The Alps – Windy, but also icy

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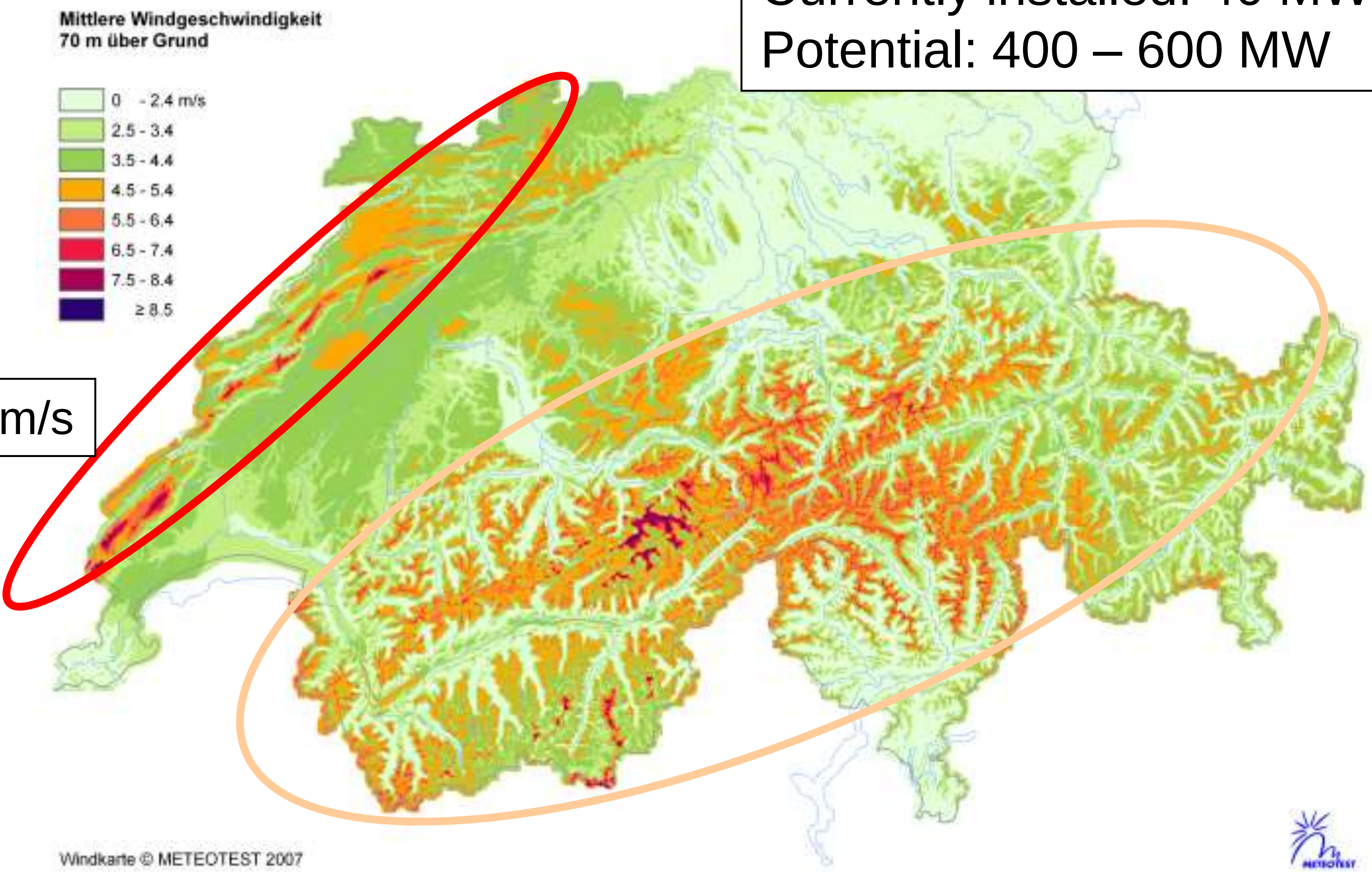
Wind map of Switzerland

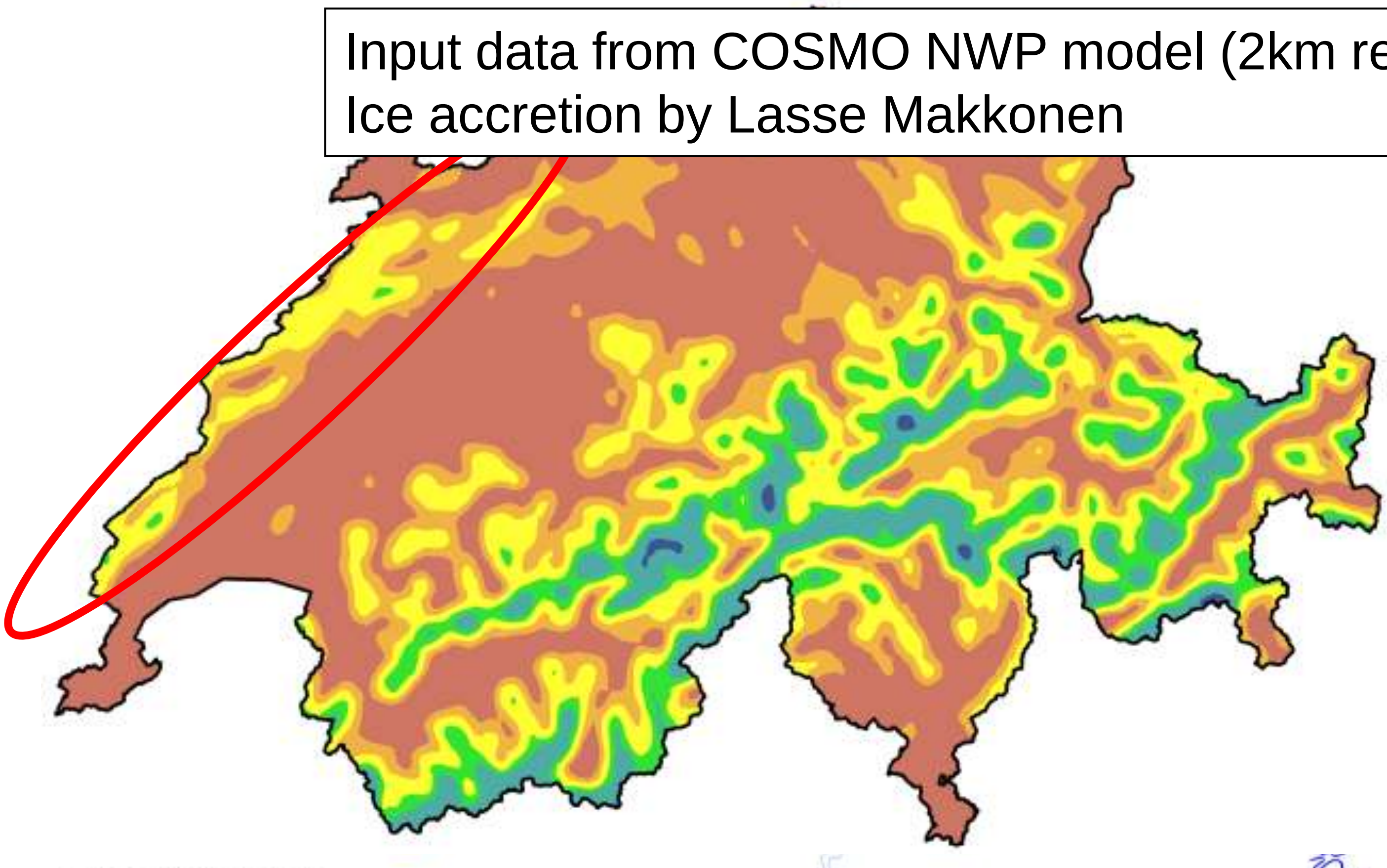
Currently installed: 40 MW
Potential: 400 – 600 MW



