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SEEWIND – WIND ENERGY RESEARCH FROM BORA TO KOSHAVA

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Summary

The FP6 Research and Demonstration Project *"SEEWIND - South-east European Wind Energy Exploitation"* was launched in May 2007. The project's main objectives are the construction of the first multi-MW wind turbines in Bosnia, Croatia and Serbia, and the examination of the operational experience gathered under the respective conditions at the various locations. Wind farm sites in SEE and especially in the area of the Balkans provide excellent conditions for wind energy utilisation, but also pose a major challenge to wind turbine technology due to extreme wind speeds, turbulences and wind shear. In most cases those local wind systems are generated by different levels in temperature and air pressure between separate areas. To get more background information for operating wind turbines under these conditions the "fingerprints" of the most dominating local wind systems will be assessed. Additionally, innovative technologies for measuring wind streams above complex terrain like SODAR and LIDAR and computer programs for micro-scale simulation of wind flow will be applied and examined. After construction of the pilot wind turbines the operational data will be evaluated and at two project sites power curve measurements will be carried out.

SEEWIND
South-East European
Wind Energy Exploitation

1. INTRODUCTION

The regions of former Yugoslavia (Slovenia, Croatia, Serbia, Montenegro, Bosnia/Herzegovina and Macedonia) and their local wind systems such as the "Bora" or the "Koshava" offer excellent possibilities for the use of wind power. In spite of the high wind potential, the rocky and complex nature of the terrain and extreme wind conditions pose enormous challenges for site assessment and operation of wind turbines.

2. THE PROJECT

The R&D project SEEWIND is coordinated by Energiewerkstatt and has a duration of 3 years. Start date was May 2007.

The consortium of the project consists of 10 members from 6 different countries:

- Energiewerkstatt, Austria
- German Wind Energy Institute, Germany
- Offshore and Certification Centre, Germany
- Meteotest, Switzerland
- Meteo BiH Sarajevo, Bosnia Herzegovina (BiH)
- University of Mostar – Mechanical Faculty, BiH
- University of Belgrade – Institute for Multidisciplinary Research, Serbia
- Adria Wind Power d.o.o., Croatia
- Vjetroenergetika d.o.o., BiH
- Masurica d.o.o., Serbia

Objectives of the project

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

Financing

- Total budget: € 9.6 Mio.
- Cost share of wind turbine operators: € 5.3 Mio.
- Funds from European Commission: € 3.7 Mio.
- Source of funds:

6th Framework Program

3. PILOT SITES

The pilot sites for the demonstration activities are located in three different countries on the Balkans. Each location is characterised by a rather complex orography and specific local wind conditions.

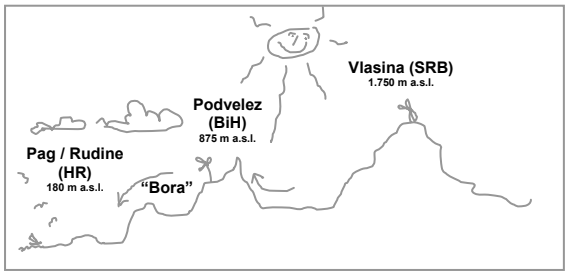


Fig.1: Pilot sites in landscape profile

The first wind farm site **Podvelez** is located on a mountain plateau 700 m above the city of Mostar in Bosnia Herzegovina.

The second site **Rudine** is located 20 km north to the City of Dubrovnik in Croatia on a karst ridge appr. 2 km away from the Adriatic Sea Coast. Both sites Mostar and Rudine are affected by strong Bora winds. Originally this second pilot site was planned on the island of Pag, where the first wind farm of Croatia is operating since 2004. After assessment of the wind data it was decided to change the site, because the results of the calculation have shown, that the requirements of the IEC turbine class IA were exceeded. Therefore it was not possible to find a turbine manufacturer who was willing to deliver a Multi MW turbine to the island of Pag.

The third site is located on the northern foothills of the Balkan Mountains in Serbia, closed to the border to Bulgaria. The site **Vlasina** has a sea level of 1.750 m and, besides of the strong and turbulent wind conditions, also heavy icing has to be expected there.

Fig.2: Pilot sites located on the peninsula of the Balkans

4. RESEARCH WORK

The R&D work is carried out in different work packages (WP):

WP03 "*Wind measurements at the pilot sites"* is going on since the start of project. A 3-years long term measurement campaign at each of the pilot sites and also detailed measurements for the investigation of local characteristics like turbulences and vertical inflow over complex terrain are carried out.

Fig.3: Wind measurement at Vlasina site (SRB)

WP04 "*Vertical wind profile"* is aimed to gain more knowledge for energy yield assessments in complex terrain. Therefore measurement campaigns with SODAR and LIDAR have been carried out during the Bora season of winter 2007/08. First results are encouraging and show the necessity of such instruments for wind assessment in these areas.

