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ENVIRONMENTAL FACTORS OF WIND ENERGY USAGE – NOISE EMISSION

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ABSTRACT
Getting electrical energy from the wind energy has been developed increasingly in over 10 last years. In late 2006, B&H is planned to get its first wind-energy capacities installed. With regard to this source of energy, noise emission has been often mentioned as one of the negative environment factors. This paper presents results of research of the authors on this topic.
Keywords: wind turbines, noise

1. INTRODUCTION
Generally, environmental situation on the Earth, as a result of fossil fuels usage, has reached a limit of intensive climate changes that threaten entire life on this Planet. Due to the need to sanitize these processes and necessity of increased energy capacities, through decisions by UN bodies, participant countries made commitment to environmental protection. Development of new technologies in the field of thermo-energetics and solar and wind energy usage is a quality response to the environment protection issue.
A rapid development of the equipment for electrical energy from the wind energy in EU countries caused intensive dynamics of investment in energy systems. Countries of Western Balkans joined these processes in the period 2000 – 2006. Increased research on the wind characteristics has been performed in Bosnia and Herzegovina and it already resulted in project documentation for wind farm systems in the areas of Livno, Tomislavgrad and Mostar, with capacities from 500 up to 600 GWh annually. With installed equipment of 188 MW and energy efficiency coefficient of about 30%, these capacities are very interesting for the existing and future investments. Preliminary results of the research and data bases from the Federal Meteorogical Institute of B&H show that possible capacities of the wind farms for commercial production of electric energy are from 1 200 up to 1 400 MW type and an annual production of 3,5 TWh annually. Since a part of the area is planned in the existing town-planning maps to be close to urban and tourist areas, analyses are needed on the influence of equipment usage on the environment. The existing standards of B&H in the field of environment protection, construction industry and town planning provide criteria for phases of both designing and exploitation of these energy systems. Noise effects, shading and disturbance of electrical-magnetic waves (GSM and RTV) have to be carefully observed by designers with regard to selection of localities and equipment type at concrete micro and macro localities of the wind farms, [1,2].

2. SOUND AND ENVIRONMENT
Depending on species, every living creature reacts differently to sound in their environment. In terms of sound characteristics, this influence can cause unwanted effects to fauna and humans that live in the areas of the noise emitters. Research on noise influence on humans is developed enough for

defining of environmental protection criteria through standard systems in designing of technical products. Influence of sound and its characteristics on a wide range of species is still to be researched and legally defined, for sake of life balance in environment. Sound affects humans through senses of hearing. Subjective sense of hearing helps a man to detect sound through the three of its features: tone pitch, timbre and intensity [3].
Tone pitch is directly connected with frequency (acoustic frequency specter).
Tone timbre is determined by tone oscillations character. Only rarely sound represents clearly harmony oscillations and is usually consisted of complex oscillations. Composition of such oscillations determines timbre.
Sound intensity is energy quantity transmitted by a sound wave in a unit of time through a unit-surface that is vertical to the direction of waves spreading.
Within the range of audibility (10^{-12} W/m^2 and f = 1 500 – 2 000 Hz) up to the pain level (1 W/m^2 and f = 10 - 2 10^4 Hz), by logarithm scale, sound influences human body in various ways.
Legislative system and technical standards in EU countries defined criteria on allowed vibrations and sound intensity for every type of equipment and working environment in which it is used (VDI 2056, ISO 2372, ISO 2373, BS4625, EN ISO/IEC 17025:2000). Application of these regulations is binding, for both equipment producers and wind farm system designers. Analysis of the equipment certification procedure and methodology of theory of calculation of equipment characteristics influence on noise effects prove that this process is implemented by empirical methods that don't cover all possible influences on noise characteristics for specific project situations (equipment, terrain, locality, environment atmosphere).

