Y. Serikov, H. Parhomenko

THE TECHNICAL AND ECOLOGICAL ANALYSIS OF WIND ENERGETICS AND WIND ENERGY POWER STATIONS, AS SOURCES OF NOISE POLLUTION

Kharkiv national academy of municipal economy
12, Revolutsii Street, Kharkiv 61002, Ukraine, KNAME
Telephone: work (057)707-32-73; home (057)705-45-17
E-mail: serikov@ksame.kharkov.ua

The usage of alternative sources of electric energy is one of the ways to solve the problems of global warming, environmental pollution and natural resources conservation. The dynamics of wind energetics development, as one of the representatives of such sources of energy, was described. The comparative data of electric energy production in different countries of the world is provided. Along with considerable positive effect of wind turbine usage there is a number of negative anthropogenic factors, which are caused. Noise is one of the factors influencing negatively on ecology and staff working conditions. The analysis of basic sound pressure sources of wind turbines and their classification was provided.

Permanent development of energetics serves as a guarantee of stable state development. In this case, the development and implementation of alternative sources of energy is one of the main sectors of this problem solving. It became widely spread in the whole world not only because of this reason. The usage of alternative sources of energy was caused by the worsening of global warming problem and by the crisis in fuel energy complex.

Based on system analysis, the U. N. O. development program, U. N. O. committee of permanent development and a number of other international organizations and institutions over ecological problems, energetics and permanent development came to the unambiguous conclusion, written in special résumé. It states that modern operational models of production, the distribution and usage of energy on national, regional and global levels are unstable and unreasonable. Ecological environment and financial expenditures are obstacles for permanent social and economic growth in many countries of the world.

Nowadays 48 economically developed countries support the development of renewable sources of energy and are searching for alternative fuel sources through legislation acts. Overall world investments into renewable energy technologies reached 30 billion dollars in 2005. It constituted almost one fourth of all investments intended for energetic sector development.

One of the directions of this problem solution is wind energetics. The usage of wind turbines gives an opportunity to make a considerable impact on environmental protection and save traditional fuel. The advantages of the usage of wind turbines are formulated in the following statements:

- Wind turbines do not pollute environment
- Wind energy can successfully compete with traditional sources of energy under the following conditions (high enough and relatively constant velocity of wind, expensive fuel for ordinary electric power stations).

The growth of wind energetics reached 24% by 2005. Nowadays the share of this sector in the world electric energy production constitutes 1%. However, in some countries the share of electric energy produced by wind turbines constitutes more than 20% (Figure 1) .According to the information of World Wind Energy Association, installed capacity of wind energetics will reach 120, 000 megawatt by 2010.

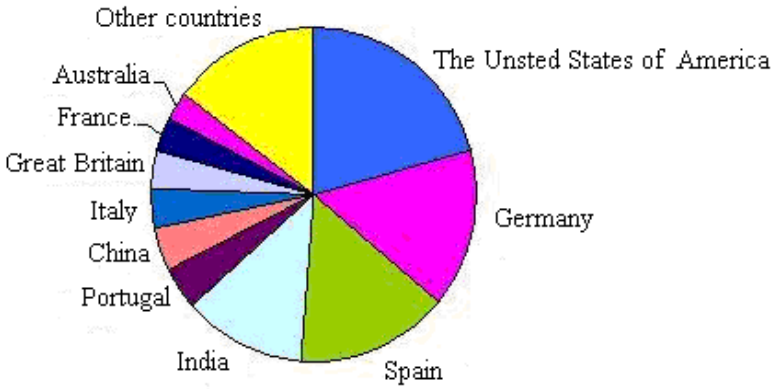

Figure 1. Comparative distribution of wind energy production in the world

It is necessary to specify that not just obvious positive sides characterize the development of this direction of alternative sources of electric energy usage but also a number of problematic questions to solve. They are the problems of technical, economical, ecological sphere, the securing of normative staff working conditions. We will analyze some of these problems on the example of Ukraine.

