THE SPATIAL ASPECTS OF THE WIND FARMS IMPACT ON THE ENVIRONMENT

BOŠKO JOSIMOVIĆ

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REVIEWERS:
Professor Aleksandar Jovović
Professor Dejan Filipović
Dr Mila Pucar, scientific advisor

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Dr Saša Milijić, Director

EDITORS:
Dr Sanja Simonović Alfirević
Dr Marina Nenković-Riznić

DESIGN AND LAYOUT:
Dr Tanja Bajić
MSc Aleksandra Gajić

TRANSLATION:
Goran Stanić

PROOF-READING:
Bojana Dodić

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FOREWORD

As I was ruminating on the introduction to what I hope is an interesting, but doubtless relevant topic of this volume, I could not help but think that it would be appropriate for this foreword to comprise thoughts by some of the prominent thinkers and luminaries of the global scientific and public scene – those who have directly or indirectly touched on the use of 'green' energy. I am happy to be able to dedicate this book to my family: Marija, Vuk and Tara; to my parents; to my sister Bilja and her children Ivana and Luka; and to provide below some of the thoughts that I can fully subscribe to and which I often come back to with pleasure.

‘Throughout space there is energy. Is it static or kinetic? If static our hopes are in vain; if kinetic — and this we know it is, for certain — then it is a mere question of time before men will succeed in attaching their machinery to the very wheelwork of Nature.’

(Nikola Tesla)

Of all the forces of nature, I should think the wind contains the largest amount of motive power—that is, power to move things. Take any given space of the earth’s surface— for instance, Illinois; and all the power exerted by all the men, and beasts, and running-water, and steam, over and upon it, shall not equal the one hundredth part of what is exerted by the blowing of the wind over and upon the same space. And yet it has not, so far in the world’s history, become proportionably valuable as a motive power. It is applied extensively, and advantageously, to sail-vessels in navigation. Add to this a few windmills, and pumps, and you have about all. … As yet, the wind is an untamed, and unharnessed force; and quite possibly one of the greatest discoveries hereafter to be made, will be the taming, and harnessing of it.

(Abraham Lincoln, 1860)

‘… there is the power of the Wind, constantly exerted over the globe…. Here is an almost incalculable power at our disposal, yet how trifling the use we make of it! It only serves to turn a few mills, blow a few vessels across the ocean, and a few trivial ends besides. What a poor compliment do we pay to our indefatigable and energetic servant!’

(Henry Thoreau, 1866)

‘If we do not learn to eliminate waste and to be more productive and more efficient in the ways we use energy, then we will fall short of this goal. But if we use our technological imagination, if we can work together to harness the light of the Sun, the power of the wind, and the strength of rushing streams, then we will succeed.’

(Jimmy Carter, 1979)

We won't have a society if we destroy the environment.

(Margaret Mead)

‘We should utilize natural forces and thus get all of our power. Sunshine is a form of energy, and the winds and the tides are manifestations of energy. Do we use them? Oh, no; we burn up wood and coal, as renters burn up the front fence for fuel. We live like squatters, not as if we owned the property.’

(Thomas A. Edison, 1916)

‘The future will either be green or not at all.’

(Bob Brown)

‘Try to leave the Earth a better place than when you arrived.’

(Sidney Sheldon)

‘Whether humans are responsible for the bulk of climate change is going to be left to the scientists, but it’s all of our responsibility to leave this planet in better shape for the future generations than we found it.’

(Mike Huckabee)

Most of these thoughts were visionary at the time of their writing or saying, and pointed to the need for, and importance of, the use of renewable energy sources in generating electricity. Some of them focused only on grasping the energy potential of renewable resources, while others put the use of renewable natural resources in the context of the need for environmental protection. Nonetheless, whether directly or indirectly, both pointed out, as they still do, the importance of and the need for protecting the environment by using 'green' energy. A direct correlation between using renewable energy sources and environmental protection is in this sense indisputable, and this book focuses on one specific aspect of this correlation, contained in the title itself.

Author

1. INTRODUCTION

In the recent decades, humanity has faced excessive consumption of fossil fuels. This has resulted in significant planet-wide disruptions, manifest in climate change and a serious debate within the scientific and professional communities on this topic, as well as in the ozone layer depletion and the degradation of the basic environmental factors. Besides the adverse environmental effects of fossil fuel use, these fuels have a limited capacity and are not renewable. These facts have led to an increased focus on the development and use of renewable energy sources.

