

Siemens Blade De-icing



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Date 1 - dec. 2011

Siemens WindPower in Cold Clima

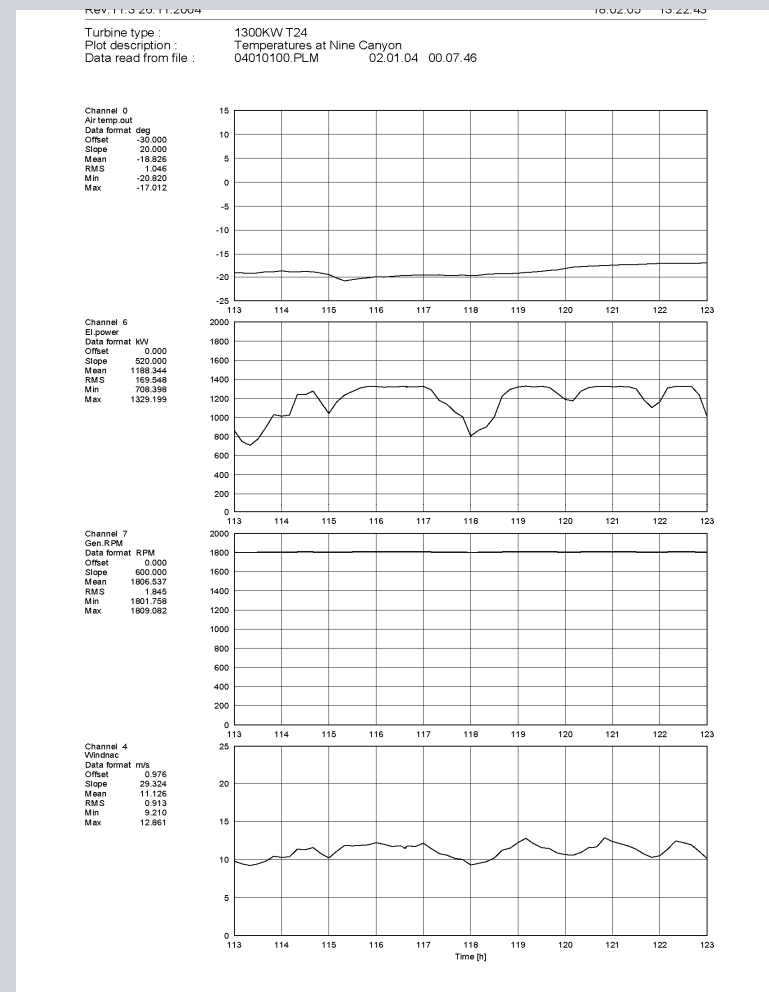
Long experience with turbines in cold clima with and without De-icing

First Cold Weather Package in Quebec 1986:

Operation - 25 deg.
Stand still - 45 deg.



Headed gearbox, hydraulic oil & anemometers



Long experience with de-icing

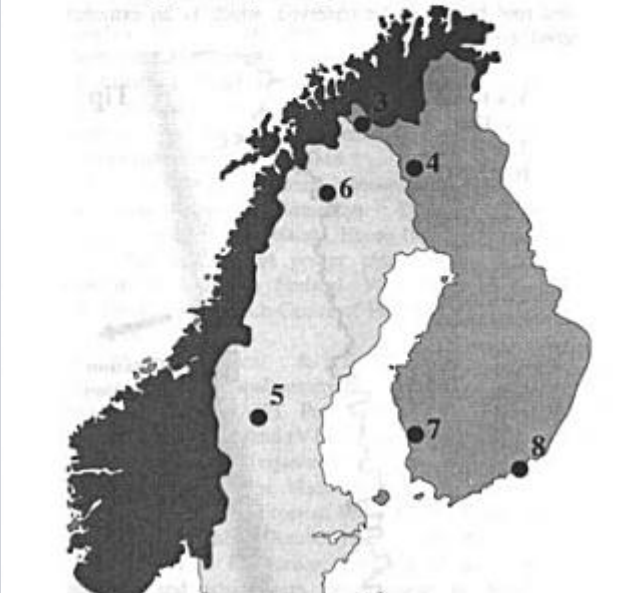
Long track record on turbines with deicing
 Started in Yukon Canada in 1994 1x150 KW



Figure 4. Bonus 600 kW wind turbine provided with the blade heating system on the top of Lammasoaiivi Fell in the most Northern parts of Finland.

3	Lammasoaiivi	2 x 450 kW 1 x 600 kW	Bonus Bonus	96 98
4	Olos	2 x 600 kW 3 x 600 kW**	Bonus Bonus	98 99
5	Vemhån	1 x 600 kW	Bonus	98
6	Suurva	1 x 600 kW	Bonus	98
7	Pori	4 x 1 MW**	Bonus	99
8	Kotka	2 x 1 MW***	Bonus	99

* The turbine modified to include the blade heating system in 1994.
 ** Project under construction
 *** Project under planning



Think Tank Project

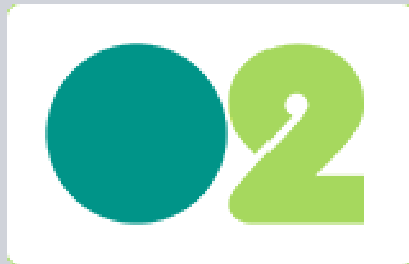
1 ½ ago started a Think Tank project started in Siemens Wind Power.

We found De-icing as a interesting project.



Think Tank project

Meeting between O2 – Gören Ronsten – Siemens Wind Power

**SIEMENS**

Opportunity to have a test site at Brahehus and later at Kyrkberget with Jämtkraft.

