COLD CLIMATE TEST CENTER IN SWEDEN

Winterwind 2018

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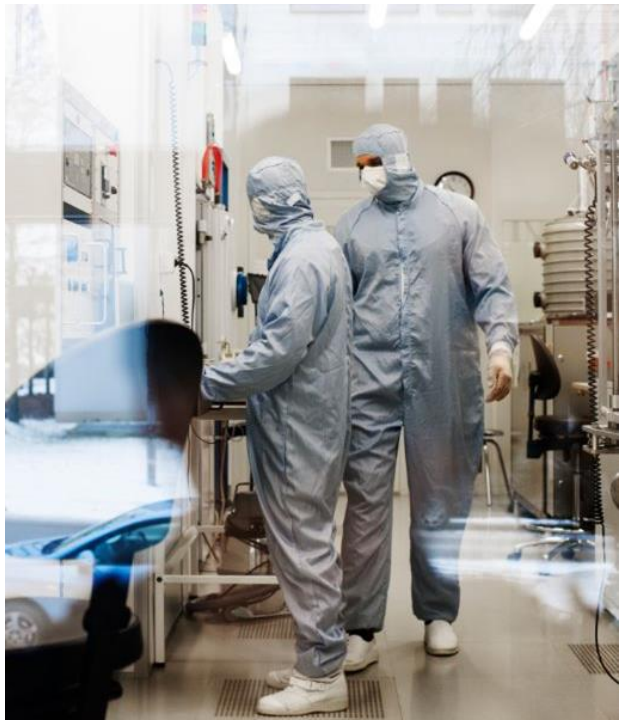
Research Institutes of Sweden

RISE in brief

- Present across the whole of Sweden. And beyond.
- 2,300 employees, 30 % with a PhD.
- Turnover approx. SEK 2.5 billion (2016).
- SME clients, accounting for approx. 30 % industry turnover.
- UN 17 sustainable development goals is a central pillar of our business strategy
- Runs 100s of test and demonstration facilities, open for industry, SMEs, universities and institutes RISE is owner and partner in 60 % of all Sweden's T&D facilities.



Our combined offer

- **Applied Research and Development**
  - Research and Innovation projects
  - Expert consultation
  - Service design and design processes
  - Innovation support for SMEs
- **Industrialisation and Verification**
  - Testbeds and demonstration facilities
  - Technical assessments and verification
  - Prototypes and pilot line production
- **Quality Assurance**
  - Certification

