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ANALYSIS AND ASSESSMENT OF THE 2.3MW WIND TURBINE IMPACT ON THE ENVIRONMENT

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Abstract: Analysis and assessment of the impact of a selected wind turbine on the natural environment. For the analysis, a division into types of impacts resulting from the operation of a wind turbine was used, as well as highlighted elements of the environment that are exposed to threats. The analysis was based on the technical and technological characteristics of the selected wind turbine model and the location in which the selected model is located. Impact assessments were made in a subjective manner on the basis of the results of tests carried out before the construction of the object and the analysis of the environmental impact of the object.
Keywords: energy sources, impact analysis, environmental impacts, wind turbine

ENERGY SOURCES IN POLAND

Poland is at the forefront of countries emitting a total amount of air, which then, along with the wind, also get into neighboring countries. Polluted air is very dangerous for people and the whole environment, it can cause many chronic diseases, among others asthma in children and other respiratory diseases. Conventional energy in Poland is the main source of electricity - 85% of these carriers are hard and brown coal.

More and more countries are striving to ensure that as much energy as possible comes from renewable sources in the future. In Figure 1 projected changes of energy production sources until 2050 are shown. It can be seen that humanity seeks the largest possible share of unconventional energy sources in the global energy balance [1].

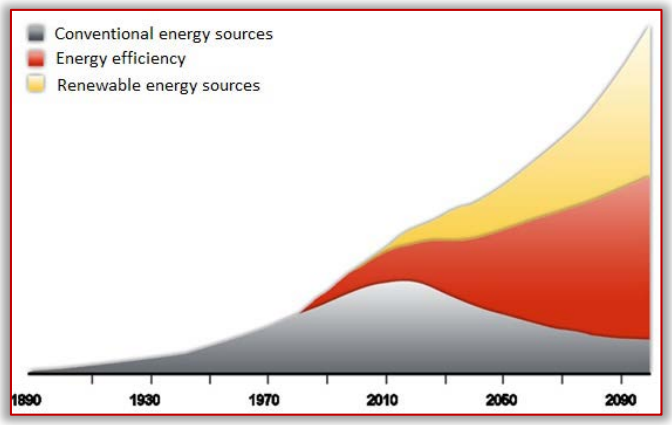

Figure 1. Planned changes in electricity generation in the years 1890 – 2090 [2]

Wind energy is developing dynamically in the world. Over the past several years, it has become an important source of electricity in many countries. By increasing their energy independence and limiting emissions. The total global capacity of wind farms amounted to approximately 198,000 megawatts at the end of 2010 (fig. 2.). Despite the crisis, 23.7% of the capacity increased this year - new farms with a capacity of 37,642 megawatts were created [1],[2].

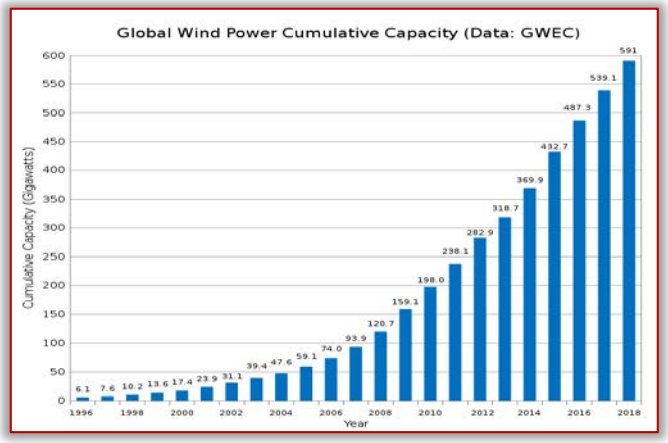

Figure 2. Global growth of installed capacity [7]

Germany comes first in terms of the degree of use of wind energy in Europe. They have wind farms with a total capacity of 27.2 GW. Then it is Spain - 20.7 GW and Italy - 5.8 GW. In Poland, the development of wind energy in Poland has developed significantly in recent years. Despite large legal barriers and restrictions, companies have developed more and more efficient ways of dealing with market difficulties. In 2010, 382 MW wind farms arrived in Poland, which gives 7th place in Europe in terms of absolute power increase [7].

WIND FARM IMPACT ANALYSIS

Wind farms, like all other buildings, interfere with nature. These are usually located in agricultural areas, where there are plenty of plants and natural areas. These are areas valued for their botanical diversity and beautiful landscapes.

Power stations affect flora and fauna, mainly bats and birds. Flying animals have no chance of survival in collision with wind turbine blades, hence the numerous protests of environmentalists.