6-7.5 m/s

Wind map of Switzerland   Icing map of Switzerland

Input data from COSMO NWP model (2km resolution)
Ice accretion by Lasse Makkonen



Windkarte © METEOTEST 2007

→ Almost all Swiss sites under icing conditions

Alpine Test Site Guetsch – COST Action 727

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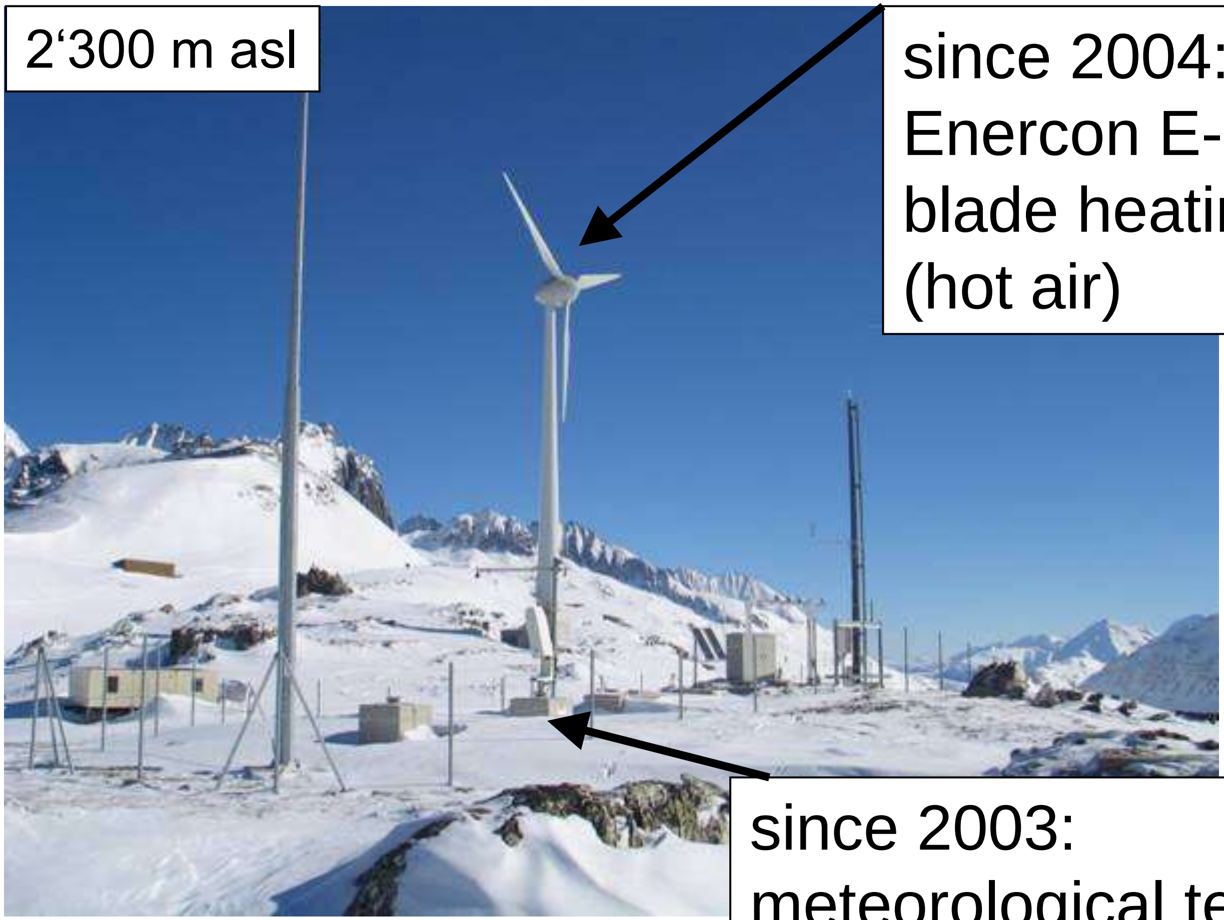
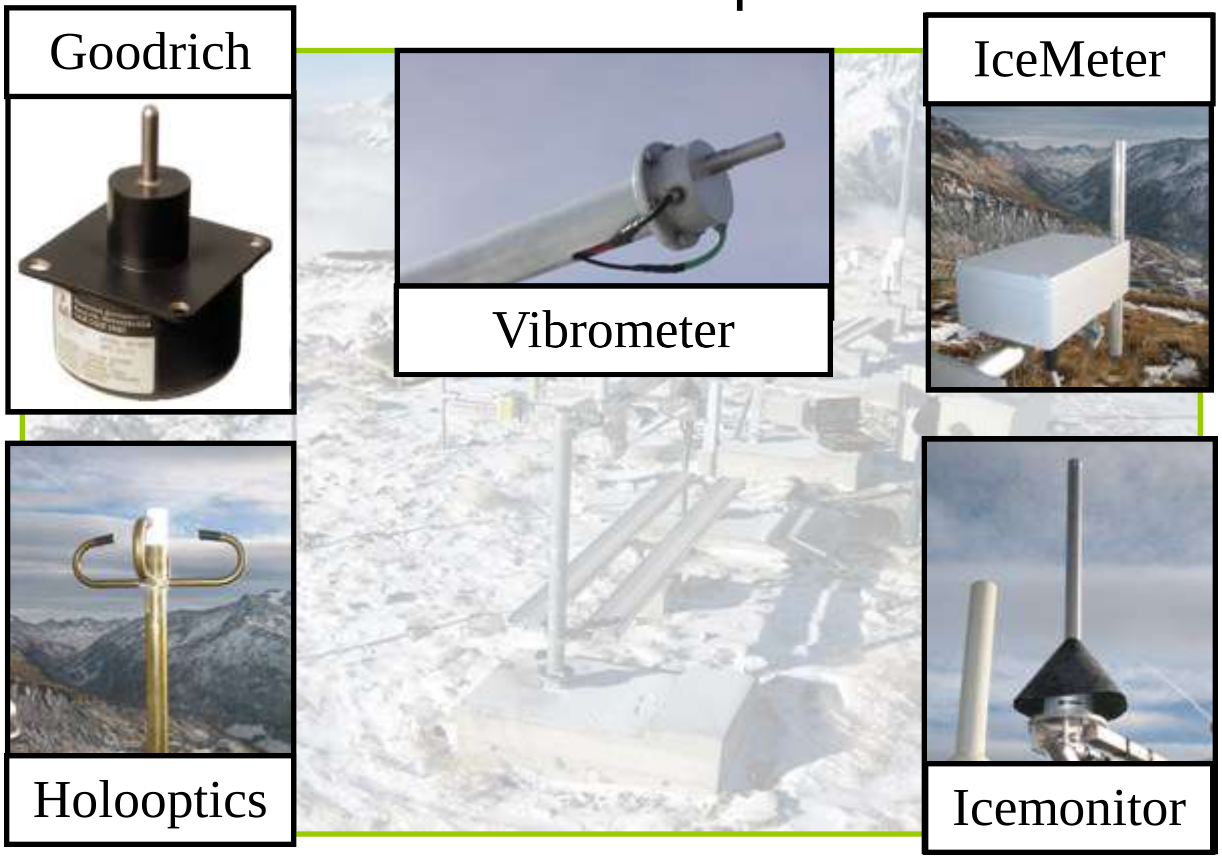


