GL Renewables Certification

GL-Technical Note for Cold Climate – An Overview

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Winterwind2011
Wind energy in low temperature and icing conditions

UMEÅ, SWEDEN
February 9-10 2011

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Contents

- Introduction – GL
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  - Load assumptions
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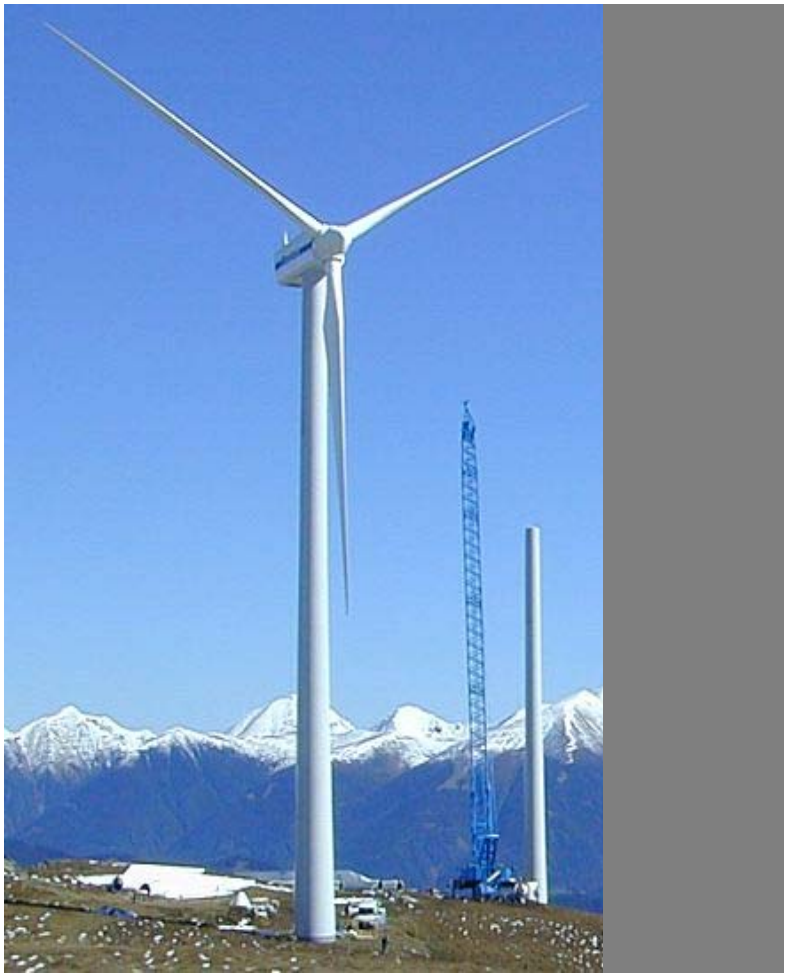
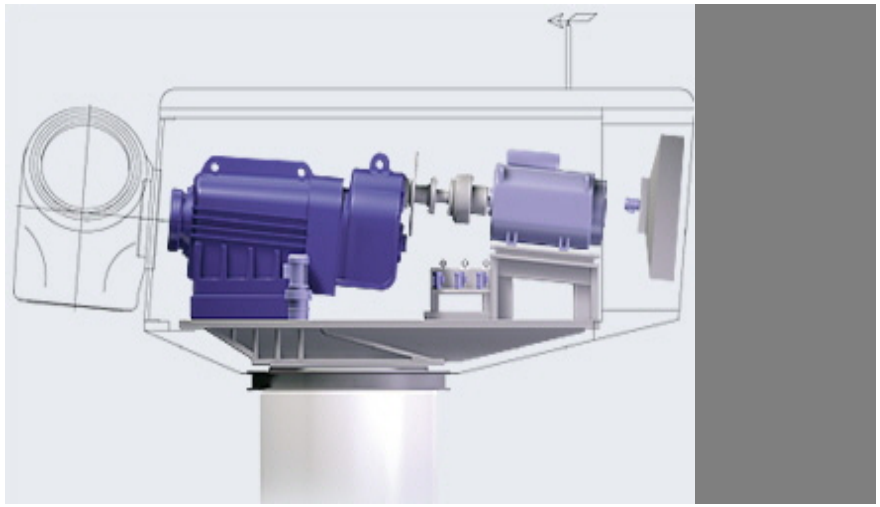
  - Automatic ice detection
  - Manuals
  - Rotor blades, nacelle cover and spinner
  - Machinery components
  - Strength verifications
  - Building structures
  - Electrical installations
- Summary



