Use of LIDAR for power curve measurements in Nordic climate

Martin S. Grønsleth (KVT, NO),
Ove Undheim (KVT, NO), Utku Turkyilmaz (KVT, SE)

The case

- LIDAR used for power curve measurement in a wind farm with icing conditions (site name undisclosed)
- 1 year of data -> Full power curve
- Winter power curves of two turbines with/without anti-icing
- Evaluated anti-icing system by comparing power production of the two turbines

Why use LIDAR

- Easy and cheap to deploy (and move)
- Undisturbed wind measurements regardless of operational state of turbines
- Multiple measurements over the rotor plane
- Recommended for use in cold climate in IEC 61400-12-1, 2nd ed. 2017-03
    - Also: Rotor Equivalent Wind Speed (REWS)

Leosphere


SITE ASSESSMENT
POWER CURVE
200 m
WINDCUBE v2
LIDAR REMOTE SENSOR

Windcube product features

- Constant accuracy at 12 simultaneous heights (40-200 m)
  Vertical beam for direct measure of vertical components (-> flow inclin.)
- Easy installation (45 kg), low power consumption (45 W)
- 24/7 automatic and manual remote web monitoring
- Proven complex terrain mode (FCR)
- Wind resource assessment and power curve measurements campaigns in line with IEC 61400-12-1, 2nd ed. 2017-03

Setup for power curve measurements

Ideally:

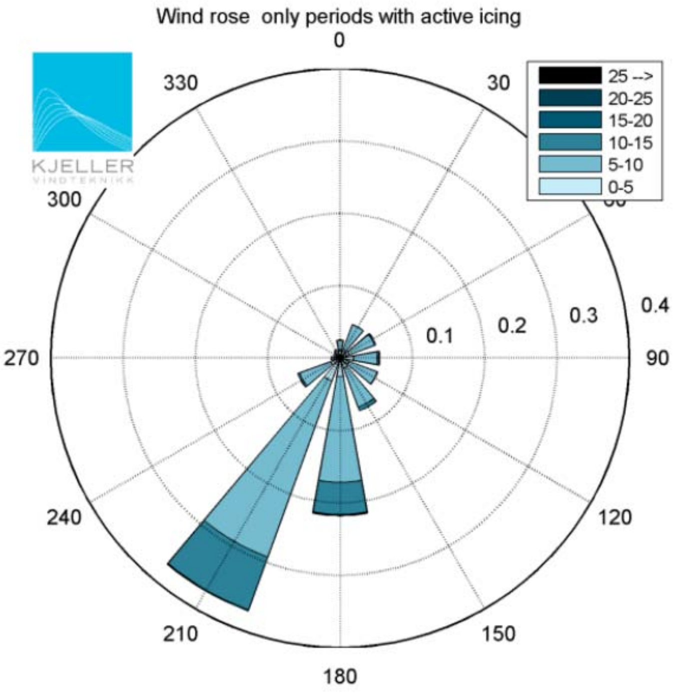
- Choose two turbines at same height, non-complex terrain, equal wind field, etc.

In practice:

