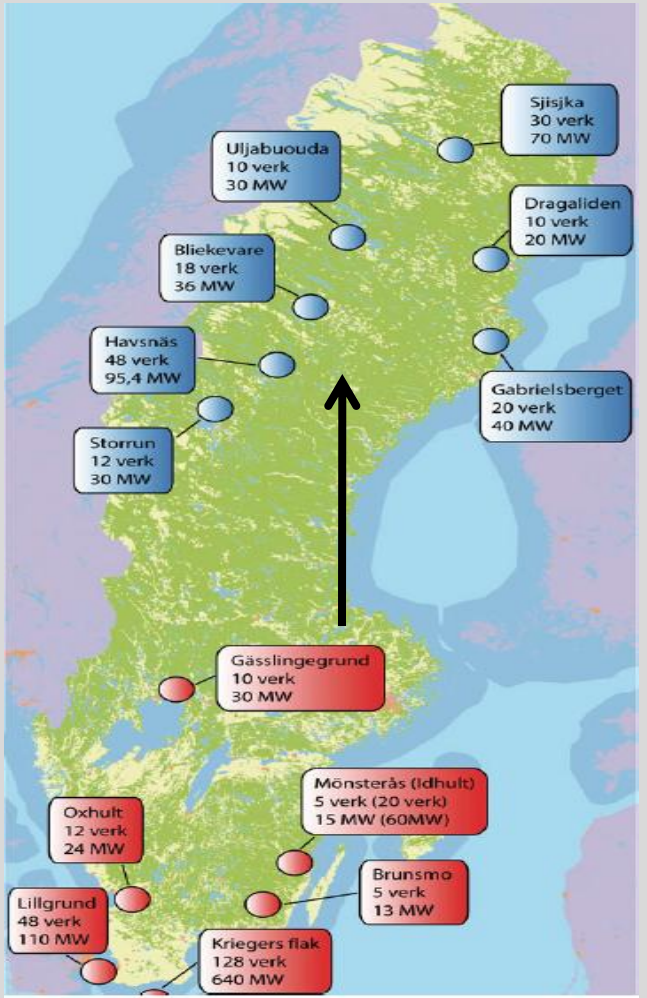
2008 – 2015

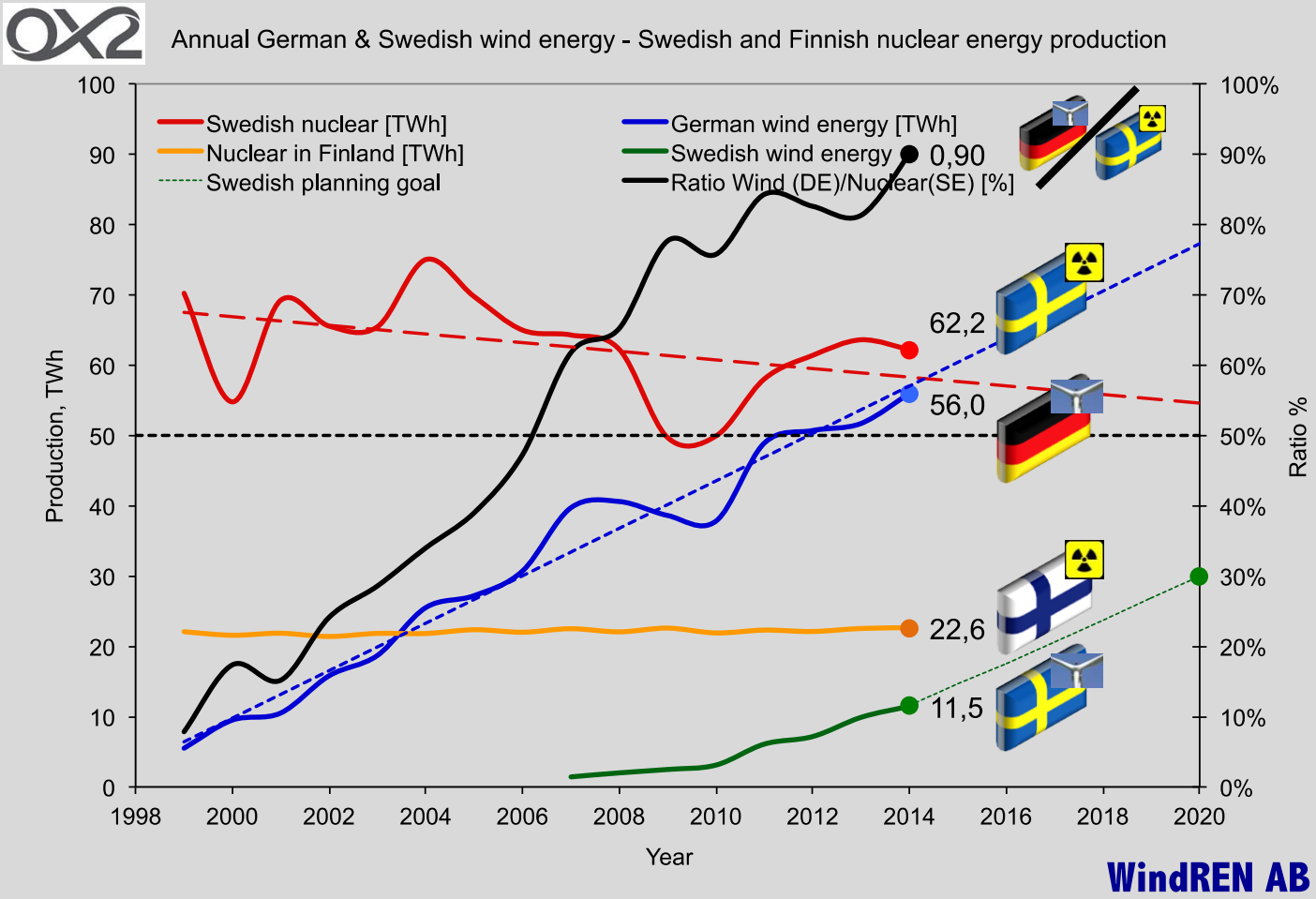
7.2 MEuro

Swedish Energy Agency

Wind pilot projects: 70 M€ over 10 years

From offshore to cold climate and forest





Can wind make a significant contribution?