Another negative aspect is the noise caused by turbines or the strobe effect.

People often think that a building several meters high will negatively affect the landscape, which is associated with a decrease in the price for land in a given place, or discourage potential tourists. All these factors influence the negative perception of wind farms by society [1], [6].

ANALYSIS OBJECT

≡ Location

The selected facility is a 2.3 MW wind farm located in Wola Załężna in the Łódź Province. The area intended for investments has an area of 4.6 ha. It is an area excluded from building development, i.e. it meets the requirement of a minimum distance of 500 m from dense built-up areas [5].

≡ Technical and technological characteristics of the wind farm

The selected wind farm consists of a tower, whose diameter at the base is 4.3 m and the diameter at its top is 2.2 m. The turbine blades have a range of 41 m. At a height of about 109 m from the ground level, the axis of the wind turbine hub is located. The power plant foundation is made of reinforced concrete and has a diameter of 17 m and a depth of 2.9 m.
Additional elements of the power plant equipment are the tower transformer station, which is located in the turbine tower and connected to a control and measuring station by means of a cable line and pinned to a 15 kV energy-saving line [5].

≡ Wind turbine specifications

A 2.3 MW E-82 E2 wind turbine with a horizontal axis of rotation, manufactured by ENERCON GmbH, was used. Basic technical information about the wind farm is included in Table 1.

Table 1. Technical data of the wind farm - turbine model E-82 E2

Construction and technological parameters	Parameter value
The height of the wind farm	149.0m
Support tower height	108.3m
Rotor diameter	82.0m
Number of blades	3 pieces
Generator power	2,3 MW (400V)
Nominal speed	12 m/s
Minimum speed	2,5 m/s
Maximum speed	25 m/s

The power plant was designed in such a way that a transformer and voltage switchgear are placed inside the tower. A transformer from ENERCON was used. It is a type of transformer that is cooled with oil and its burning temperature exceeds 300 degrees C. The transformer is hermetically protected and made of silicone. This type of transformer has many advantages, among others is more secure than dry transformers. Less iron is used for its production, and its larger surface area allows for more efficient cooling of the device. It is another advantage is increased resistance to all overloads, mechanical stresses and load fluctuations [5], [8].

ANALYSIS OF ENVIRONMENTAL IMPACTS

The impacts that have been taken into account result from the analysis of the investment location, the state of the environment prevailing in the area of the wind farm, as well as the technical and technological characteristics of the investment.

≡ Impact on birds

Impact on birds by wind farms is associated with:

- Collision of birds with blades,
- Are an obstacle for flying birds,
- They may result in a loss of feeding grounds, as the use of the land changes.

Construction works were carried out to minimize the threat to birds associated with habitat loss. In addition, the wind turbine blades are bright in color so that the birds can see the obstacle from afar. The power line was routed underground to minimize the risk of electric shock to birds.
Before the wind farm was built, there were annual bird observations. Observations have shown that the place for the investment is not an attractive feeding ground for birds or at any other time. The share of birds of around 7% was not considered to be environmental impact because there are no protected species in this group of birds. The investment has no barrier effect or other cumulative impacts [3],[5].

≡ Wind farms

Wind farms can be a dangerous obstacle for bats. Not only because of the direct collision of the animal with the turbine blades, but also cause the "barotrauma effect". The impact of a wind farm depends on the bat species. Power plants pose the greatest threat to species that fly fast, with little maneuverability and over long distances, and for those hunting in large open spaces. The location of wind farms is also of great importance. Places near forests, wooded areas or any water reservoirs are more dangerous to bats.
According to research conducted in the USA and Germany, these animals die in contact with turbines 5 times more often than birds. One turbine can cause up to 30 fatal accidents involving bats per year. This is a high mortality rate because these mammals breed at a very low rate and their numbers are low.
Studies cannot predict bat mortality by a given turbine. For this purpose, before the investment is created, the only option is to perform monitoring in a given area. Such monitoring was carried out in the period March - November, where there is increased activity of these animals. Monitoring was carried out at the site of the power plant, as well as in nearby areas. The bat routes and their intensity were determined in it. This helped determine the threat that a turbine might pose. For the purpose of observation, special equipment and methods were used to allow accurate analysis.
Studies have not shown places of hibernation of bats near the investment. No colony sites or hibernation of these animals was noted. The area for the wind farm was also not attractive for bats, because it is in an open field, no forests nearby, no water reservoirs, no old farm buildings. Only common bats have been reported to occur in nearby areas, but their activity has been low. The species, whose level of risk associated with collision with the power plant is medium, occurred in the study area in a very small number, less than 24 flights of all species per hour.
Actions taken to minimize the threat are to maintain an appropriate distance: about 200 m from the wood avenue in the area, which is a feeding ground for late twilight and dwarfs. A 3-year monitoring was also carried out to

accurately observe the bats at the height of the turbine rotor. Constant control of bat mortality during turbine operation is also carried out. The impact on bat mortality by turbines is low. The turbine does not interfere with mammal feeding grounds or their flight routes [5],[6].