- Deal with the constraints, work around challenges

In this case: Complex terrain ->

  - LIDAR: Flow Complexity Recognition (FCR™)
  - Numerical site calibration



Setup

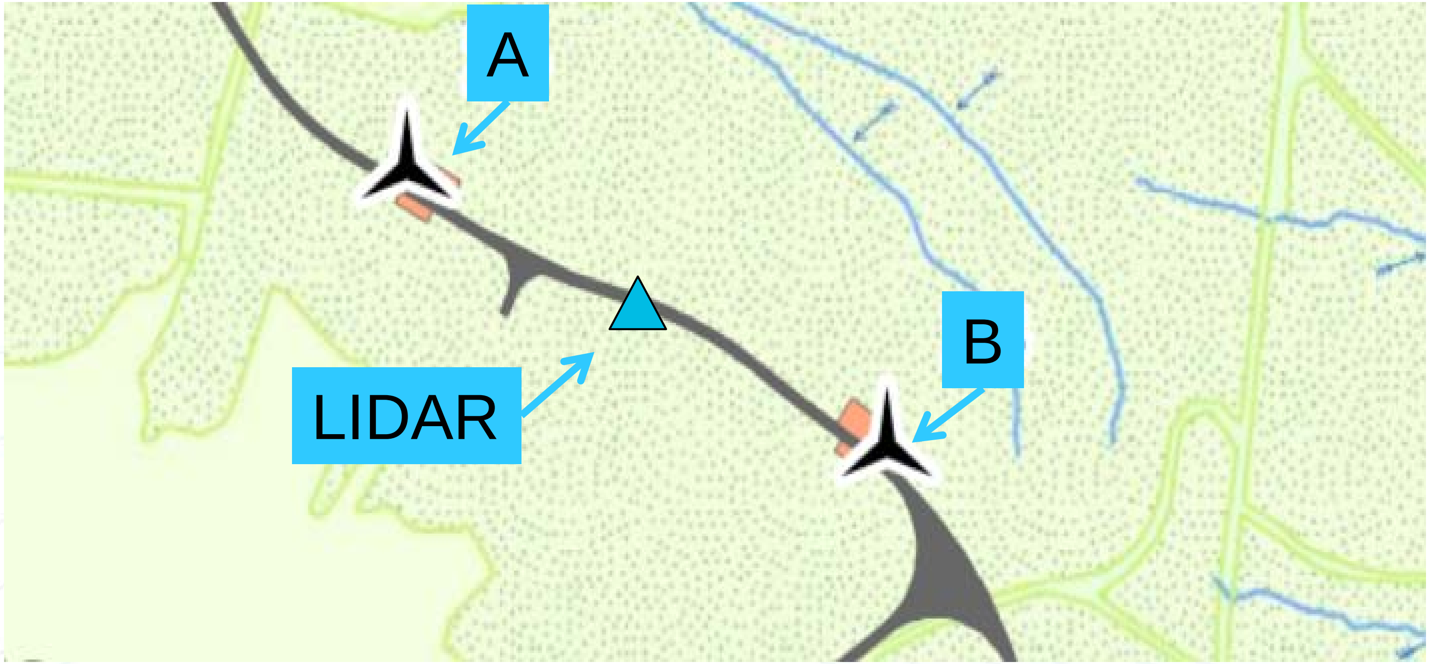
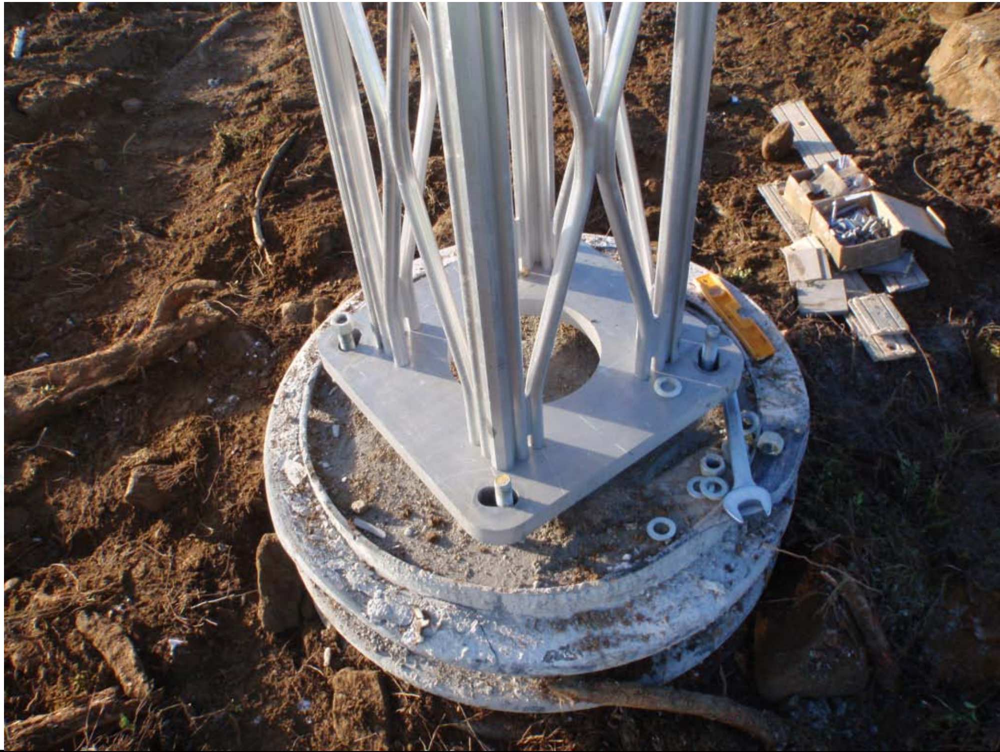
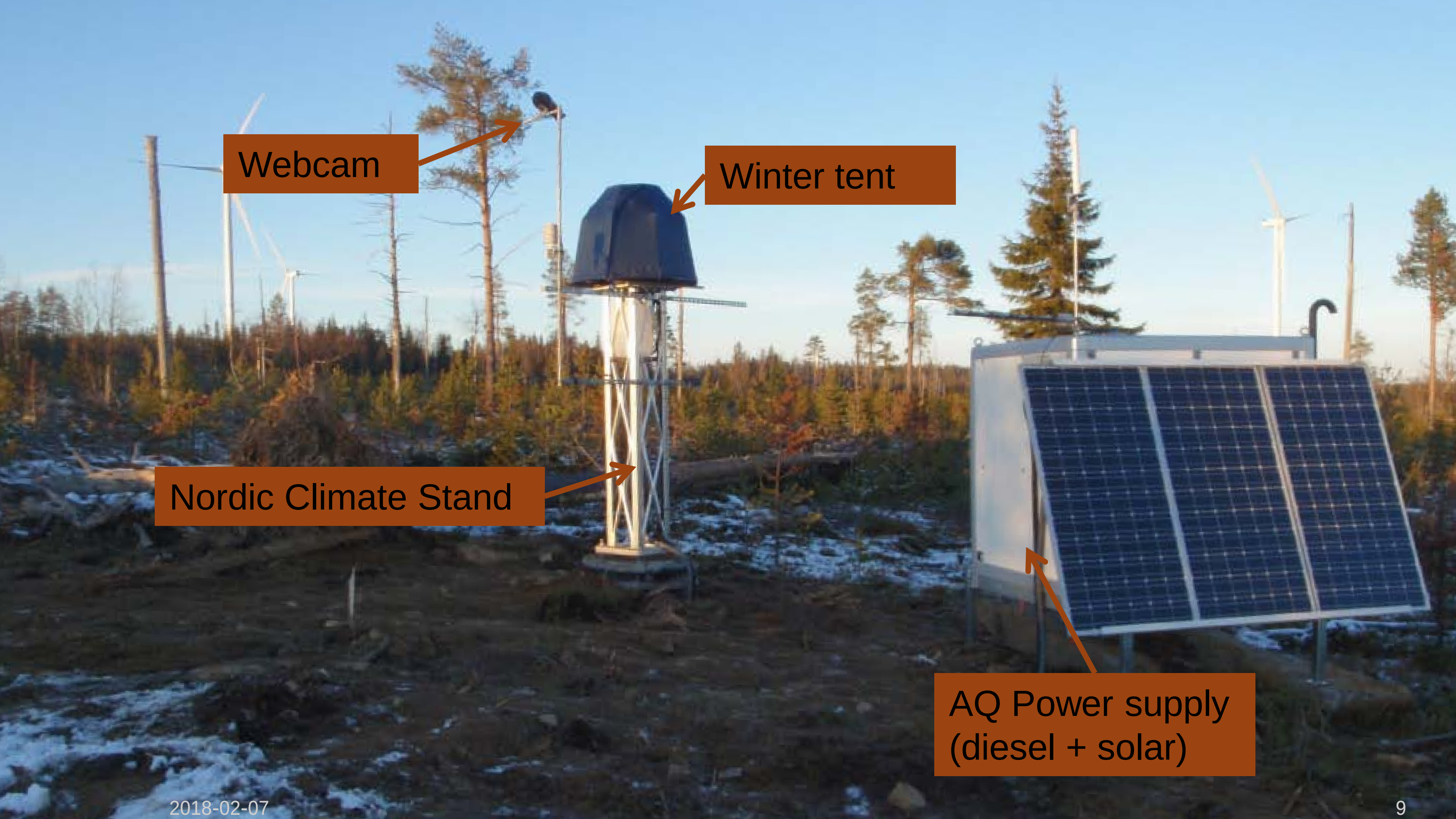