Detect and Remove Snow & Ice

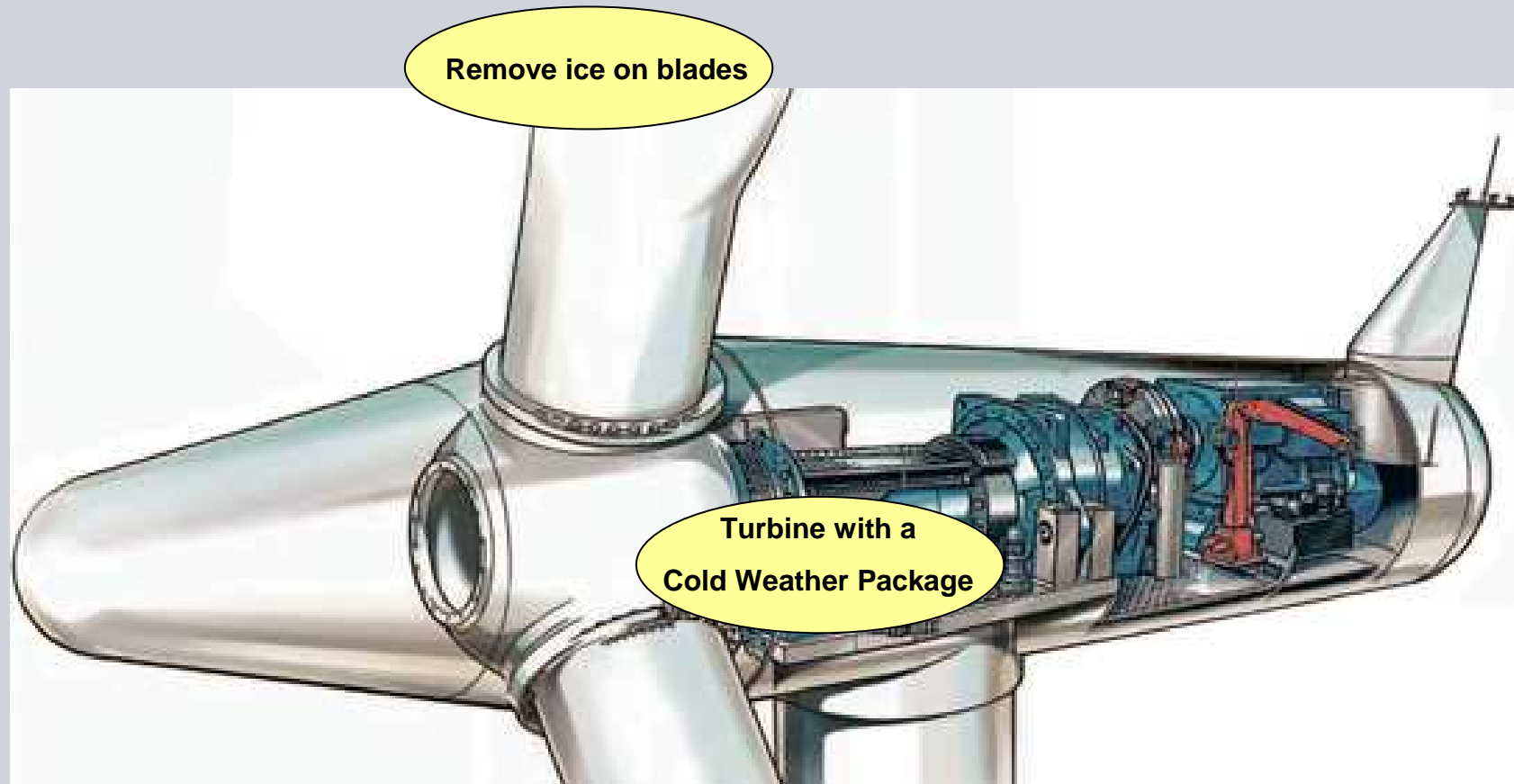
Challenge is:

Detect ice on the blades quickly and efficiently.

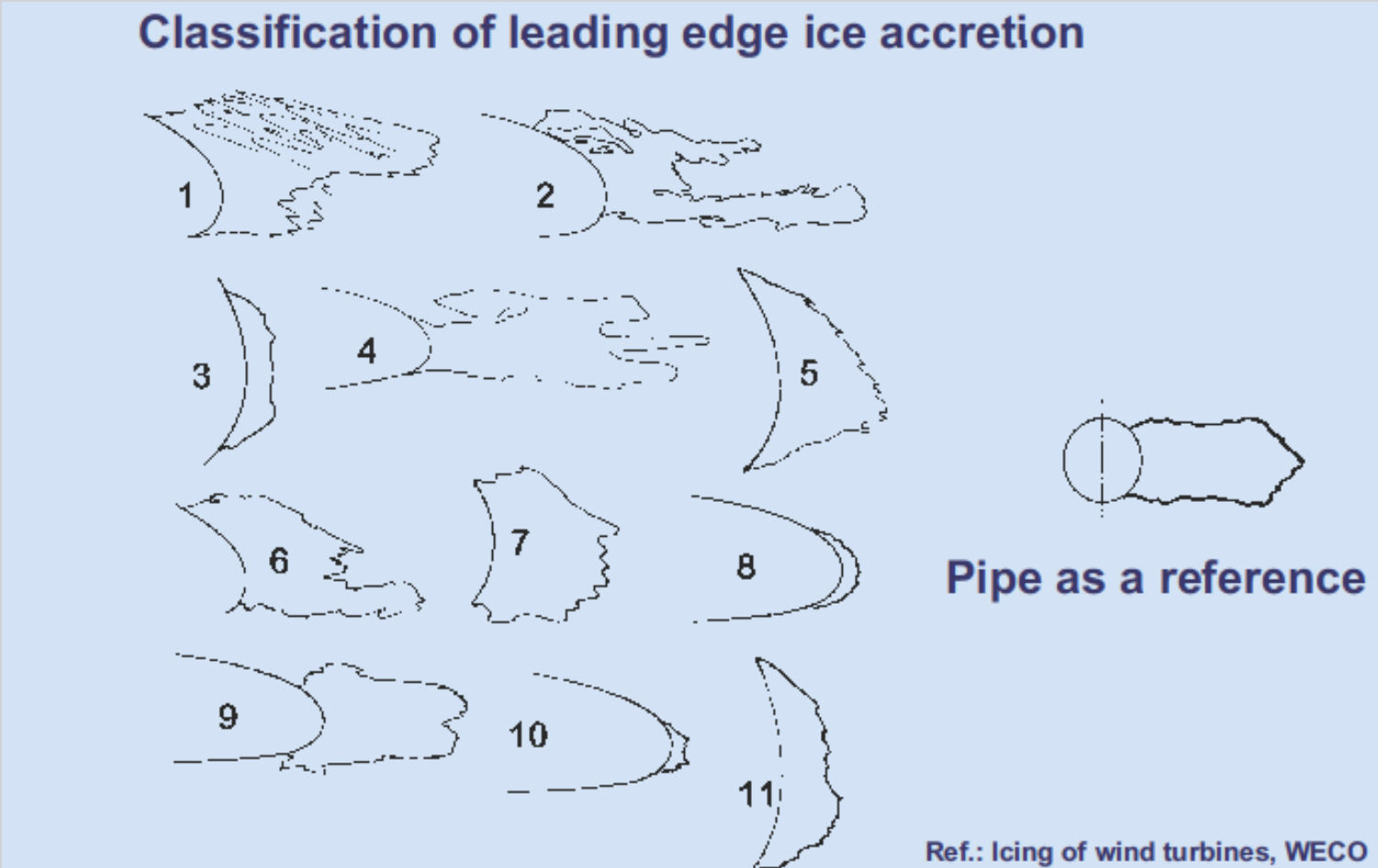
Remove it from the blades - and avoid downtime.