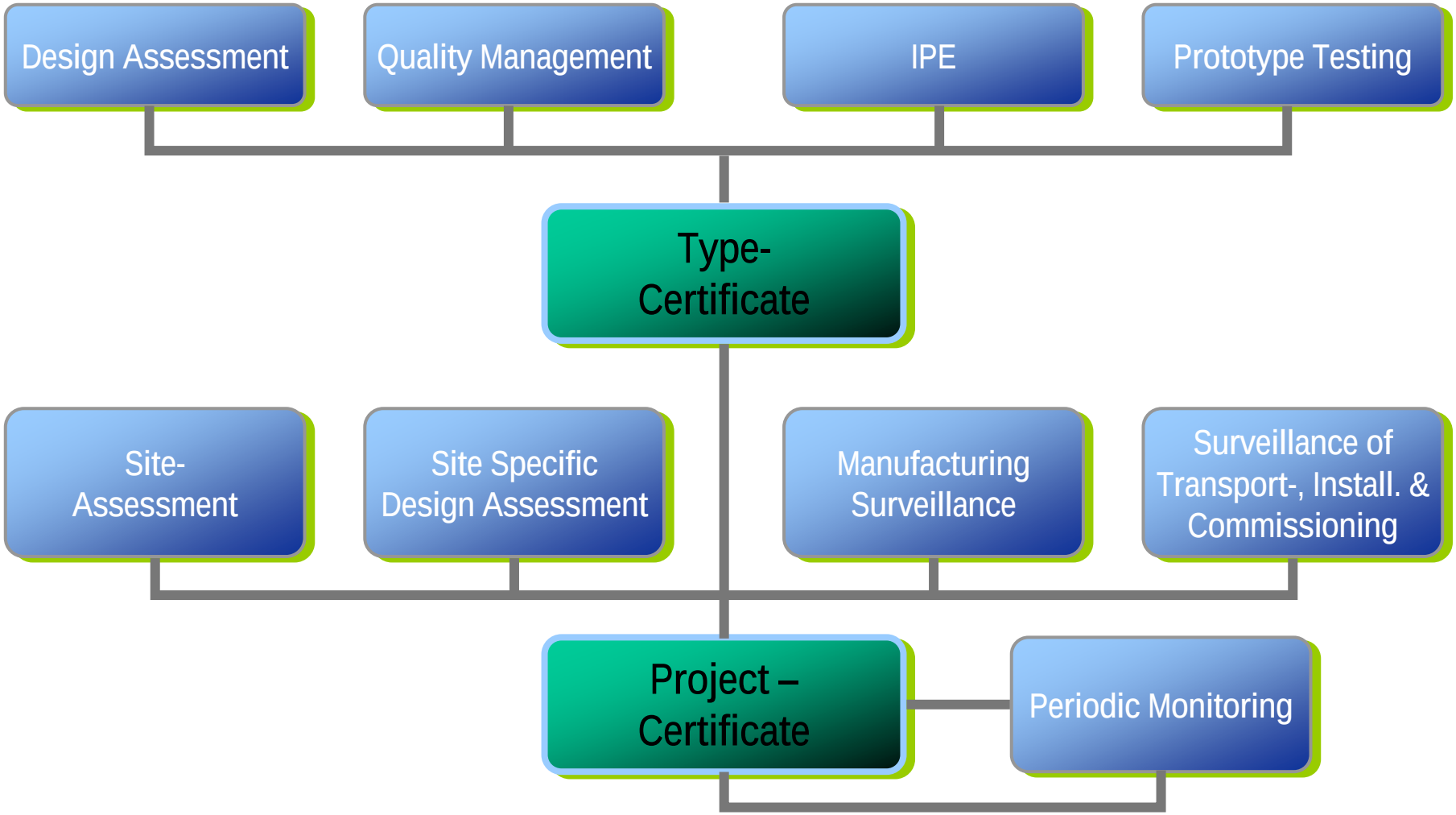
- type certification



- project certification

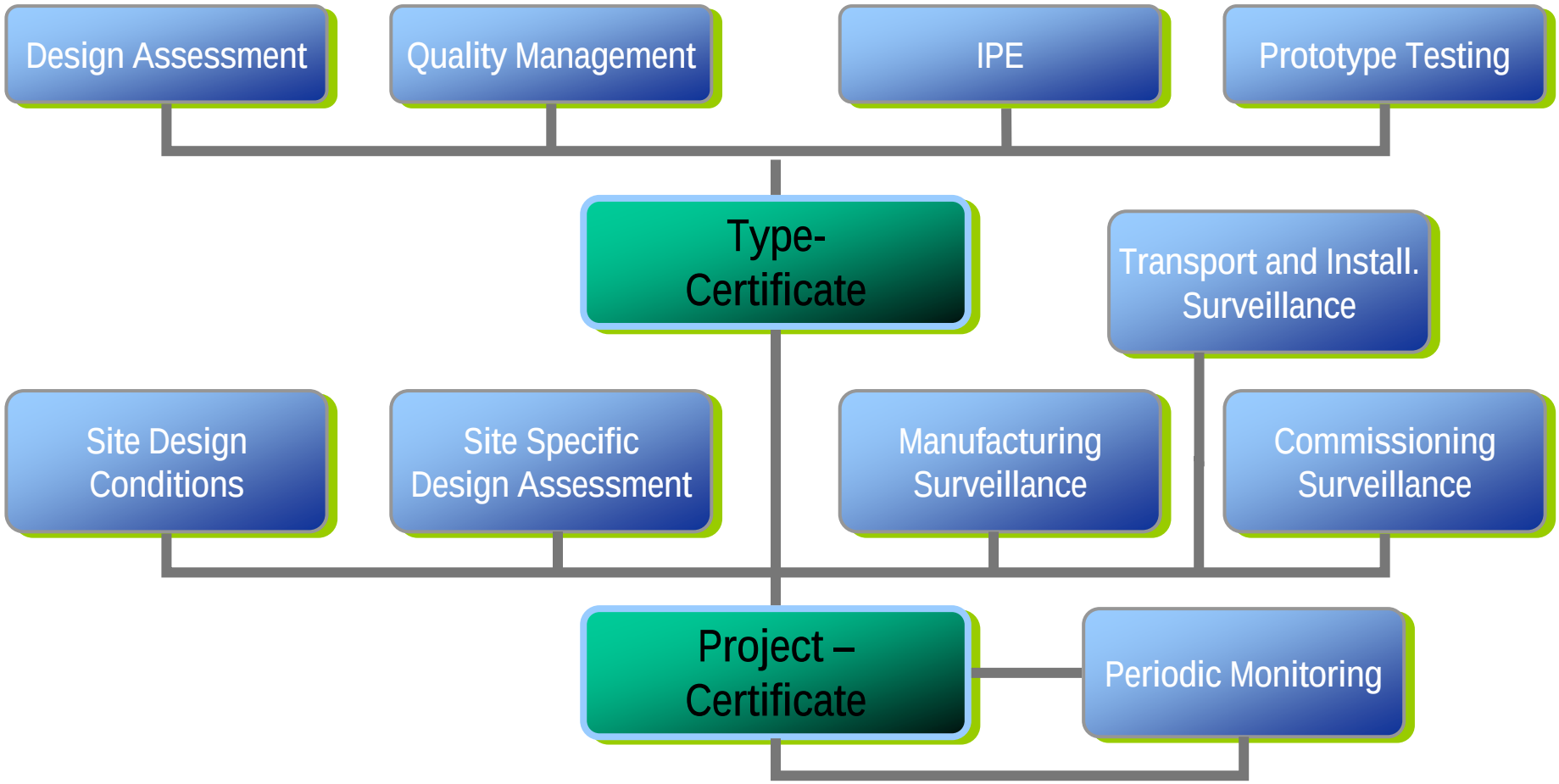
Services / Basis – GL 2003/2004

IPE = Implementation of design-related requirements in Production and Erection



Services / Basis – GL 2010

IPE = Implementation of design-related requirements in Production and Erection



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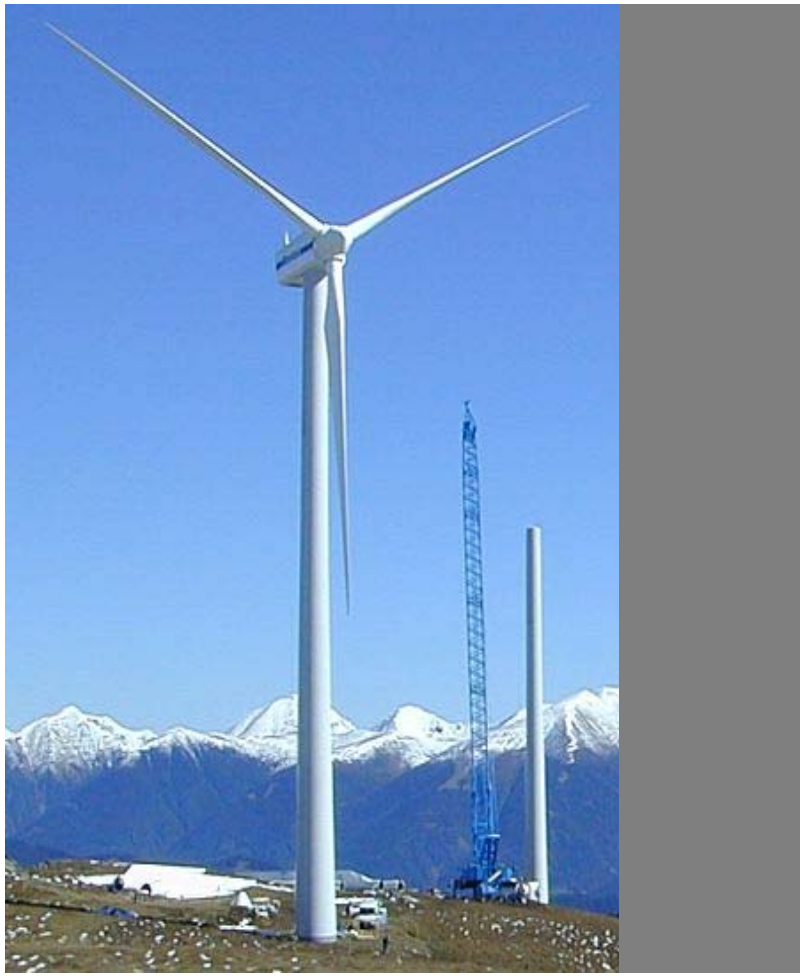

Introduction (1)