China 2012:
60 GW of wind = All electricity from the China's 17 nuclear power plants

China 2013:
75 GW of wind = 150 TWh = Sweden's electriciy consumtion

China 2014:
115 GW of wind

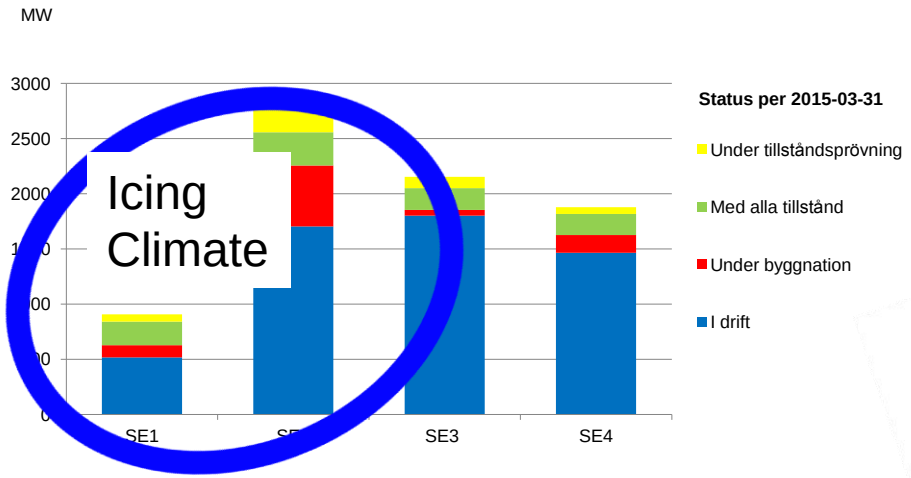
Installed power per electric region Dec 2018, Base scenario

Sweden

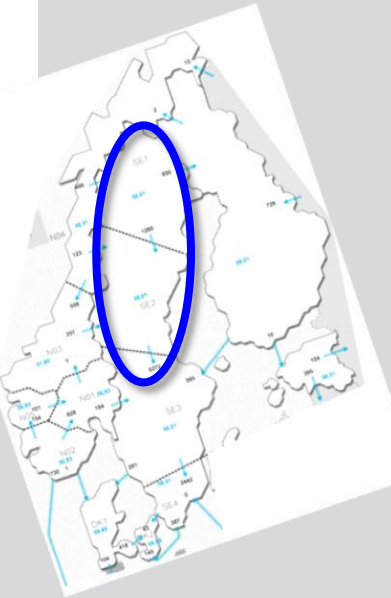
Installed power per region Q1, 2015

2018 scenario

Blue	Installed
Red	Constr.
Green	Permits
Yellow	Applied



Svensk Vindenergi



North → South

The main challenge in Sweden is icing, not low temperatures

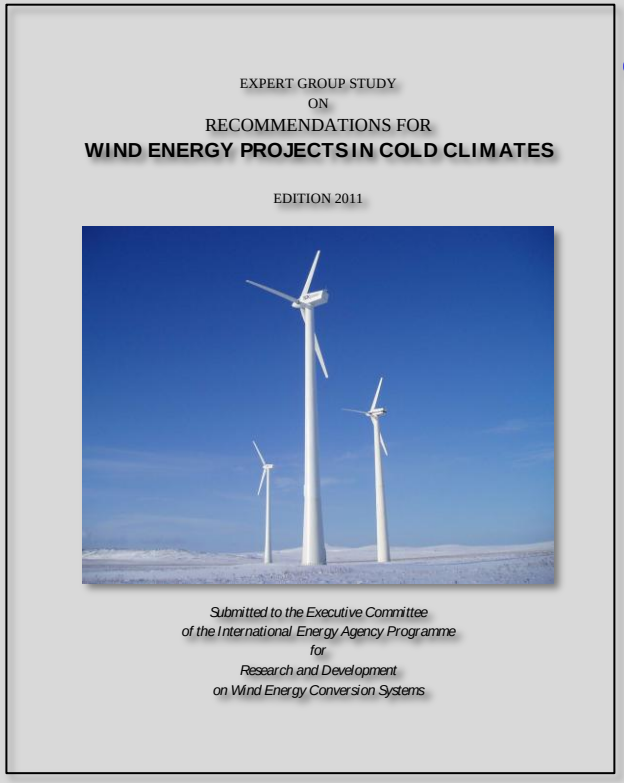
International influence on OX2´s wind pilot project

International interest in CC: IEA RD&D Wind, Task 19 meeting in Beijing, Oct 2013

Participants from:
Austria
China
Finland
Germany
Sweden

Not in photo
Canada
Denmark
Switzerland
Belgium

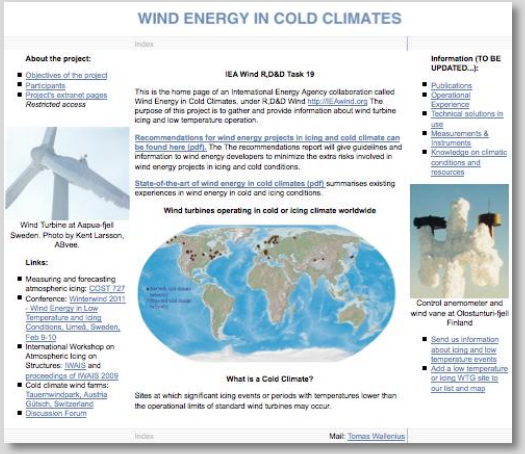
IEA Task 19 home page - http://arcticwind.vtt.fi/