Nowadays the overall technologically achievable energy potential of alternative sources of energy in terms of equivalent fuel is 63 million tones. The territorial disposition of Ukraine provides large-scale possibilities for wind energy power plants building. The following statements can be viewed as problems and shortcomings of wind energy power stations operation:

- The solution of wind potential estimation and wind power station sitting
- The negative impact of wind energy power stations
- The exclusion of power supply system destabilization due to additional source of energy connection.
- The insufficient scientific and technical basis for wind energy power stations
- The instability of wind velocity is in its unexpected wind gusts and wind calm. It makes the constant production of wind energy complicated. This factor is one of the most essential and unavoidable disadvantages of wind power stations. The search of technical solution to solve the task of this factor compensation is the main aim of wind energetics.
- The negative influence of the wind energy power station work is the occurrence of background noises for television and radio waves
- Wind energy power stations create a considerable level of noise on the territory of its allocation and in residential area.
- The aim is to define and evaluate the negative production factors, to develop steps and security facilities to provide comfortable staff working conditions.
- The negative impact upon the ecology of the Earth. Wind energy power stations harm birds, if they are situated in the areas of their mass accumulation; the air streams have a negative influence on nearby flora.
- The insufficient financing of this field of energetics.

The corresponding development in the field of energetics, aerodynamics and the protection of labor and environment is necessary to remove all the shortcomings, arising while wind energy power station work.

One of the most considerable negative factors of wind energy power station work is the level of sound pressure. The level of negative impact upon staff and the residential areas of cities and towns, situated nearby, must be considered in the analysis of wind energy power stations influence. The negative potential ecological effect of wind turbine must be taken into account too.

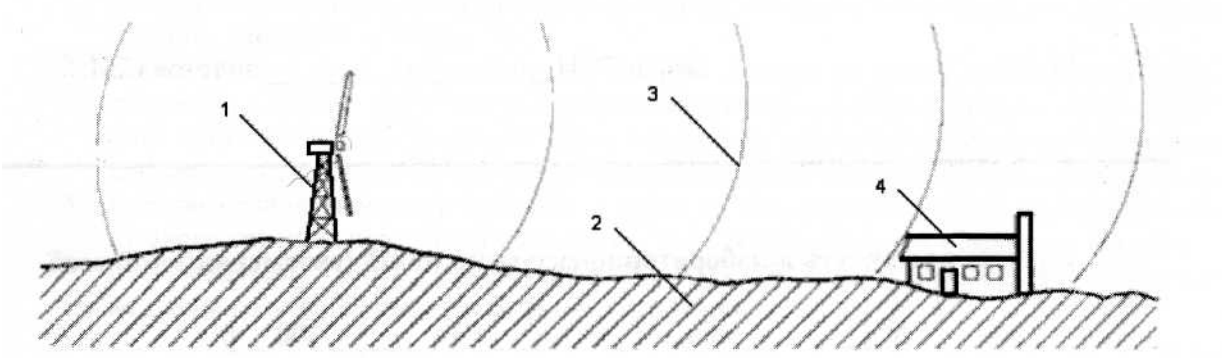

Figure 2. Examples of sources, receivers, and propagation paths 1- Wind energy power station (source of noise); 2- terrain; 3- sound propagation path; 4- noise receptor

The level of sound pressure near wind generator in wind wheel axis of relatively powerful wind energy power station can exceed 100 dB. The atmospheric air turbulence changes have aggressive influence upon environmental flora. Table 1. presents comparison of sound pressure level

characteristics according to different sources of noise. In the following scheme, a review of source of sound pollution allocation, the receivers (industrial or residential area) (Figure 2), and sound propagation is given. The level of sound pressure depends on the following basic factors:

1. The level of intensity, frequency, frequency distribution and patterns of the noise source ;
2. Sound sources characteristics of wind energy power stations ;
3. The terrain characteristics between the emitter and the receptor;
4. The nature of the receptor;
5. Receptor's allocation against the emitter.