De-icing system



Examples of ice on a blade



Kyrkberget Feb 2011



How to remove ice on blades

Passive (surface coatings)

- **Blades painted black**
- **Nanotechnology / hydrophobic**

Active

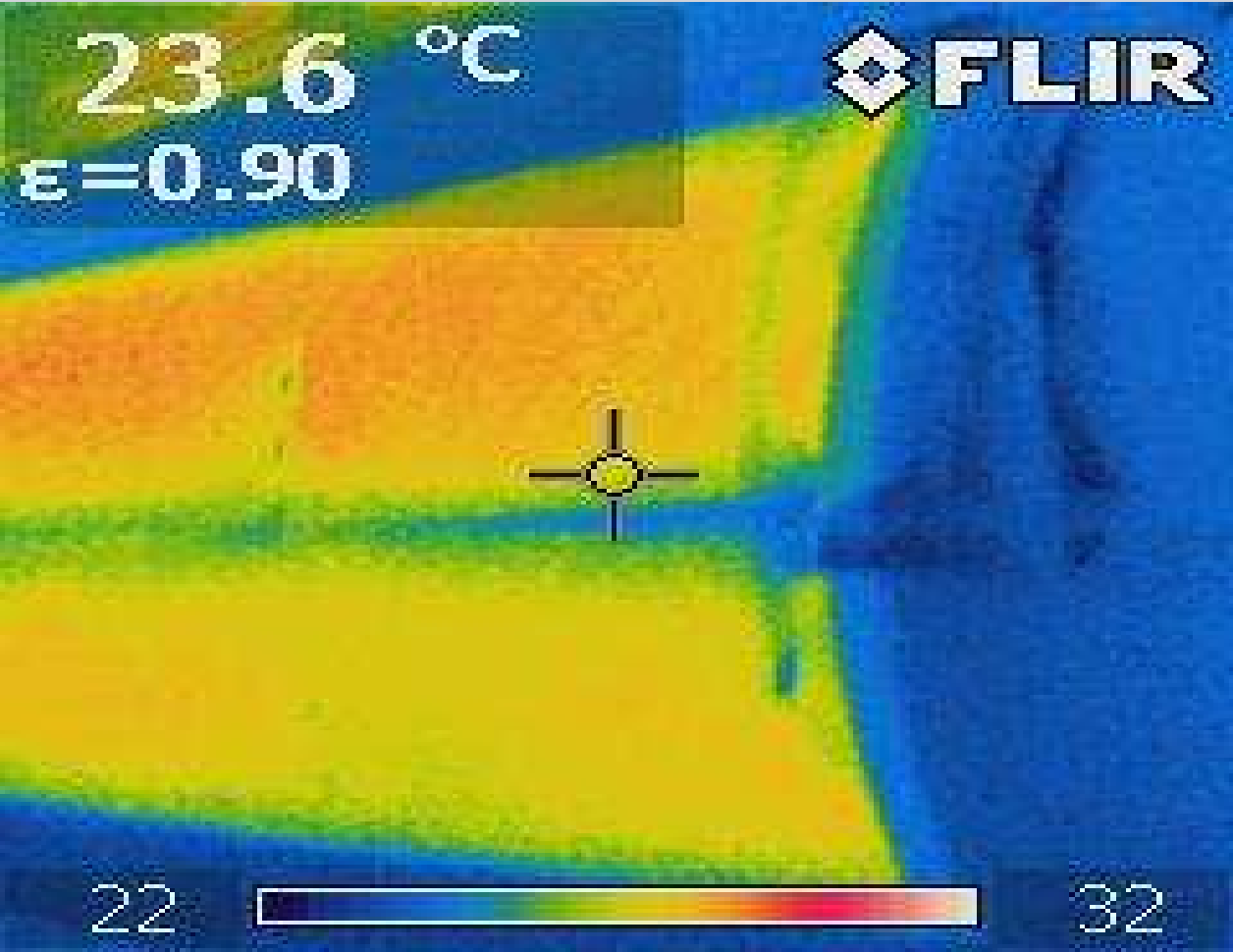
- **Chemical**
 - **Spray-on chemicals**
- **Mechanical**
 - **Change air flow by pitching**
 - **Mechanical solution** bug wipers”, inflating balloons
 - **Shaking the blades**
- **Thermal**
 - **Microwaves**
 - **Heated air inside the blades**
 - **Hydraulic heated hoses**
 - **Electrical heated foils**
 - **Build in electrical heaters**