Fig.4: SODAR and LIDAR campaign at Podvelez site (BiH)

WP05 *"Local wind systems"* is one of the main parts of the project because the area of the former Yugoslav states shows a number of different wind systems with specific local characteristics. It is foreseen to investigate the basics of these local winds by meteorological research and analysis of wind measurement data.

WP06 *"Meso-scale simulations"* is aimed to gain more basics for reliable reanalysis of long term wind conditions in SEE and small scale wind forecasts in the complex and turbulent environment. State of the art weather models such as MM5 and WRF are evaluated in this work package.

WP07 *"Micro-scale simulations"* is focused on the use of CFD-models for the calculation of turbine loads and energy yields which are required by the complexity of the terrain and the presence of strong turbulences and extreme winds at the pilot sites. Two approaches will be tested and compared against each other in order to gain more experience in this field.

WP08 *"Site development"* is aimed to optimize the wind farm layouts at the pilot sites and to elaborate site specific conditions for assessing the requirements to the turbine technology.

WP09 *"Certifications & standards"* is based on the knowledge which was gained about the specific wind conditions and will be resumed in a "Site Specific Certification" for each site. The building codes and related standards for wind turbine construction in Western Balkan countries will be evaluated and compared with European standards.

WP10 *"Construction of pilot wind turbines"* - In this work package the construction work for the turbines and infrastructure at the pilot sites will be assisted.

WP11 *"Evaluation of operational data"* is focused on recording and analyzing the operational experience in terms of the prevailing climatic conditions at the sites.

WP 12 *"Power curve measurement"*- At two project sites power curve measurements will be carried out in close cooperation with the turbine manufacturers with the aim of testing the suitability of the wind turbines under the specific conditions.

5. LOCAL WIND SYSTEMS

Wind farm sites in SEE and especially in the area of the Balkans provide excellent conditions for wind energy utilisation, but also pose a major challenge to wind turbine technology due to extreme wind speeds, turbulences and wind shear. In contrast to wind systems in northern and western parts of Europe, these wind conditions are mainly "home made". In most cases the local wind systems at the Balkans are generated by different levels in temperature and air pressure between sea and mainland or between mountains and valleys.

To get more basics for operating wind turbines under these conditions the "Fingerprints" of the most dominating local winds will be assessed:

Bora (Bura): A cold, very strong and gusty downwind between the Dinaric/Balkan Mountains and the Adriatic Sea

Jugo (Scirocco): A warm and dry wind which comes from southeast (Sahara) along the Adriatic coast.

Koshava: Wind from south-east between the Carpathian and the Balkan mountains.

Vardarac: A cold downwind from the Balkan mountains to the valleys of Macedonia (Vardar) and the Aegean Sea.

Gornjac: Wind from north-west which comes along the Danube river.

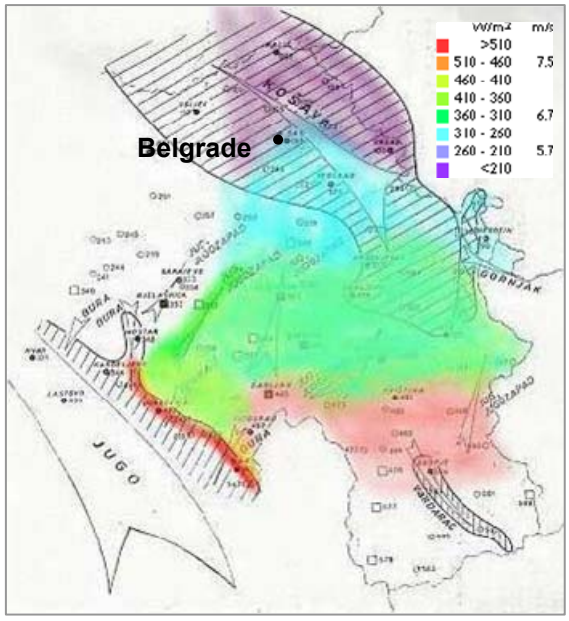


Fig.5: Map of wind resources in Serbia and Montenegro [1]

6. REQUIREMENTS TO TURBINE TECHNOLOGY

The state of the art turbine technology is designed for the demands at typical sites in Europe. These turbines are not at all suitable for the wind conditions in SEE because the characteristics of Bora, Koshava or Vardarac show "unusual" frequency distributions. Long periods with low speeds are followed by periods with strong and turbulent winds. Those specific characteristics show moderate average wind speeds (about 7 m/s) but high specific power (up to 800 W/m²). At a typical site in Germany, 60% of energy is available at wind speeds below nominal speed of the turbine (14 m/s) and only 40% above. On the other hand most of the sites on the Balkans show a characteristic distribution of 25-30% below and 70-75% above nominal speed of the turbine (see figures 7 - 10).