Cold Climate Test Centre

Full scale test and validation
for the wind industry

www.coldclimatetest.com

RI.
SE

The Cold Climate Test Centre consortium

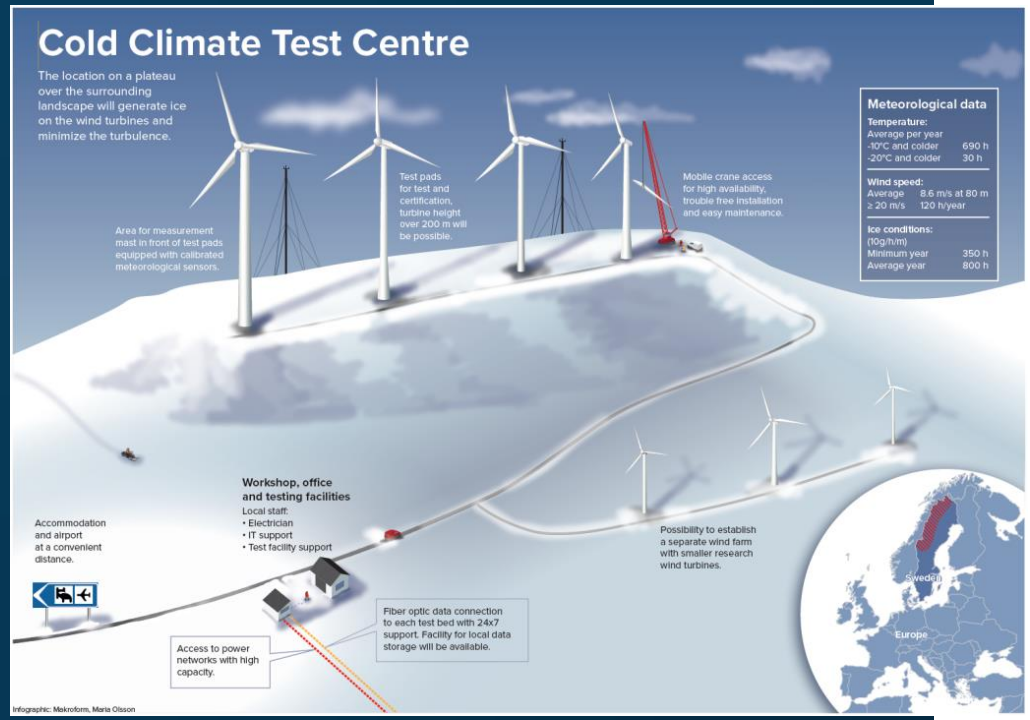
- **RISE** – the largest research institute in Sweden specialising in energy technology, material properties and safety, focusing on research, test and validation services to a variety of industries.
- **Vattenfall** – a utility company producing 6 TWh wind power per year, operating more than 1 000 wind turbines from the cold Nordic to places further south in Europe.
- **Skellefteå Kraft** – a regional developer and power utility operating more than 100 wind turbines, all in cold climate conditions, producing almost 1 TWh wind power per year.
- **Swedish Wind Power Technology Centre (SWPTC)** – a research centre formed by the technical universities of Chalmers and Luleå.
- **Vindkraftcentrum** – an organisation in the northern part of Sweden who promotes the establishment of wind power.
- **Vinnova** – the Swedish national research funding agency for innovation and sustainable growth.
- **ECN (Energy Research Centre of The Netherlands)** – the energy research institute in the Netherlands.

Why we believe in a full scale cold climate test site

- The history of severe icing problems in cold climate areas combined with upcoming projects in such areas around the world indicates a need for increased focus on reliability of cold climate turbine technology, including proven and reliable de-icing and anti-icing systems. These need to be tested, validated and certified.
- 25 % of all onshore installations are located on places with icing problems some time during their lifetime.
- Sweden has put a lot of effort into solving the cold climate issues within wind energy and has a leading position to gather the industry as well as a worldwide research community to discuss the icing problems.
- Combining industry test and validation activities with research projects will benefit product development and knowhow of cold climate conditions.

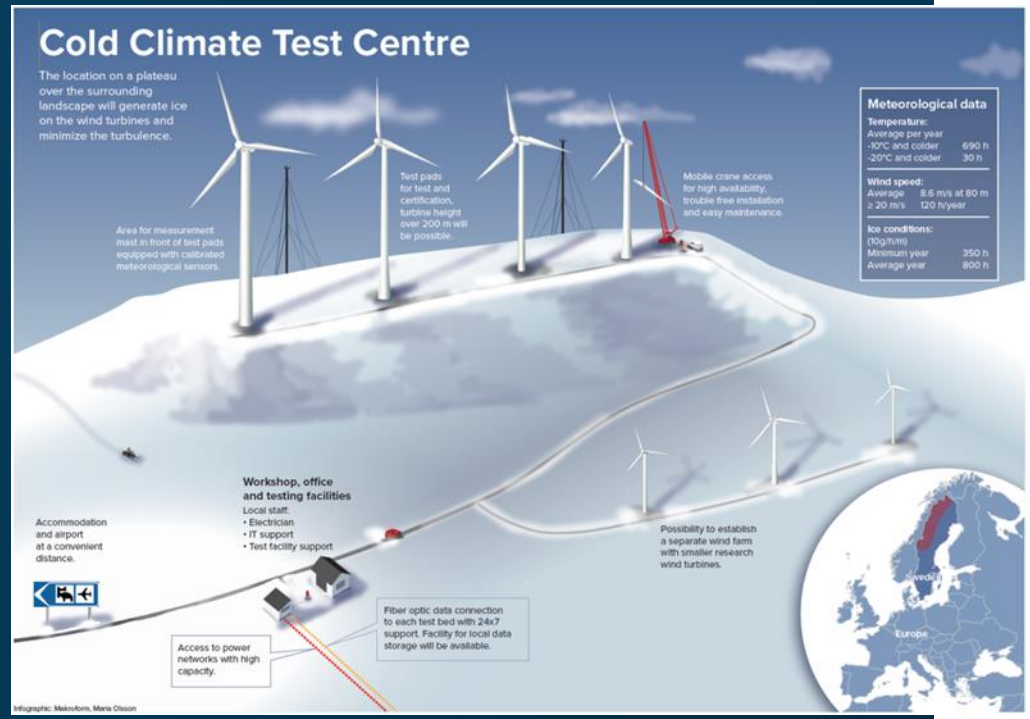
Why industry needs the full-scale test site?