Renewable energy sources (*RES* for short) are sometimes labelled as permanent energy sources, represent energy resources used for the production of electrical, heat, and mechanical power, whose reserves are continuously or cyclically renewed. An important characteristic of their renewability is the lack of harm to the environment, alongside the reduced emission of CO_2 in the power generation process, which is especially significant in the 'era of sustainable development'. The very terms *renewable* and *permanent* come from the fact that power is spent in the amount which never exceeds the rate at which it is generated in nature.

Renewable energy sources can be divided into two main categories: *traditional energy sources* such as biomass and big hydroelectric power plants; and the so-called *new renewable energy sources* such as solar, wind, and geothermal power, etc. As much as 24.5 per cent of the total global power was obtained from renewable energy sources by the end of 2016, with a dynamic growth rate standing at around 5 per cent annually between 2015 and 2016. The share of wind power generated from renewable sources in the total global power generation at the end of 2016 stood at 5 per cent. It is precisely wind power that has had the fastest growth of all renewable energy sources (Renewables global status report, 2017).

The share of renewables in the total power generation globally is increasing at an accelerated rate and this trend has been evident. If we look no further than the European continent, this trend is helped along by the fact that the European Union has adopted and is implementing an ambitious plan for the share of renewables in the gross final consumption to be bumped up by 2020 to 20 per cent and to 30 per cent by 2030 (The European Commission, 2017). The plan has a number of measures to stimulate private investment in the facilities for converting renewables into usable power.

The development of projects using renewables is important for several reasons:

- Renewable energy sources play an important role in the reduction of greenhouse gas (*GHG* for short) emission into the atmosphere, above all carbon-dioxide (CO_2). The reduction of CO_2 emmissions is also the policy of the European Union and many other states around the world ;
- Increasing the share of renewables enhances the system energy sustainability. Further, it helps reduce the dependence on importing energy resources and electrical power;
- It is expected that renewables will become economical competitors to the conventional energy sources in the mid-term.

A large part of power generation from renewable energy sources is a result of raising environmental awareness on the one hand, and economic benefits on the other.

One of the growing aspects of renewable energy sources is win power, which can be used to generate electricity. The wind power use sector is becoming one of the fastest-growing sectors of renewable energy source use, itself growing practically at an exponential rate recently.

Research projects in the area of wind power use are intensifying, with new techniques to convert wind power into electricity constantly discovered. All these projects are pushed forward by an increasing seriousness with which governments around the world approach the issue of reducing energy dependence and the diversification of energy sources into multiple branches which operate independently. Renewable energy sources are ideal for implementing these policies.

Bearing in mind the relevance and expansion of wind power use around the world, the present volume will be concerned with that topic, giving special emphasis to the spatial/territorial aspects of the impact (both positive and negative) of wind farms on the quality of the environment, steering clear of the technological and economic aspects of their use. This is a topic that has not received a sufficient treatment in the past. There are not many scientific and professional papers written on the subject in publications with an international standing. The present author believes that the wish to contribute to the development of wind power by only foregrounding its positive effects on the environment (which is not rare in scientific and professional publications) does not contribute to an adequate, objective, and comprehensive treatment of these issues.

Although some of the benefits of using renewables for the quality of the environment have been previously mentioned, each of the projects utilizing renewables can also have specific adverse effects on the environment. This is not an exception even in using wind power in wind farms. The present author intends to address in this volume the possible negative aspects of wind power without denying all of the positive effects of wind power on the environment; rather, the aim is to provide a comprehensive account and so ensure a positive contribution to the efforts to resolve environment-related problems by pointing out some of the important phenomena and processes which need to be taken into consideration in the planning and implementation of the wind farm projects.

It is in this context that both positive and negative environmental aspects of implementing wind farms will be analysed, as well as the possibility of applying instruments of environment protection in the planning and designing wind farms.

The initial chapters of the present volume (chapters 2-4) are concerned with the theoretical aspects of the environmental impact of wind farms, including a historical overview of wind power use and a review of the existing trends in wind power development at the global, European, and local levels. Special attention in this part of the book will be paid to the discussion of the possibilities and application of the instruments for assessing the impact of wind farms on the environment, focusing on understanding the spatial aspect of possible effects by drawing up the Strategic Environmental Assessment. Chapter 5 represents a practical portion of the volume, which uses a concrete example to demonstrate the methodology of determining the strategically important territorial effects of wind farms on the environment and the elements of sustainable development.

The book makes use of the author’s experiences gained in assessing the impact of over ten wind farms on the environment in Serbia and Montenegro – a good sample for identifying the key issues in the impact assessment, use of methodology, defining appropriate conceptual solutions for impact reduction, etc.