≡ **Noise emission**

There are two types of noise caused by turbine operation. Mechanical noise is created by turbine operation, it is generated by a generator, and aerodynamic noise is generated by a rotating rotor with blades.

Aerodynamic noise dominates on large wind farms. This is due to the air flow that flows between the blades. The higher the blade speed, the louder the noise. The diagram (Fig. 3) shows the noise emitted by a wind turbine at specific wind speeds. Above 8 m / s noise emission has the same value. 104.0 dB is the loudest noise emitted by the E-28 E2 turbine [3],[5],[6].

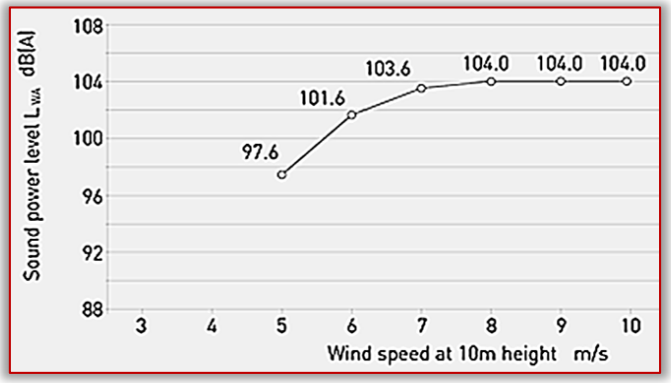

Figure 3. Graph of noise emission by Enercon's E-28 E2 turbine, tower height 108m [5]

Tests were carried out for the described wind farm. At a height of 4 m, the turbine emits a noise of 45 dB. This is an acceptable noise value also at night. The range of this sound is 220 m from the power plant. There are areas under protection due to farm buildings in the area, but their distance is 315 m from the turbine, so they are out of noise range. At a height of 1.5 m, the noise range is 110 m. This is the radius from the location of the power plant and was calculated for a value of 45 dB. During operation, the wind farm does not exceed the permissible noise level at night for the environment [5].

≡ **Infrasound emission**

The wind power plant has a mechanism that causes infrasound, i.e. inaudible sounds to the human ear. They have a low frequency and are characterized by a large wavelength. These waves can penetrate various physical barriers, among others concrete walls.

Infrasound has a frequency of 2 to 16 Hz, so a human cannot hear them, only receives receptors of the feeling of vibration. In nature, infrasound sources include waves in the sea, waterfalls, strong gusts of wind, etc. This is a harmless type of infrasound. Infrasound occurring in industry and produced by devices is a kind of sound dangerous to people. The limit value for infrasound emission according to regulations is 100 dB at 20 Hz sound pressure level.

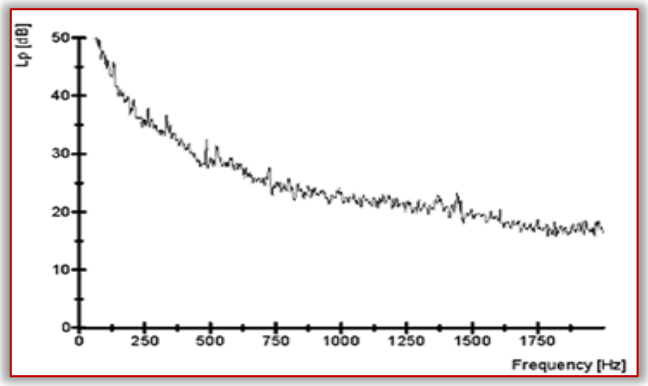

Figure 4. Emission level of infrasound by the 2MW Vestas V-90 wind turbine [3]

The wind power plant does not exceed the prescribed standards and does not cause negative impacts on the health of residents. The harmful emission level is more than 110 dB at 20 Hz, or 100 dB at levels between 20 and 250 Hz. Infrasound impact analyzes on animals show that infrasound noise scares away birds. This is a positive effect, as their mortality due to direct collision with the wind turbine decreases [1],[3],[5].

