Balkan Wind Energy Conference

REQUIREMENTS FOR A SUCCESSFUL WIND RESOURCE INVESTIGATION IN THE BALKAN REGION

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Energiewerkstatt

Wind Energy

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CONSULTING ENGINEERS & ASSOCIATION FOR RENEWABLE ENERGY

- Project Development
- Wind Measurement
- Planning & Implementation
- Research & Demonstration

ENERGIEWERKSTATT more than 28 years EXPERIENCE

FP6 PROJECT SEEWIND

R&D Project Objectives:

- To test innovative measurement and simulation techniques for complex terrain (SODAR/LIDAR)
- More knowledge about wind potential in SE-Europe
- To standardize and harmonize building codes for wind turbines in SEE
- To gain knowledge in constructing and operating wind turbines at sites with complex terrain and specific local wind conditions
- **Multi-MW wind turbines at three different sites in Croatia, Bosnia-Herzegovina and Serbia**
- To provide an impulse to wind energy exploitation

Financing:

- Funds from European Commission € 3.7 Mio.

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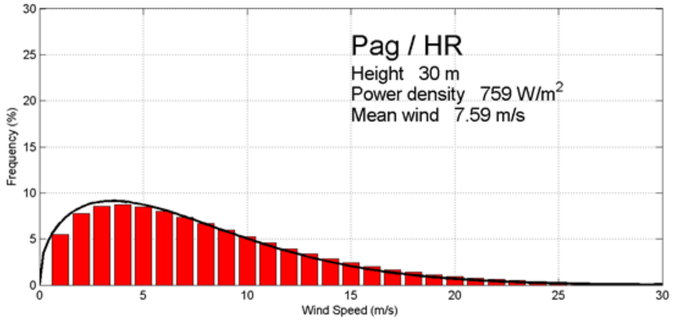
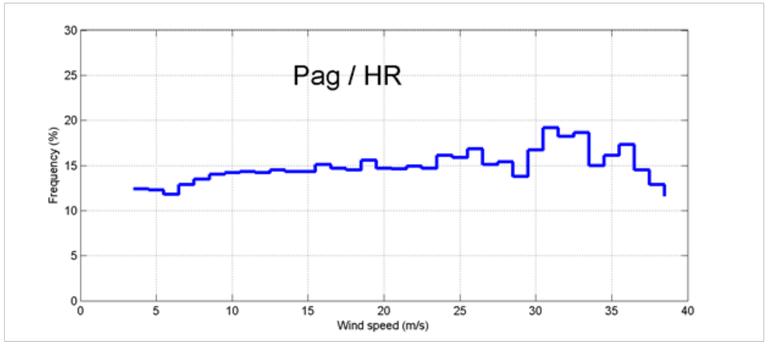
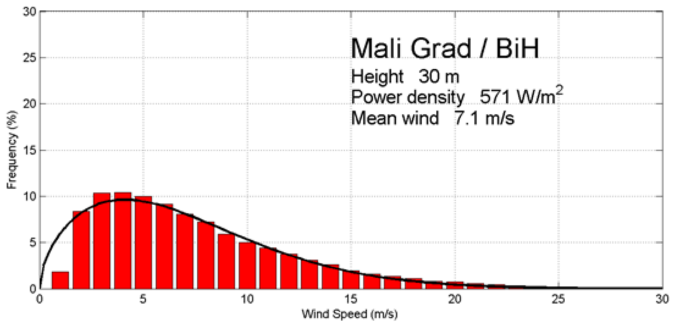
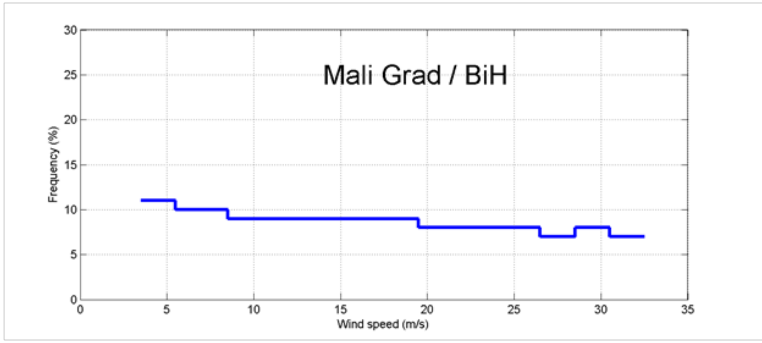
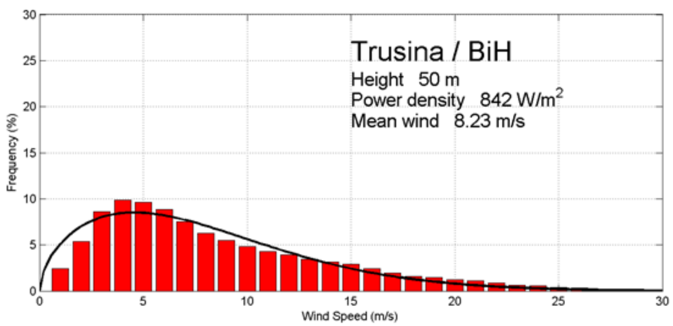
Wind Resources