- Owners and operators want to purchase proven products
- Suppliers need to prove suitability of their products
- Developing safe routines for installation, operation and maintenance in harsh conditions
- Field testing at production sites effects production at the site
- R&D dependent on the site service personal at a real production site – low priority
- There are limited degrees of freedom for R&D at a real production site
- Influence and be part of the development of standards and regulations



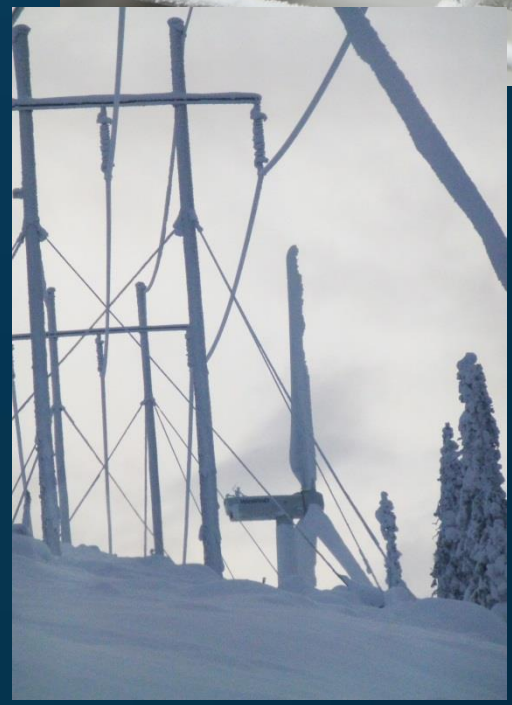
Why industry needs the full-scale test site?

- Facilities and workshop customized for R&D
- Detailed metrological data for a test turbine at a test site
- Secure good HSE conditions and procedures for R&D activities
- Repeatability of tests, procedures and test conditions as parameters can be better controlled
- The independent centre allows cost splitting for i.e.
  - joint product validations
  - benchmark test
  - …
- Do joint R&D projects