Figure: Illustration (from another site)

Installation at <*Nordic site with icing*>

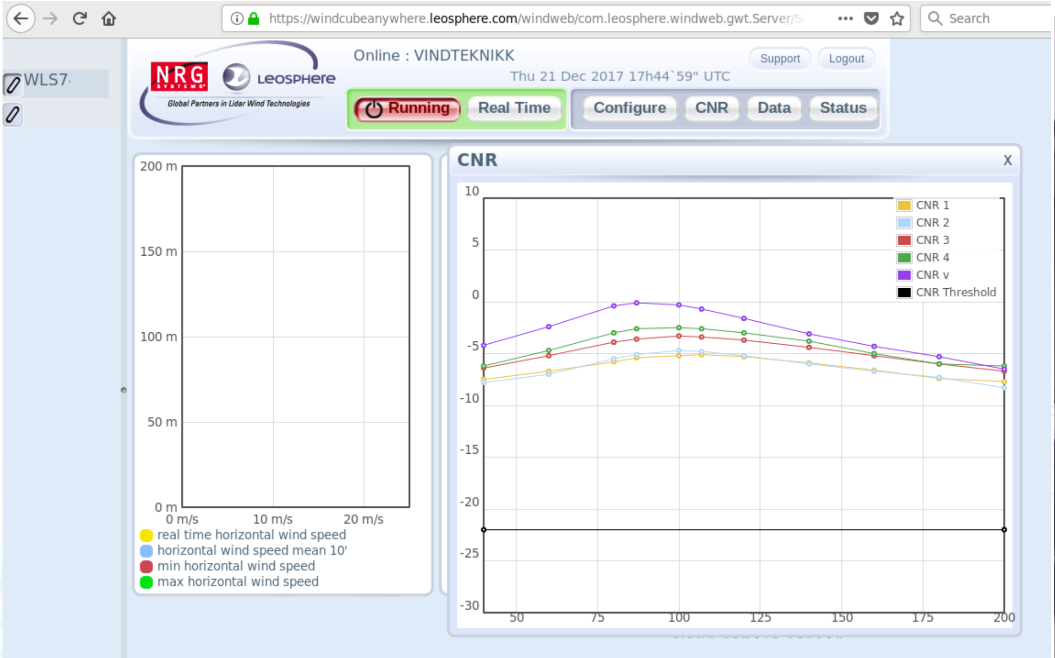
- Installed before winter
- Use of Nordic Climate Stand
- Solid anchoring
- Winter tent




Webcam
Winter tent
Nordic Climate Stand
AQ Power supply
(diesel + solar)

Monitoring

- Realtime data in web portal (Windcube Anywhere) + Webcam



Webcam image

LIDAR data availability in cold climate

Month	Technical availability	Height	Data availability
November	100 %	120 m	71 %
December	100 %	120 m	79 %
January	100 %	120 m	89 %
February	99 %	120 m	77 %
March	100 %	120 m	75 %
November	100 %	120 m	70 %
December	100 %	120 m	66 %
January	100 %	120 m	89 %
February	94 %	120 m	71 %
March	99 %	120 m	73 %

Analysis

- The LIDAR provides accurate and independent wind measurements also during icing periods

- Numerical site calibration – because of terrain
  - Different wind field at turbine locations
  - CFD model (Windsim) to transfer LIDAR wind to turbine locations

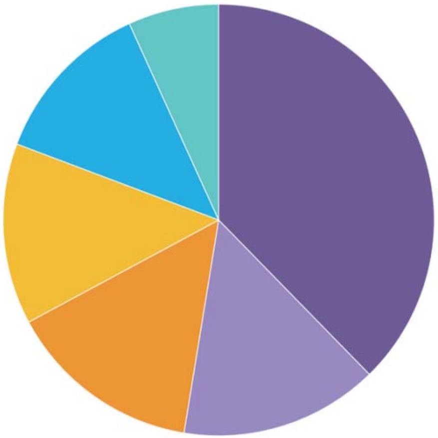
Analysis

Tasks:

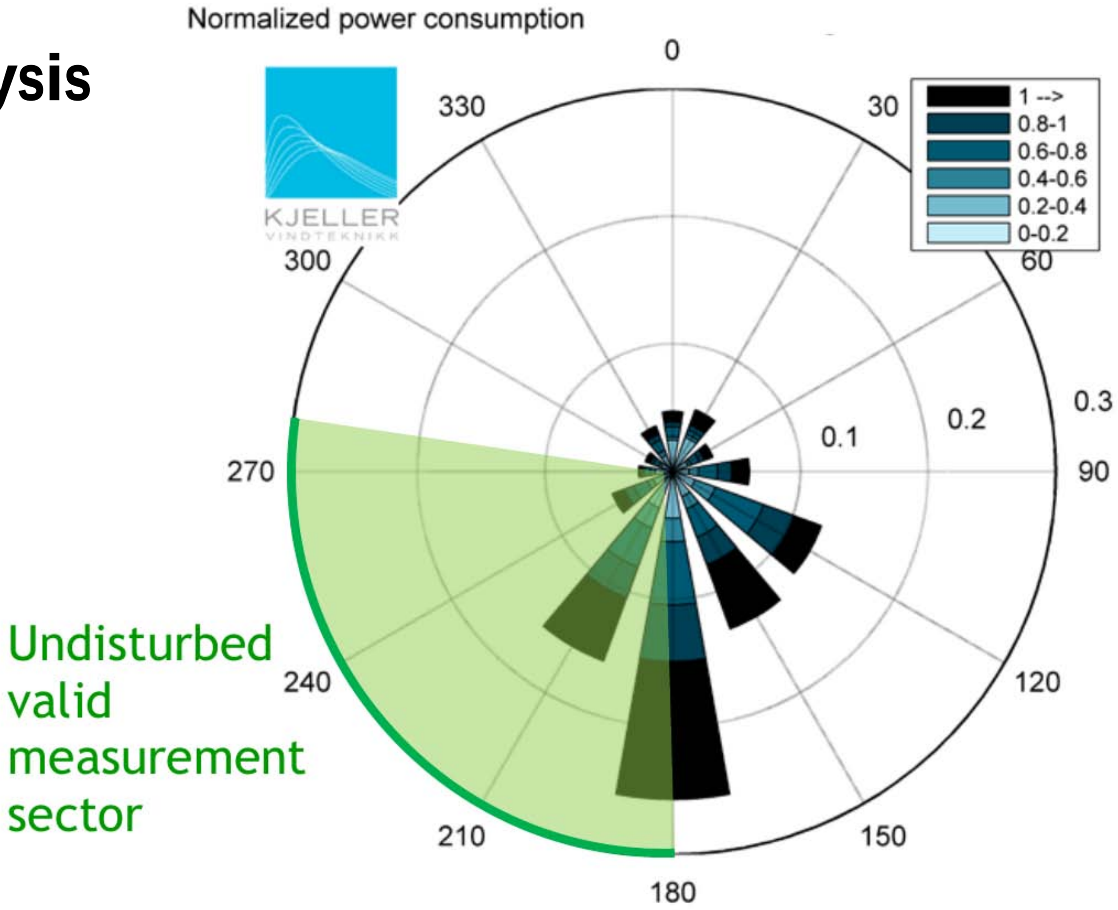
1. Find full power curve
2. Compare power production of turbine with/without anti-icing (AIS)

Method:

- SCADA data: Filter out concurrent valid periods
- Also filter on valid sectors and availability of LIDAR
- Time resolution: 10 minutes