2‘300 m asl

since 2004:
Enercon E-40
blade heating
(hot air)

since 2003:
meteorological test station

Alpine Test Site Guetsch – COST Action 727
Ice detector comparison



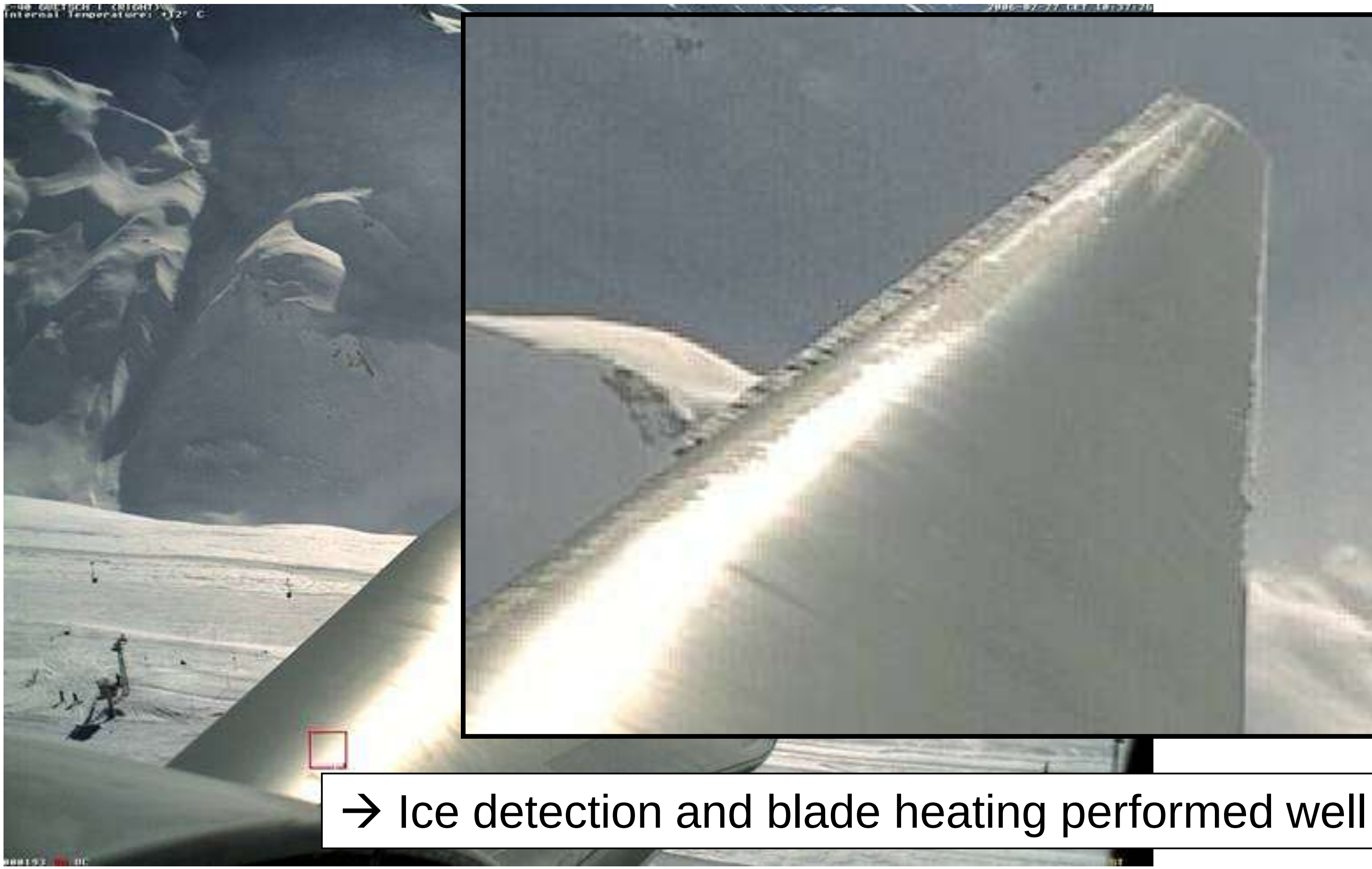
→ There is no instrument which works reliably and automatic

Alpine Test Site Guetsch – COST Action 727

Wind turbine monitoring with web cameras

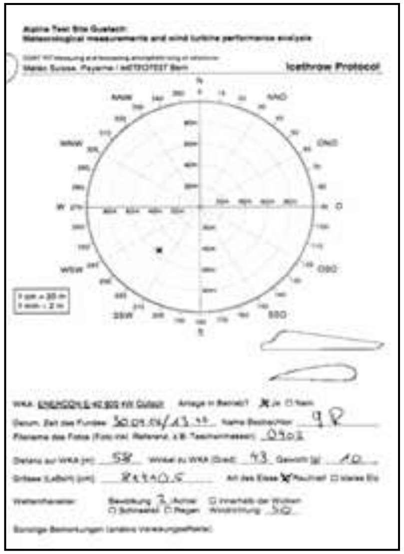
Alpine Test Site Guetsch – COST Action 727

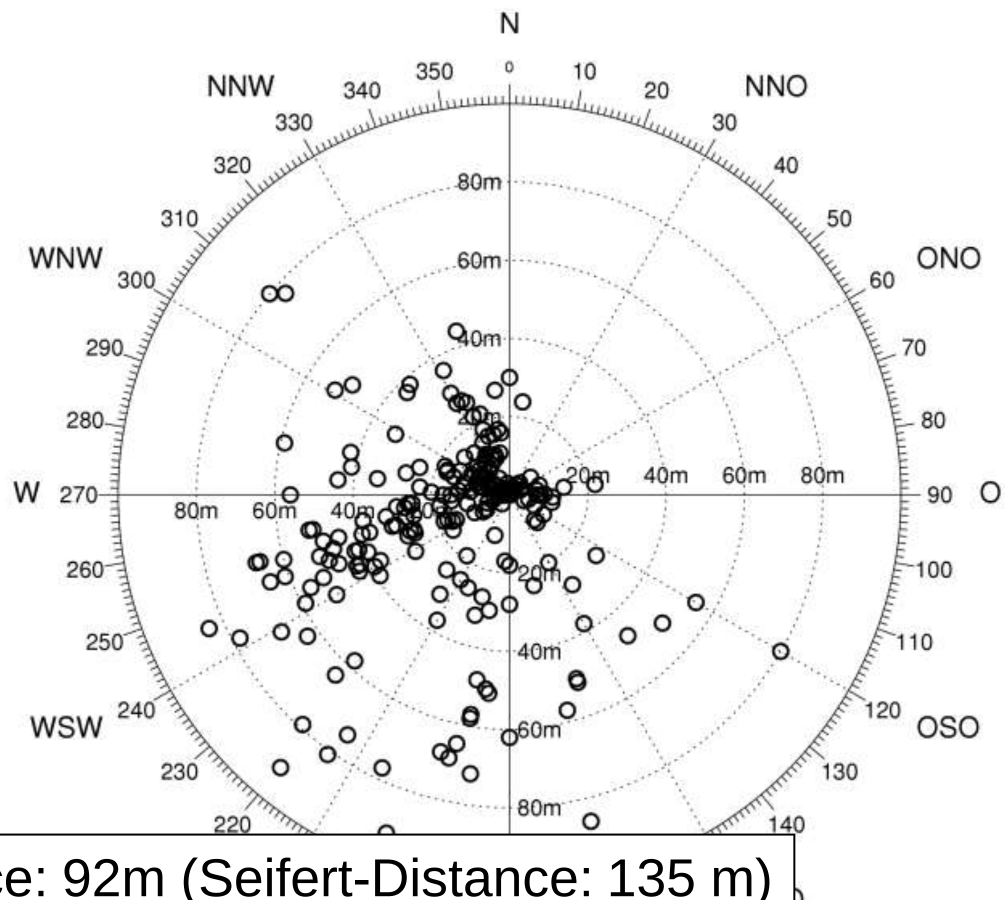
Wind turbine monitoring with web cameras



→ Ice detection and blade heating performed well

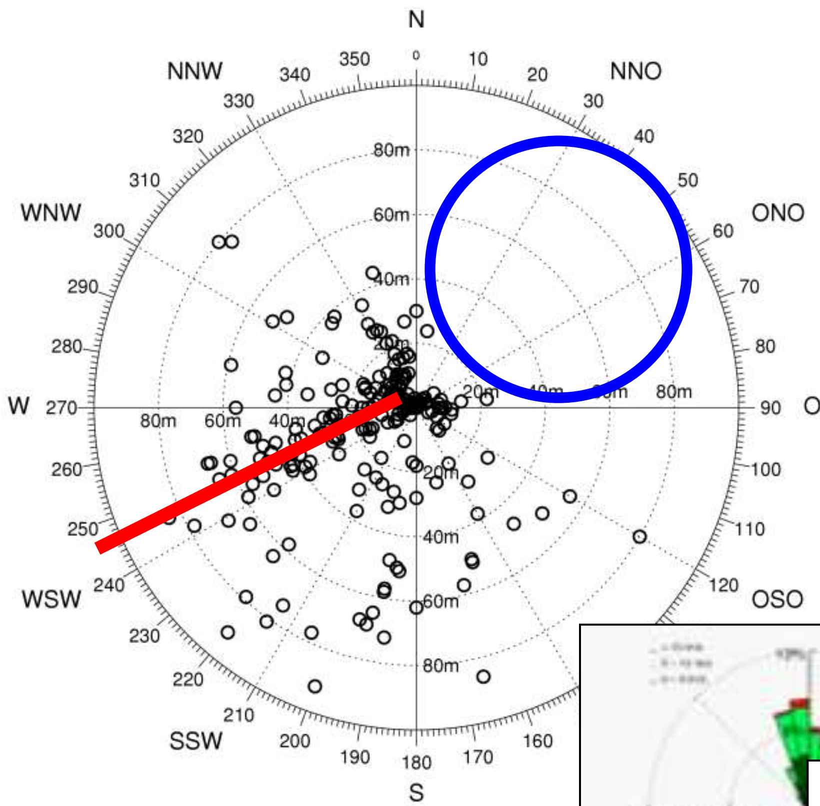
Alpine Test Site Guetsch – COST Action 727
Ice Throw Study