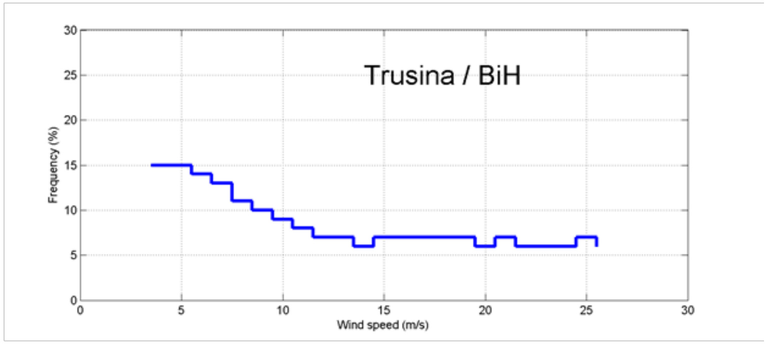












Wind Resource Assessment

Vertical Extrapolation of the Measurement Data

Temporal Extrapolation (min. 10 years)

Horizontal Extrapolation

Representative Wind measurement (min 12 months)

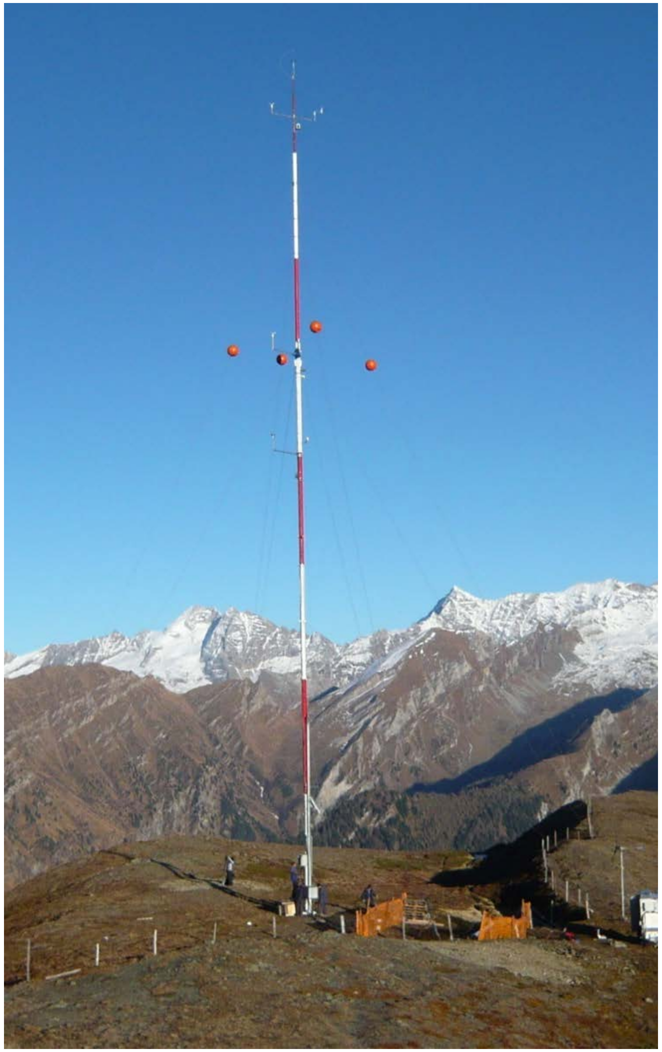
Wind Resource Assessment in the Balkan Region

01	**COMPLEX TERRAIN**
02	THERMAL STRATIFICATION
03	ICING
04	CASE STUDY

Complex Terrain

CHALLENGES:

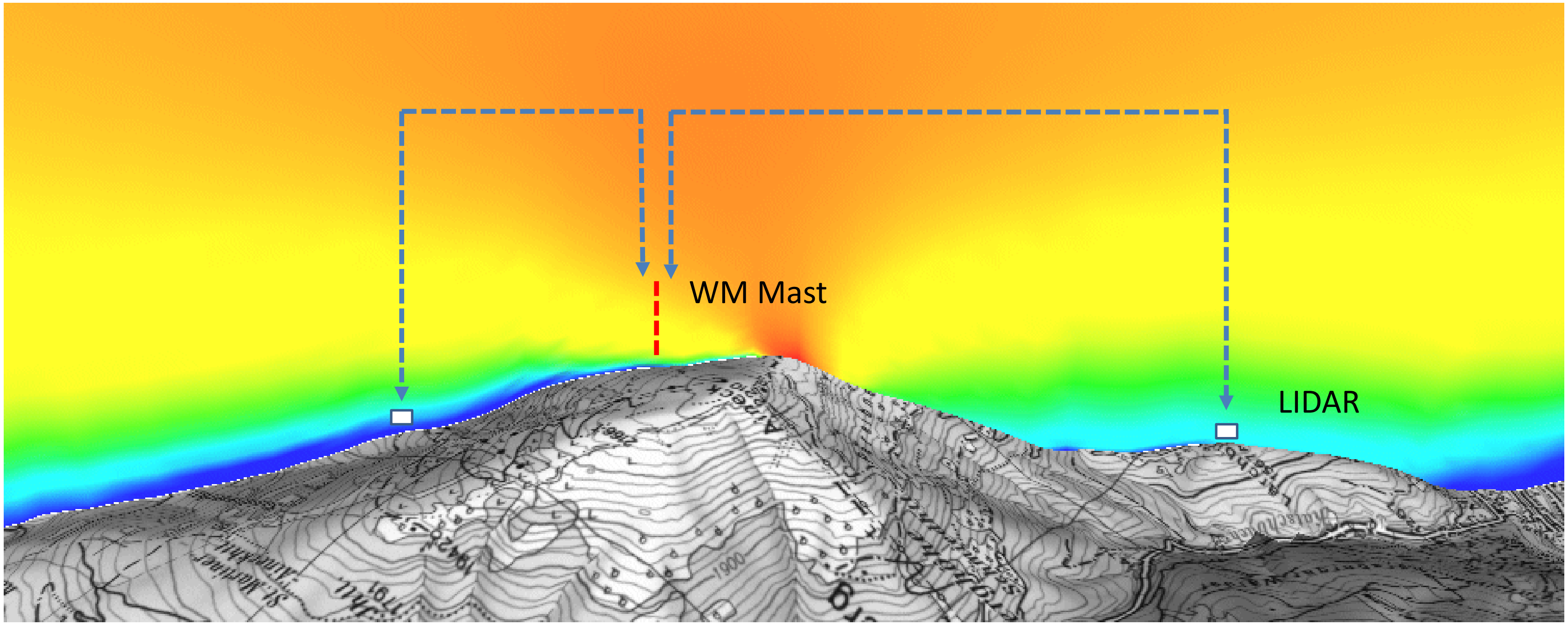
- Flow inclination [IEC 61400: < ± 8°]
- Wind Shear [IEC 61400: 0<α<0,2]
- Horizontal extrapolation of measured wind data
- Accuracy of CFD simulations
- Accuracy of SODAR / LIDAR measurements in complex terrain
  - Relative Deviation from results of cup measurements



Complex Terrain

CFD simulations:

- With one measurement - Accuracy of simulation results limited
- Validation of the modelled vertical wind profiles using additional LIDAR measurement campaigns



