VLASINA WIND PROJECT – RESULTS AND PERSPECTIVES

by

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This paper describes activities and main results of investigation for the Vlasina Wind Project, implemented within National Energy Efficiency Program, segment that deals with alternative and renewable energy sources. The main objective of the project was investigation of possibilities of wind energy generation in mountain areas of the Republic of Serbia. Problems of choice of location, measurement of wind energy potential, choice of type and unit size of wind turbine generators, as well as the interconnection of wind turbine generators and wind power plants to power system are considered.

Key words: *wind energy, wind farm, wind turbine generator, energy efficiency*

Introduction

In recent years, using of wind as renewable source of energy is undergoing rapid development. Wind as "the fuel" is very attractive, especially in areas where the transmission infrastructure is not fully developed for several reasons:

- "the fuel" there is no cost,
- there is no need to purchase, transport, and store expensive fuels,
- its use is flexible, both for households and industries, and
- it belongs to the class of "clear technologies" – it does not produce any harmful emissions in the process of electricity generation, unlike other technologies, based on fossil fuels.

As per information presented by EWEA (European Wind Energy Association), fig. 1 [1], by the end of 2005, total installed capacity of wind turbine generators (WTGs) in Europe was 40,800 MW with participation of Germany 45.5%, Spain 24.7%, Denmark 7.7%, and other countries 22.1%. On the world level, as per IEA (International Energy Agency) forecast [2, 3] until the year 2020, an installed capacity of 1,245 MW is expected to be achieved, with the annual production capable of matching 12% of total world's demand for electricity.

Based on world experience, Ministry of Science and Environmental Protection of Serbia paid special attention to alternative and renewable energy sources within the National Energy Efficiency Program (NEEP). This paper presents some of the results related to use of wind energy facilities for regional electricity supply within mountain areas of Serbia, on example of Vlasina region.