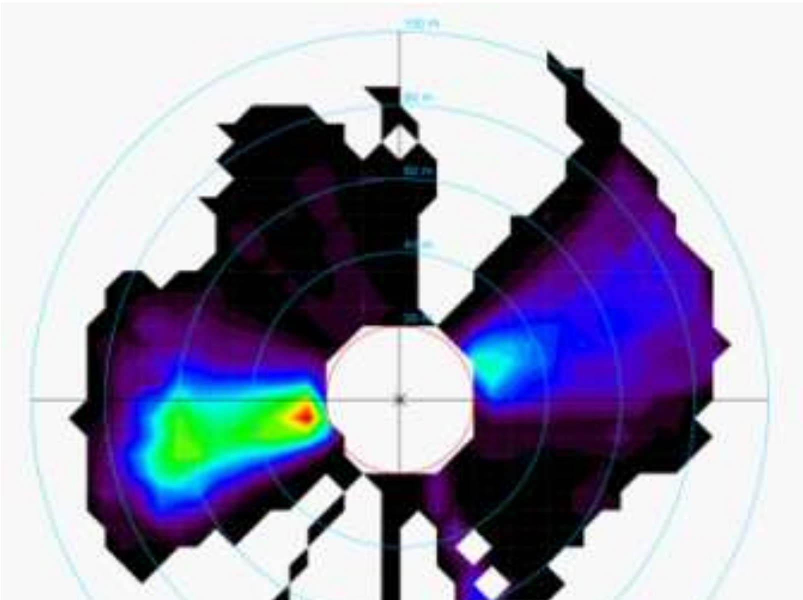


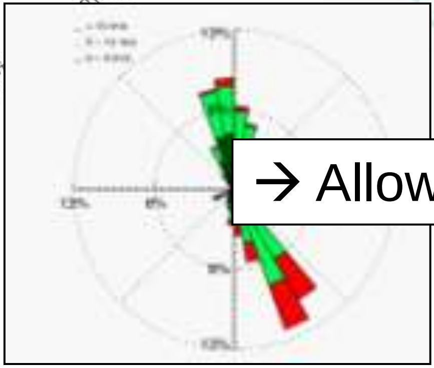


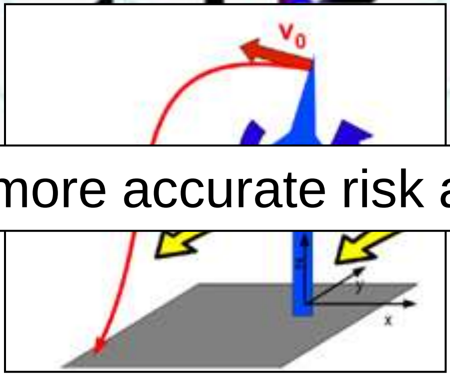
Maximum Distance: 92m (Seifert-Distance: 135 m)
Maximum Weight: 1.8 kg (5 m distance)

Alpine Test Site Guetsch – COST Action 727
Ice Throw Simulation





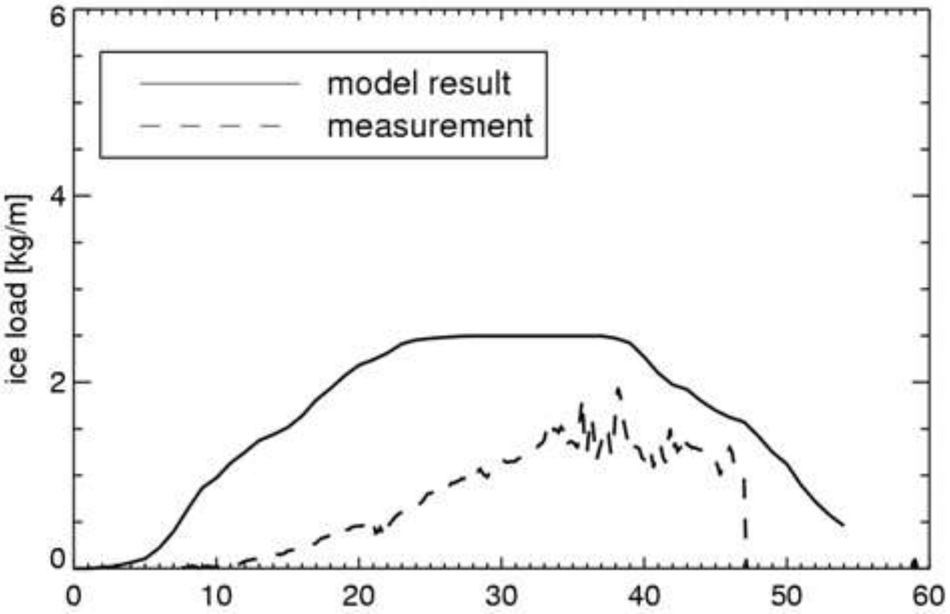




→ Allows more accurate risk analysis

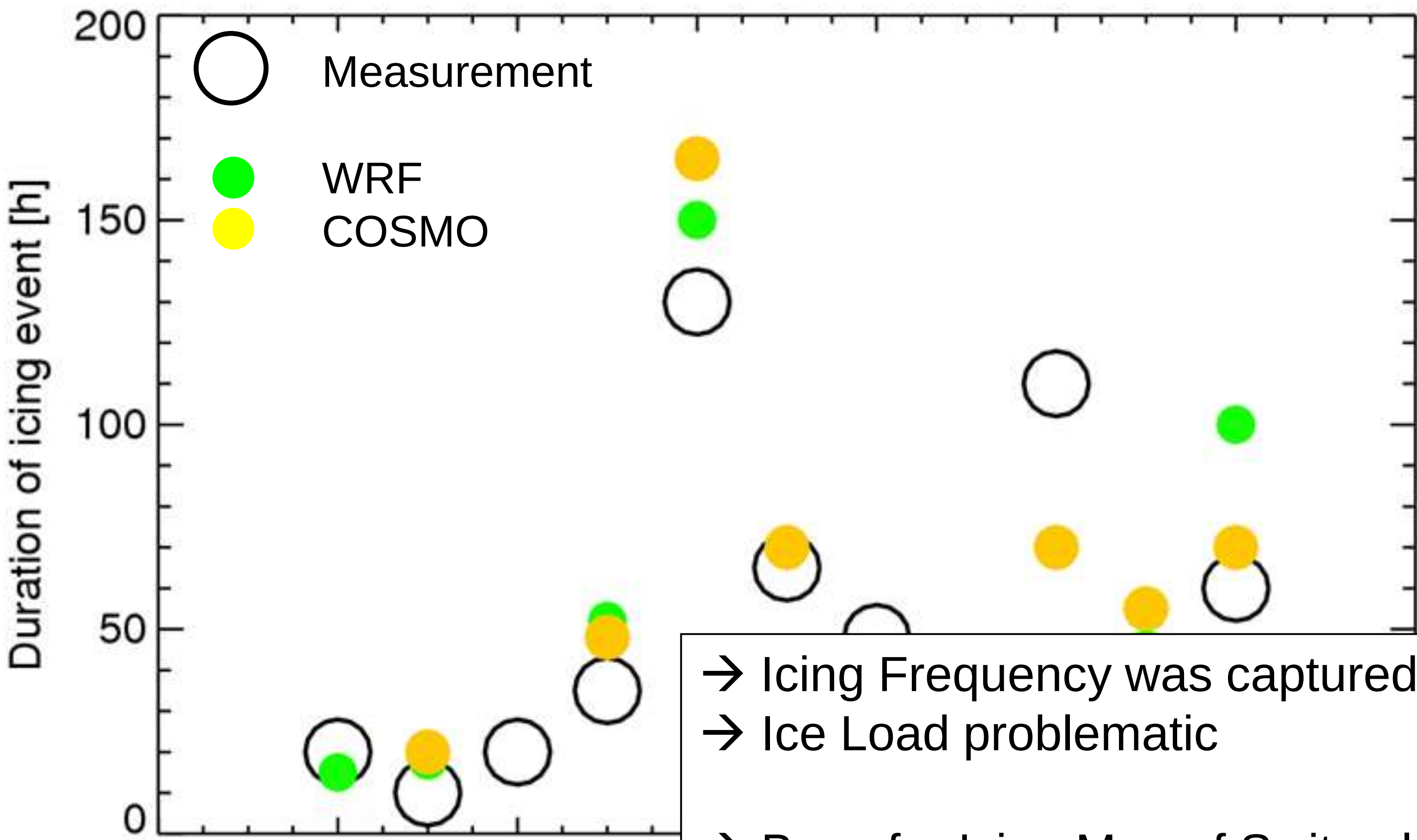
MEMFIS: Measuring, Modelling and Forecasting Ice Loads on Structures