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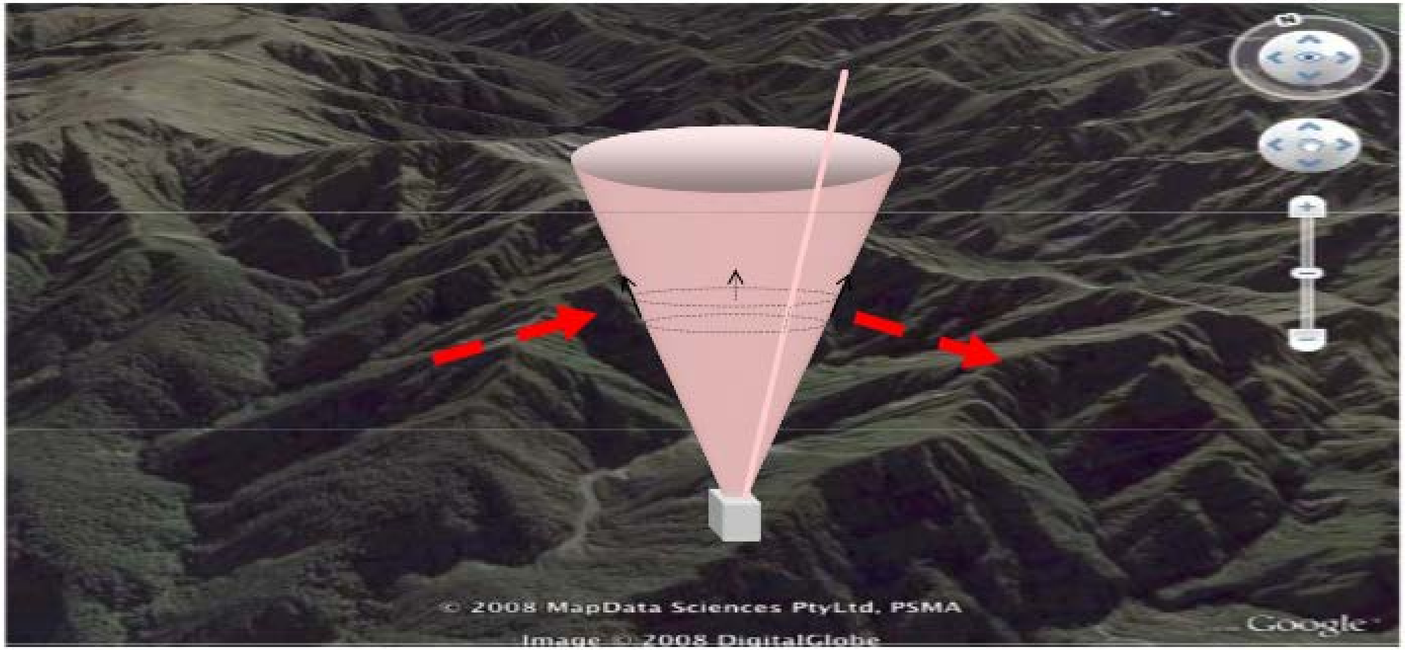
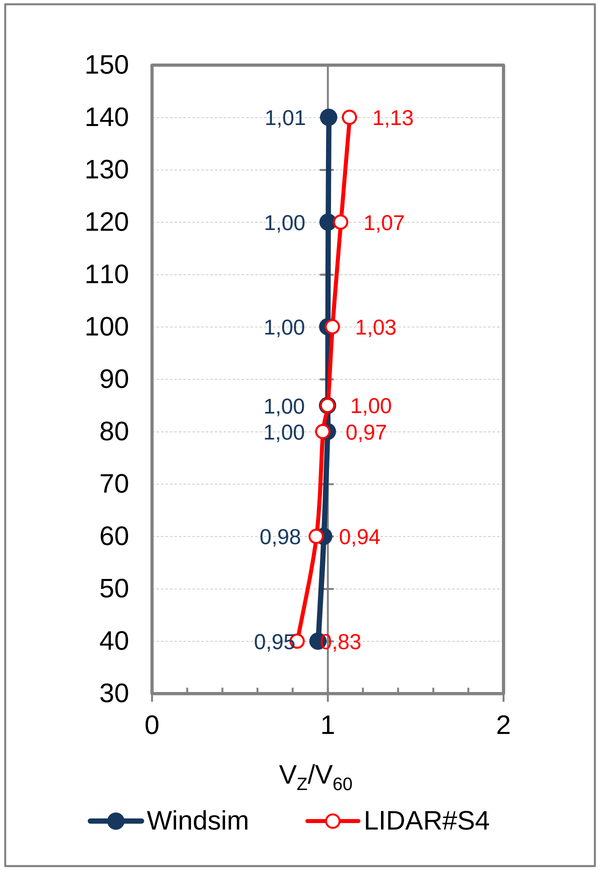
Complex Terrain

Drawbacks of LIDAR measurements in complex terrain:

- The assumption is that the flow at any height is uniform
- This is almost never true in complex terrain



Complex Terrain



Comparison of modelled and measured vertical wind profile

SOLUTIONS / MEASURES:

- Wind measurements in different heights using 3D ultrasonics
- Correction Tools for LIDAR measurement results in complex terrain
  - CFD Implemented correction
  - LIDAR-device implemented optimisation (e.g. FCR – Flow Complexity Recognition)

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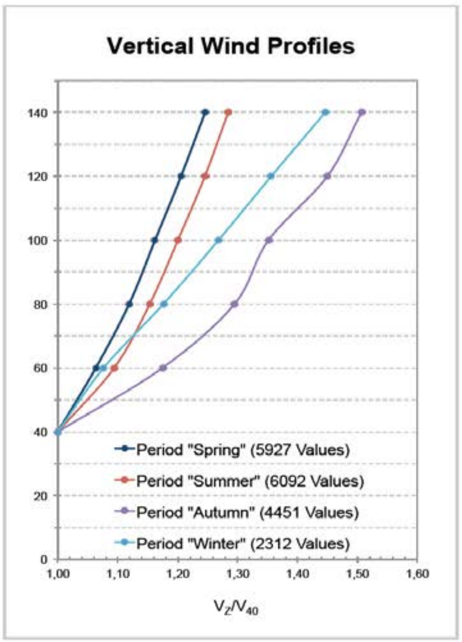
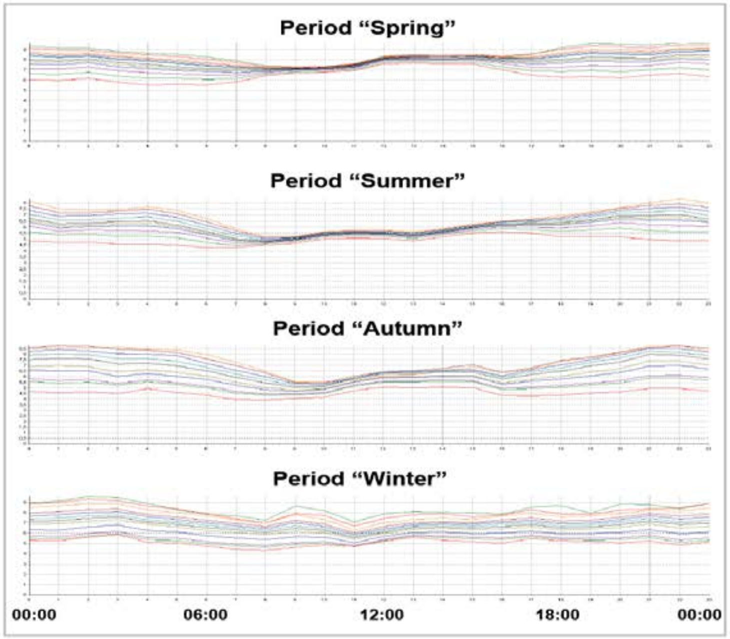
Wind Resource Assessment in the Balkan Region