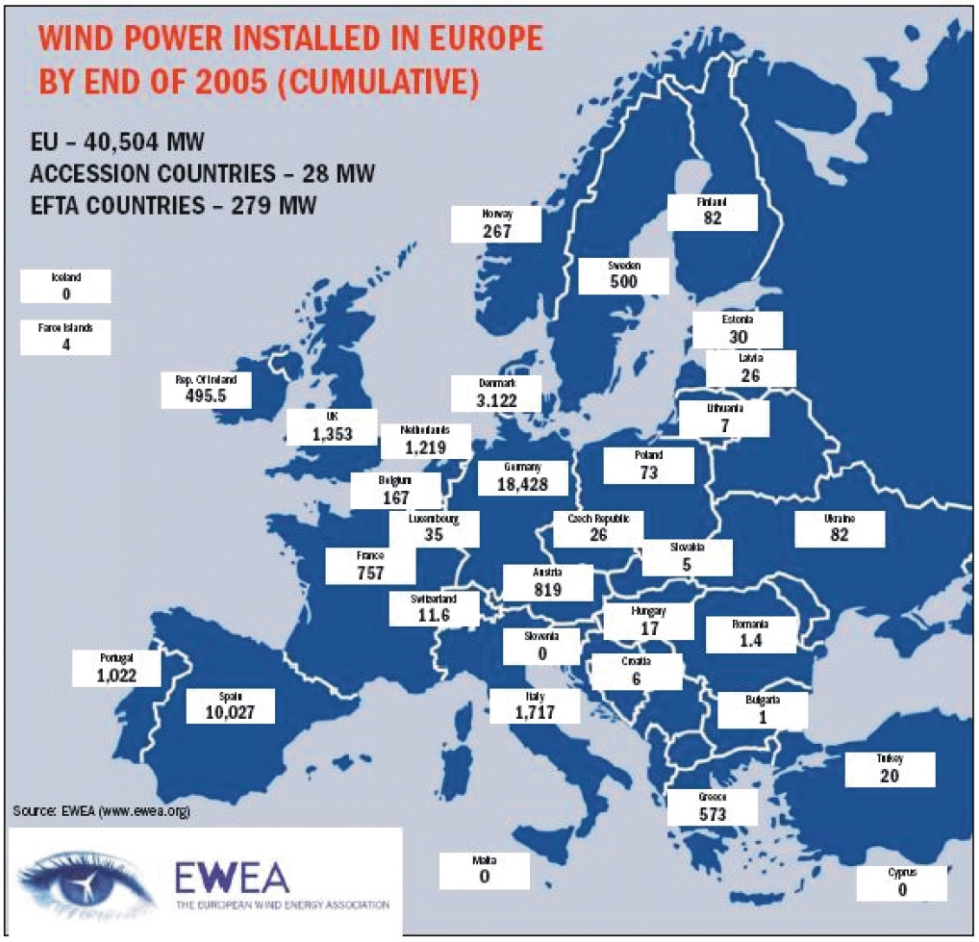


Figure 1. Wind power installed in Europe by end of 2005

Vlasina wind project – general information

Wind power plants that have been implemented so far, both in Europe and the rest of the World, are predominantly located in flat regions or off shore, 1-12 km from the sea coast. Since the territory of the Republic of Serbia is predominantly hilly, the focus of our interest was oriented to possibilities of wind use in mountain areas. For these reasons, the Vlasina wind project has been initiated, with the purpose, as follows:

– to evaluate energy and economic feasibility of wind energy use for the electrical energy production in mountain areas of Serbia,

– to demonstrate the use of wind as the renewable energy source for the electrical energy production in region of Vlasina, and
– to analyze effects and experiences for future wind energy projects within the country.

As per the NEEP rules, the participants on the project were Scientific Research and Development Centre (NIRC) of Energoprojekt Company (as research organization), EPE ENTEL, EPE Architecture and Urban Planning, as well as Energovlasina Surdulica (as users of the research results), and CLEPS AB Tingstäde, Sweden (as the partner for project implementation).

Following activities are planned within the Vlasina wind project:
– choice of the wind energy plant location,
– data collection (measurement) and analysis of wind energy potential in Vlasina region,
– choice of WTG concept – unit type and size, its connection to the electrical network and environmental impact assessment,
– design and technical specification preparation for equipment purchase and erection works,
– equipment delivery and erection works, and
– supervision of plant operation and effects evaluation.

Location choice

Vlasina region as the possible location of wind power plant was selected for several reasons:
– this area has perspective development plans to become tourist area based on Vlasina lake,
– in this area there is no any "dirty" industry as a source of pollution,
– the "Energovlasina Surdulica" is a local company established by Energoprojekt and local municipality, that enables the local support to project implementation,
– within the main planning document for this region [4] it is foreseen to build the wind energy production facilities, and
– water pumping station PAP Lisina located in this area enables to overwhelm "bursty" nature of wind – electrical energy produced by wind is possible to be used for pump supply and transport of the water to Vlasina storage lake, to be used in existing hydropower system "Vlasina", when it is necessary from the aspect of optimum system operation.

Wind potential assessment

Preparing to wind measurements, we committed professional institution to carry out wind flow analysis of the area of interest. The subject of analysis was square territory 5 5 km, with center positioned at Golemi Vrh, fig. 2. Computational fluid dynamics

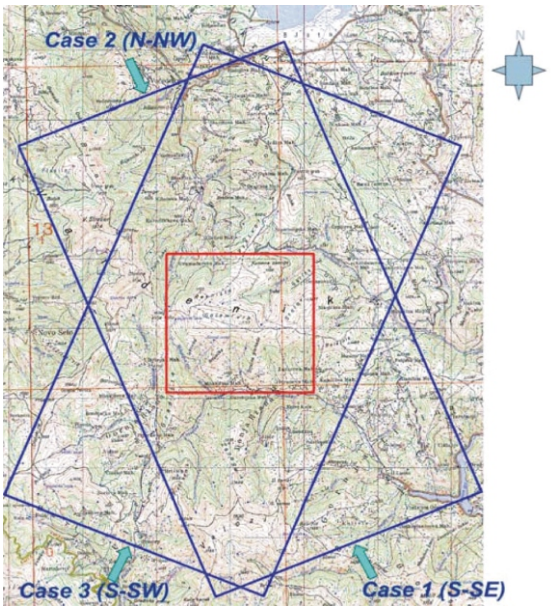


Figure 2. Computational assumptions – Analyzed area and computational volume: 3 cases (color image see on our web site)