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

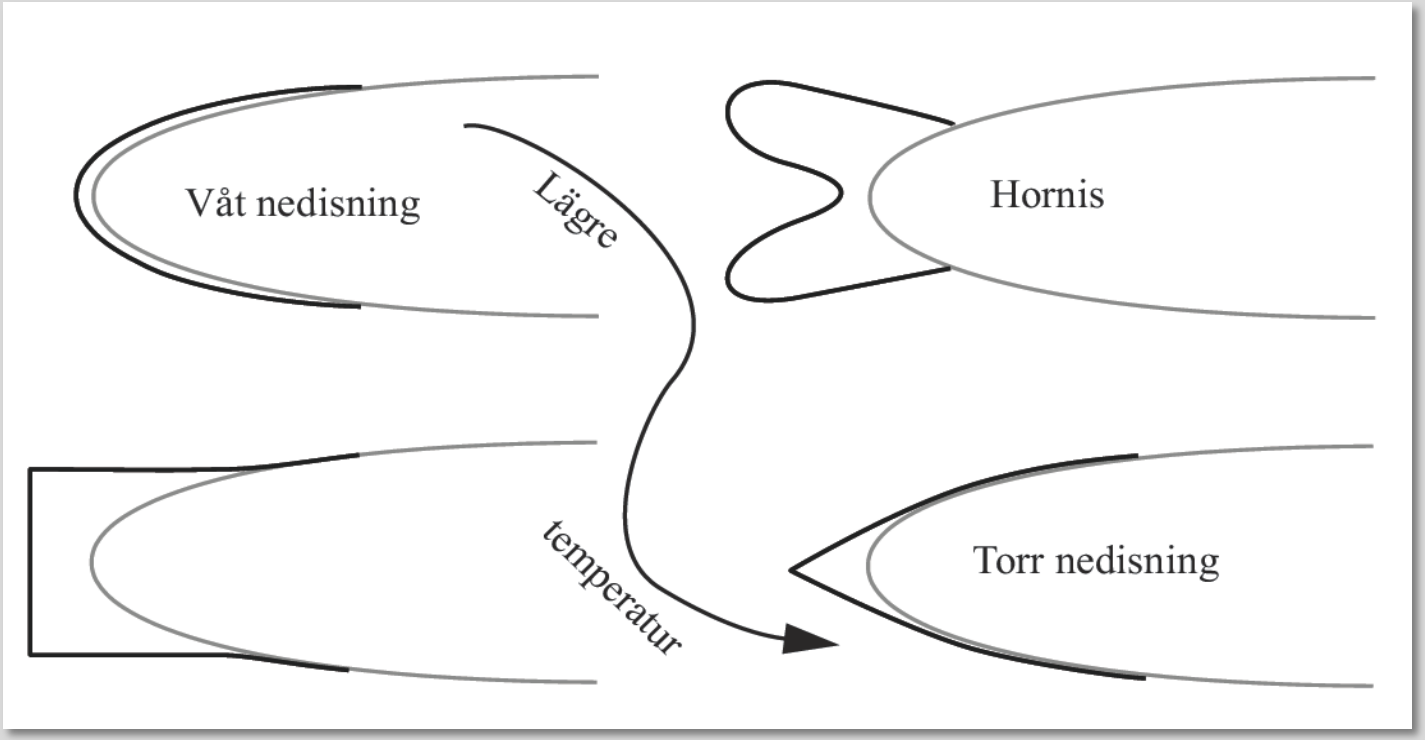
- Recommendations report – 2012!
- State-of-the-art report - 2012
- Continuation 2013 - 2015



Technology development for WE in cold climates
Market study required **– Available in BTM's WMU 2012 (Mar 2013)**