Thermal stratification

Challenges:

- Economic decision regarding optimum hub height
- Diurnal and seasonal variations in the vertical wind profile due to temperature influence
- Logarithmic wind profile not always appropriate (i.e. for stable conditions)

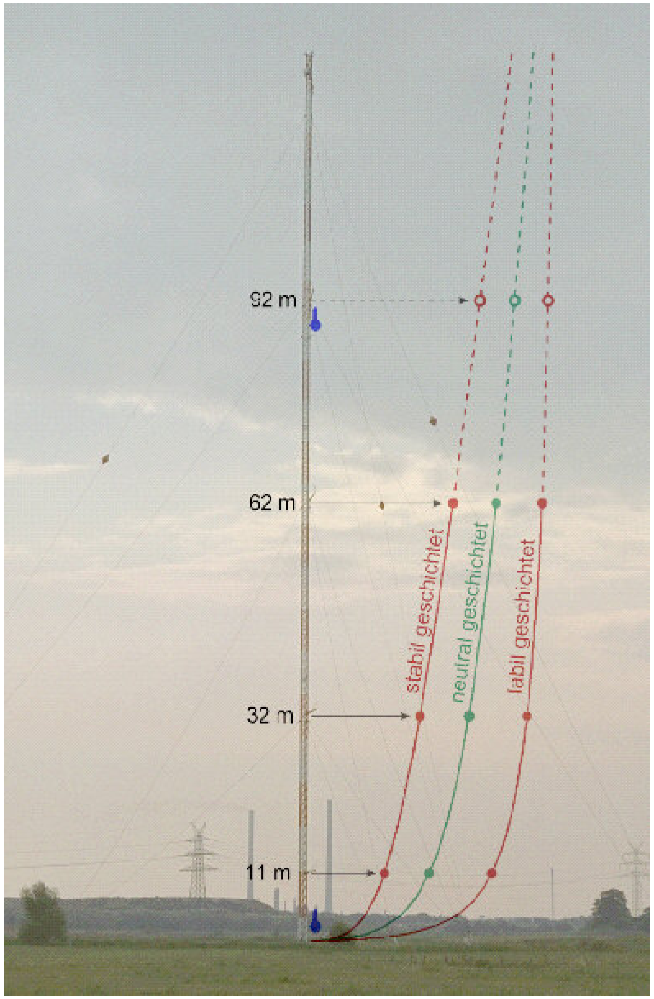




Thermal stratification

Solutions / Measures

- Wind <u>and temperature</u> measurements in different heights
- SODAR / LIDAR short-term measurement campaigns for the evaluation of the different stratification conditions
- Temporal weighting of the stratification conditions by balancing the LIDAR profiles with the measured temperature stratification (Monin–Obukhov length)