There are four types of sound that can be generated by wind turbine operation: tonal, broadband, low frequency, and impulsive:

1. Tonal: Tonal sound is defined as sound at discrete frequencies. It is caused by components such as meshing gears, non-aerodynamic instabilities interacting with a rotor blade surface, or unstable flows over holes or slits or a blunt trailing edge.

2. Broadband: This is sound characterized by a continuous distribution of sound pressure with frequencies greater than 100 Hz. It is often caused by the interaction of wind turbine blades with atmospheric turbulence, and also described as a characteristic "swishing" sound.

3. Low frequency: Sound with frequencies in the range of 20 to 100 Hz is mostly associated with downwind rotors (turbines with the rotor on the downwind side of the tower). It is caused when the turbine blade encounters localized flow deficiencies due to the flow around a tower.

4. Impulsive: This sound is described by short acoustic impulses or thumping sounds that vary in amplitude with time. It is caused by the interaction of wind turbine blades with disturbed air flow around the tower of a downwind machine.

The sources of sounds emitted from operating wind turbines can be divided into two categories:

1) Mechanical sounds, from the interaction of turbine components

2) Aerodynamic sounds, produced by the flow of air over the blades.

Mechanical sounds originate from the relative motion of mechanical components and the dynamic response among them. Sources of such sounds on wind energy power stations can be:

1. Gearbox
2. Generator
3. Cooling Fans
4. Auxiliary Equipment (e.g., hydraulic units of wind energy power stations)

Aerodynamic sound is broadband. It originates from the flow of air around the blades. Aerodynamic sound generally increases with rotor speed.

The various aerodynamic sound generation mechanisms are divided into three groups:

Low Frequency Sound is generated when the rotating blade encounters the wind flow

1. Inflow Turbulence Sound depends on the amount of atmospheric turbulence. The atmospheric turbulence fluctuations result in local force or local pressure fluctuations around the blade and bring the inflow turbulence sound level changes.
2. Airfoil Self Noise. This group includes the sound generated by the air flow right along the surface of the airfoil. This type of sound is typically of a broadband nature, but tonal components may occur due to blunt trailing edges, or flow over slits and holes.

Table 1. Comparative data of different sound sources

Sound Pressure Source	Sound pressure level, dBA
Threshold of pain	120
Jet engine (25m distance)	105
Pneumatic hammer (7m distance)	95
Heavy truck (50 km/h speed; 100 m distance	65
Business office	60
Average motor car (65 km/h speed)	55
Wind turbine (350 m distance)	35-45
Countryside nighttime sound level pressure	20-40

In conclusion it is necessary to mention that Germany, Great Britain, the Netherlands and Denmark passed the laws, restricting sound pressure level of wind turbine operation to 45 dBA in the daytime and to 34dBA at night. These laws also regulate the minimum distance from wind energy power station to residential areas, which must be no less than 300m.

Wind energy is developing and requires considerable efforts of the state, researchers and designers. Alongside with the solution of organizational, economical and technical problems, the problems of labor protection must be considered while planning new and operating the existing wind energy power stations. As a result, the classification of sound pressure sources of wind energy power stations will specify the task of the reduction of sound pressure level. This will serve as a basis of essential methods and means of personnel and environmental protection development.

R E F E R E N C E S

1. Korobco B., Energetika and stable development. K.: 2006.

2. The program of the state support of development of alternative nonconventional and renewed sources energy sources both small hydro- and warmthelectric power station K.: 1997.

3. Wind energetic development Ukraine: a sight on of development for 20 years – K.: 1999.

4. V.C. Krivtsov, A.M.Oleknikov, A.I.Jakovlev. Inexhaustible energy wind technique, wind energetic. – Kharkov KAI 2004.

5. «Wind Turbine Acoustic Noise», Renewable Energy Research Laboratory, Department of Mechanical and Industrial Engineering, University of Massachusetts at Amherst.