Ice Load Measurements



Icing Simulations with WRF/COSMO

MEMFIS: Measuring, Modelling and Forecasting Ice Loads on Structures



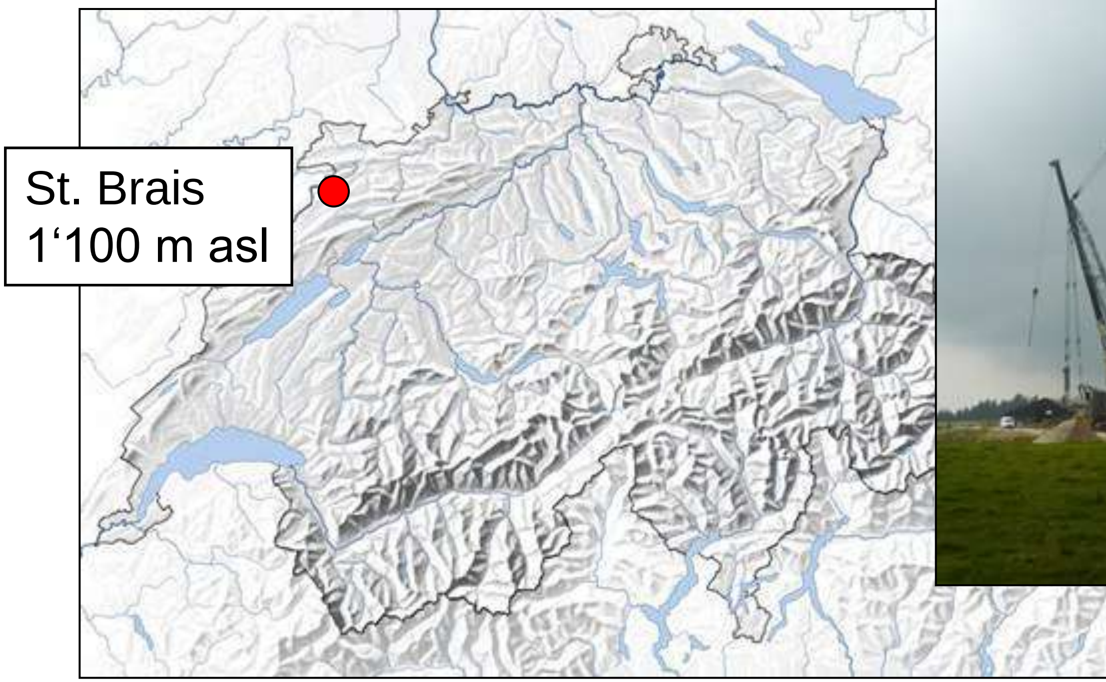
→ Icing Frequency was captured well
→ Ice Load problematic

→ Base for Icing Map of Switzerland

Icing Project S

(2009 to 20

2 Enercon E-82
Hub height 78 m
Blade heating (~70kW)



Icing Project St. Brais

(2009 to 2011)

1) Monitoring of a 2-MW-wind turbine in the Jura arc (2/3 of the planned Swiss wind parks) concerning **icing, turbulence and wind shear**

2) Evaluation and validation of different **systems for ice detection and de-icing**

3) Evaluation of the **production loss** due to icing and of the **gained energy** based on use of ice detection and de-icing systems

4) Evaluation of the **additional loads** caused by icing

5) Evaluation of the **noise emissions** of a wind turbine under icing conditions

→ Will be presented on Thursday

Company Profile Energiewerkstatt

Wind Energy

- Wind Measurement
- Project Development
- Planning & Implementation
- Training and Education
- Research & Demonstration

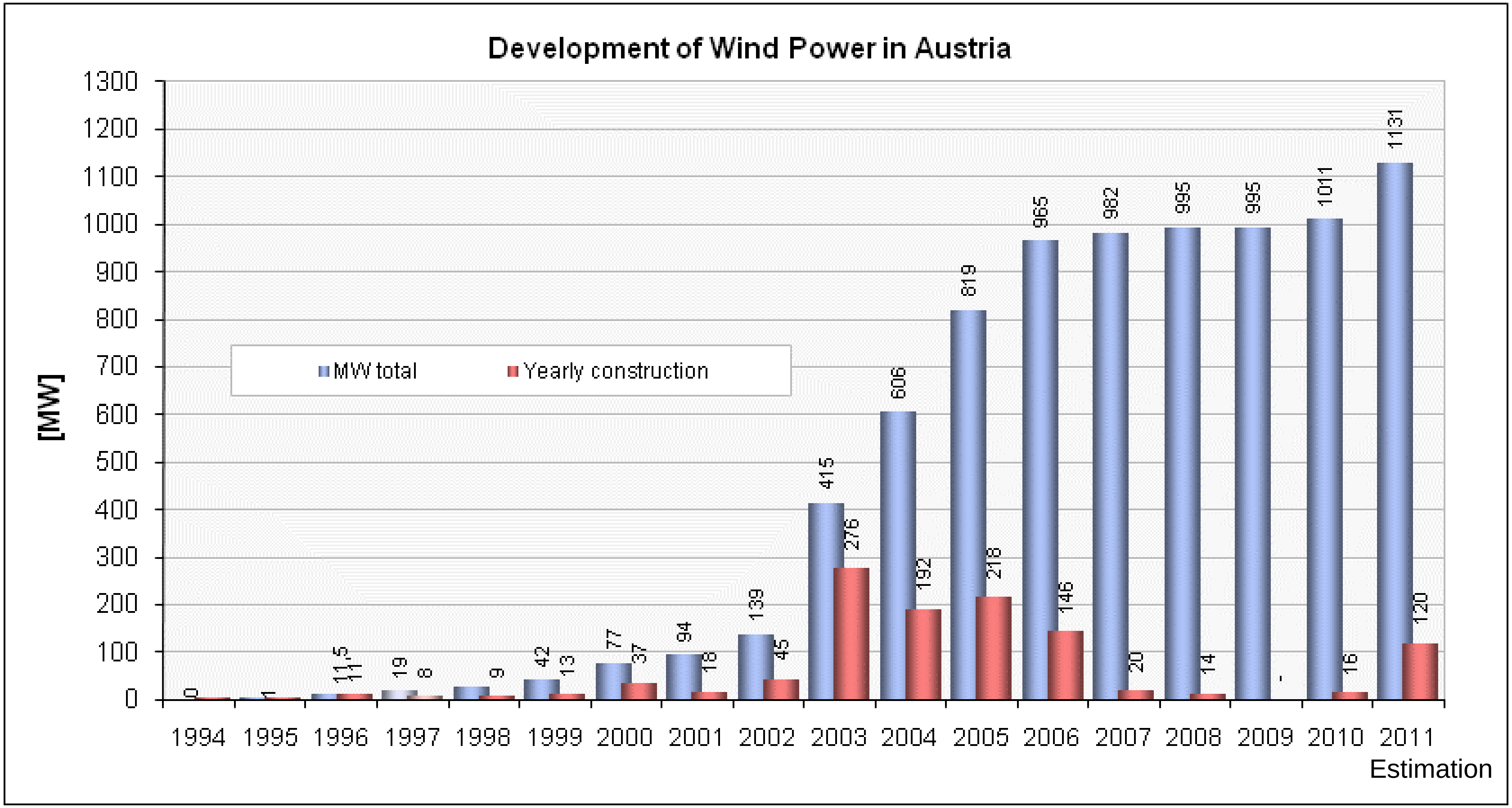
energiewerkstatt www.energiewerkstatt.org