3. ANALYSIS OF THE EXISTING DESIGNING METHODS

The basic criterion for placing of wind farms is that sound intensity in the nearest residential building is under 45 dB for day and under 35 dB for night exploitation conditions.

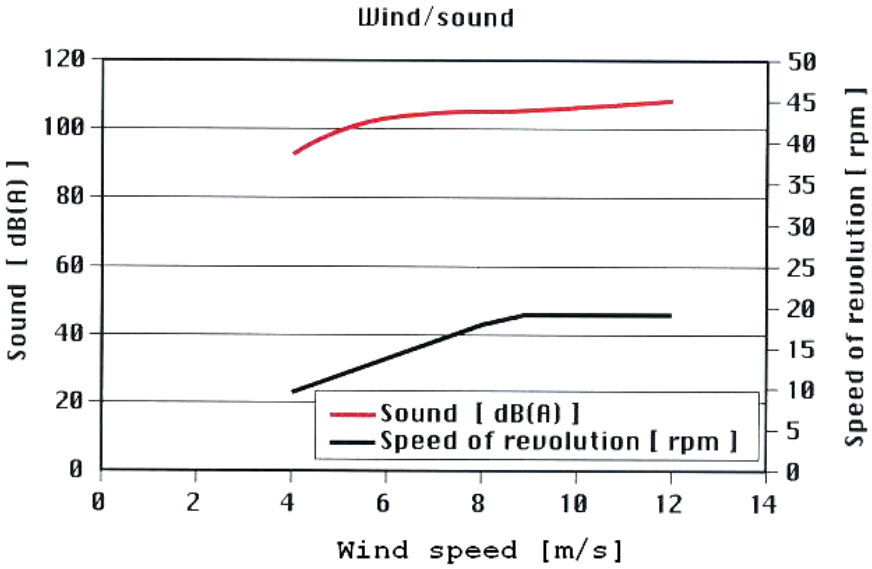

Figure 1. The relationship between wind and sound levels and speed revolutions for turbine V80-2.0

To decide on environmental influence, a designer uses producer certificate which presents sound intensity by the noise emitter for every type of the wind turbine (Figure 1). Testing wind farms is obligatory for the wind speed of 8 m/s. Equipment producers undertake this test for another two wind speeds in the specter of working characteristics (4 - 25 m/s). Disadvantages of such certification are:

- Noise values specter is not given for working and real conditions specter of wind characteristics (3 – 35 m/s).

- It lacks analysis of spectral noise caused by mechanical vibration on the equipment and aerodynamic contaminants on construction elements of the wind farms (post, propeller, nacelle).
- Certificate is issued for new equipment, but with unknown effects for equipment before the overhaul is done (after 20 years of usage)
- The measured sound characteristics (intensity) are not divided spectrally in dominant frequency tones, which is very important for analysis of its influence on humans and fauna in the environment.