Modern LED obstacle lights need heating to be seen

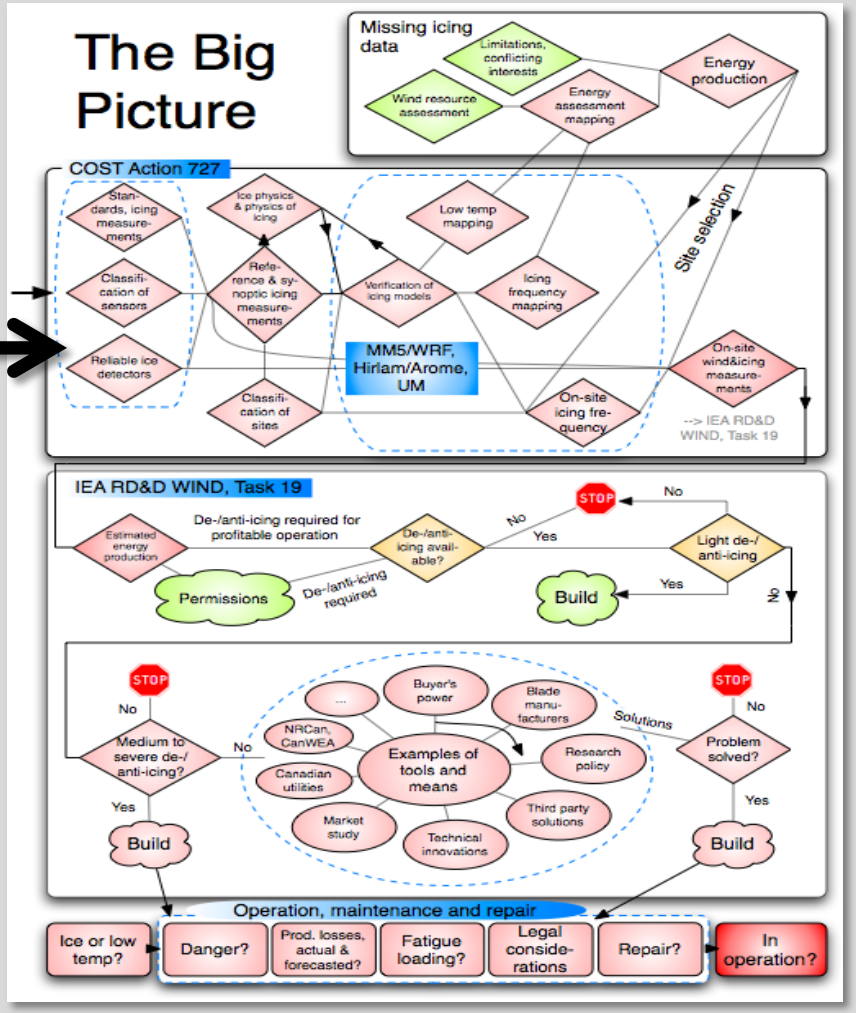
Icing versus temperature




ØPA
HEADLA

Schematic, estimated de-icing capability 2008

A plan to keep WT in icing climates in operation

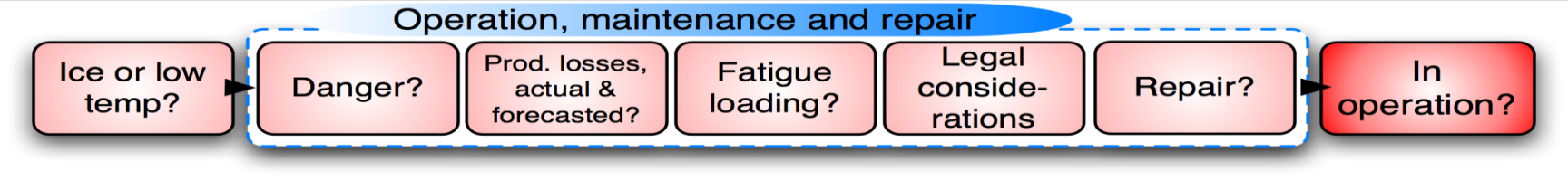


Planning
Standards
Sensors
Models
Measurements

De-icing

Rules, O&M

How to deal with practical issues?

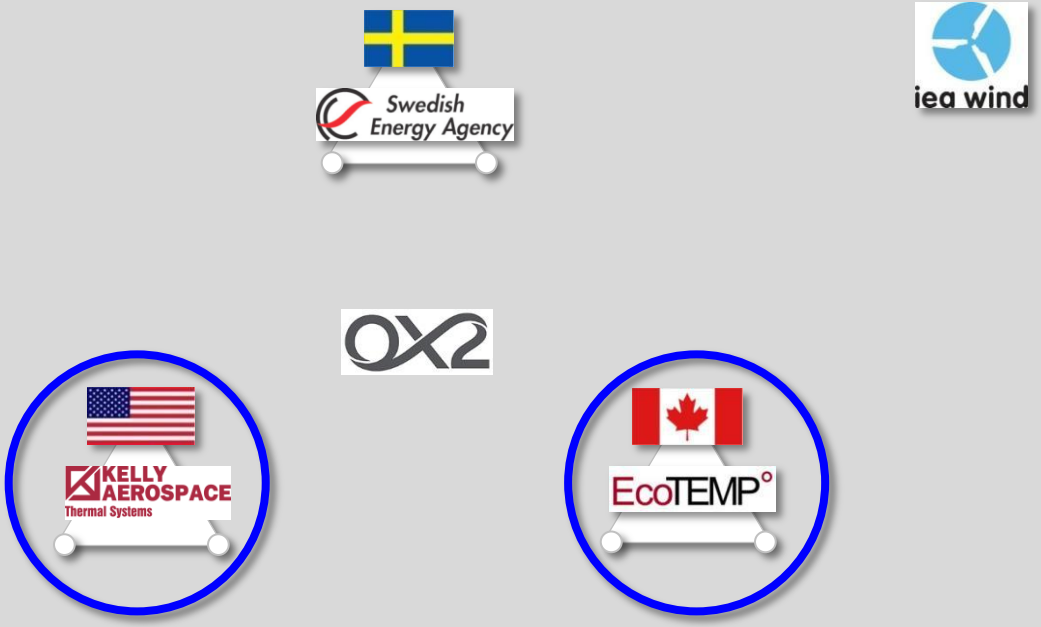


Anti-icing (40 WT) and icing measurements (13 stations, 11 sites),

Bliekevare, Brahehus, Sjisjka, Glötesvålen and other, 2008-2015, **R&D: 7.2 MEuro**

OX2 SIEMENS Vestas KELLY AEROSPACE Thermal Systems EcoTEMP COMBITECH IN SITU ...