The present author has decided to limit the analysis and research to the so-called *on-shore* wind farms, as the analysis of off-shore wind farms would require a considerably different approach than the one explored in this book.

2. USING WIND POWER

2.1. The history of wind power use

The energy of moving air masses – win has always attracted the attention of researchers wishing to find a use for it. The data on wind power use dates as far back as 5,500 BC and can be found in painted Egyptian vases showing boats with sails, which indicates that even before this period humans started to think about wind power use. Around 200 BC, simple windmills were used in China to pump water, followed soon after by mills for wheat and other grains. The oldest known ones are found in Persia (Iran). These mills had blades that resembled big round oars. Persians also used wind power to pump water (Wind Energy Foundation, 2016).

Using wind to provide mechanical power first arose in the antiquity, and the first practical mills driven by wind power are assumed to have been in use in Sistan, a region in Iran bordering on Afghanistan (Figure 1), by the 9th century, possible as early as the 7th century. This so-called panemone windmills were horizontal windmills with long vertical axes with six to twelve rectangular wind-catching blades covered in reed or fabric (Hassan and Hill, 1986). These windmills were used to pump water as well as in the sugarcane industry (Lucas and Adam, 2006). Windmill use became widespread in the Middle East and Central Asia, making its way later to China and India (Hill, 1991). The vertical ones were subsequently widely used in north-western Europe to make flour at the beginning of 1180, and many examples persist to the present day (Lohrmann, 1995). Windmills were used until 1000 AD for pumping sea water in salt production in China and Sicily (Kurlansky, 2002).

Figure 1. *Panemone windmills, Khaf, Sistan in Afghanistan (photo: Ghader Ageli, original).*

The idea spread from the Middle East to Europe. Data on gristmills and windpumps were recorded in the 12th century England and the Netherlands. The Dutch improved the basic windmill structure, introducing elliptical vanes and utilizing cloth spread on them. They used gristmills and windpumps in reclaiming land below sea level. The oldest reference to windmills in this period dates as far back as 1185 to the town of Veedley in Yorkshire, although there do exist numerous earlier sources related to windmills, dated to 12th century Europe, but with less certainty (White, 1962). Although it is sometimes claimed that the crusaders could have been inspired by the windmills in the Middle East, this is not very likely as the European vertical windmills were considerably differently designed to the horizontal windmills which could be found in Afghanistan. Lynn White Jr., specialist for medieval European technology, claims that the European windmills is an 'independent invention' and that it is unlikely that the invention of the horizontal windmill in Afghanistan spread to the West during the Crusades (White, 1962).

The Dutch developed the first windmill on which only the cap rotates in the 14th century. These windmills had a fixed wooden structure with a milling assembly and a movable top consisting of the roof, sails, axis and brakes. In this manner, only the cap would rotate towards the wind, rather than the whole structure, as had been the case. This design made it possible for windmills to become quite large and to perform multiple tasks. Bigger windmills meant a higher wind utilization. In addition, it was the Dutch that developed slats rather than sails, which was a revolutionary idea. By the 19th century, windmills had spread around Europe and had been introduced to North America. The colonists in America used windmills for milling grains, extracting water from deep wells, as well as for cutting wood in sawmills. Towards the end of the 19th century wind power started to be used for the production of electricity, but mostly in small local facilities.

The first wind turbine used to produce electricity was built in Scotland in July 1887 by Professor James Blyth of Anderson's College in Glasgow. Blyth's 10-meter wind turbine (Figure 2) was mounted in the garden of his country house in Marykirk, Scotland, and was used to charge batteries developed by the French Camille Alphonse Faurea in order to illuminate the country house (Price and Trevor, 2005). This effectively made the country house the first house in the world to use wind-generated electricity (Shackleton and Jonathan, 2008). Blyth offered the extra electricity to the people of Marykirk for illuminating the main street but they refused the offer as they thought that electricity is 'devil's work' (Price and Trevor, 2005). Although he later built a wind turbine for providing the Montrose infirmary and dispensary with electricity, the invention never really caught on as the technology was not considered economically viable (Price and Trevor, 2005).

