

Renewable energy sources and wind power are becoming the topical issue increasingly due to the energy crisis and climate change, as well as the need for Serbia to increase their share in the total balance of electricity production.

As the theme of designing and exploitation of wind farms is a relatively new and unknown field in the professional and general public in Serbia, a lot of supporting aspects are not precisely regulated by law, or engineering practice.

Electricity production from wind power plants is a contribution to reducing carbon dioxide emissions, but also entails the need to assess the different impacts on the environment. Especially expressed environmental considerations are relating to the protection of birds and bats, noise produced by the individual generating units of wind turbines. In order to prevent adverse effects on the environment adequately and in accordance with plentiful international experience, the monitoring of birds and bats, as well as noise simulation software of the future plant are conducted. Based on the obtained results it is performed the optimization of the project solution, which needs to have sufficient generating characteristics in the final design solution with minimum of negative affect on the environment.

Amendments to the Law on planning and building in 2009 created the legal conditions which enabled to build and exploit wind farms in Serbia. The role of renewable energy sources in electricity production is becoming more important in the strategic documents of Serbia, as well as among the wider public.

Wind farms, as a new form of technology for electricity production, are comprised of individual generator units, which are spaced from 300 to 800m (depending on the type of equipment and configuration), underground interconnections cables (usually 20 or 35kV) and switchgear with administrative building and substation, and connection to the transmission system (110 kV or higher voltage). Configurations of wind farms which are in commercial use after 2010 usually have an installed capacity of several tens of megawatts, while the individual generator units are of installed capacity of 2.0 to 3,3MW. Maximum lift heights (towers) on which generators are mounted amount from 80 to 149m.

One of the primary reasons for the application of wind farms is that they produce electricity from renewable source - wind, natural phenomena and which is free. Once installed, the plant will produce in its service life a significant amount of electricity without the considerable emissions of carbon dioxide. As it is impossible to perform production and related activities without any impact on the environment, it is presented, through this work, the primary environmental impacts that wind farms may have, and the way in which they can be predicted and reduced during the process of exploitation, with the aim to achieve the

minimum of adverse impact on the environment and to satisfy regulations.

The role of wind farms in the process of reducing carbon dioxide emissions

Estimated consumption of electricity in Serbia for 2013 is 3901 kWh per capita, of which 53% of the total is spent on the household. Because electricity is largely consumed for heating purposes due to their economic advantage, and also significant amounts of it is produced from fossil sources, predominantly coal, it is evident that that connection represents a significant source of CO<sub>2</sub> emissions into the atmosphere, which in 2009 totaled 35.614kt. In addition, as an added disadvantage that contributes to greater emissions the following should be taken into account: the poor heat insulation properties of buildings, losses in the transmission of electricity and conceptually irrational conversion of heat into electrical energy which is again converted into heat by the electricity end consumers.

Wind farms are not particularly distinguished from other forms of renewable energy – given that the primary energy source of renewable source, wind, in the process of exploitation of power plants caused no pollution as and emissions of greenhouse gases it is by the burning of fossil fuels. In the above context, it is necessary to observe the energy produced by wind farms and compare it with conventional plants – thermal power plants, in order to establish the positive environmental impact of the electricity production.

For example, it is reasonable to consider a generic case of the wind power plant of installed capacity of 50MW. Depending on the type of equipment and configurations, as well as locations of wind potential, such wind farm in Serbia can annually deliver the frame energy in the range of 90 to 130 GWh. By averaging the values shown at 110GWh a year, it is possible to calculate the approximate equivalent value of CO<sub>2</sub> emissions that would be emitted if the same energy applied obtained from conventional sources that use fossil fuels, and it would be about 83,6kt a year. Also, by the produced energy the needs of about 7,000 households could be provided, and according to the International Panel on Climate Change (IPCC – International Panel for Climate Changes) it is also possible to calculate the amount of coal that would have been consumed, depending on the calorific value.

By comparing the total value of the emissions of Serbia from the year 2009, the leading to the improvement of ecological impacts, and reduced CO<sub>2</sub> emissions by about 2.5 ‰ could be achieved if the wind power plant of about 50 M be installed. That value represents a small effect in the overall balance, but it should be emphasized that the installed capacity of these wind farms are relatively small. Illustrative shown, reduced CO<sub>2</sub> emissions of 5% in Serbia, by the same current production of electricity, could be achieved if the total of about 1GW of wind turbines would be installed, or about 20 wind farms with installed capacity of 50MW.