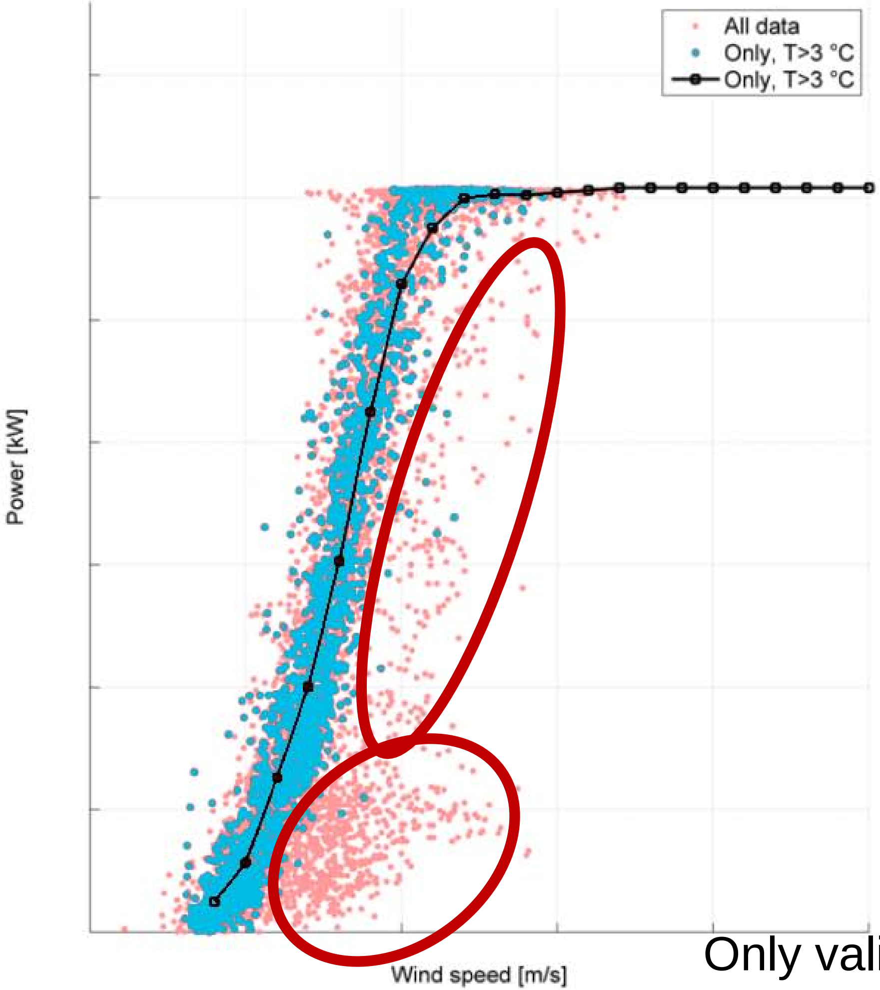
Analysis

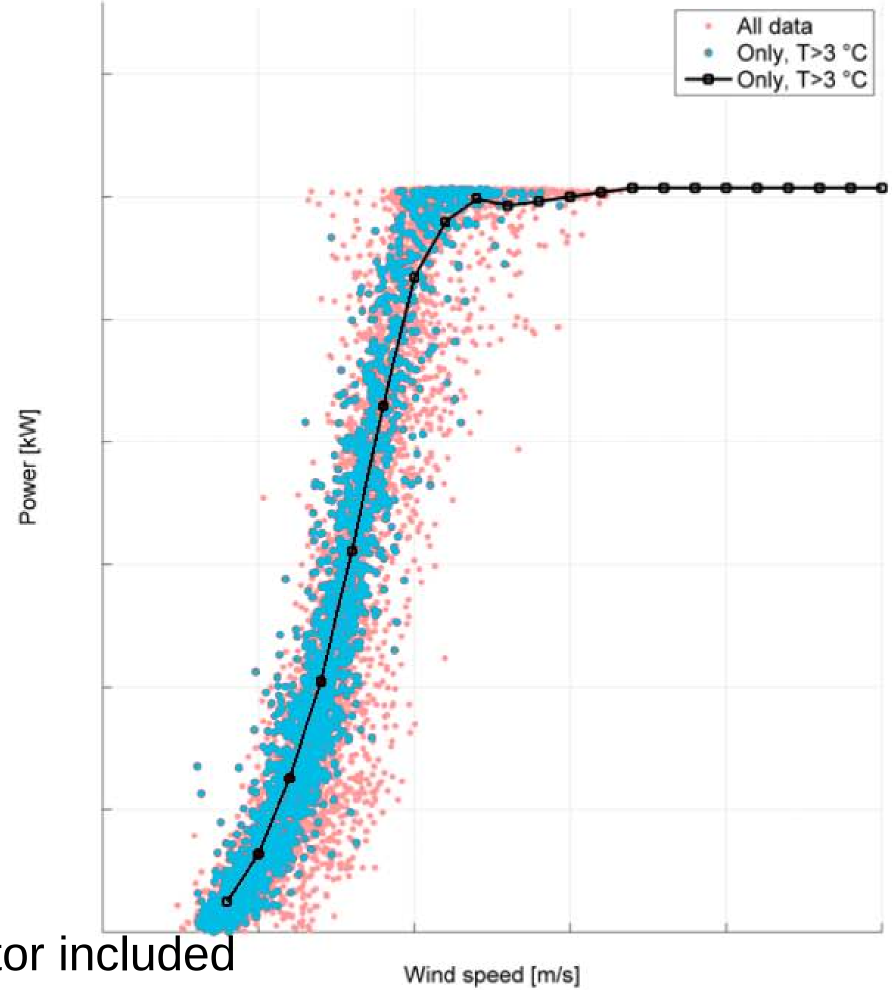

Normalized power consumption
0
30
60
90
120
150
180
210
240
270
300
330
0.1
0.2
0.3
1 -->
0.8-1
0.6-0.8
0.4-0.6
0.2-0.4
0-0.2
KJELLER
VINDTEKNIKK
Undisturbed valid measurement sector