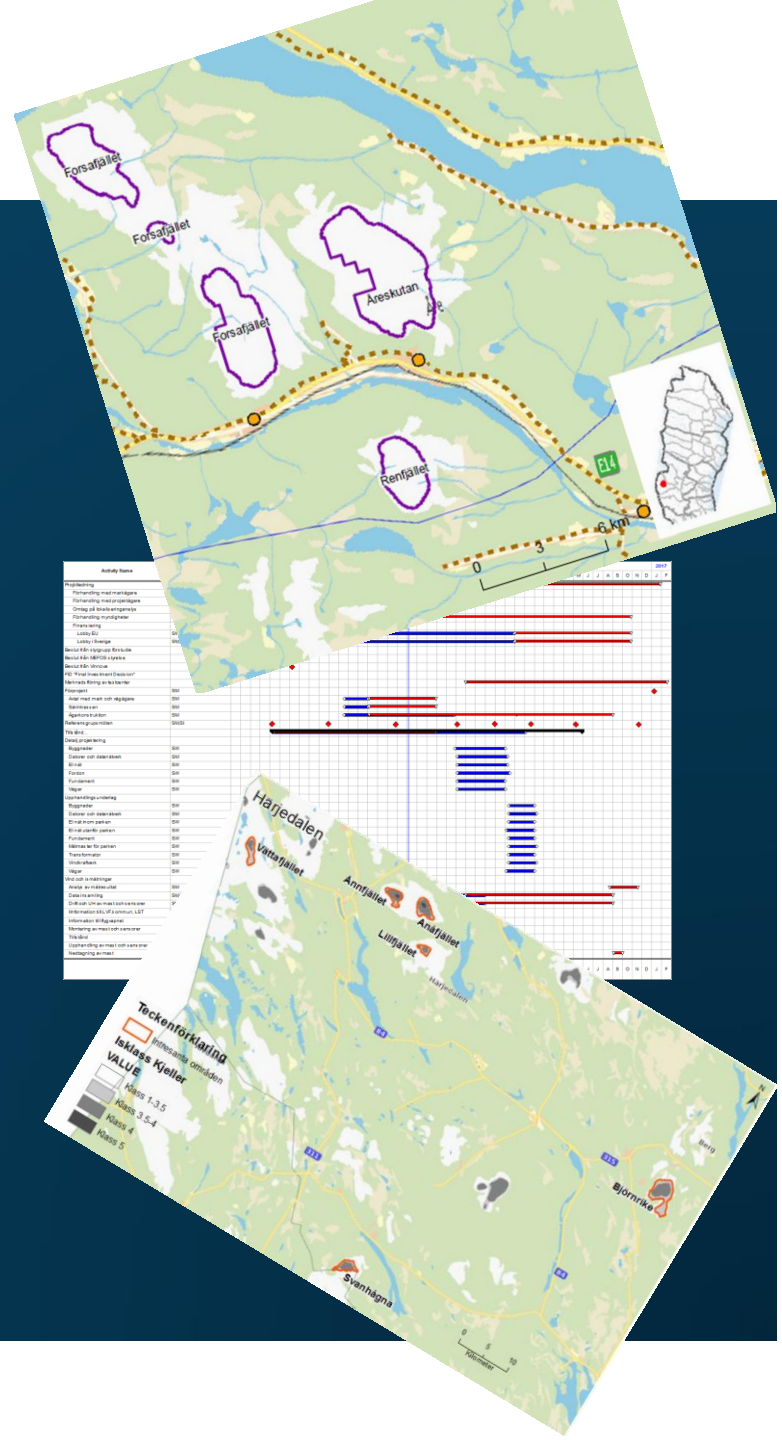
Cold Climate test activities

- Prototype testing
- Calibrated site for certification and test programs according to standards
- Measurements at site
  - Wind measurements
  - Temperature
  - Humidity
  - Liquid water content
- Service & Operation
  - On-site operation personnel
  - Safe access to test site & to the test pads
  - Crane access
- Forecasting
  - Subscription of detailed local weather forecasts
- Infrastructure
  - Grid connection
  - High speed data connection & data storage
  - Workshop, offices, accommodation,…



History of the test centre project

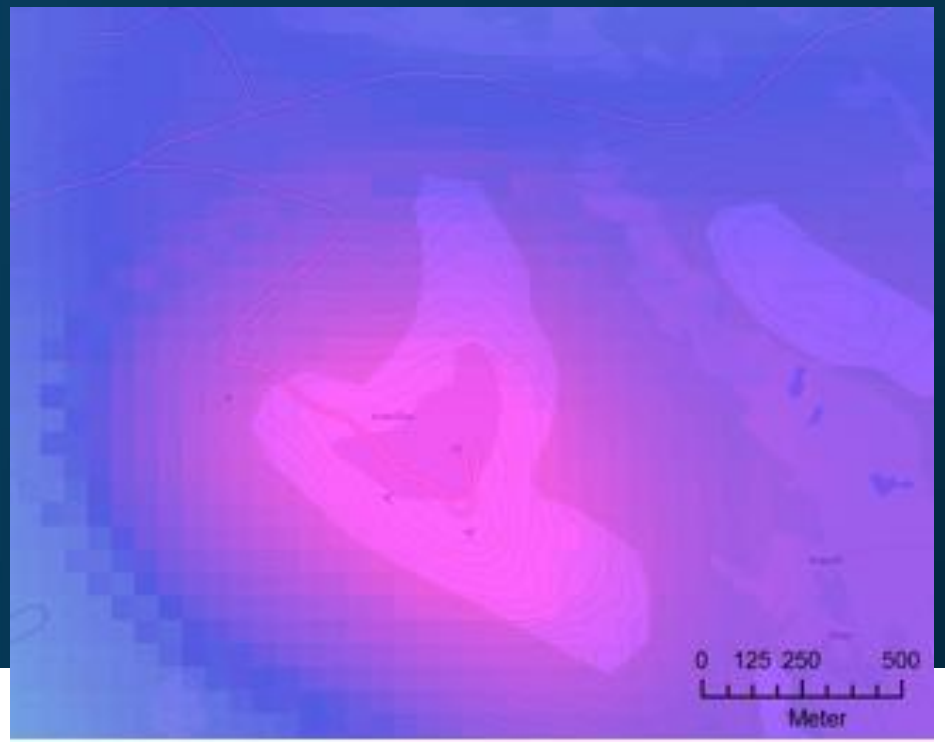
- 2011 — Feasibility study by SWPTC and Power Circle.
- 2012-2013 — First location study with short list of locations and preliminary business plan and budget by consultant Scandinavian Wind.
- 2013-2015 — Swerea Mefos take over the project and initiates discussions about several locations with municipalities and interest groups. Permitting process to complicated at all of them.
- 2016-2018 — RISE take over project and initiate a new study of for alternative locations. Focus on selection of a new location and LOI with land owner and municipality, meeting and dialogue with wind industry as well as a funding strategy.