- Rising interest for installation of wind turbines at notably low temperature sites
- Present Guidelines do not explicitly account for the specific demands of cold climate
- The solution: Cold Climate Certification according to the Technical Note of GL – especially developed for such sites
  - Based on: Onshore Guidelines of GL (Edition 2003/2004 and 2010)
  - Including: whole wind turbine
  - Including: experience of GL
  - Inlcuding: knowledge of wind energy committee
  - Including: experience of certification projects since first edition in 2005

Introduction (2)

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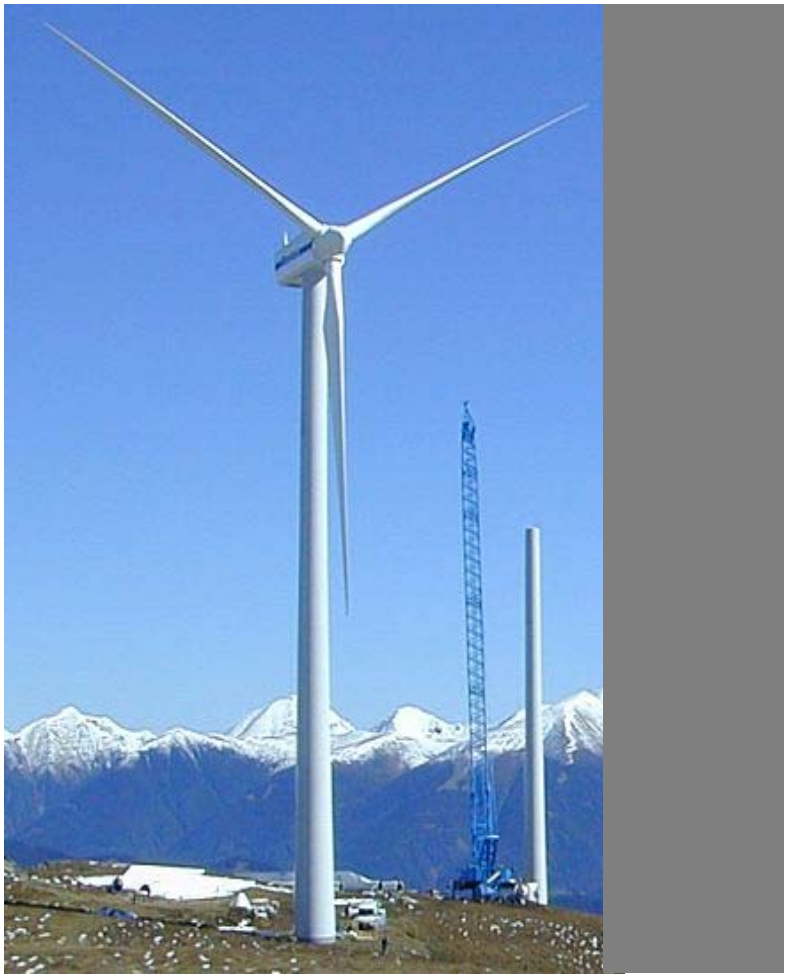

Definition of cold climate site / conditions

- normal climate ambient temperatures:
  - $\theta_{mean\ year} = 15^{o}C$
  - $\theta_{1year\ min/max} = -20$ to $+50^{o}C$ (survival temperature)
  - $\theta_{min/max\ operation} = -10$ to $+40^{o}C$ (operational temperature)
  - standard air density $\rho = 1.225 kg/m^3$

- cold climate criterion and ambient temperatures:
  - 9 days per year below $-20^{o}C$ (appr. p=0.02)
  - operation of turbines below -15°C
  - manufacturer defines $\theta_{mean\ year}$, $\theta_{1year\ min}$, $\theta_{min\ operation}$

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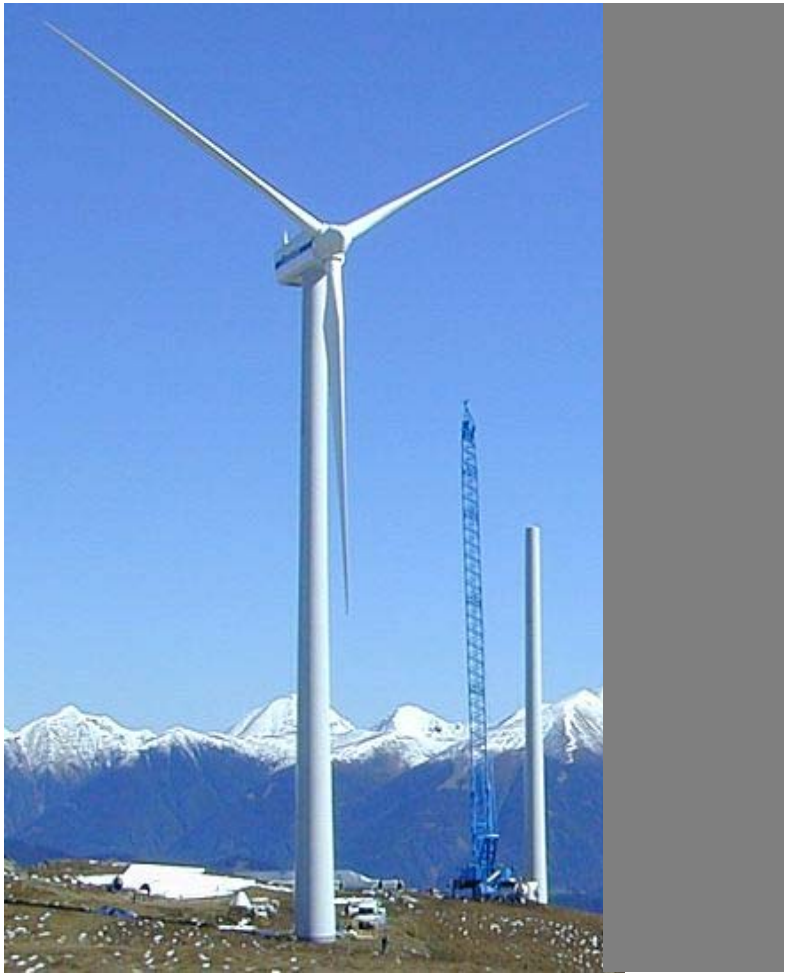
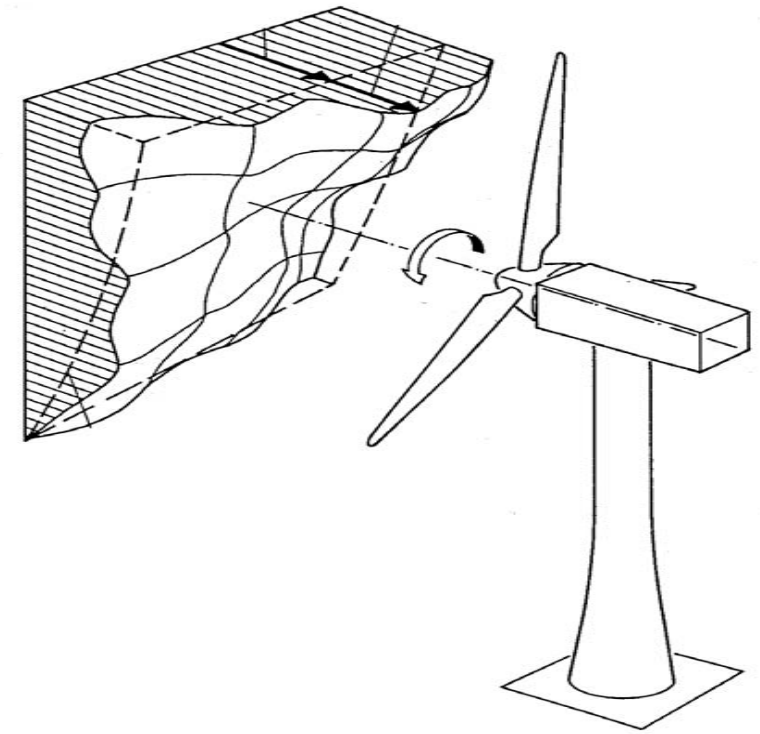


Why increased loads at cold climate sites?