Figure 7: Typical coastal site in Germany

Sea level	120 m
Vav (65 m)	7.4 m/s
Specific Power at 65 m	480 W/m²

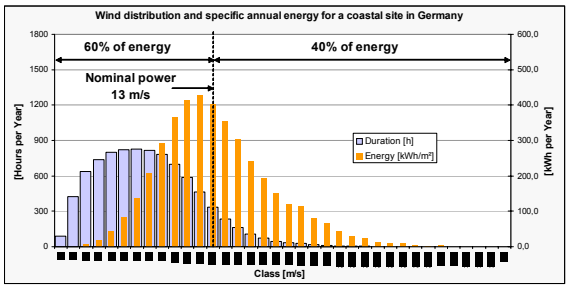


Figure 8: Föhn / Austria

Sea level	920 m
Vav (30 m)	6.18 m/s
Specific Power at 30 m	470 W/m²

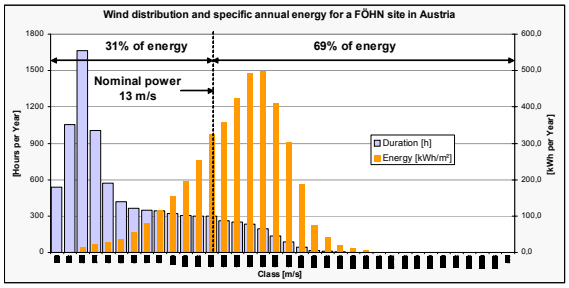


Figure 9: Bora / Croatia

Sea level	60 m
Vav (50 m)	7.23 m/s
Specific Power at 50 m	780 W/m²

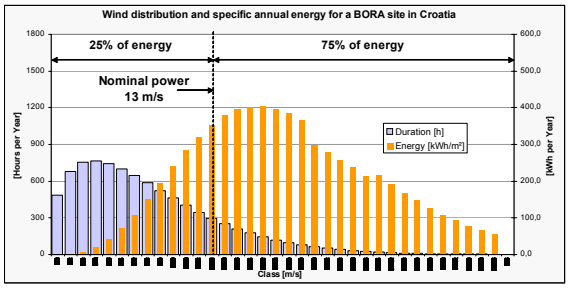
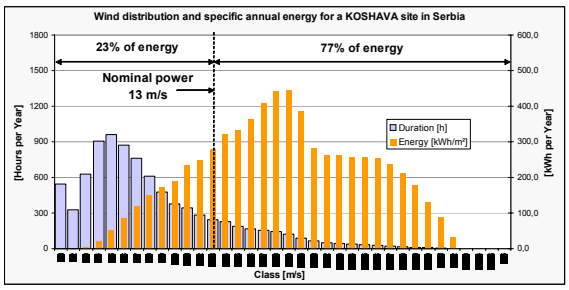


Figure 10: Koshava / Serbia

Sea level	533 m
Vav (35 m)	7.25 m/s
Specific Power at 35 m	760 W/m²



Following the above mentioned criteria it can be concluded, that turbine technology has to focus on harvesting maximum energy at higher wind speeds.

This means that turbine manufacturers have to consider the following requirements:

- Specific installed power
- Cut out speed
- Cut out hysteresis
- Influence of turbulence intensity on the power

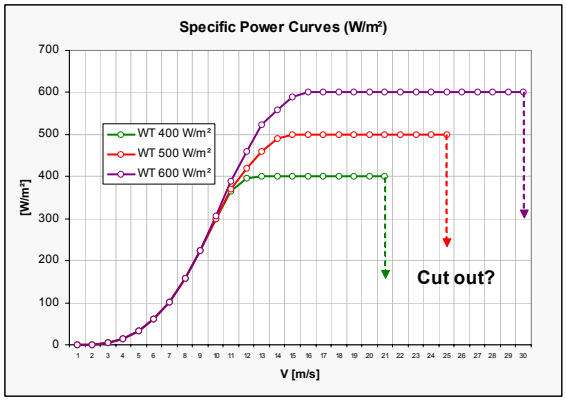


Fig.11: Specific installed power (W/m³)

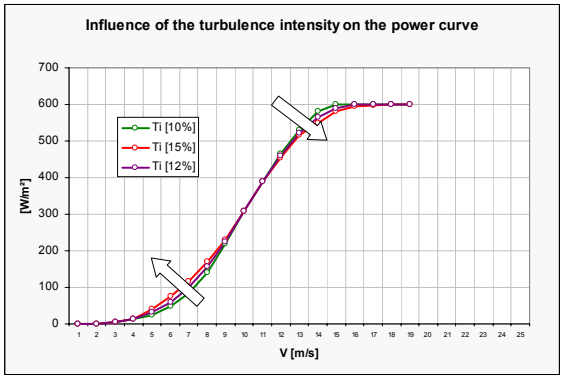


Fig.12: Influence of turbulences on the power curve [2]

7. REFERENCES

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Web: www.seewind.org