Heat test at the Blade factory

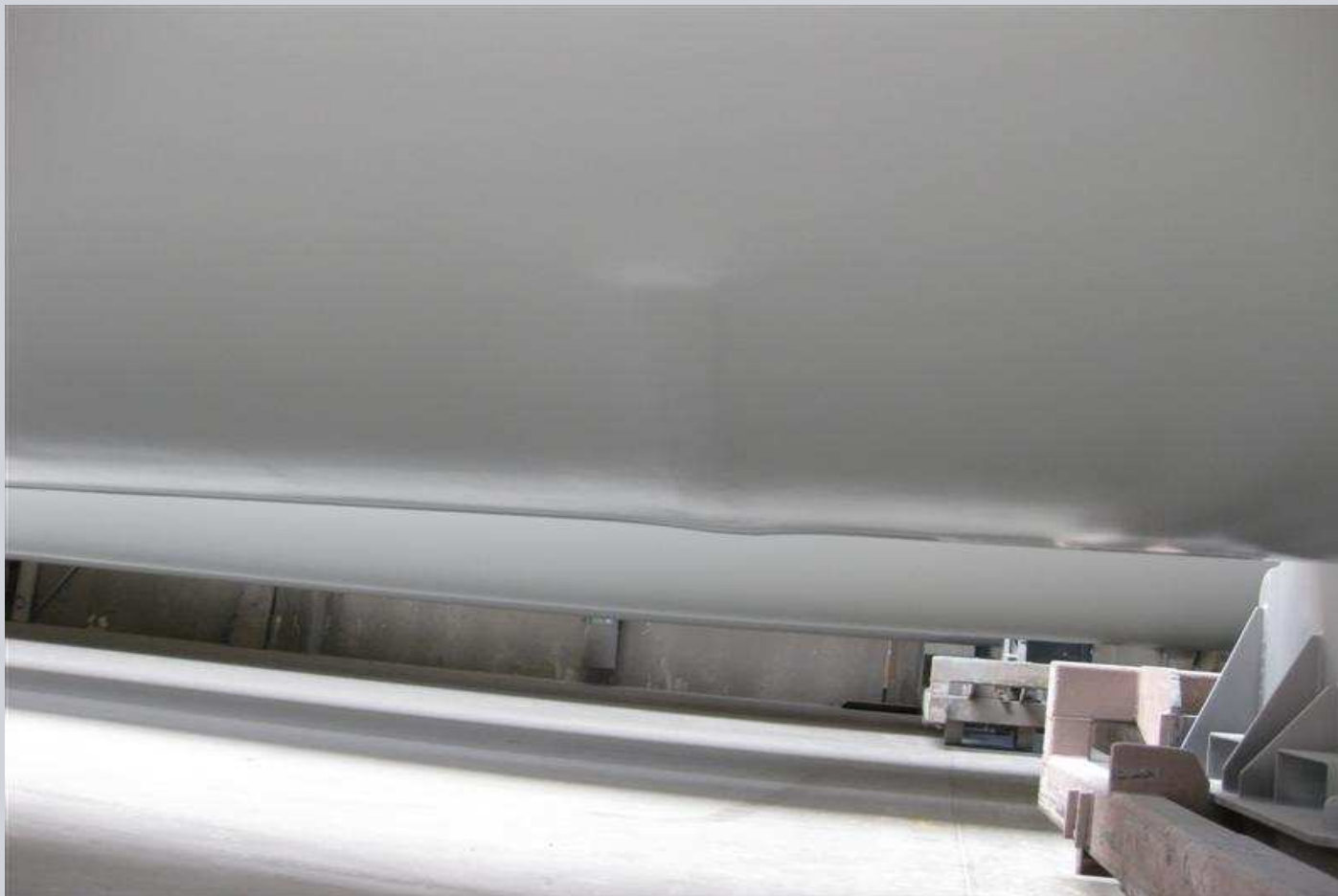
Distribution of heat
in a test setup