- wind turbine loads are caused by dynamic pressure as function of wind speed and air density
- dimensioning loads occur mostly at power production $\geq v_{rated}$
- cold climate sites differ in climatic characteristics concerning superposition of high wind speed and air density

Information for load assumptions (1)

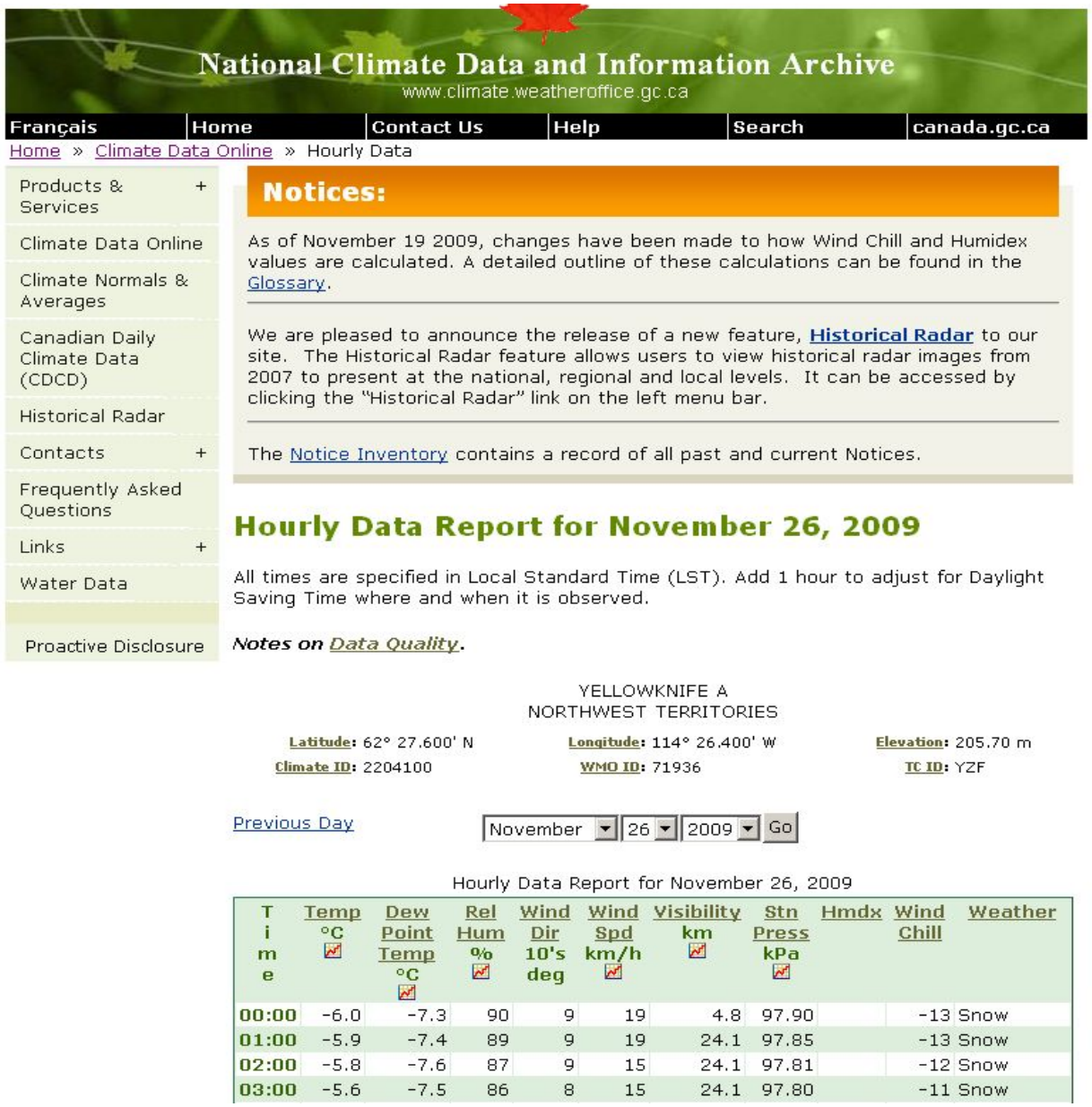
- Air density correction to prevailing temperature and altitude
- Adaption of power curve and control behaviour



Examples for Cold Climate Sites - Canada

Data source

- period 2000 to 2006
- hub height 10m
- hourly mean



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Home » Climate Data Online » Hourly Data

- Products & Services +
- Climate Data Online
- Climate Normals & Averages
- Canadian Daily Climate Data (CDCD)
- Historical Radar
- Contacts +
- Frequently Asked Questions
- Links +
- Water Data
- Proactive Disclosure

Notices:

As of November 19 2009, changes have been made to how Wind Chill and Humidex values are calculated. A detailed outline of these calculations can be found in the Glossary.

We are pleased to announce the release of a new feature, **Historical Radar** to our site. The Historical Radar feature allows users to view historical radar images from 2007 to present at the national, regional and local levels. It can be accessed by clicking the "Historical Radar" link on the left menu bar.

The Notice Inventory contains a record of all past and current Notices.

Hourly Data Report for November 26, 2009

All times are specified in Local Standard Time (LST). Add 1 hour to adjust for Daylight Saving Time where and when it is observed.

Notes on Data Quality.