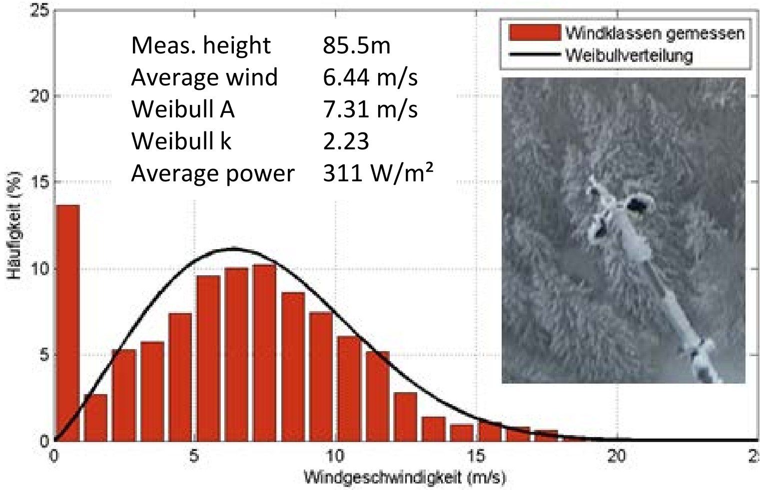


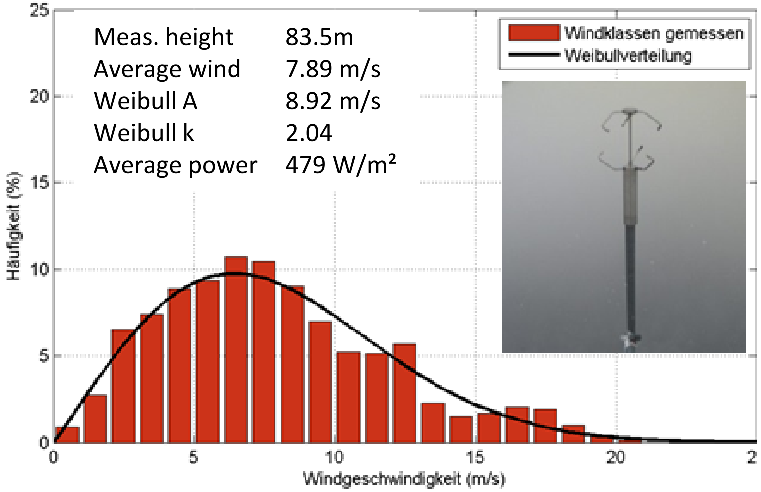
Wind Resource Assessment in the Balkan Region

01	COMPLEX TERRAIN
02	THERMAL STRATIFICATION
03	**ICING**
04	CASE STUDY

Icing

Especially at higher altitudes → Utilisation of heated anemometers!





Meteorological Icing

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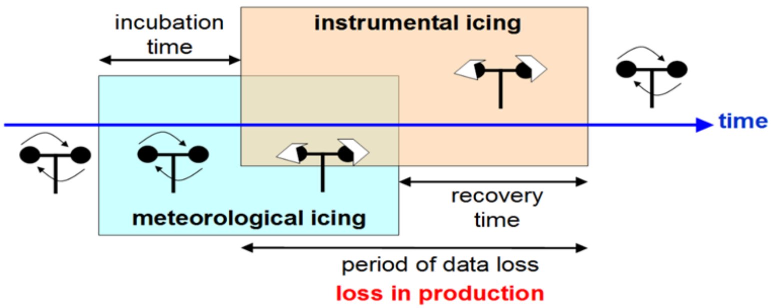
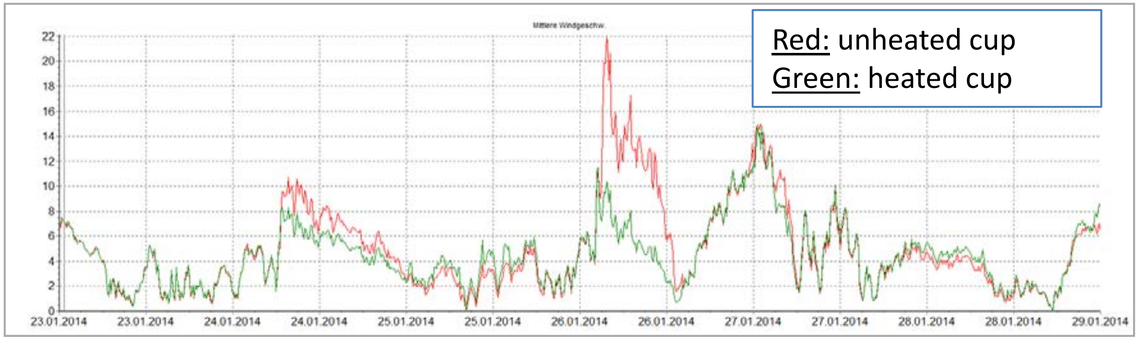
Instrumental Icing

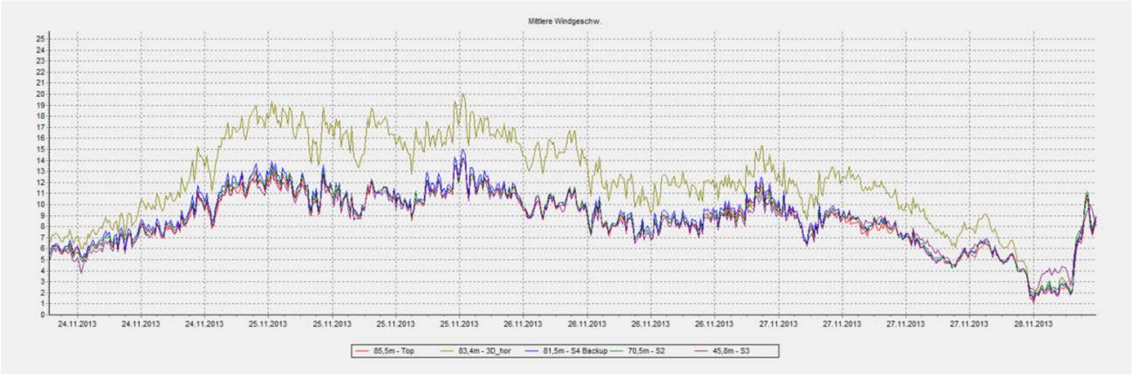


Icing

Data availability and data quality



Careful selection of appropriate sensors!