(CFD) analyses were performed for three cases of wind direction (S-SE, N-NW, and S-SW), assuming that wind speed is 6 m/s. Results of analysis [5] covered vector flow field, streamlines, velocity distribution, velocity (fig. 3), and wind power potential at 50 m above ground and were used for choice of measuring masts locations. Two measuring masts were erected during December 2004 – the main 50 m mast at Golemi Vrh (1753 m a.s.l.) and another 30 m mast at Stolovi (1704 m a.s.l.) aimed to measure the wind speed and direction, humidity, and temperature. Measurements started in the middle of December 2004, and it was planned to be collected within the period at least 12 months, with intermediate check points after 3 and 6 months.

Figures 4 to 7 present part of the results that have been recorded so far [6].

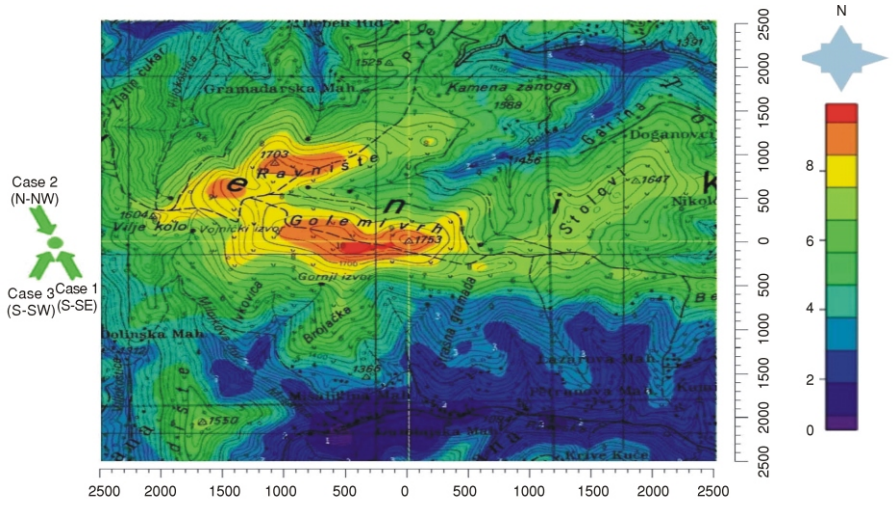
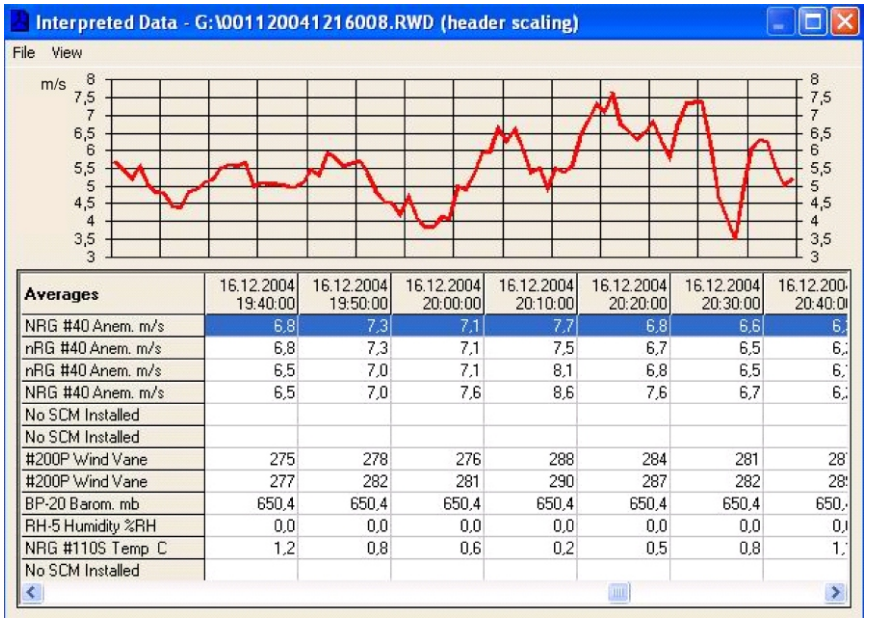