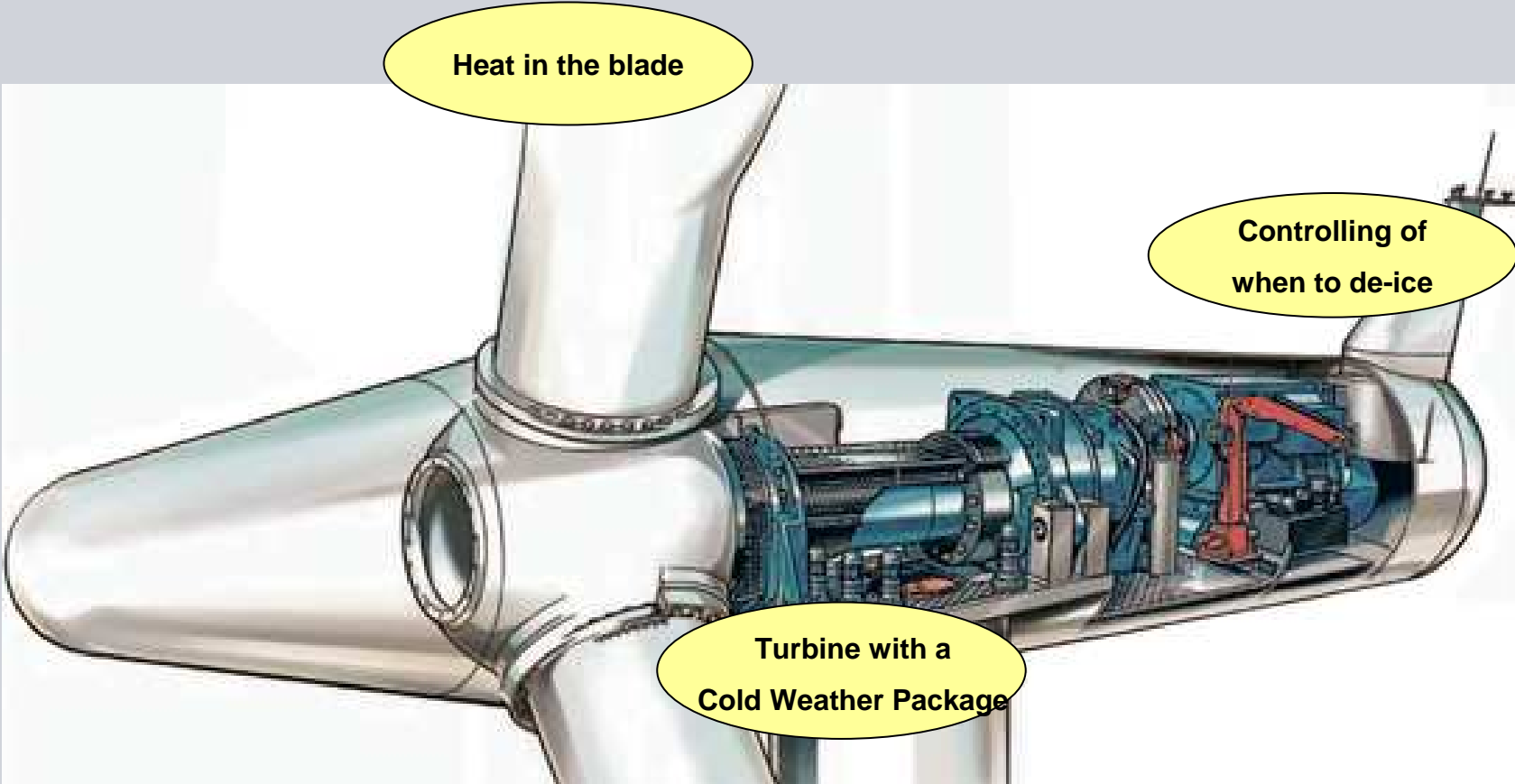
IR camera picture



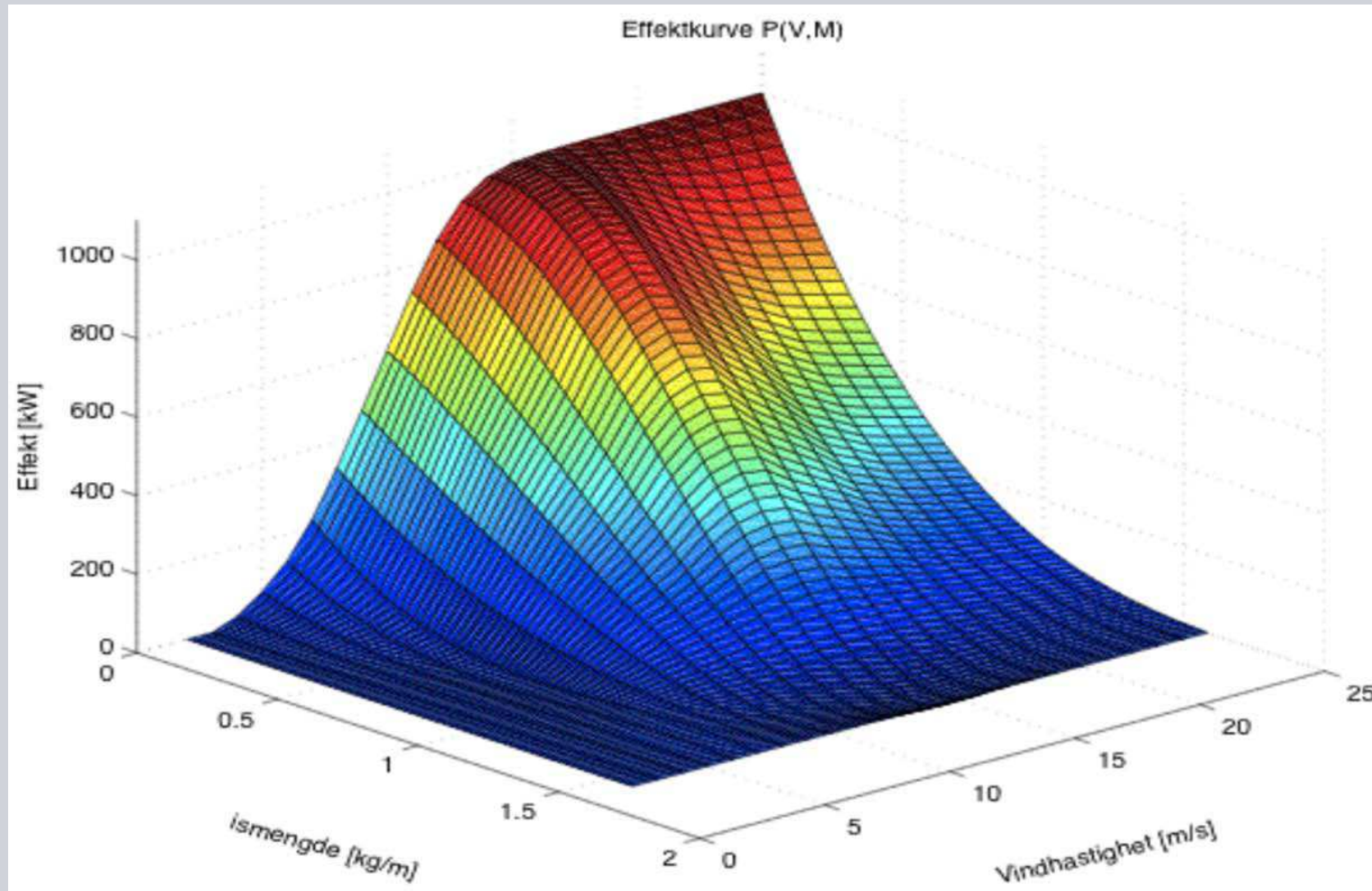
Only “change”