YELLOWKNIFE A
NORTHWEST TERRITORIES

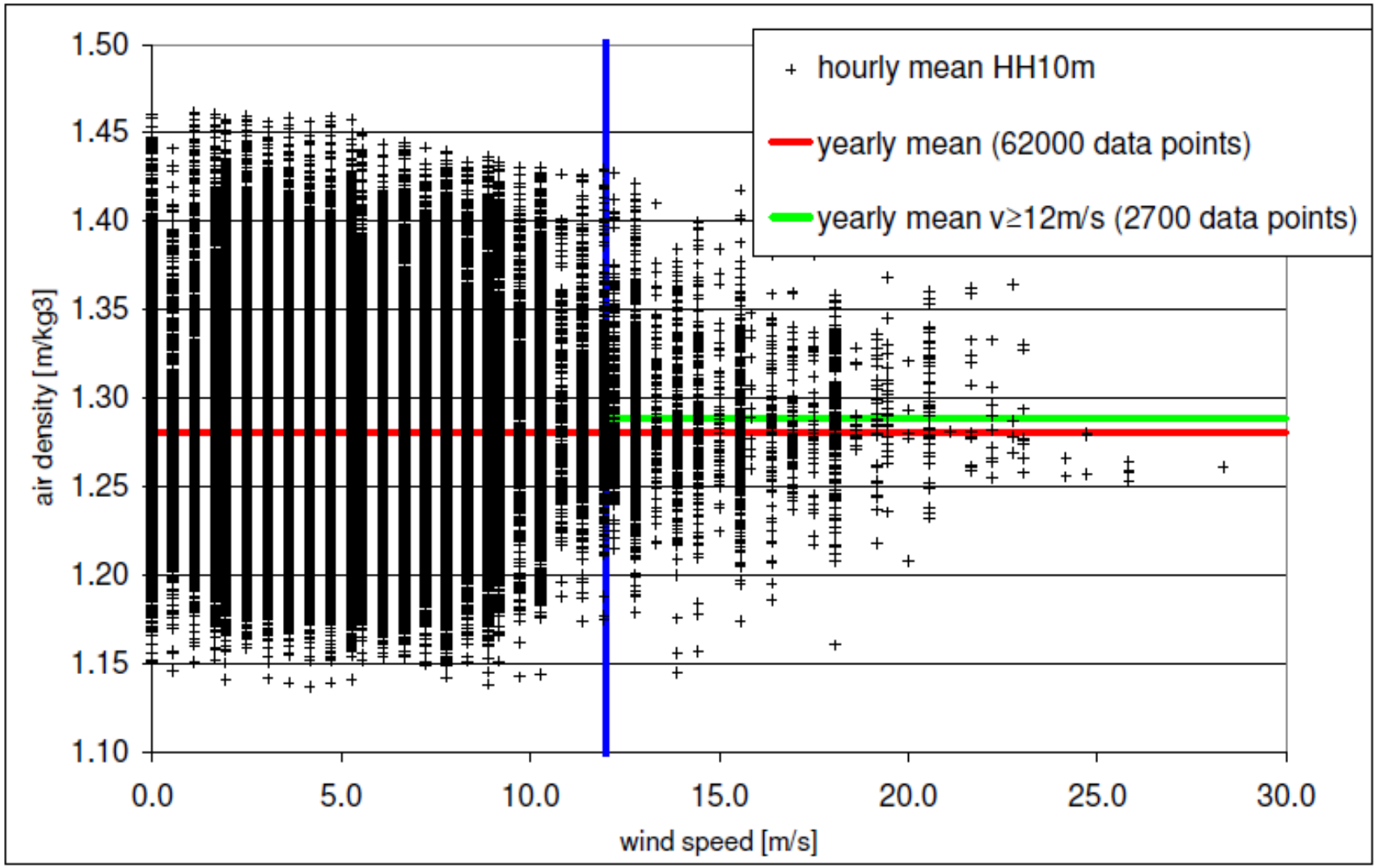
Latitude: 62° 27.600' N | Longitude: 114° 26.400' W | Elevation: 205.70 m
Climate ID: 2204100 | WMO ID: 71936 | TC ID: YZF

Previous Day | November | 26 | 2009 | Go

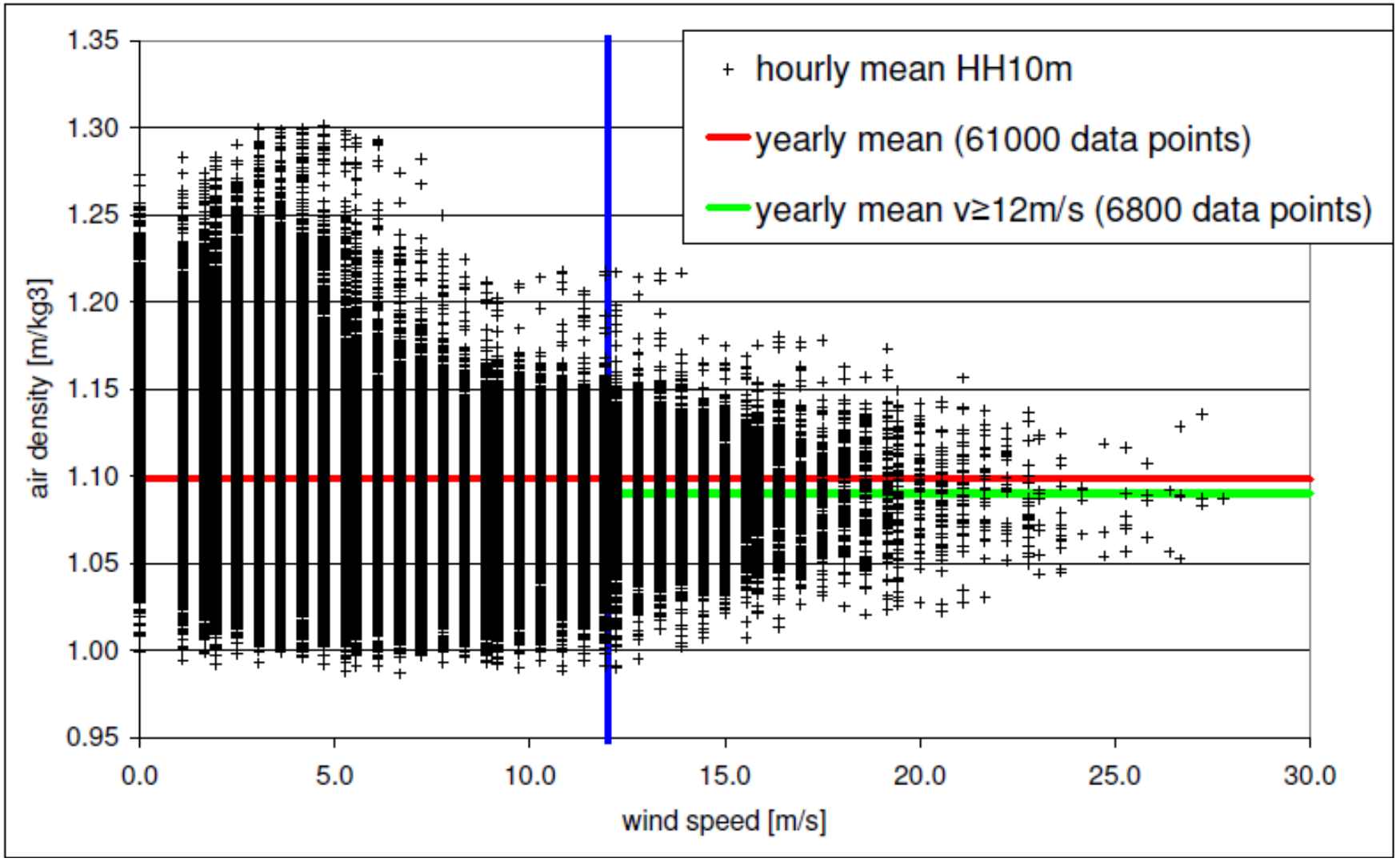
Hourly Data Report for November 26, 2009

Time	Temp °C	Dew Point Temp °C	Rel Hum %	Wind Dir 10's deg	Wind Spd km/h	Visibility km	Stn Press kPa	Hmdx	Wind Chill	Weather
00:00	-6.0	-7.3	90	9	19	4.8	97.90		-13	Snow
01:00	-5.9	-7.4	89	9	19	24.1	97.85		-13	Snow
02:00	-5.8	-7.6	87	9	15	24.1	97.81		-12	Snow
03:00	-5.6	-7.5	86	8	15	24.1	97.80		-11	Snow

Cartwright (15m altitude)