Turbine A without AIS

Power Curves all year

Turbine B with AIS



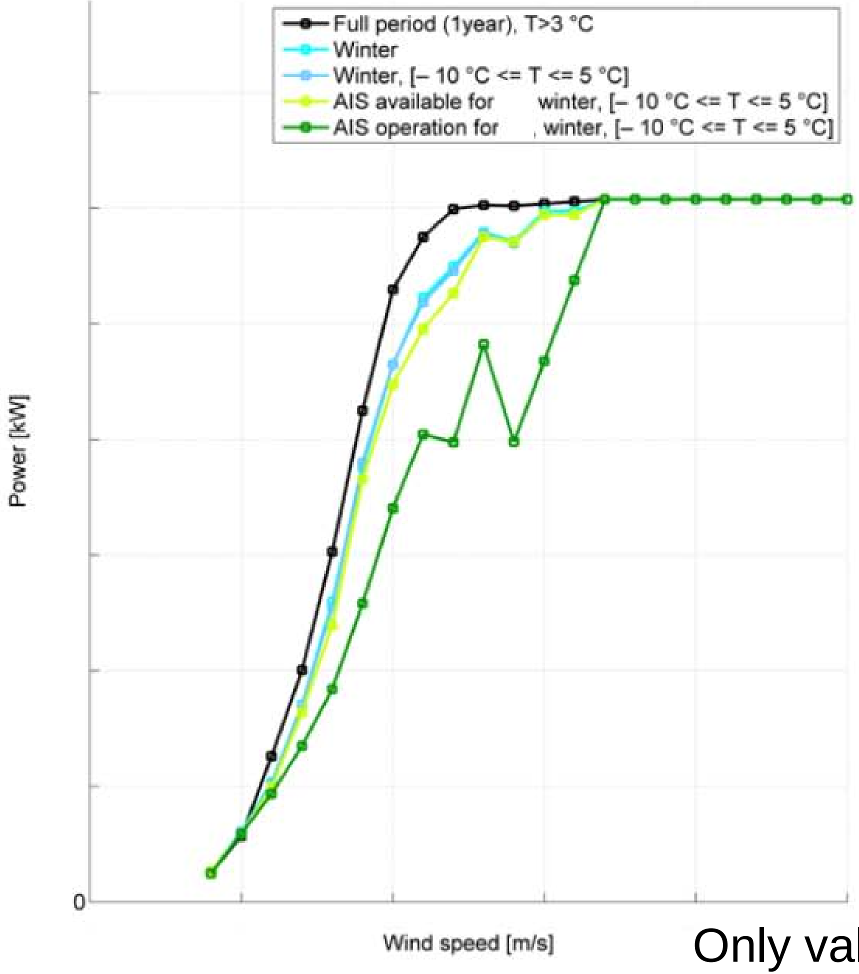


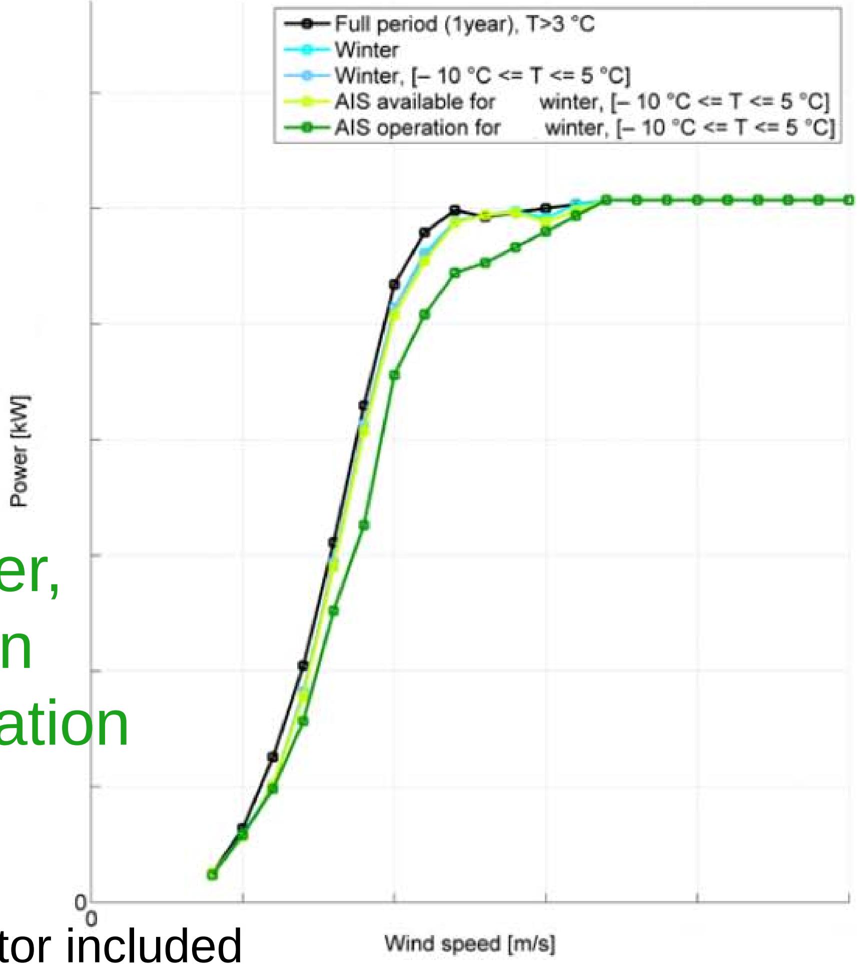
Only valid sector included

Turbine A without AIS

Derived Power Curves

Turbine B with AIS





Winter, AIS in operation on B

Only valid sector included

Results

	Production loss due to icing (one winter)	Annual loss	Long-term corrected annual loss
Without AIS	19 %	10 %	**8 %**
With AIS	7 %	4 %	**3 %**

- Derived power curves not strictly following IEC 61400-12-1 (require met mast, from 40 m height)
- Results valuable nevertheless

Conclusions

- LIDAR is well suited for power curve measurements
  - Also in cold climate
  - Data availability good
  - Avoid implications of nacelle anemometers

- Site challenges can be mitigated
  - Complex terrain -> Numerical site calibration

- Valuable results even without strictly following IEC 61400-12-1

martin.gronsleth@vindteknikk.no
www.vindteknikk.no

20 YEARS
ANNIVERSARY
1998 - 2018

LEOSPHERE