Often no clear picture about the actual situation:

→ Utilisation of webcams

Icing

External Power Supply

- Site-specific adoptable design of used Hardware components: Wind generator, PV-modules, Fuel-cell, battery backup, webcam
- EMS-board for perfect interplay of components, intelligent sensor heating, data monitoring and remote control
- Reduced O&M costs for remote locations (no maintenance trips, no refueling…)
- Several test cases:
  - 100% technical system availability
  - 100% filtered data availability (no data losses)

Icing

Solutions / measures

- Appropriate masts
- Heated anemometers
- Careful data filtering → data quality
- Reliable Power supply for heated sensors
- Assessment of energy losses due to icing
- Ice detection and blade heating systems
- Assessment of risk (Ice-fall, ice-throw)

Wind Resource Assessment in the Balkan Region

Case Study

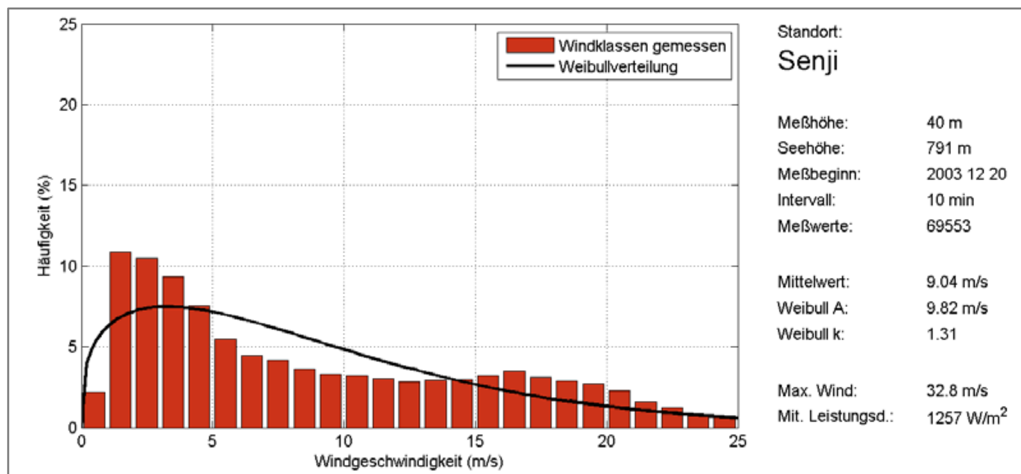
Case Study - WIND FARM SENJ / HR

Project:

Wind turbines	14 x Vestas V90
Nominal power	3.000 kW
Total power	42 MW
Hub height	90 m

Long-term wind climate (40 m)

Average wind	8,4 m/s
Power density	1.020 W/m²
Predominant wind	ENE (Bora)