International participation in OX2's wind pilot project




ARBETSMILJÖ
VERKET


EcoTEMP°

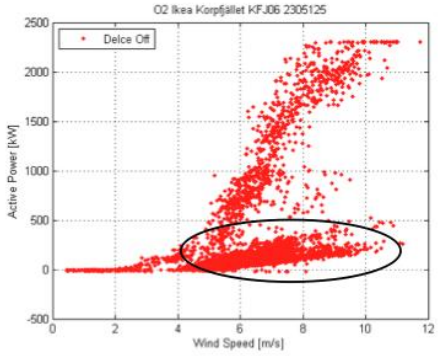
KELLY AEROSPACE
Thermal Systems

International participation in OX2's wind pilot project

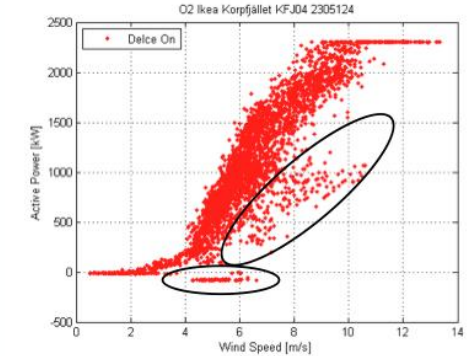
Turbines keep operating in spite of icing conditions

SIEMENS

Power curve from reference turbine

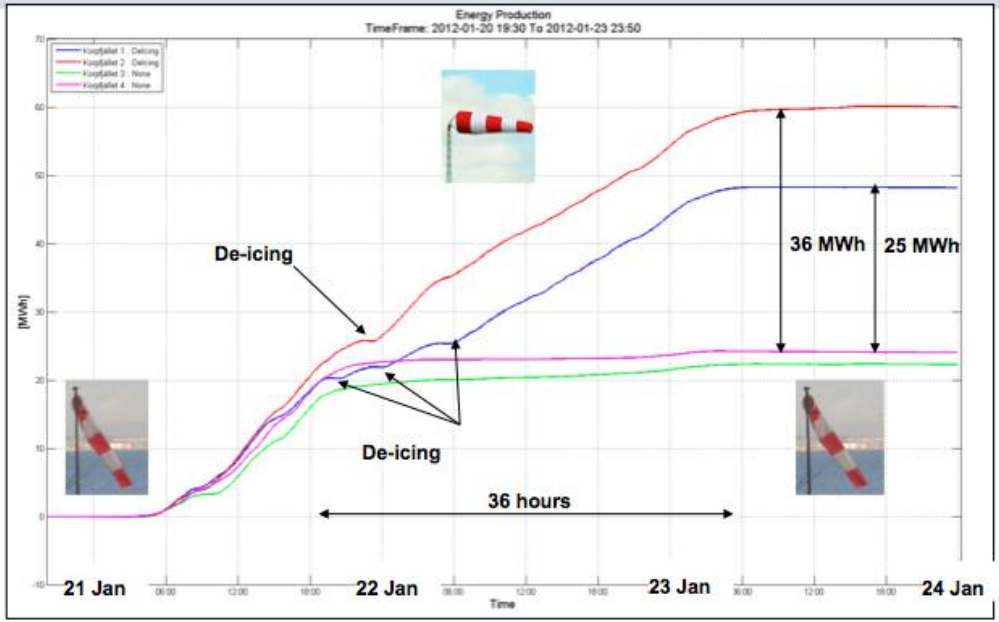


Power curve from turbine with de-icing



SIEMENS

Power production in icy conditions



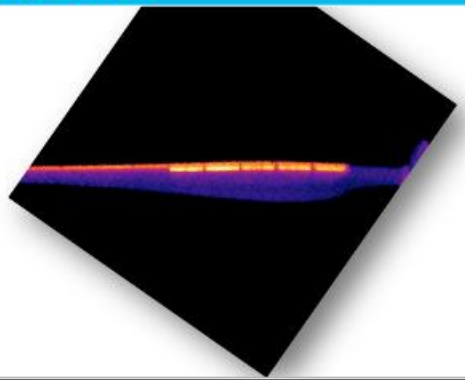
International participation in OX2's wind pilot project

Testing Active: Outside hot panels

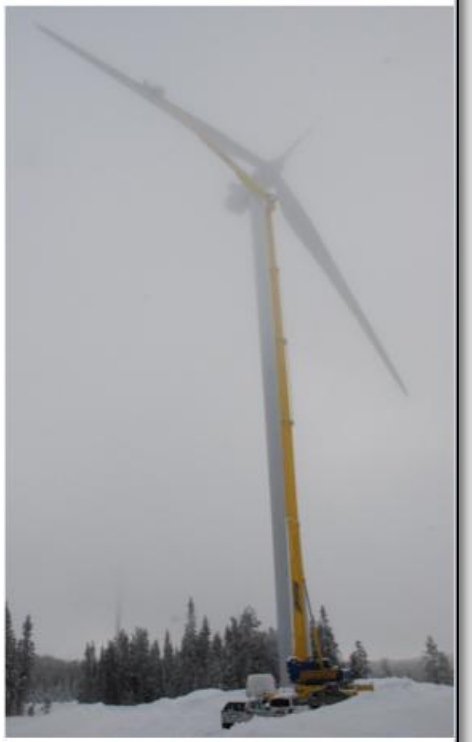
Top 5 reasons for not pursuing leading edge heating

- 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.™

As presented by Vestas at Winterwind **2012**

Applying external panels isn't a proven technology

Vestas De-icing system

Designed for production optimization and operation

- **Active** blade de-icing solution
- **Hot Air technology** within each blade root
- **Simultaneous** de-icing of blades
- **Automatic system** based on power curve and ambient conditions

- No impact on overall turbine performance – **20 year lifetime** maintained
- **No impact** on lightning protection
- **Easy access** for service from the hub and blade root end
- Full **turbine software** implementation
- Follow type certificate with a **statement of compliance**