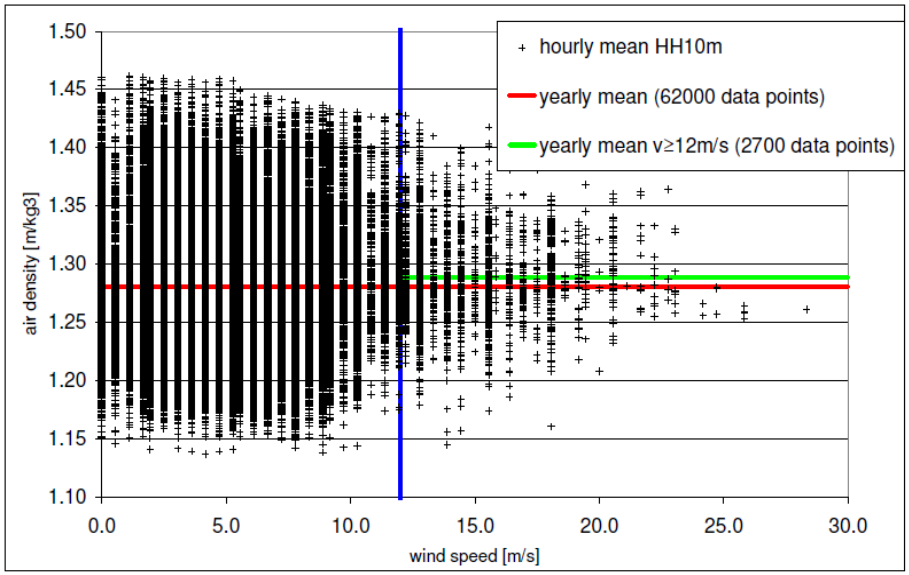


Pincher Creek (1200m altitude)



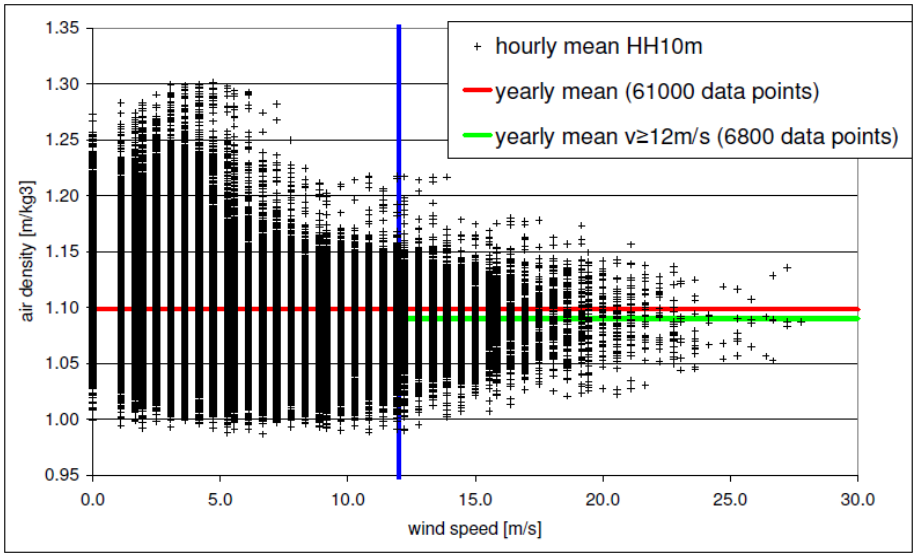
Cold Climate Class A (e.g. Cartwright)

- identical to approach up to now (Rev. 1 to 3 of Technical Note):
- high air densities and wind speeds ≥ v_{rated} occur simultaneously
- can be assumed to be fulfilled, if mean air density $\rho_{mean\ year} \geq 1.25\ kg/m^3$ for $v \geq v_{rated}$
- air densities calculated with
  - $\theta_{mean\ year}$
  - $\theta_{1year\ min}$
  - $\theta_{min\ operation}$



Cold Climate Class B (e.g. Pincher Creek)

- new in Rev. 4
- high air densities and wind speeds ≥ v_{rated} do not occur simultaneously
- application of lower extreme air densities
  - $\rho_{1year\ min}$ is calculated with $\theta_{1year\ min}$ +35 K
  - $\rho_{min\ operation}$ is calculated with $\theta_{min\ operation}$ +25 K
- corresponds to approach for normal conditions (of existing guidelines)
- $\rho_{mean\ year}$ is calculated with $\theta_{mean\ year}$



Example for temperatures and air densities

θ(example)	ρ acc. Class A	ρ acc. Class B
$\theta_{mean\ year}$ = +5°C	1.269 kg/m³	1.269 kg/m³
$\theta_{1year\ min}$ = -40°C	1.514 kg/m³	1.317 kg/m³
$\theta_{min\ operat}$ = -30°C	1.452 kg/m³	1.317 kg/m³

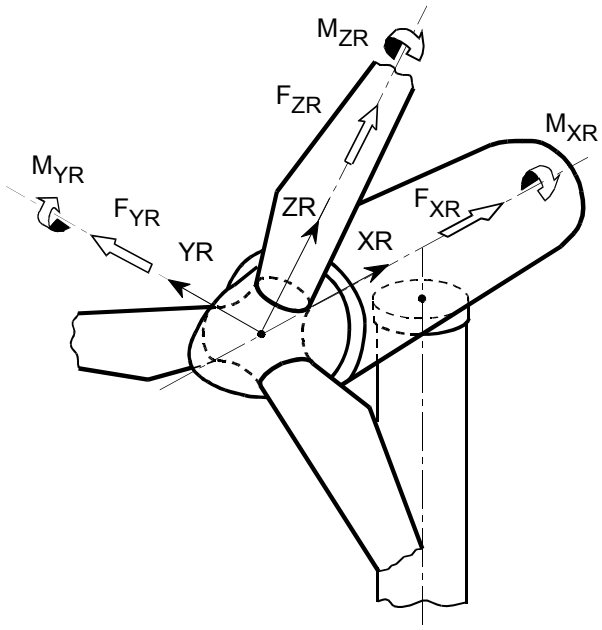
- basis: ideal gas law with standard air pressure
- corrections for different altitudes possible

Information for load assumptions (2)

- Fatigue Loads:
  - Calculation with $\theta_{mean,\ year}$
  - Additional ice masses, if operation with ice-formation
- Extreme Loads:
  - 1-year recurrence: $\theta_{1year,\ min}$ with normal external conditions
  - 50-year recurrence: $\theta_{mean,year}$ with extreme external conditions
- Fault:
  - Conditions after fault to be combined with $\theta_{1year,\ min}$

Information for load assumptions (3), TN Rev. 3 (GL 2003/2004)

Temperature	Load case (DLC)
θmean,year	1.2; 1.3; 1.6; 1.7; 1.8; 1.9; 1.12; 1.13; 2.3; 3.1; 4.1; 6.1; 6.2; 6.3; 6.4; 8.2; 8.3
θmean,year	1.1_earthquake_conditions 1.12_earthquake_conditions 6.0_earthquake_conditions
θmean,year ≤ 0°C	1.10; 6.5
θ1year,min	6.0; 6.6; 7.1
θ1year,min or θmin,operation	1.0; 1.1; 1.4; 1.5; 1.11; 2.1; 2.2; 3.2; 3.3; 4.2; 5.1
θ1year,min/max or to be specified by the manufacturer	8.1



XR in direction of the rotor axis
ZR radially, orientated to rotor blade 1 and perpendicular to XR
YR perpendicular to XR, so that XR, YR, ZR rotate clockwise

Fig. 4.A.4 (GL 2010) Rotor coordinate system

Information for load assumptions (4), TN Rev. 4 (GL 2010)