Figure 3. Average wind velocity at 50 m above the ground (color image see on our web site)



Averages	16.12.2004 19:40:00	16.12.2004 19:50:00	16.12.2004 20:00:00	16.12.2004 20:10:00	16.12.2004 20:20:00	16.12.2004 20:30:00	16.12.200 20:40:0
NRG #40 Anem. m/s	6,8	7,3	7,1	7,7	6,8	6,6	6,
nRG #40 Anem. m/s	6,8	7,3	7,1	7,5	6,7	6,5	6,
nRG #40 Anem. m/s	6,5	7,0	7,1	8,1	6,8	6,5	6,
NRG #40 Anem. m/s	6,5	7,0	7,6	8,6	7,6	6,7	6,
No SCM Installed							
No SCM Installed							
#200P Wind Vane	275	278	276	288	284	281	28
#200P Wind Vane	277	282	281	290	287	282	28
BP-20 Barom. mb	650,4	650,4	650,4	650,4	650,4	650,4	650,
RH-5 Humidity %RH	0,0	0,0	0,0	0,0	0,0	0,0	0,
NRG #110S Temp C	1,2	0,8	0,6	0,2	0,5	0,8	1,
No SCM Installed							

Figure 4. Location Golemi vrh – The first day recorded data

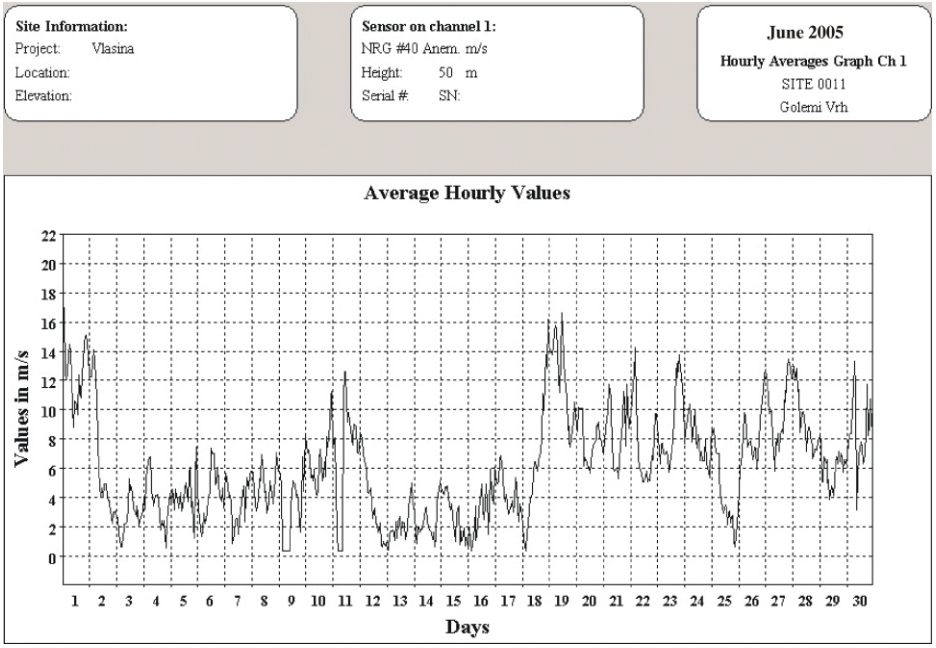


Figure 5. Location Golemi Vrh – Hourly averages, June 2005

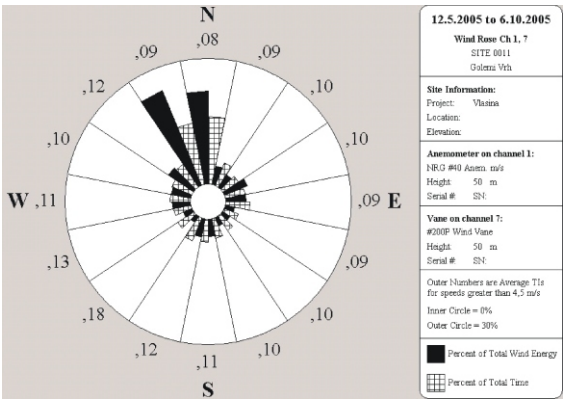


Figure 6. Location Golemi Vrh – Wind rose (Period May-October 2005)

Results that have been recorded so far show that the dominant wind direction is N-NW, with the average wind speed about 5.7 m/s and wind speed higher than 5 m/s within 55% of time.

WTG type and unit size choice