### Impacts of wind farms on the environment

The main impacts of wind farms on the environment are reduced to the problem of jeopardizing the animal world and noise resulting of operation of generator units (the impact of the substation is not considered as it is necessary for any plant). As wind farms and individual generators use the latest technology, i.e. "dry" type transformers which do not contain oils whose eventual outpouring contaminate the environment. Some generator units equipped with mechanical installations for rotor controlling contain oil, grease and other substances that are potentially dangerous to the environment and they are, as a rule, properly insulated and protected. In the above context, regular maintenance of the equipment with the proper handling and disposal of toxic substances do not cause environmental pollution.

Regulation on the List of projects for which impact assessment is mandatory and the List of projects for which the environmental impact assessment may be required (Off. Gazette no. 114/2008) provides that the power plants with installed capacity over 50MW certainly required preparation of impact assessment; accordingly the mentioned provision applies to wind turbines. In practice, the conditions of the authorized institution are provided - the Institute for Nature Protection and the Provincial Institute for Environmental Protection - which provide more precise provisions how the exploration works have to be undertaken and act according to their results. For the plants of smaller installed power (from 1 to 50 MW) the preparation of the impact may be required, depending on the competent institutions, and mechanisms that are identical for the larger plants.

Considering that the individual generator units of wind farms may have blades radius of 120m and over, which by running, can be threat to flying organisms, primarily birds and bats. As the Republic of Serbia has ratified several international conventions on the protection of flora and fauna and all species of bats and most species of birds are protected by law (Off. Gazette no. 36/2009, 5/2010), conservation of populations and prevention of their extinction is a legal obligation, and the intentional killing, mayhem and harassment as well as habitat destruction is prohibited. The projects of preventing or reducing the negative impact on them are engaged in the process of impact assessment on the environment (Off. Gazette no. 135/2004, 36/2009, 69/2005, 84/2005). The issue of noise is regulated by the Law on Protection from environmental noise (Off. Gazette no. 36/2009, 88/2010), and the limit of 40dB is prescribed for the night zones, i.e. residential areas at night periods. In other words, this means that the level of noise that comes from wind farms in the house or apartment at night do not exceed the specified threshold value, and in practice it is necessary to determine accurately the required distance of generator units from residential

areas.

The impact of wind farms on the environment, which is not regulated by rules of Serbia until 2015, is present in two visual aspects - impact on the landscape or terrain and the impact of shadow flicker (so-called "Flickering"). The first is based on the relative aesthetic parameters where it is assumed that the wind farms could affect the landscape to become repulsive or the advent of wind farms to be dominated in relation to natural features. This is partly justified because the wind turbines have moving parts which generally attract more attention of the observers than static scenes of natural characteristics. Another impact is reduced to frequent moving shadows which source are the rotating blades which may have an adverse effect on the subjective feeling of people who are constantly exposed to the changes of shadows and sunlight. Although these two categories are relative, in international practice are insisted on an audit of their parameters, and sophisticated software tools offer opportunities for evaluation and calculation of quantitative indicators.

#### Monitoring of birds and bats

Monitoring of fauna in a particular area is the basic approach used for inventorying, determining the structure of living communities, habitat preferences of individual species and their groups, as well as the determination of their status of population and protection. For the studies of the impact assessment of construction and functioning of the various projects on the environment and environmental monitoring of at least one calendar year enables consideration of seasonal dynamics, spatial and migratory characteristics of the fauna elements. This is particularly important when you want to explore the potential impact of wind farms on flying vertebrates - birds and bats.

In order to implement bird monitoring it is necessary to identify observation points from which the activity of members of the species will be observed and inventories conducted. If the terrain is hilly or rolling, it is necessary to select a point with the higher altitudes, in order to cover the review of all major geographic regions and planned future positions of wind energy generation units. During observation it is necessary to pay attention to the broader environment in order to determine the potential impact of wind farms on migratory corridors. Access to the observation points is enabled by road vehicles and walking (at inaccessible points), while observation is performed by standard equipment for visual detection of species of birds (binoculars, telescopes, etc.). In order to obtain true and valid data monitoring and inventory is required to be performed by persons who have the necessary knowledge and experience. After observing and documenting it follows the inventory and further data processing - quantification of the results, the identification of protected and strictly protected species, preliminary assessment of the impact of future

wind farms, as well as recommendations on the best way to prevent and / or reduce any adverse impacts.

Targets for the implementation of bats monitoring are given very concise, clear and practical in the manual of methodological guidelines for assessing the impact on the environment [6]. By the previous analyzes the presence of existing species are evaluated (in Serbia mostly there are no archival data of this type), then whether a potential habitat could be affected by the planned wind farms, as well as whether there are zones with the most important functional elements of the habitat - copulation, hibernation and transitory shelters, flying corridors and hunting territories. Based on preliminary analysis the preliminary assessment of potential conflicts of planned wind farms and the expected species is carried out and they usually depend on the environmental specificities of species and populations of bats on the site. Conflict analysis should be applied to all phases of the project - research and planning, execution and construction, exploitation of wind farm, its shutdown and dismounting.