Wind. It means the world to us.™

As presented by Vestas at Winterwind **2014**

Challenge 2014/2015 – 30 Vestas V90 equipped with hot air based de-icing

IKEA

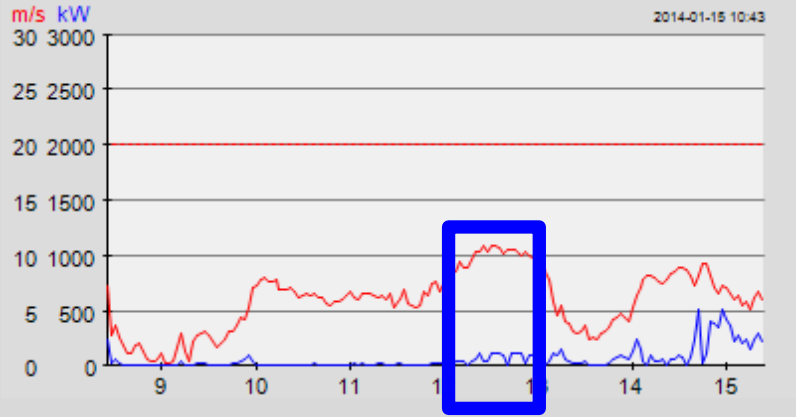
Vestas

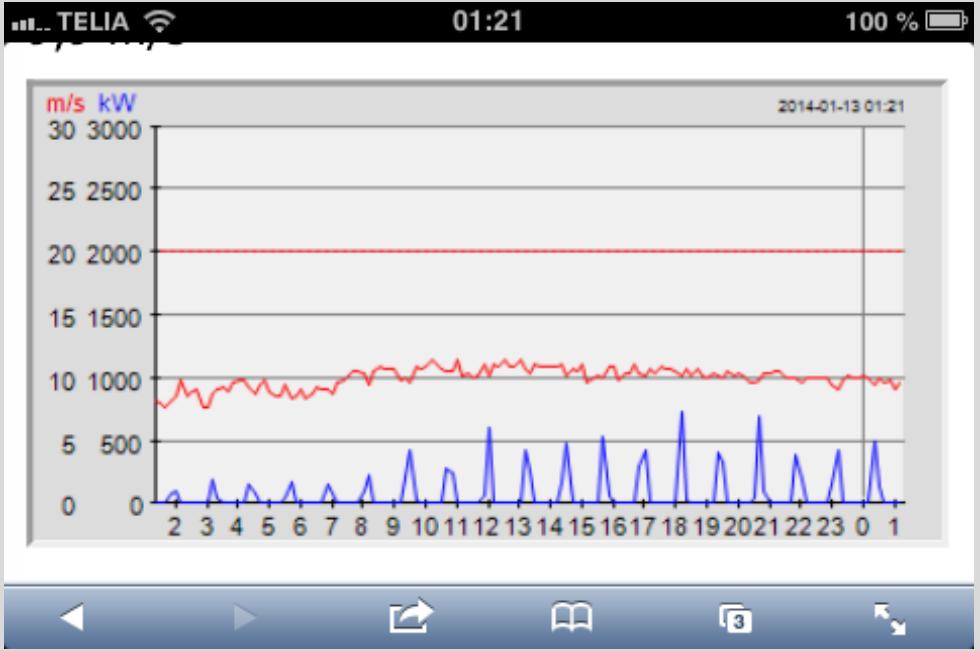
Glötesvålen

Challenge 2014/2015 – 30 Vestas V90 equipped with hot air based de-icing

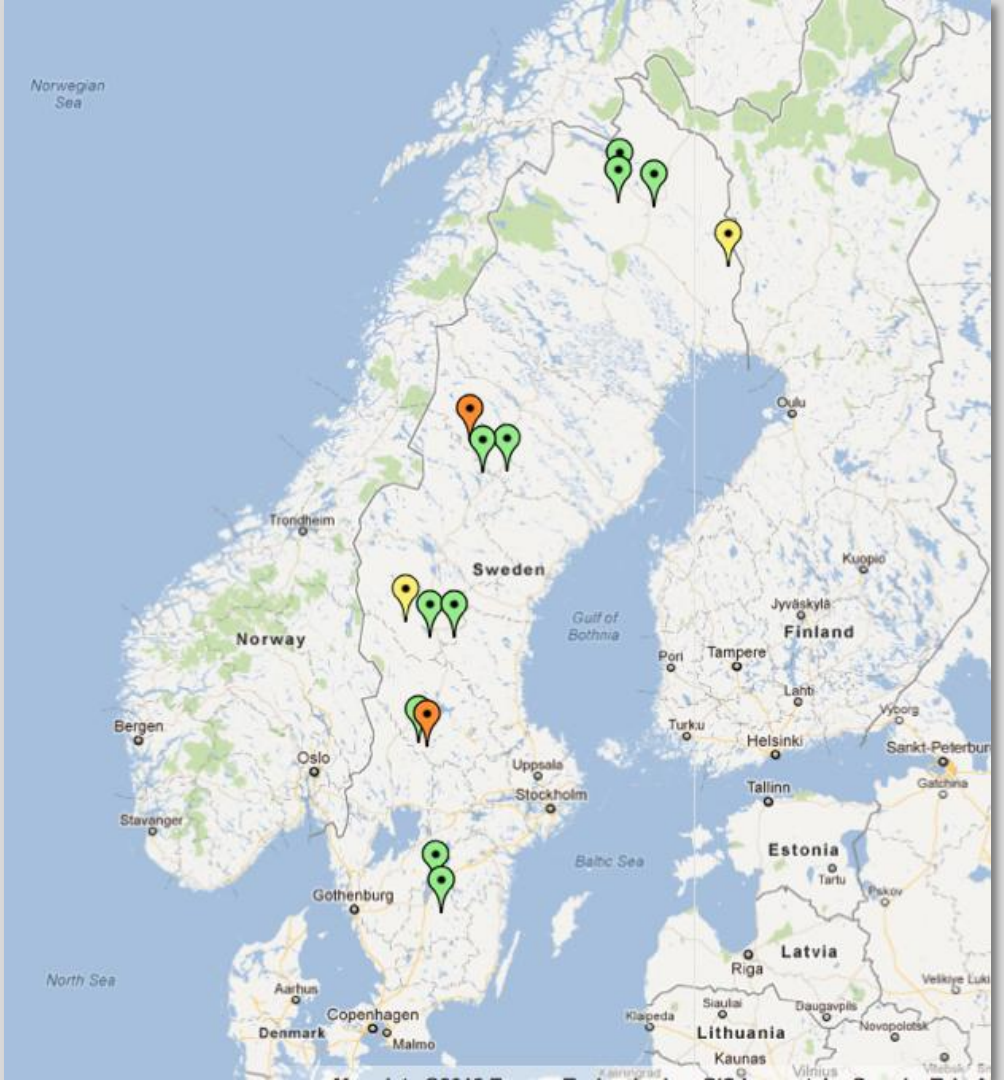
Q: Will the power transfered by menas of hot air suffice on Glötesvålen?