	GL 2010	GL 2003/2004 and IEC 61400-1:1999	IEC 61400-1:2005 and IEC 61400-1:2005A1
Temperature	Load case (DLC)	Load case (DLC)	Load case (DLC)
$\theta_{mean,year}$	1.1_fatigue_analysis; 1.3; 1.6; 1.7; 2.1_fatigue_analysis; 2.2_fatigue_analysis; 3.1; 4.1; 6.1 ; 6.2; 6.3; 6.4; 8.2; 9.2_fatigue_analysis; 9.3_fatigue_analysis; 9.4_fatigue_analysis; 9.5_earthquake_conditions; 9.6_earthquake_conditions; 9.7_earthquake_conditions	1.2; 1.3; 1.6; 1.7; 1.8; 1.9; 1.12; 1.13; 2.3; 3.1; 4.1; 6.1; 6.2; 6.3; 6.4; 8.2; 8.3; 1.1_earthquake_conditions; 1.12_earthquake_conditions; 6.0_earthquake_conditions	1.2; 1.3; 1.4; 1.5; 2.4; 3.1; 4.1; 6.1; 6.2; 6.3; 6.4
$\theta_{mean,year} \leq 0°C$	1.8; 9.1	1.10; 6.5	
$\theta_{1year,min}$	7.1; 9.8	6.0; 6.6; 7.1	7.1; 8.2
$\theta_{1year,min}$ or $\theta_{min,operation}$	1.1_extreme_analysis; 1.4; 1.5; 2.1_extreme_analysis; 2.2_extreme_analysis; 3.2; 4.2; 5.1; 9.2_extreme_analysis; 9.3_extreme_analysis; 9.4_extreme_analysis	1.0; 1.1; 1.4; 1.5; 1.11; 2.1; 2.2; 3.2; 3.3; 4.2; 5.1	1.1; 2.1; 2.2; 2.3; 3.2; 3.3; 4.2; 5.1
$\theta_{1year,min/max}$ or to be specified by the manufacturer	8.1	8.1	8.1

Information for safety and control system

- Adjustment of safety concept and safety / control system to cold climate conditions
- Description of measurement instruments and sensors
- Systematic consideration of possible faults
- Description of start-up procedure(s)
- Overheating protection on heatings

Information for automatic ice detection

- Ice detection systems (ice sensors) can be certified according to GL Guideline
- Useful hints and requirements are included in the Technical Note, Rev. 3 for GL 2003/2004 (for GL 2010 this is included in the Guideline itself)

Additional information for manuals (1)

- Assembly instructions
  - Concrete procedures
  - Assembly of bolted connections
  - Bonds, weldings
  - Paint works
  - Handling of operating resources (e.g. oils and fats)

- Documents for commissioning
  - Adjusting of the operating values for heatings, cooling and control system
  - Tests and inspections at the components, which are switched on additionally at extreme temperatures
  - As the case may be test of the ice sensor and the turbine behaviour (respectively park behaviour)

Additional information for manuals (2)

- Operating instructions
  - Possibly limited temperature ranges for
    - Activation of the rotor lock
    - Certain turbine states or operating procedures

- Maintenance manual
  - Inspections of the operating values for heatings, cooling and control system
  - Tests and inspections of the components, exist due to the extreme temperatures
  - As the case may be maintenance and test of the ice sensor and the turbine behaviour (respectively park behaviour)
  - Assembly of bolt connections
  - Handling of operating resources

Information for rotor blades, nacelle cover and spinner

- Design for $\theta_{1year,\ min}$ due to high loads during standstill
- Snow and ice loads on nacelle cover and spinner

Information for machinery components (1)

General (valid for all slides following regarding machinery components)

- Description of heating concept
- Description of ventilation concept
- Description of component cooling
- Confirmation of component manufacturer / sub-supplier
- Measurements or tests (e.g. information on cold chamber tests) → contact GL

Information for machinery components (2)

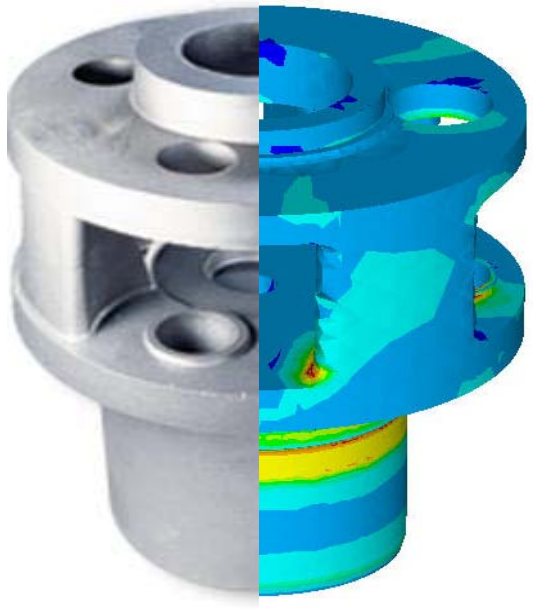
Heating

- List of components to be heated including temperature
- Description of heater functionality
- Criteria for operation of heaters

Information for machinery components (3)

Materials and Operating Resources

- Material properties shall allow for whole temperature range at the site
  - Fracture toughness
  - Notch bar impact value
  - Modulus of elasticity
  - Expansion



Information for machinery components (4)

Bearings

- Operability of the bearing sealings
- Behaviour of the used lubricants

Information for machinery components (5)

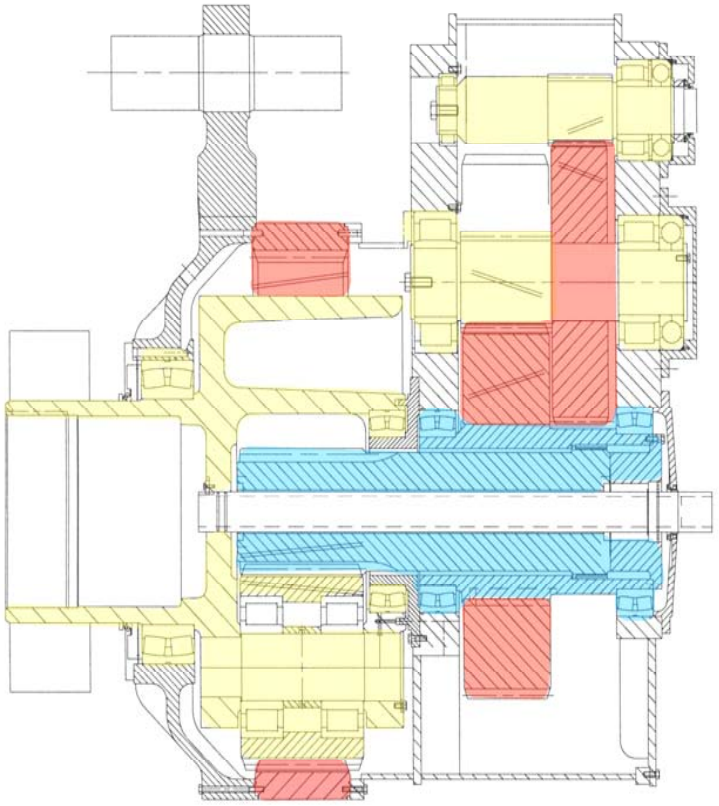
Blade pitch and yaw system

- Tests of operability and commisioning of electrical drives (incl. gearbox and brakes, if any) as well as the interaction with other components
- Specification of breakaway torque and achievement of sufficient pitch rates
- Specification of bearing friction torque
- In case of hydraulic pitch systems at least the component manufacturer shall state the suitability for use of the system under cold climate conditions

Information for machinery components (6)

Main Gear

- Limit values for turbine control
- Power / torque limitation
- Lubrication System, idling of drive train
- Test of start-up procedure in cold climate chamber (preferably including the lubrication system)



Source: Moventas

Information for machinery components (7)