How we select location

Main criteria in order of priority:

- High probability for light ice growth during a long period
- High probability to get necessary permits
- Low cost of grid interconnection
- High probability for extreme low temperatures
- High probability for extreme wind conditions
- Not to far from airport, roads, accommodation etc.



Selection in numbers

Meteorological parameters

Ice

- Number of hours >350 h/year (2 weeks) with 10g/h/m ice growth the minimum year

Temperature

- Extreme temperature - number of hours < -10oC (rating)

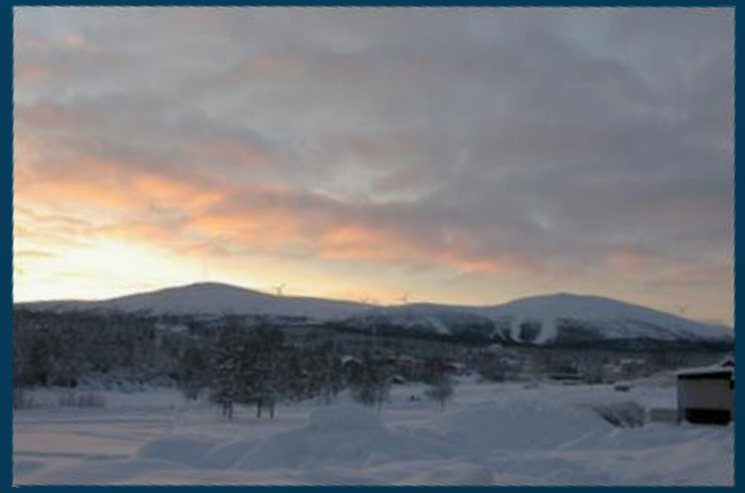
Wind speed

- Average wind speed > 7 m/s
- Extreme wind speed - number of hours < 20 m/s (rating)

10 g/h/m = Light ice growth

50 g/h/m = Medium ice growth

250 g/h/m = Heavy ice growth



IEA Ice class Meteorological icing

IEA Ice class	Meteorological icing	Instrumental icing	Production loss
	% of year (h)	% of year	% of anual prod.
5	>10 (877-)	>20	>20
4	5-10 (439-876)	10-30	10-25
3	3-5 (264-438)	6-15	3-12
2	0.5-3 (45-263)	1-9	0.5-5
1	0-0.5 (0-44)	<1.5	0-0.5

Classification for sites, to be used:

- as a basis of recommendations
- for wind turbine design load cases,
- for describing and comparing sites