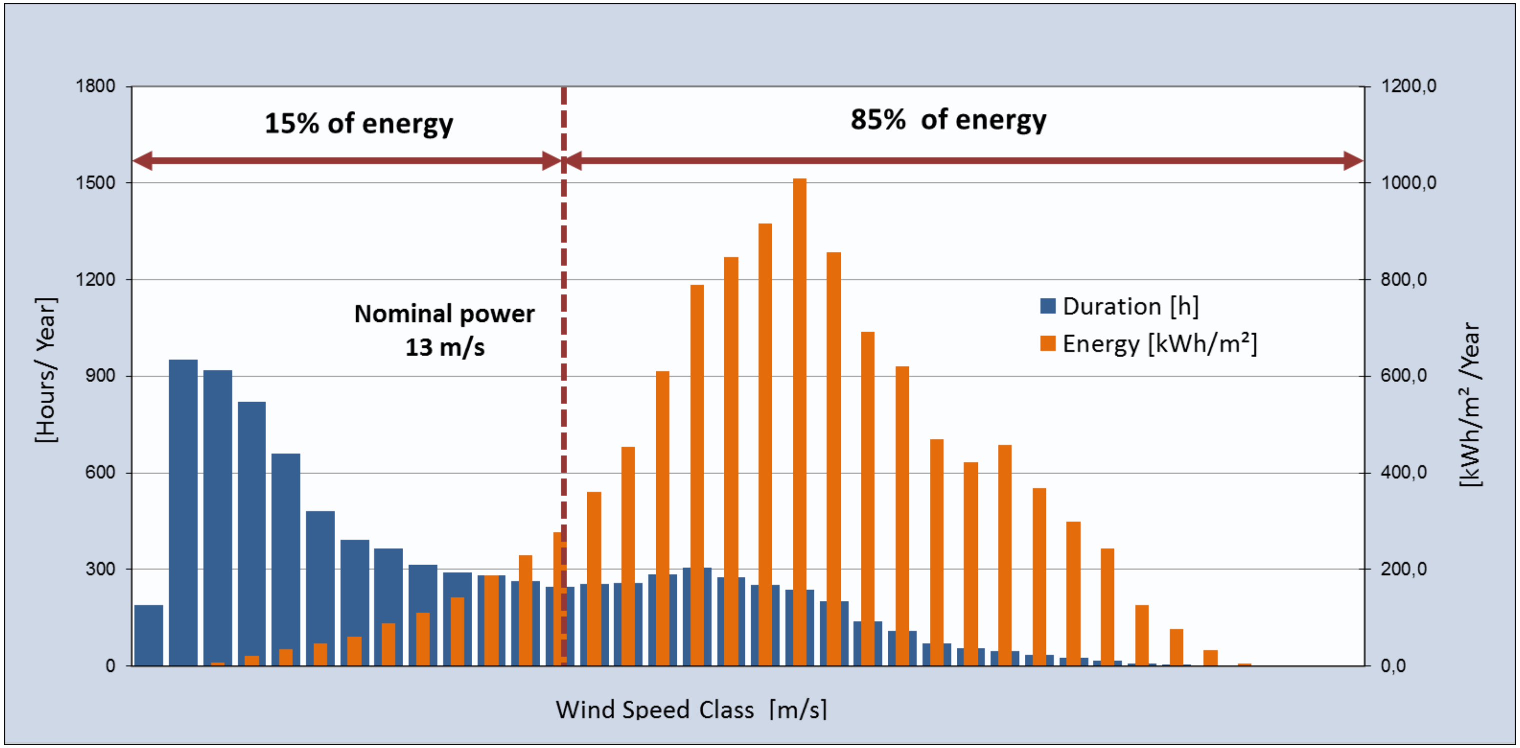


Case Study

Specific site characteristics

Coastal site in Germany: 40% of energy above 13 m/s

Wind farm Senj: 85% of energy provided above 13 m/s



Case Study

WIND FARM SENJ

Calculated Energy Yield	Gross value	AEP reduced by 10% technical losses
Calculated AEP	149,1 GWh	134,2 GWh
Calculated (AEP P75)	132,5 GWh	119,3 GWh

Start of operation: March 2010

	Availability	Production	Difference to calculation (P50)
Production 2012	69.9%	85.2 GWh	- 36.5%
Production 2013	94.5%	108.3 GWh*	- 19.3%

*) Improvement 2013 because of a „Bora-warning system“

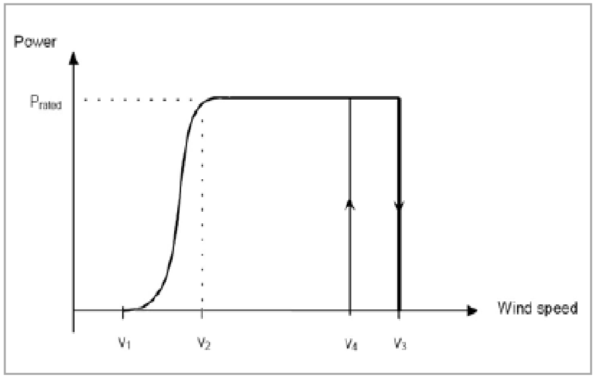
Case Study

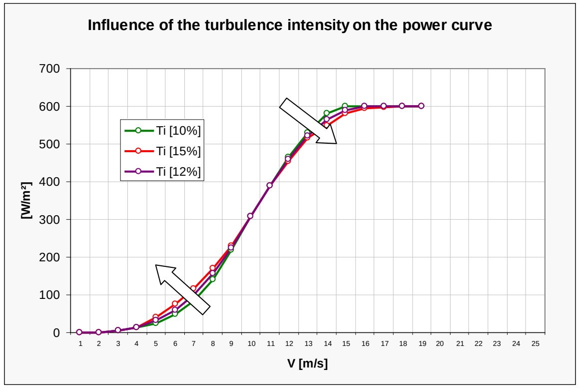
Up to 30% „missing energy“

Overprediction? ⟺ Underperformance?

Reasons for the deviation:

- Wind measurement and assessment of Gross Annual Energy Production have been correct
- Underestimation of Hysteresis effect: The cut-off settings of a standard WT lead to high energy losses
- Deviation is caused by a wrong appraisal of the technical losses (10% are not enough)





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Thanks for your Attention.