The selection of WTG type and unit size should always be a compromise between economic and technical issues. We analysed technical characteristics of the most significant world WTG suppliers, fig. 8 [7] and different solutions – a wind turbine with gearbox (with asynchronous generator), without gearbox (with synchronous generator) or a hybrid (gearbox with synchronous generator), dimensions, weight, unit size (from 850 kW to 2.3 MW), power control variants, *etc*.

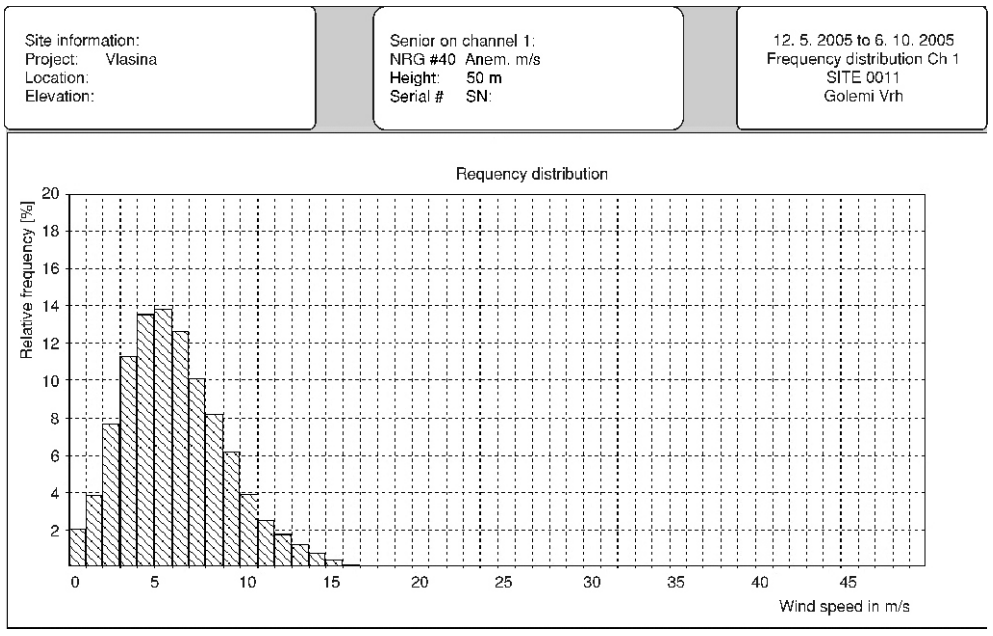


Figure 7. Location Golemi Vrh – Typical frequency distribution of recorded wind speeds (Period May-October 2005)

It was decided to apply WTG with variable speed asynchronous generator and horizontal axis, and unit size of 850-1500 kW. There are many reasons for this choice:

- we expect that problems with smaller unit are easier, and it is better to gain the initial experience for future projects,
- access roads for WTG transport to plant locations are now under the construction and size of particular unit is limited with transportation conditions,
- the choice of asynchronous generator is based on higher robustness and lower investment and operation costs comparing to synchronous one, and
- the nearby source of reactive supply from overexcited synchronous motors is available in water pumping plant PAP Lisina.