After the completed preliminary works and the detection of potential conflicts it follows the field monitoring that aims to mapping all species of bats and their quantification. Field studies should be focused on those ecological functions of habitats and immediate environment which might be affected by the influence of the wind farms.

For example, if the removal of vegetation is planned (woody vegetation or similar) it is necessary to determine the role that such vegetation can have - whether there are shelters or hunting territory of bats, which species are present and what is their significance. Monitoring results may just show and valorize, how and how much, the planned wind farms adversely affect the present population.

Regarding the monitoring of birds and bats it is necessary to emphasize that it is about a complex ecosystem analysis and that it cannot be reduced solely to the observation of birds and bats, but also includes the analysis of other species or communities on which the behavior of birds and bats may be depended - rodents who are often prey of protected birds of prey, insects that are prey of bats, vegetation and other elements of habitat that may be nesting sites, the structures in which bats find shelter in different phases of their life cycle and the like.

#### The noise impact

In the previous part of the article it is mentioned that the protection against noise, prescribed by law, are conducted so that the value does not exceed 40dB in residential zones. Sources of noise of wind farms come from the operation of the equipment in the nacelle (generator) which is set on the top of the column, and the rotation of the blades that

drive the generator. The noise of generator is usually of high frequencies characterized by extremely high frequencies, and the noise caused by the passing of the blades through the air causes the low-frequency and pulsating sources of noise. The best way to check the noise manifestation is by measuring, but this phase includes the construction of the plant. In order to avoid possible conflicts and enable the operation of wind farms under the regulations and with no negative impact on the environment it is necessary the calculations to be carried out.

Production specification catalog lists the value of the noise emitted by wind generators during operation, and volatility values depending on the mode. The available values are digitized and used as input data for the software simulation for calculating the noise impact on the environment in general cases 6. In the simulation of processes the noise emitters are spatially identified (positions of future wind generators) and receptors (residential zone, i.e. the zones in which the impact of noise does not exceed the limit values). After the given input data the calculation simulation follows and that way the graphical results are obtained with clear limits of different noise intensity.

If the calculation shows that the receptors located in the zone of noise whose values is above the limit, in practice, the relocation of the wind generators position, away from receptors, has to be planned. In this way it is achieved a compromise solution that is in accordance with regulations. In cases where it is not possible to relocate the position of the wind generators two alternative solutions can be applied - using equipment that emits lower noise level or regulation of the equipment so that it does not emit the maximum noise level during operation. However, alternative solutions entail modification of configuration or reduction of production of electrical energy and that is the reason why the preventive analysis is always recommended instead of subsequent correction.

#### Optimization of design solution

The issue of the impact of wind farms on the environment and fauna lies predominantly on the likely effects of mortality or displacement of animal species, as well as problems by the population, which can be long-term exposure to noise. These influences are among the guiding optimizing of the planned solution, which should be feasible and profitable. In addition to the environmental impact, optimizing of wind farm projects includes compliance with other aspects: geological, legal property, infrastructure, planning, energy (wind resources) and others. All these aspects can be mapped, and then according to them the critical points has to be identified and the adequate solutions found.

It should be noted that the optimal solution does not always imply maximum possible installed power and the number of individual generators. In some cases, where relocation

leads to weaker wind generators affect the use of a smaller, but more efficient wind power, should be considered. In this way it is possible to achieve the better environmental, but also economic and financial indicators of investment.

The role of wind power plants in electricity production in Serbia is still at the beginning, but it shows the potential of the possibilities for reducing CO<sub>2</sub> emissions that can be of significant value if installed capacities reach a respectable value. Exploitation of wind farms entails also possible negative impacts on the environment - especially the fauna and residential zones. In order to prevent or minimize the negative effects it is necessary to conduct preliminary analyses to identify potential conflicts, and then perform field analysis and monitoring of the existing species of birds and bats and their habitats, as well as software simulation of the expected noise level. In these processes it is necessary to comply with legislative regulations and good practice examples, and it is very desirable to hire staff with relevant experience. Regular and analytical approach can avoid mistakes that will later lead to the loss or impairment of production, and a weakening of economic and financial indicators. In order to optimize the investment it is necessary to apply compromise solutions that are based on compliance of the complex parameters obtained on the basis of investigations and existing software tools.

Source; Energy Watch Balkans ESIASEE/SEEC.rs