Wind Energy in Austria

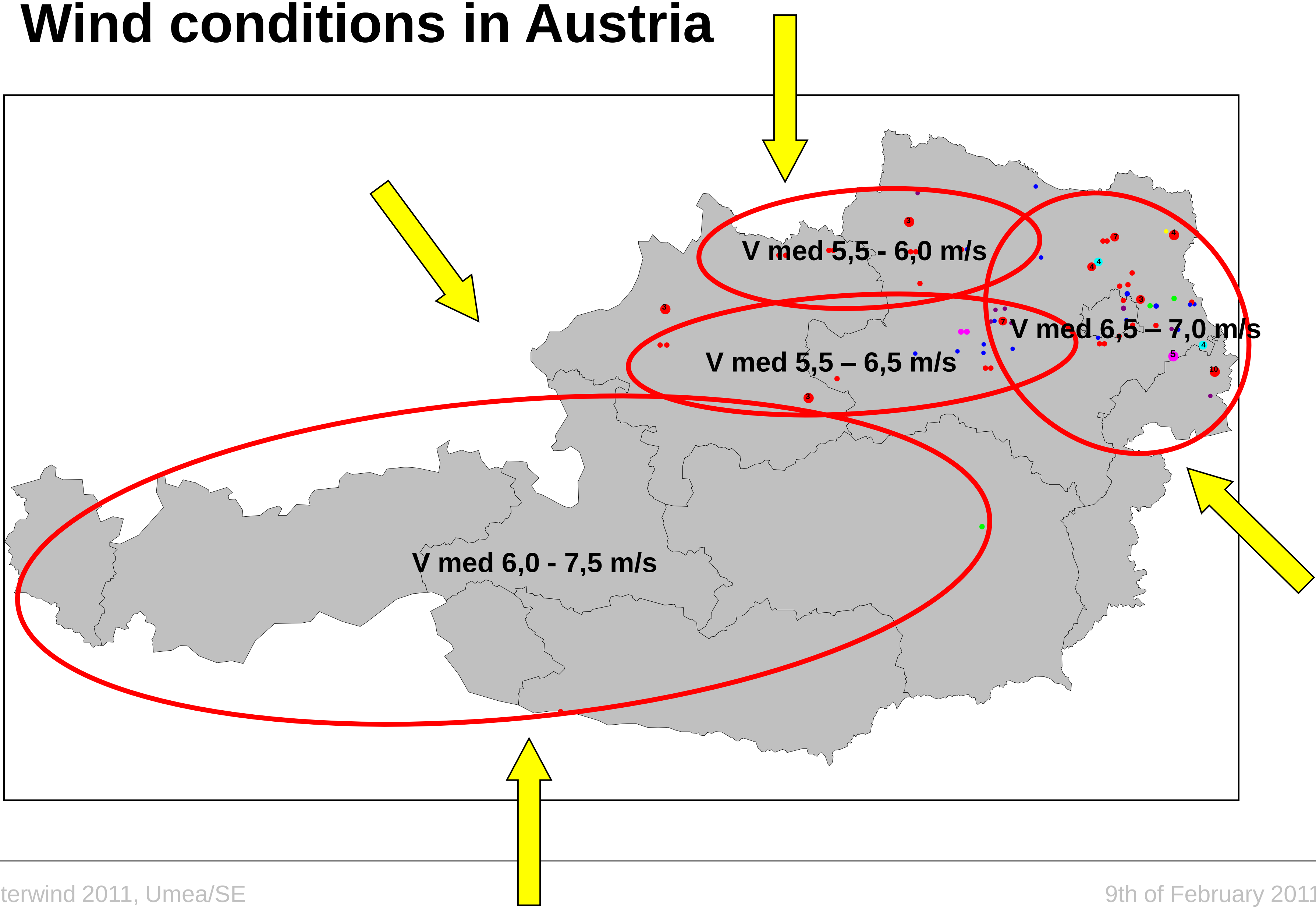
State 31.12.2010

- 625 Wind turbines
- 1.011 MW installed power
- 2,34 TWh electricity generation per year
- 3 % of Austrian electricity demand