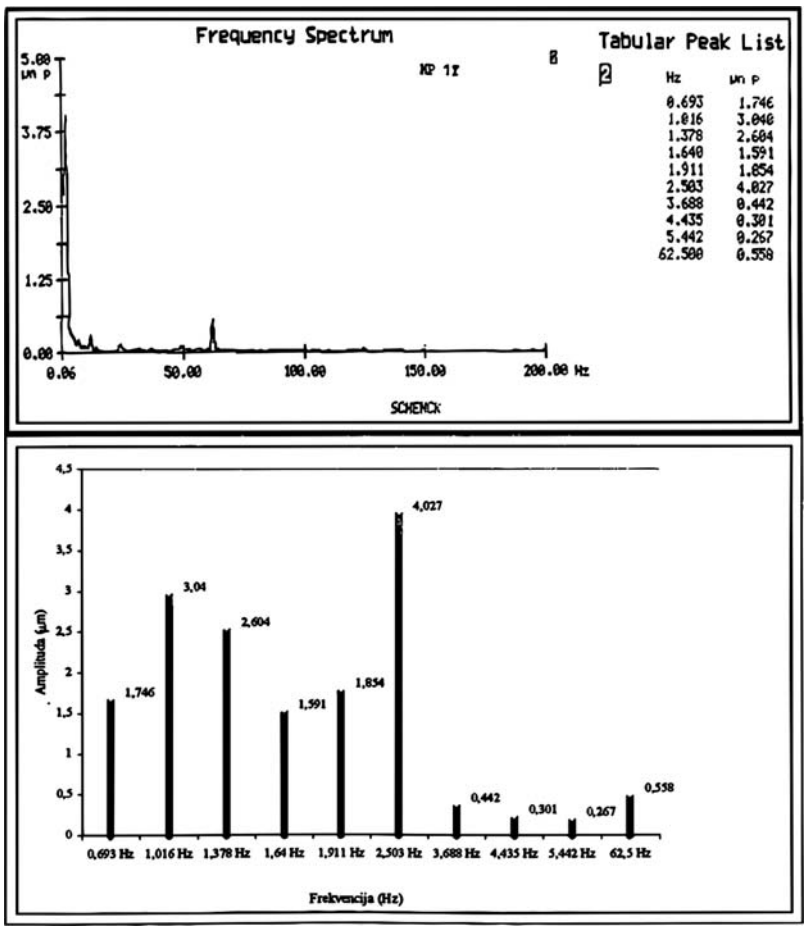

Figure 2. Frequency spectrum and frequency analysis [4]

In the designing process for noise influence, a designer can use two methods: standard VDI 2159 (Germany) or some program package (e.g. WindPro etc.). In using the standards VDI 2159, the following influences are taken into account: wind farm power expressed through the value of the rotor radius, wind speed at the wind farm locality, distance from the noise emitter and influence of the number of wind turbines at the locality of the wind farm. All these elements are basis for the calculation, and they are defined in the form of empirical patterns, adjusted to the conditions in Germany. Disadvantages of this methodology are as follows:

- Constructive characteristics of the equipment are not taken into account in the specter of the strain type as a noise emitter.
- For spreading of the sound, working temperatures of air are not considered (Figure 2).
- Impact of air characteristics (density, molecular mass) on the localities (see level) and atmosphere circumstances (pressure, humidity).
- Influence of terrain orography on the sound emission diffraction effect.

- Influence of different working conditions (wind speed) of every wind turbine at the wind farm locality, and appearance of superposition of sound waves from different emitters and possible interference.
- Wind intensity impact on spreading of sound waves.
- Influence of constructive wind farms characteristics (sound pitch) on the effect of sound waves spreading.
- Numerical methods of calculations in designing of noise areas for defined wind farm take into consideration the following: orography elements, atmosphere characteristics and locality of noise sources for several turbines. Possible influences of constructive characteristics (equipment worn-out), as well as influence of wind characteristics are not taken into consideration.

4. CONCLUSION

A proposed procedure for project documentation development aimed at environment protection concerning noise emission, are as follows:

- For definition of wind farm locality and performed optimization of the wind turbines localities, type of turbines with regard to maximum energy exploitation, it is necessary to do a preliminary estimate of noise spreading, by using simulation methods.
- Additional information is to be requested from the equipment supplier on the noise emitters in exploitation (the oldest one for a specific type of the equipment), selectively for each source of mechanical and aerodynamic noise in form of spectral analysis.
- To install equipment for noise emitter simulation during measurement of wind characteristics in the measuring station installed at the locality of a future wind farm. Simulator locality selection as well as characteristics (intensity and frequency) of the noise emitter is to cover the working specter of the wind farms (3 – 35 m/s). For the critical wind rose, under real conditions of the locality, it is necessary to determine experimentally noise characteristics (intensity, frequency). Based on the experimental measuring, a quality of the applied program package is to be determined in the concrete area. In this way defined wind farm influence on the environment should have better validity for life quality estimate of all living things in the future wind farm locality.

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