Example of an Enercon E82 trying to de-ice during the 2013/2014 season.



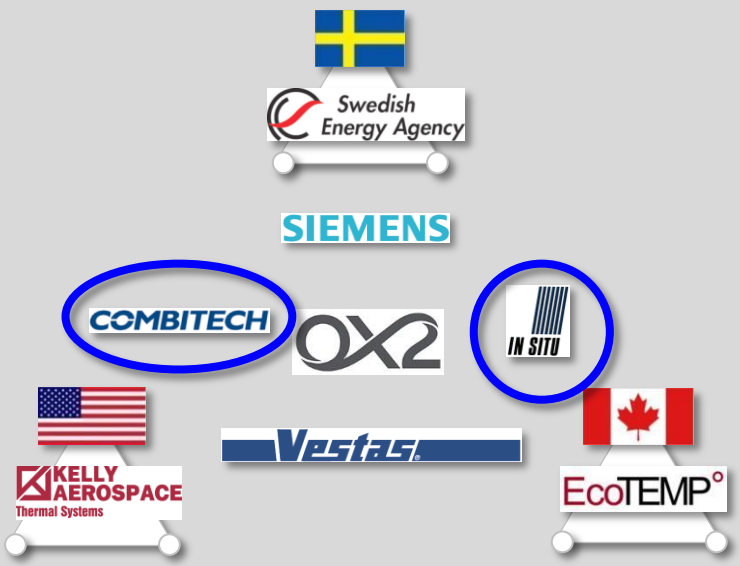


Mapping and forecasting of icing requires verification



Icing measurements **are ongoing**

International participation in OX2's wind pilot project



Equipment used on WT

Ice detector, ice load, met sensor

Long boom for WS

COMBITECH

& in the masts (13 stations)

Visibility

Camera

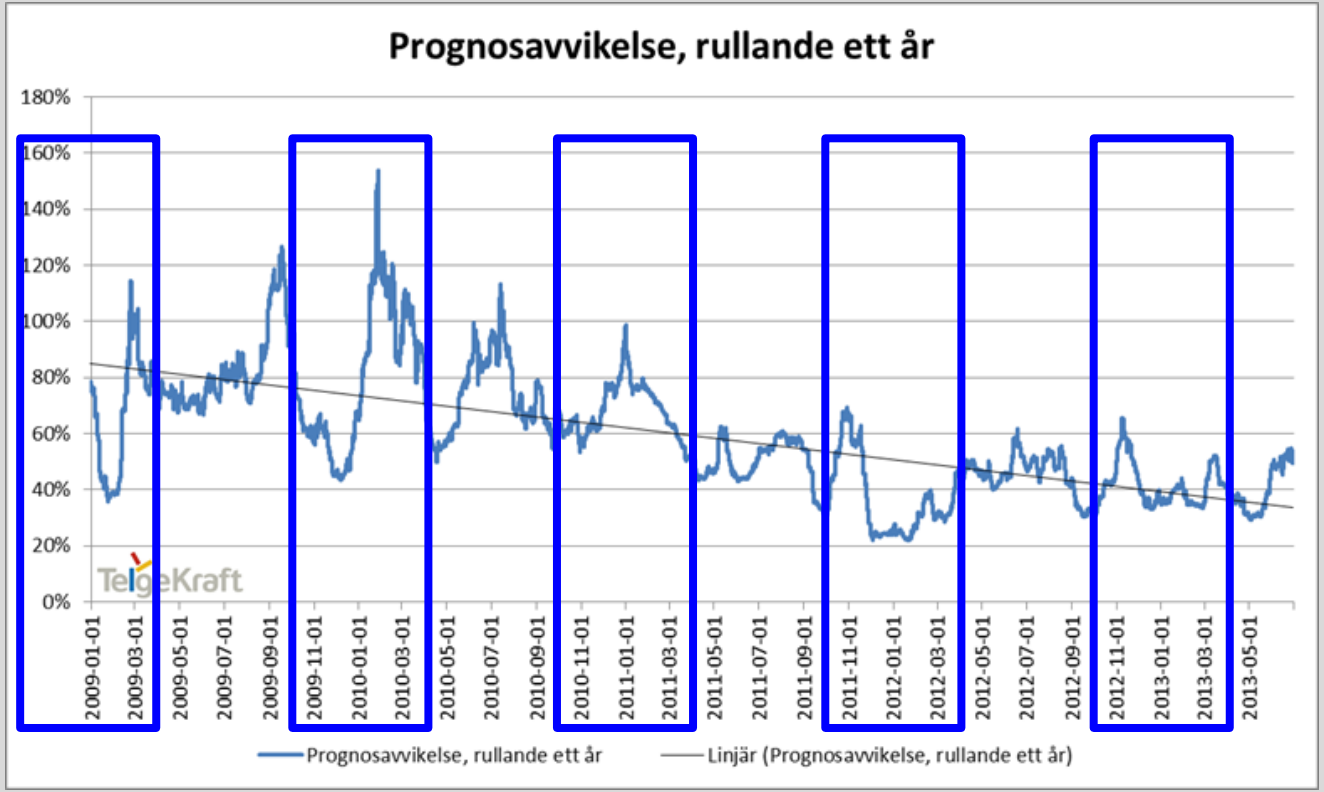
International participation in OX2's wind pilot project