Selection in numbers

Distance parameters

Road

- Preferred distance < 3 km
- Acceptable distance < 5 km

Community

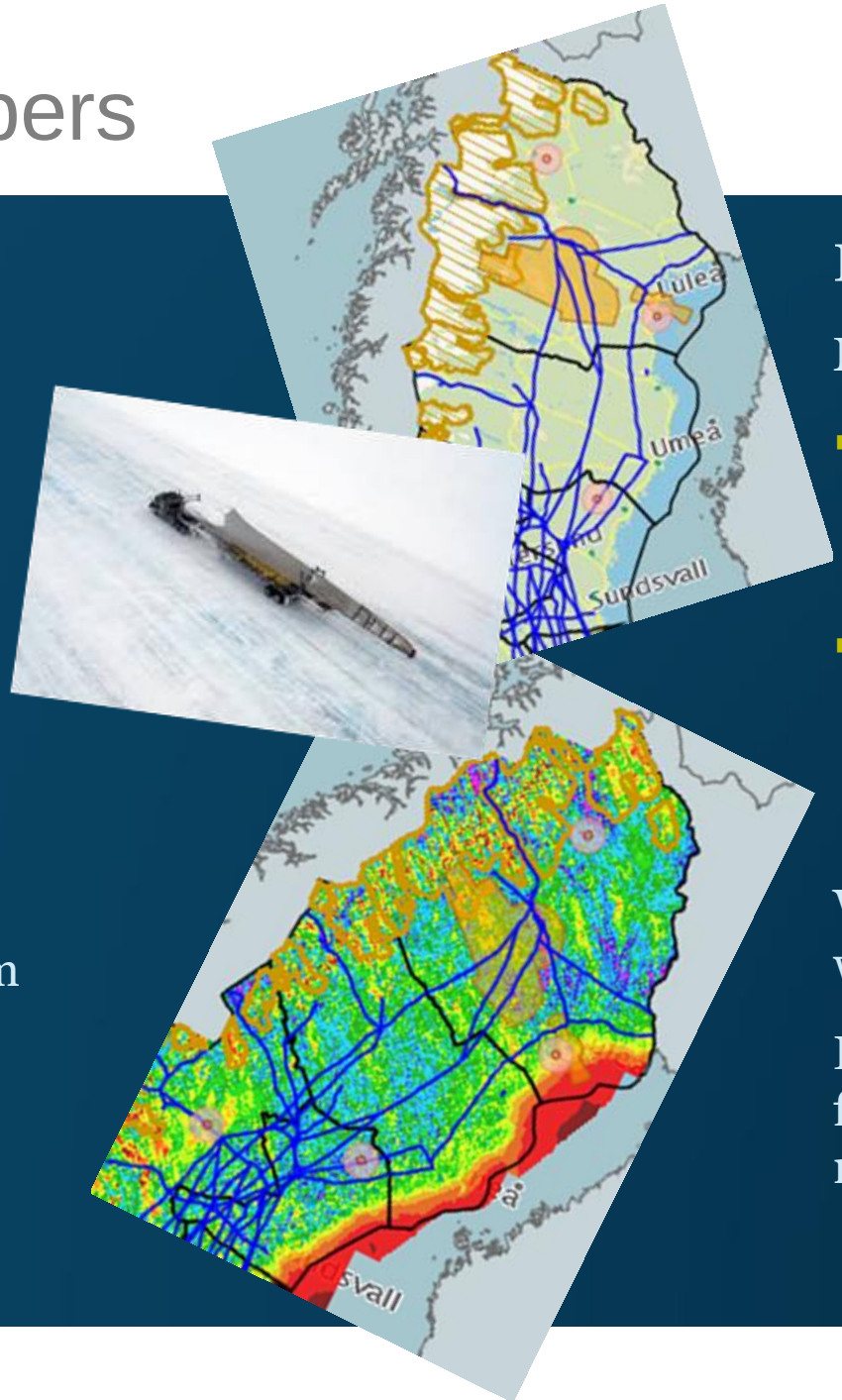
- Preferred distance < 30 km
- Acceptable distance < 70 km

Airport

- Preferred distance < 80 km
- Acceptable distance < 130 km

Grid

- Preferred distance < 5 km
- Acceptable distance < 15 km



Data sources

Meteorological data

- Kjeller Vindteknik from year 2000-2012 with 50 x 50 m resolution
- Swedish Meteorological and Hydrological Institute (SMHI) from year 2009-2012 with 1 x 1 km resolution.