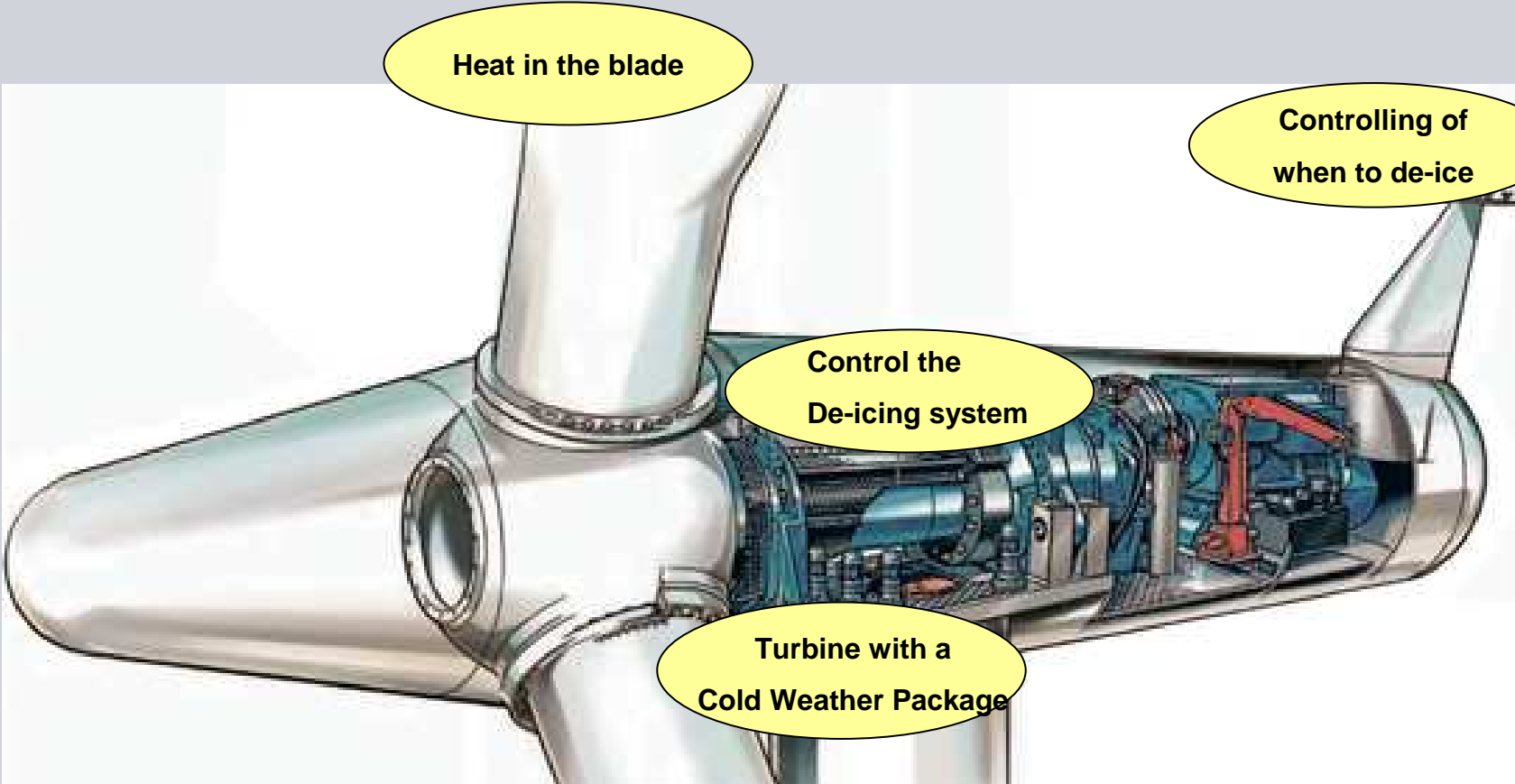
De-icing system



Detection method – Power curve



De-icing system



Controlling the De-icing system

De-icing:

Removing collected ice accretion during operation or idling

Anti-icing:

Avoid collected ice accretion during operation or idling



Icing a complex problem

Several different types of ice accretion

In-cloud icing (supercooled water droplets hits a surface below 0 C)

- -soft rime
- -hard rime
- -glaze ice

Precipitation

- -freezing rain
- -wet snow

Frost

(water vapour harden
on a cool surface)