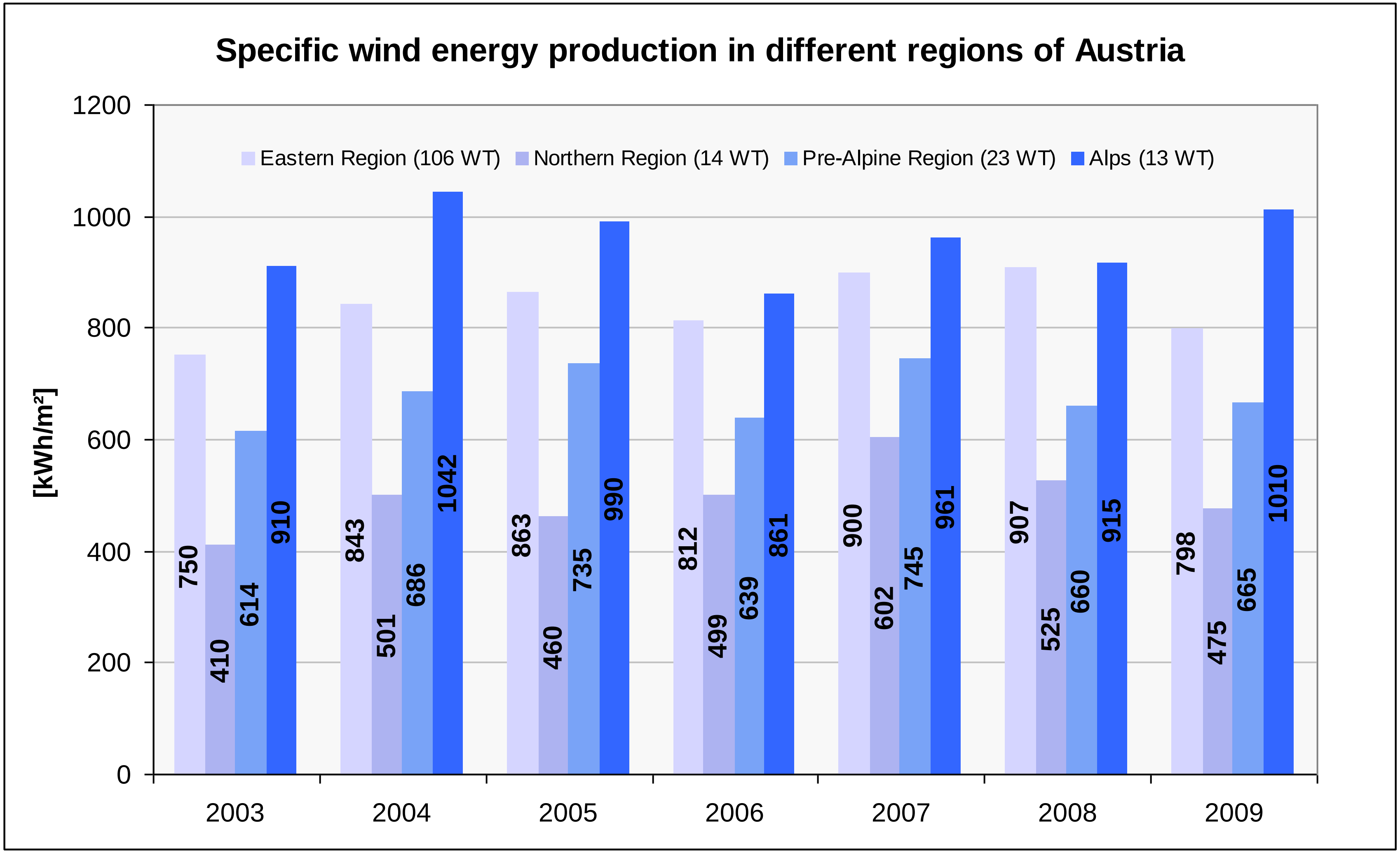
Wind Energy in Austria



Wind conditions in Austria



Specific wind energy production in Austria



Wind Farm Sternwind

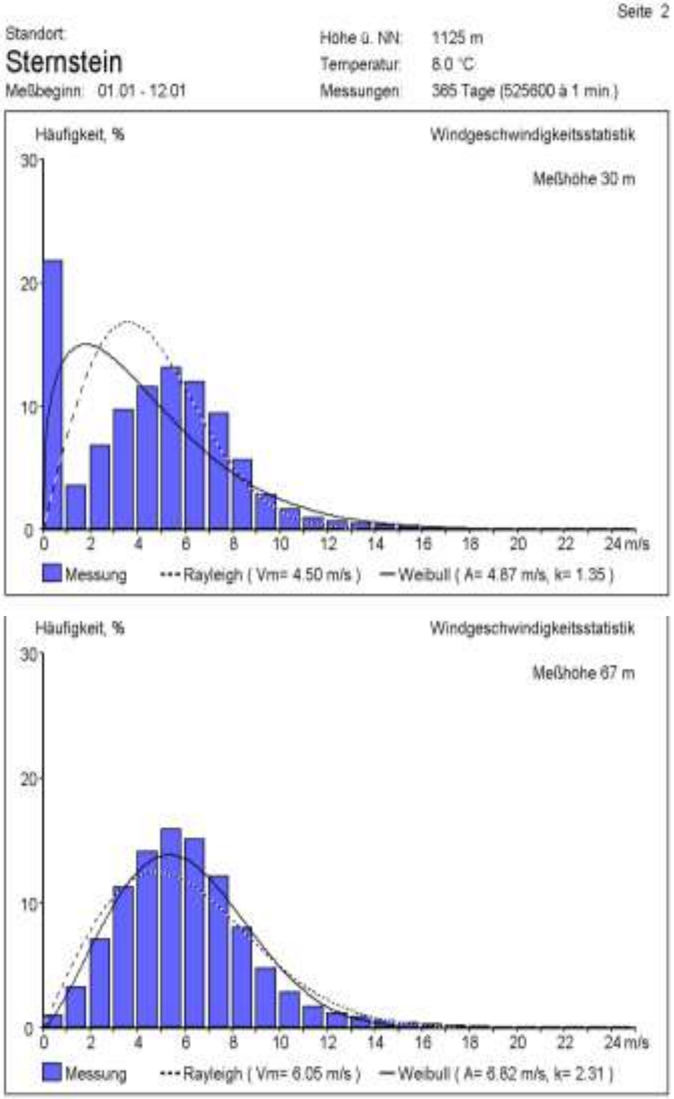
1 x VESTAS V 80 / 2 MW / 100 m hub height

6 x VESTAS V 90 / 2 MW 105 m hub height

Sea level: 970 – 1.020 m.a.s.l.

Annual Energy yield: **31 GWh / Year**

Info: www.sternwind.at



Heated and unheated Anemometer

Research Project

5th Framework Program

Partners

Energiewerkstatt (A)

TAUERNWIND Windkraft GmbH (A)

German Wind Energy Institute (D)

VESTAS DEUTSCHLAND GmbH (D)

Finnish Meteorological Institute (FIN)

Prangl GmbH (A)

www.tauernwind.com

energiewerkstatt www.energiewerkstatt.org

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Operational Experience and maintenance work during Winter

Wind Farm Moschkogel

(Mürzzuschlag/Stmk.)

5 x ENERCON E 70 / 2.3 MW / 65 m hub height

Sea level: 1.640 – 1.680 m.a.s.l.

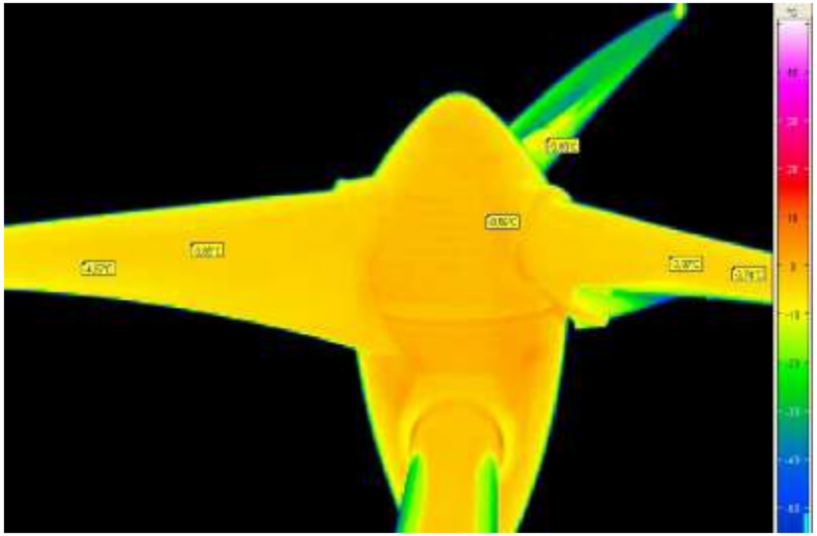
Annual Energy yield: **22 GWh / Jahr**

Information: www.viktorkaplanakademie.at

ENERCON Blade Heating

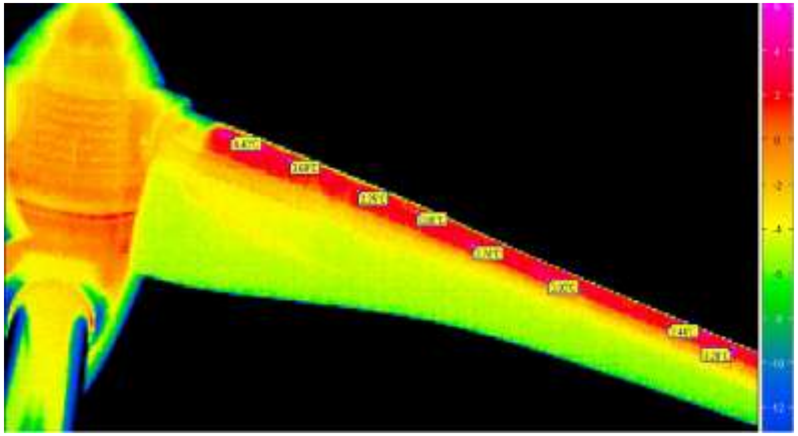
De-Icing or Anti-Icing?

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.



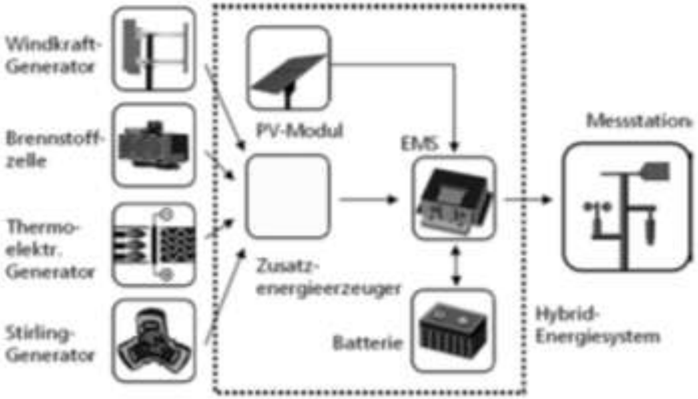
Heating by circulation of warm air inside the blade:

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.