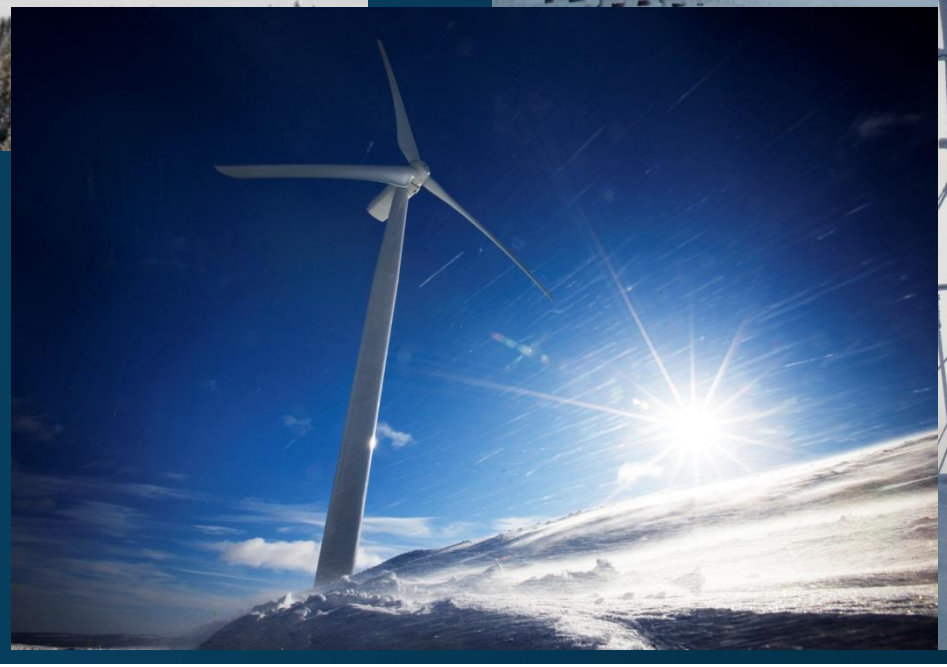
Wind speed data from national wind speed mapping

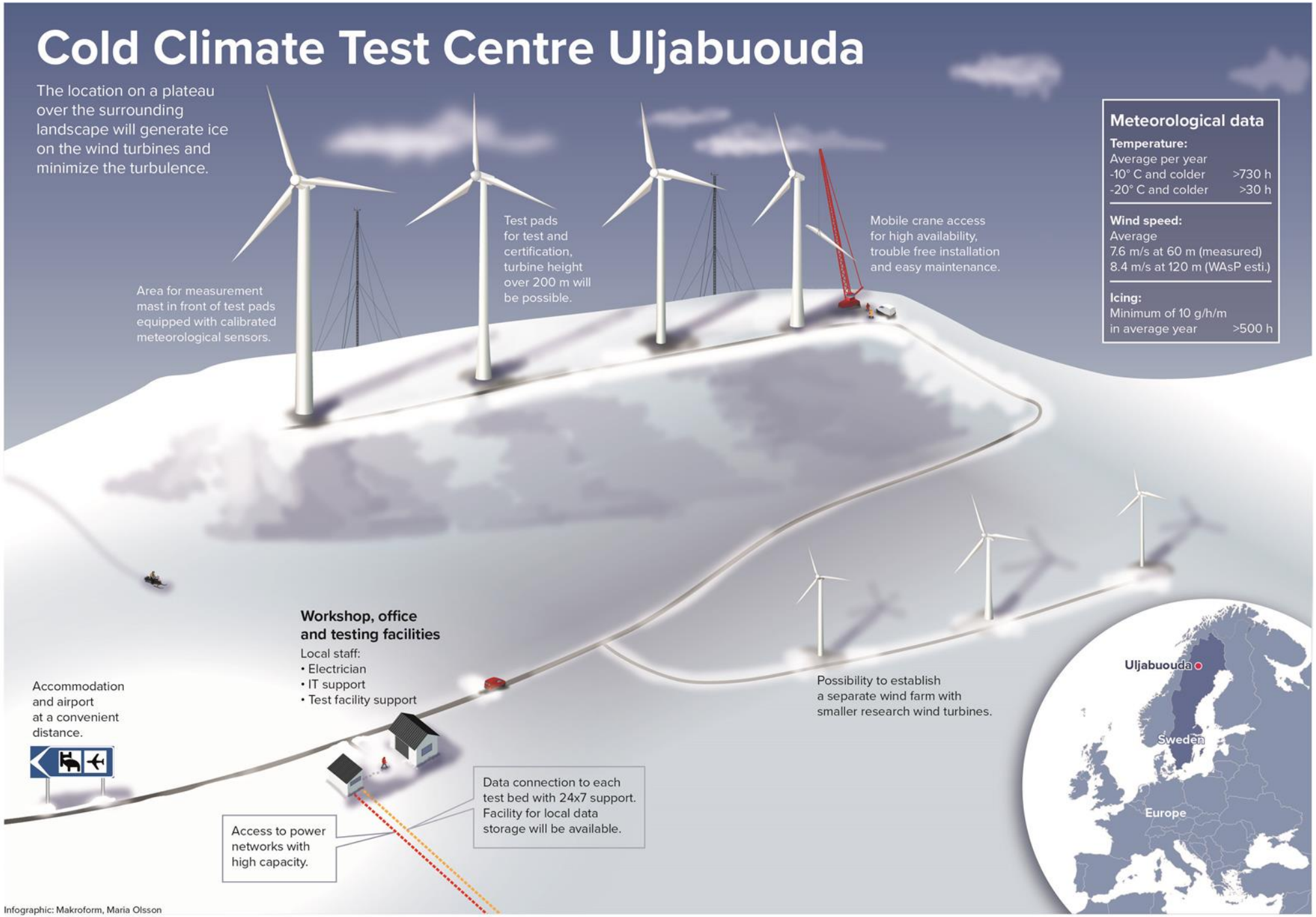
Environment impact data from national data bases and regional governments