Pricing in power systems: Sweden

- **Hydro + Nuclear + wind (90%)**
- **Large part of the rest is CHP (industrial and distr. heat) ➔**
- Price is set by the **water value** = the expected marginal cost in the future to which the water could be stored. ➔
- **Price is not set in Sweden!**

Courtesy of Lennart Söder, KTH

An example of decrease in annual moving average forecast error



The forecast error is defined per h as:

abs(prod-for)/prod

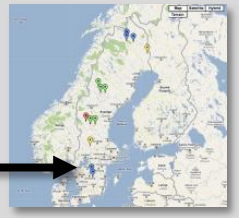
Increase in uncertainty during winter periods?

Winter - prices are generally higher!!!

	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

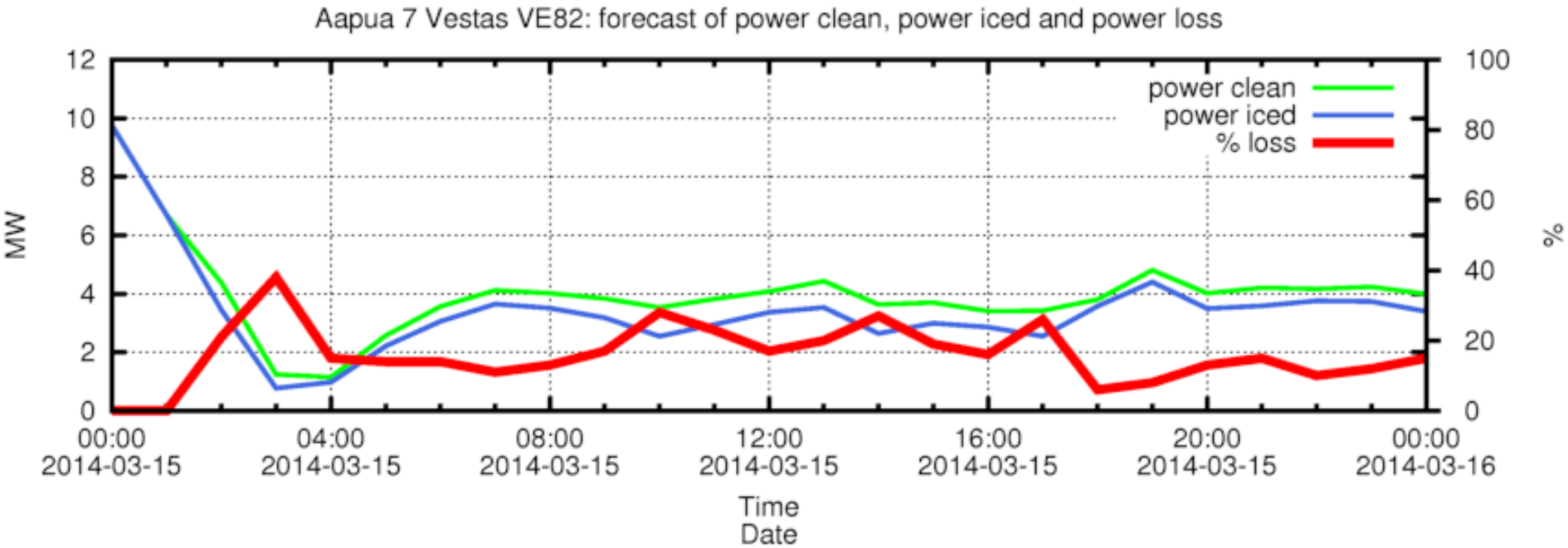
Table 55: Monthly number of hours with icing intensity $\frac{dM}{dt} > 10\frac{g}{hr}$ for Nässjö (black = 5x5km data set, red = 1x1km data set).

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



Example: Forecasted energy production with and without ice

SMHI



International activities to assess the balancing cost

*"We are studying these issues as a part of the **Icewind** project for the four Nordic countries in Nordpool spot power market: Denmark, Norway, Sweden and Finland. First we are looking at the variability of the wind and the load, country by country and for all; then at the forecasting done in the four countries and the accuracy and uncertainty of the forecasting.*
Lastly we will try to assess the impact of icing on forecast errors. At this point of time we are not sure we will be able to isolate this issue on a power market level. In any case the answer is approximately one year away."
…
So far we have only looked at the cost of balancing for Finland and found a level of 1-1.4 EURO/MWh.

Niels-Erik Clausen, Senior Advisor, Head of Study Board, **DTU Wind Energy**

*"In our project **IcedBlades** we have the target to identify short term uncertainties. So it connects directly to the first steps from the results of 2008. There will be a EWEA workshop on forecasting in Decmeber. I am not sure if they are aware of the problems that we recognize for cc sites. Details here: http://www.ewea.org/events/workshops/wind-power-forecasting/*
Michael Durstewitz, **Fraunhofer IWES**

26 European countries participated in COST 1002, Weather Intelligence for Renewable Energies (but not Sweden)
"have a look at our website, in particular our Current State report (to be officially published in a couple of months) as well as the benchmark exercise we are presently involved in. By the way, we will submit tomorrow a new COST Action... May be the SMHI will find it interesting this time...."

Dr. Alain Heimo, Meteotest

International participation in OX2's wind pilot project

Reference group Meteorology:
Silke Dierer, Meteotest
Frank McDonough, Dendrite
Carla Ribeiro, DNV GL

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

Schematic, estimated de-icing capability

Thank you!