Pictures above: Thermography of the rotor blade before and after switching on the blade heating

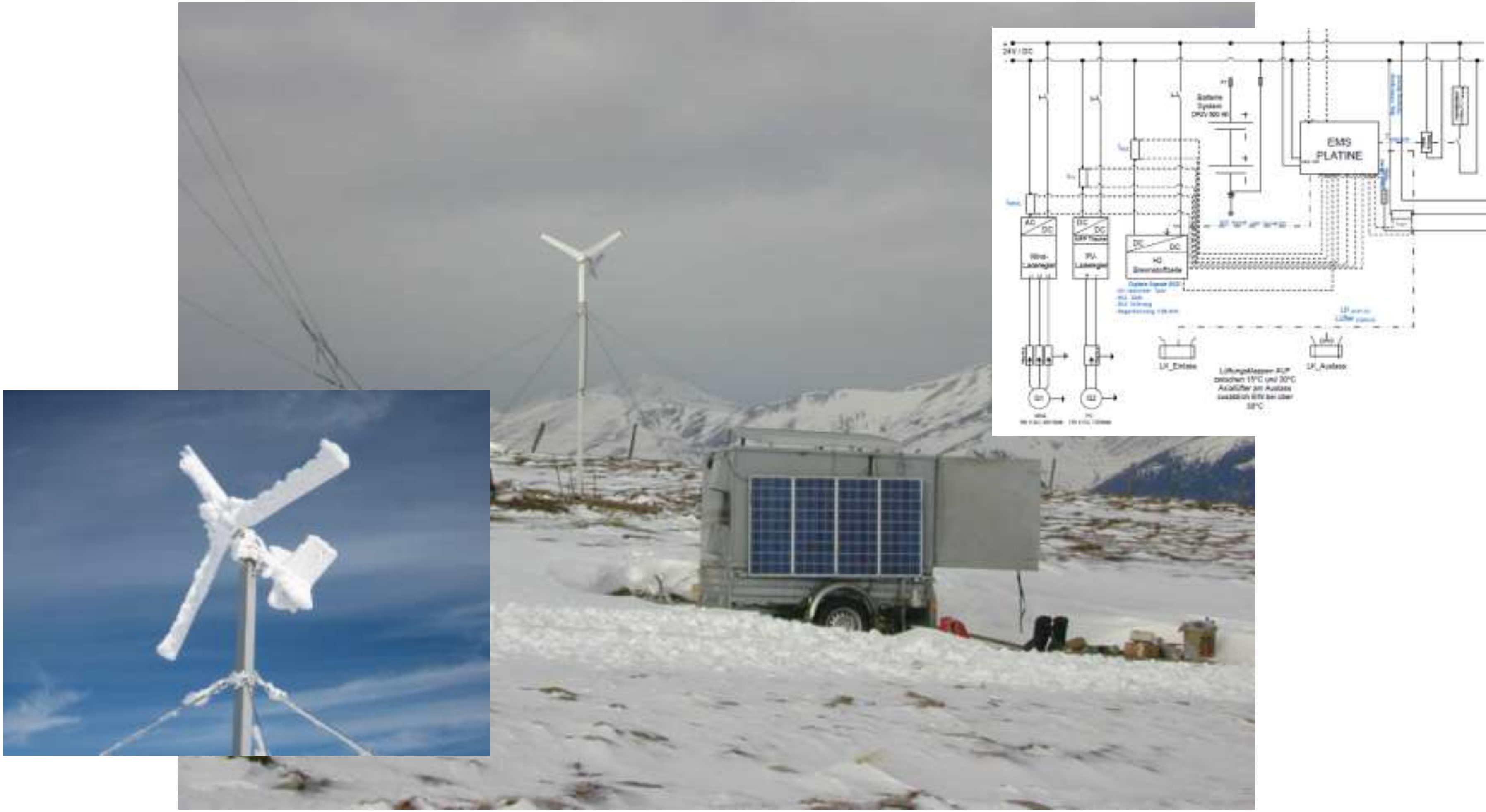
External power supply system

Provision of a mobile and reliable external power supply system for meteorological measurement stations (including SODAR & LIDAR) under extreme climatic conditions



- Selection of the most suitable components:
  - Wind generator: 900 W
  - PV modules: 4 modules with in total 720 Wp
  - Fuel cell (~40% efficiency): 65kWh energy from hydrogen
  - Battery pack: Capacity of 600 Ah
- Controlling of the system with a special EMS (Energy Management System)
  - **Production management**: Intelligent interplay of the components
  - **Load management**: Methodology in order to be able to operate and manage the power demand of the sensors according to the actual conditions
  - **Thermal management**: Intelligent provision of the required thermal conditions (for battery pack and fuel cell)
  - Provision of a **remote control** system, which allows permanent control and a remote changing of the settings

MORE – Mobile Remote Electricity



Currently: Test run of the system in the Austrian Alps

Risk due to ice-fall from wind turbines

- Due to magisterial conditions in the notification of approval
  - No “Ice-throw”, only “Ice-fall”
- Refusal of approval for operation of a Siemens turbine (D_R = 82m)
  - Approval from cantonal government in 2009
  - Owner of adjacent land plot (~50m away from the turbine tower) argued that he no longer can proceed with his farming activities during icing events
  - In 2010 High Administrative Court decided that turbine has to be dismantled
  - [Remark: Different decision regarding the installation of a telecom mast]
- Issue has a top priority for the Austrian wind community
- Energiewerkstatt has launched a research project
  - Partners:
    - University for Applied Sciences Vienna
    - Austrian Wind Energy Association
  - Project duration: January 2011 till June 2013

Risk zones in the close vicinity of a wind turbine

- Definition of Risk:
  - Occurrence probability vs. extent of loss
- Parameter to be considered:
  - Turbines' size
  - Meteorology at the site: Frequency of icing events, frequency of strong winds during ice break-off, wind rose
  - Danger of ice pieces for human beings
- Not considered:
  - Likelihood of abidance of people in the surrounding of the wind turbine; e.g. hiking trail, forest roads close-by
- Comparison of the risk with values of commonly accepted risk
  - Example: Driving 10.000 km on a highway results in a risk for event of death of $1x\ 10^{-4}$ for a single person / a
  - $1x\ 10^{-5}$ (i.e. the risk for death during office works)

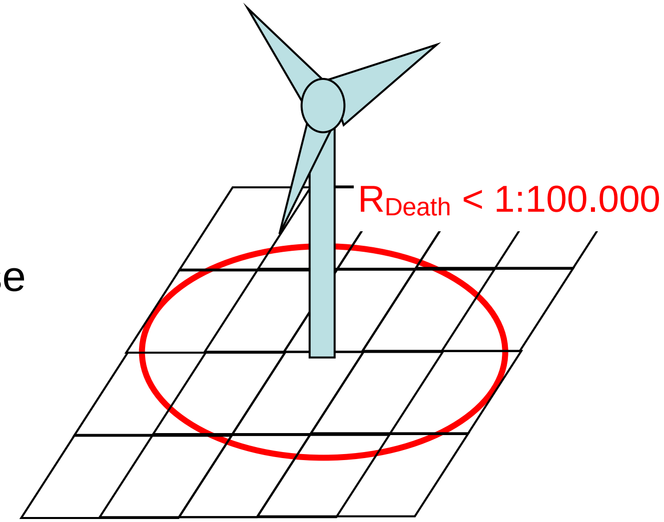


Fig.: Risk zone around WT

Project content

- Comprehensive observations and documentation of events of ice-fall
  - Systematic observations (including photo and video documentation)
  - Involvement of a large number of wind farm attendants
  - → Sufficient database regarding shape, weight, density and falling distances of ice parts
- Based on the observation results, dropping experiments are performed under constant conditions (wind speed, turbulence, height…)
  - → Establishment of a representative statistic that can be used to assess the risk for varying locations and turbine types
- Setup of a mathematical model that displays the risk zones for event of death around the wind turbine depending on
  - Meteorological conditions: icing frequency
  - Technical parameter: hub height, rotor diameter, rotor position…

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Thanks for your attention!