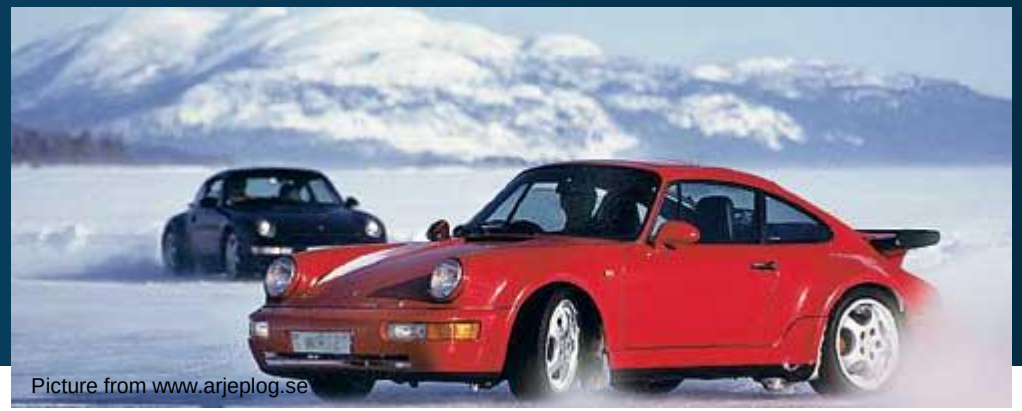
Lessons learned

- Good correlation between hours of ice growth and height above sea level (>700 m)
- Landscape profile has a influence on ice growth
- In cloud icing the most common ice type
- Further north in Sweden does not have to mean more ice
- Electrical grid will have a large impact on cost and timeline
- Sensitive terrain makes permitting process complicated

Uljabuouda wind farm owned by Skellefteå Kraft




Cold Climate Test Centre Uljabuouda
The location on a plateau over the surrounding landscape will generate ice on the wind turbines and minimize the turbulence.
Area for measurement mast in front of test pads equipped with calibrated meteorological sensors.
Test pads for test and certification, turbine height over 200 m will be possible.
Mobile crane access for high availability, trouble free installation and easy maintenance.
Meteorological data
Temperature:
Average per year
-10° C and colder >730 h
-20° C and colder >30 h
Wind speed:
Average
7.6 m/s at 60 m (measured)
8.4 m/s at 120 m (WAsP esti.)
Icing:
Minimum of 10 g/h/m
in average year >500 h
Workshop, office and testing facilities
Local staff:
• Electrician
• IT support
• Test facility support
Accommodation and airport at a convenient distance.
Possibility to establish a separate wind farm with smaller research wind turbines.
Data connection to each test bed with 24x7 support. Facility for local data storage will be available.
Access to power networks with high capacity.
Uljabuouda
Sweden
Europe
Infographic: Makroform, Maria Olsson


Picture from www.arjeplog.se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THANK YOU

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