Cold start after grid failure

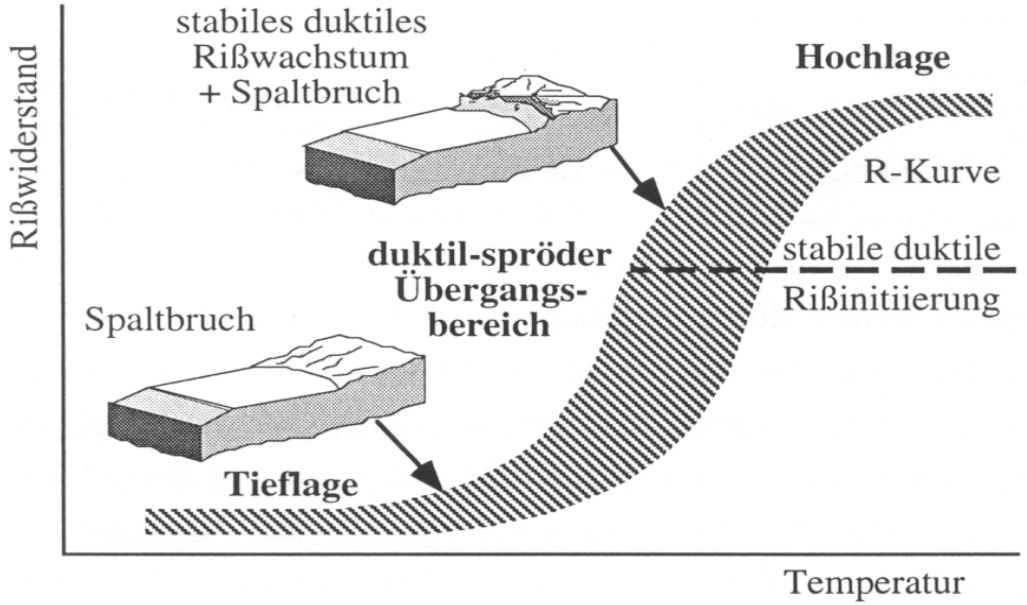
- Enduring grid disconnection
- Entirely cooled off turbine
- Re-establishing of operating state / cold start procedure (CSP)
- CSP including switch-on time and temperature of heatings and components
- Functional of CSP to be described and verified for main gear, yaw and pitch system

Information for machinery components (8)

- Elastomer bearings
- Brakes
- Energy storages
- Bolted connections
- Hydraulic system
- ...

Information for strength verifications

- Observe application range of standard
- Define additional requirements in specifications or drawings, if necessary
- Ensure integrity of structure (e.g. by additional verifications)



Information for building structures

- Additional material tests, if temperature is lower as defined in the corresponding standards
- *Note: Usability of attached parts (e.g. ladder, platforms)*
- Requirements for the construction of cast-in-place concrete structures at notably low temperatures

Information for electrical installations (1)

General (valid for all slides following regarding electrical installations)

- Definition of thermal areas
- Temperature range for each area (component / installation with highest sensibility regarding notably low temperatures)
- Confirmation of component manufacturer / sub-supplier
- Measurements or tests -> contact GL

Information for electrical installations (2)

Windings

- Motors and generator shall not be under voltage, when the measured winding temperature is below the minimum allowable temperature
- Sufficient heating shall be provided prior to a restart
- Test of generator heating within prototype testing

Information for electrical installations (3)

Transformers

- Transformer shall not be under voltage, when the measured winding temperature is below the minimum allowable temperature
- Sufficient heating shall be provided prior to a restart
- Test of transformer heating within prototype testing

Information for electrical installations (4)

Electrical Cabinets

- Review of all installations regarding their low temperature capability
- Heating shall be designed to reach the minimum temperature defined for the cabinet under all circumstances (main switch without power)
- Analysis or tests

Information for electrical installations (5)

- Slip ring
- Storage devices
- Cables and lines
- ...

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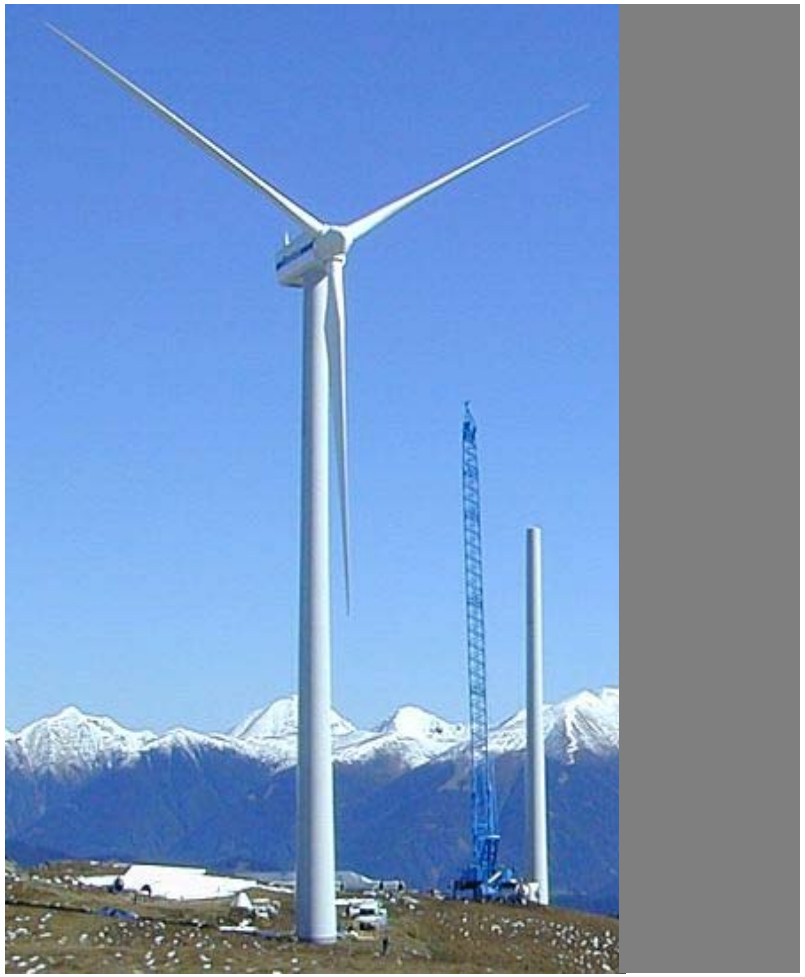

Summary

- Rising interest on cold climate sites and certification
- Certification rules for cold climate conditions available at GL
- Present Technical Note to provide certification rules from one source (links to onshore guideline)
- Further improvement of certification rules required to account for specific demands on cold climate certification
- Your input / ideas / remarks are appreciated

Summary – GL 2010

- Present Technical Note based on GL 2003/2004
- Section on Ice Detection included in GL 2010 already
- New Technical Note in addition to GL 2010 under preparation
  - Section for load assumptions done – available on request already
  - Further sections drafted – discussions in wind energy committee following
  - scope in comparable range to Rev. 3 of the existing Technical Note
- Your input / ideas / remarks are appreciated
  (draft available on request –> just email woeb@gl-group.com)

Additional Technical Note on Icing?

- cold climate sites and icing of wind turbines are not necessarily connected
- demand for independent technical note on icing
  - e.g. with standard ice classes 3 days per year, 10 days, 20 days,...
  - displays icing capabilities of turbine (ice class X) clearly in certificate (not somewhere hidden in different certification reports)
- Your input / ideas / remarks are appreciated (just email kfre@gl-group.com and/or woeb@gl-group.com)

GL Renewables Certification

Thank you very much for your attention!

Questions? Remarks?

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comments on technical note are very welcome