Parameters when we are talking ice

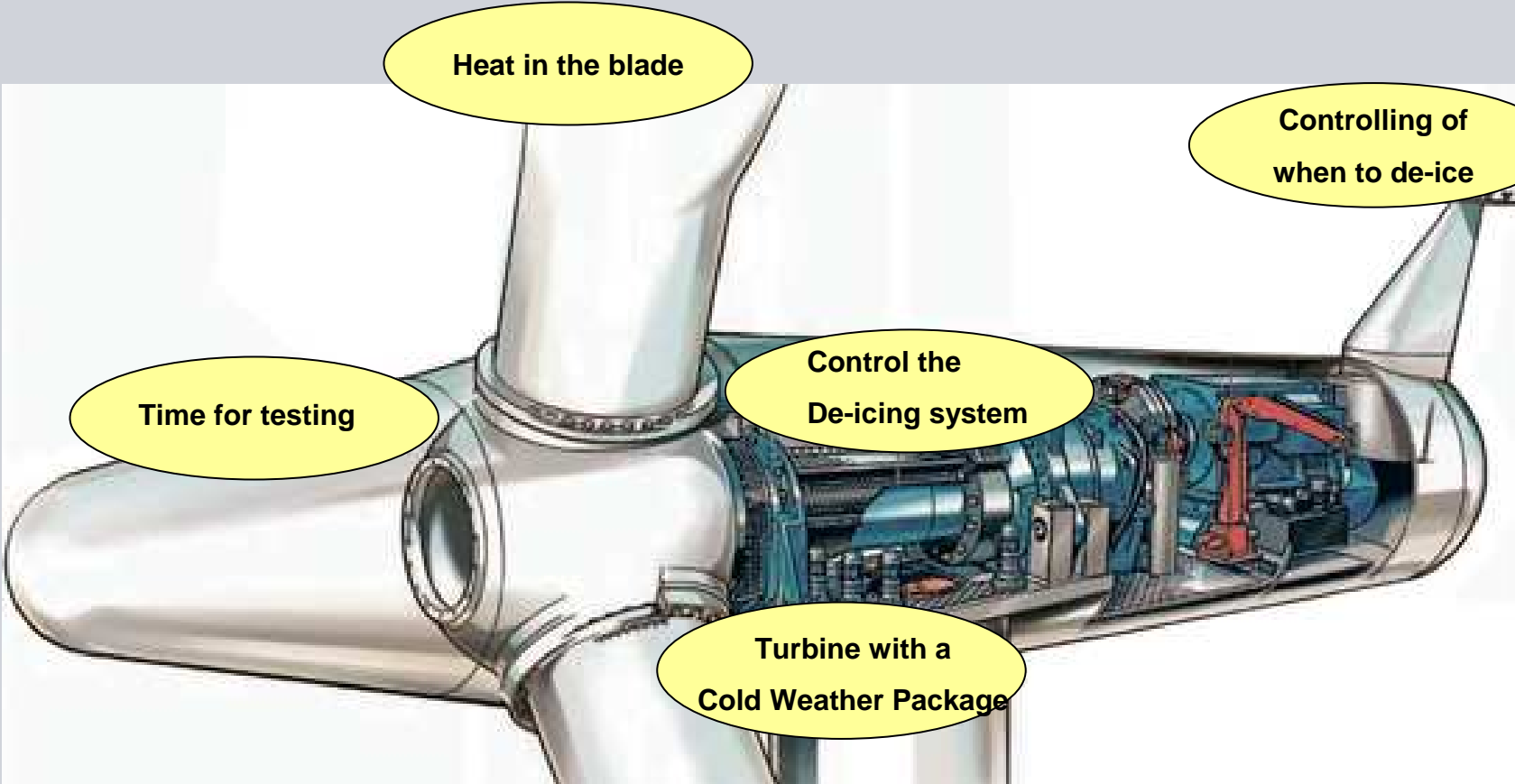
Calculations parameters for De and Anti-icing of blades.

- Temperature +2 to -15 deg Celsius
- Liquid water content 0 to ?? g/m³
- Droplet diameter 0 to ?? μm
- Wind Speed 0 to 25 m/s

Preliminary Control Strategy

- Ice on the blades
- Stop Turbine
- Yaw the nacelle so the rotor is in "back-wind"
- Start the de-icing
- After x minutes, yaw the nacelle back into the wind
- Put the turbine in operation
- When turbine is producing stop de-icing

De-icing system



Test site in Sweden 2010 - 2011

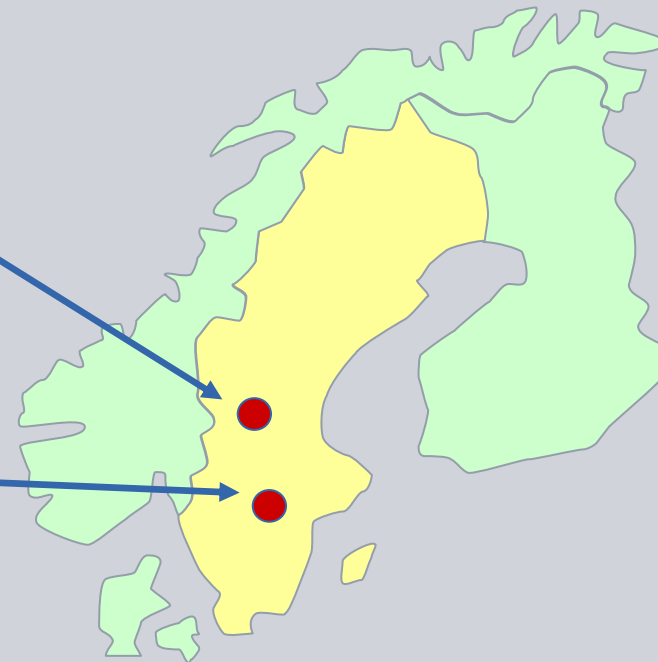
Testsite in Sweden with generation 1 BDI

Kyrkberget (SW)

1 x SWP 2,3 101
Start up W 3 - 2011
Owner: Jämtkraft

Brahehus (SW)