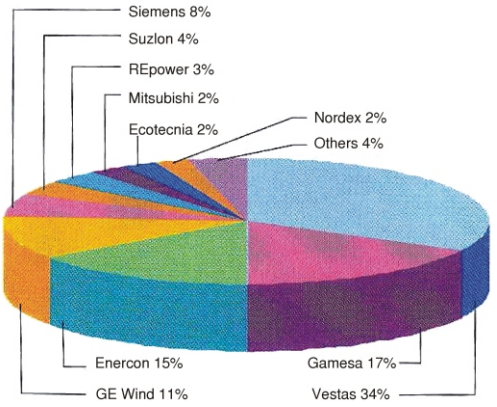


Figure 8. The world market share – Top 10 WTG suppliers (2004) (color image see on our web site)

Connection to electrical grid

This subject has two aspects, organizational and technical. Organizational view assumes that if you want to promote renewable energy sources it is necessary to have clear regulations and a permission process, which is not too complicated and doesn't take long time for approval. The energy law of Republic of Serbia [8] declared that renewable sources of energy production are privileged. It establishes frameworks for fulfilment of this condition. Also, it assumes bringing of some kind of PPA (Power Purchase Agreement) that defines price structure for sale of energy, obligation for network operator to purchase, points of metering, maintenance, grid availability, *etc*. Technical aspects cover technical conditions and regulations for connection of these generation plants to 50 Hz AC electrical network.

In this particular case, we proposed the direct connection of WTGs to 50 Hz electricity network, on distribution level of 10-35 kV by means of back-to-back solid-state converter/inverter system.

WTG environmental impact assessment

Preliminary environmental impact assessment for the Vlasina wind project covered several different aspects – visual, land use, pollution reduction, mortality of birds,

noise levels, *etc*. It was concluded that there are no any negative effects of the project to the environment within the region. Wind farm location foreseen at about 1750 m a.s.l. is far from urban areas that reduces impacts related to visual, land use, as well as noise level problems. As per our knowledge, there is no any special reason to expect bird mortality to be at a higher level than before – world experience shows that dominant cause of bird deaths are hunting, overhead power lines, traffic, cats, *etc*., with participation of WTGs, if exists, of only 0,1%.

Electricity price aspects

The establishing of wind power plants is an expensive investment project, but not more expensive than for other energy production plants. Depending on the way of calculation different figures could be obtained. If you take into account the cost of environment destruction, handling of disposals and extraction of raw material, wind power is the cheapest renewable alternative on the market today available, and among the cheapest overall. In this phase of the project, the main effort is concentrated to collecting data related to wind potential in the subject region. Activities related to assessment of economic effects have been just started, based on the preliminary results of wind potential measurements and possible plant generation. They will be the main subject of research in the future period.

Experience gained in other countries shows [6] that investment costs vary between 900 and 1150 € per installed kW (figures based on the year 2004), and these costs consist 75-80% of total energy costs. Operation and maintenance costs are on the level between 1.2-1.5 c€/kWh. Expected long-term cost reduction scenarios for wind power show that up to 2015, cost of energy produced from wind will be reduced to the current level of the cost of energy produced from conventional fossil fuel based sources.

Conclusions

This paper presents activities and results have been achieved so far related to Vlasina Wind Project as the first step of wind energy production technology use in Serbia. Based on the fact that wind potential measurement results are promising, some activities started with the aim to prepare the base for implementation of future wind farms for regional electricity production within the subject mountain region of Serbia [7].

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