≡ **Strobe effect**

The strobe effect is a cyclical phenomenon that occurs during the day after sunrise and before sunset, when the sun is lower above the horizon and the angle of incidence of sunlight is small. Frequencies above 2.5 Hz, i.e. 1 flash per second, determine if there is a strobe effect.

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The turbine blades have a length of 41 m, so the diameter is 82 m. The strobe effect is not noticeable within a radius of 410 m. The nearest buildings are located at a distance of 490 m from the wind farm, so the strobe effect is not a harmful phenomenon and burdensome for residents in this plant. In addition, to protect the observers, the power plant has safeguards in the form of anti-reflective surfaces on blades and other elements [5].

ENVIRONMENTAL IMPACT ASSESSMENT OF A WIND TURBINE

The wind farm is a tall building with a large wingspan. It contributes to the mortality of birds and bats. Its dimensions also affect the aesthetics of the landscape. The noise it generates can disturb the residents. Investors want investments such as wind turbines to produce "clean" electricity and to be positively received by society [6].

≡ **Taken to reduce negative effects on the environment**

In order to minimize the negative impact of the power plant on the environment, a number of actions have been carried out. In the wind farm, measures were taken such as: covering the turbine with an appropriate material that does not reflect sunlight, no lighting of the power plant so that it does not attract insects, which are food for bats, the cable lines are routed underground.

The whole structure was painted in a gray shade and the bottom of the tower was green. Such action minimizes the impact of the object on the landscape values of the region. The design does not stand out so much because the color is not contrasting.

Seasonal maintenance and monitoring of power plant operations are designed to reduce the risk associated with breakdowns or fluid leaks [2].

≡ **Environmental impact assessment of a wind farm**

The development of technology and modern solutions used in wind turbines have minimized the negative impact of wind farms on the environment. The use of an appropriate construction (without gears) limited the infrasound emitted to the environment. The acoustic impact will not negatively affect the residents. The construction of the turbine minimizes vibrations that are imperceptible due to the lack of moving parts, such as gears. The location of the turbine also excludes the nuisance which is the strobe effect, and the additional protection applied by the manufacturer in the form of anti-reflective coverage of the power plant's surface will eliminate this phenomenon. The emitted electromagnetic field does not exceed the permissible values. Its emission is low and does not pose a threat to health. Limiting the impact of the turbine on the landscape will not contribute to its exclusion. A power plant with a height of about 150 m is a visible element against the background of the landscape. This impact is negative on the landscape values of the area. The impact of a wind farm on the environment and people's health and life is positive because it contributes to reducing the amount of energy generated from coal. Wind farms do not emit harmful substances into the atmosphere [1], [3].

SUMMARY

All types of electricity generation have an impact on the environment. The creation of various types of power plants is interference in the natural environment. This is due to interference with the flora, because a small area of land is taken for investment, to a greater or lesser extent. The surrounding landscape is changing. However, with the development of the industrial sector, the demand for electricity increases. Wind energy is one of the friendliest ways to generate electricity. The wind potential in Poland is so high that its rational use would contribute to reducing the share of coal in the Polish economy [4].

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References

[1] Lewandowski W.M., Aranowski R., Technologie ochrony środowiska w przemyśle i energetyce, PWN, 2016, s.483,
[2] Lis P. Efektywność energetyczna w systemach budowlano-instalacyjnych, http://docplayer.pl/656555-Efektywnosc-energetyczna-w-systemach-budowlano-instalacyjnych.html [10-06-2020]
[3] Poleenergia, http://www.polenergia.pl/pol/pl/strona/otoczenie [10-06-2020]
[4] Vademecum energetyki odnawialnej, http://www.instsani.pl/ozewiatr67.htm [12-06-2020]
[5] Pełka W., Raport o oddziaływaniu na środowisko elektrowni wiatrowej w miejscowości Wola Załężna, gm. Opoczno, Piotrków Trybunalski, maj 2011
[6] Olkuski T., Analiza krajowej struktury wytwarzania energii elektrycznej z węgla kamiennego, http://www.gios.gov.pl/images/dokumenty/pms/raporty/GIOS_raport_2014.pdf [12-06-2020]
[7] https://en.wikipedia.org/wiki/Wind_power_by_country [10-06-2020]
[8] Lubośny Z., Elektrownie wiatrowe w systemie elektroenergetycznym, Wydawnictwo Naukowo-Techniczne, Warszawa 2006

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