1 x SWP 2,3 101
Start up W 11 - 2011
Owner: O2

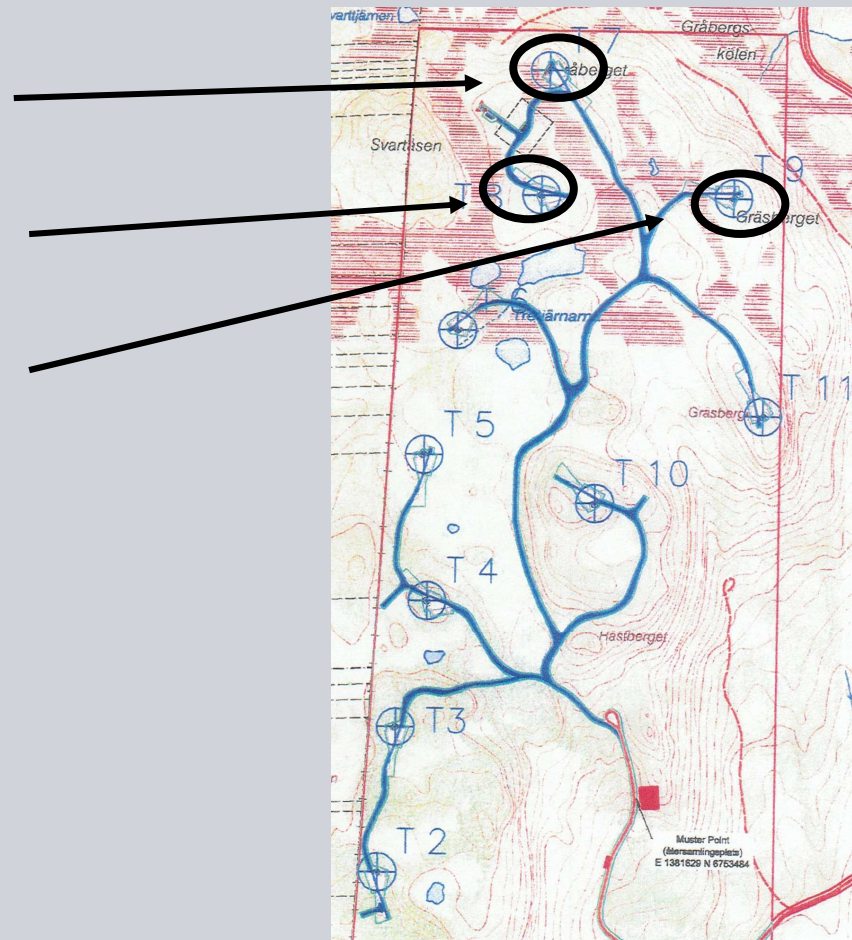


Map over Kyrkberget

T 7 Reference turbine

T 8 Turbine with Blade De-icing.

T 9 Reference turbine



Test site in Sweden now and in the future

Generation 1.

Kyrkberget	1 x SWP 2,3 101	Start up W 3 - 2011
Brahehus	1 x SWP 2,3 101	Start up W 11 - 2011

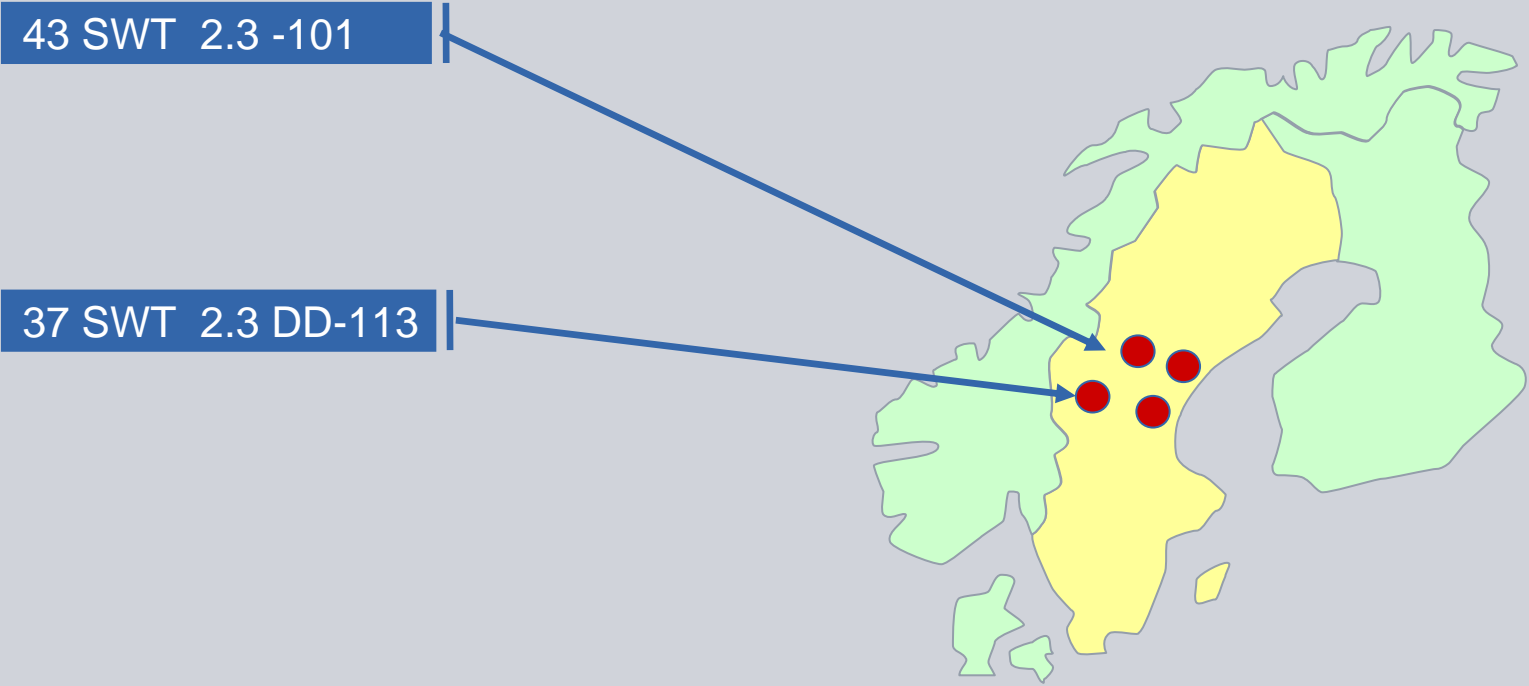
Generation 2.

Swedish project	9 SWP 2,3 101	Winter 2011 – 12
Swedish project	4 SWP 2,3 101	Winter 2011 – 12

Generation 3.

We will improve the de-icing system and control strategy.

Future projects in Sweden



SWP - Blade De-icing

Siemens BDI system:

- Built on experience from the old Bonus Energy A/S system.
- Robust and proven technology.
- No wiring in the blade. Power connections at the root end.
- Blade heating integrated at factory.
- Low risk of transport damages of the system.
- Control system based on existing sensors.

Siemens Blade De-icing system

With a Siemens BDI system, down time after icing will be reduced and paid back after few icing days per year.