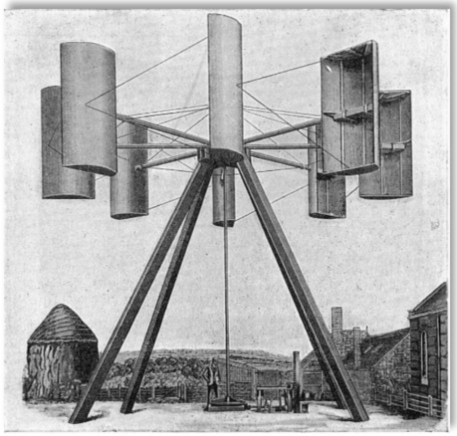


Figure 2. *James Blyth's first electricity-generating windmill (Source: CleanTehnica, 2017).*

Across the Atlantic, in Cleveland, Ohio, a bigger and better-constructed machine was designed and built in the winter of 1887/1888 according to the specification made by Charles Brush (Anon, 1890). The machine was constructed by his engineering company at his home, active between 1886 and 1900 (Danish Wind Industry Association, 2007). This windmill (Figure 3) had a 17-meter rotor and was mounted on an 18-meter tower. Although of considerable size even according to today's standards, this windmill could produce only 12kW of electricity, which was considered insufficient given that it had 144 blades. A dynamo was used to charge the battery or a battery bank, provide enough power for 100 light bulbs, or to run various engines in Brush' laboratory. The windmill stopped working in 1900, when electricity became available from the power plant in Cleveland, and was completely abandoned in 1908 (History of Wind Energy, 2007).

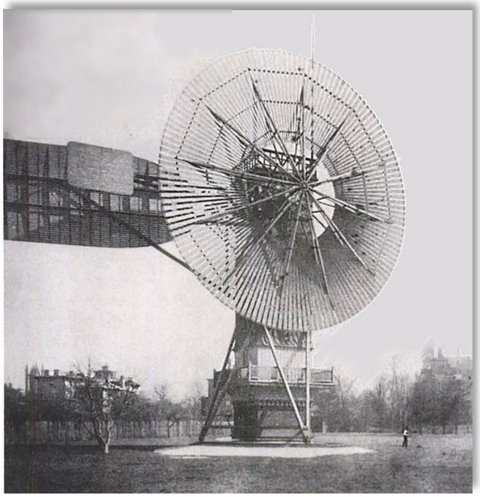


Figure 3. *Charles Brush's windmill (Source: CleanTehnica, 2017).*

Danish scientist Poul la Cour built in 1891 an electricity-generating wind turbine which was used for making hydrogen (Price and Trevor, 2005) by means of electrolysis, stored for later use in experiments and for illuminating the Askov secondary school. Her later solved the problem of continuous electricity supply by inventing the regulator, and in 1895 he turned his wind turbine into a power plant prototype, used to illuminate the village of Askov (Warnes and Kathy, 2013). By 1900, Denmark saw around 2,500 windmills, which were used for mechanical works such as pumps and mills, producing a combined power of around 300MW.

The period between the turn of the 20th century and today can be provisionally divided into two parts: the first lasted until 1973, when the use of wind farms became widespread, resulting in a competition with the facilities that used fossil fuels to generate electricity; and the second, from 1973 to the present day, when the oil price crisis and environmental pollution incited research into alternative energy sources.

During the first period, wind power use in generating electricity started to develop towards the end of the 1920s, which is when the construction of the first wind power facilities began. At the time, the first multi-kilowatt wind turbine, producing 100 kW of energy, was built in Crimea, on the Black Sea coast. This wind turbine operated for over two years (Hau, 2006). In 1941, the first generation of wind turbines was made which could produce over one megawatt of energy, and was connected to the local electricity grid in Vermont, USA. It was designed by Palmer Cosslett Putnam and manufactured by S. Morgan Smith. This Smith-Putnam 1.25 MW wind turbine operated for 1,100 hours before a blade broke at a point which was not reinforced due to material shortages during World War 2. A similar-sized wind turbine was not to be built for almost 40 years (Noble Environmental Power, 2010).

The second period, from 1973 onwards, is characterized by the oil shortages of the 1970s which changed the way energy was seen in the world. This sparked an interest in alternative energy sources, opening up the possibility for a fresh development of wind turbines for electricity generation. From that moment on, a renaissance started in the area of renewable energy sources, and thus in the area of wind power.

Between 1974 and mid-1980s, the US Government collaborated with the industry in order to improve the technology and enable the development and mounting of big commercial wind turbines. Big wind turbines used for exploring the possibility of industrial production were developed as part of a programme overseen by the National Aeronautics and Space Administration. With the financial support from the National Science Foundation and, later, the US Department of Energy, 13 experimental wind turbines were commissioned which used four basic wind turbine designs. This research and development programme represented pioneering work for wind turbines with power exceeding 1MW, which are in use today. Large-scale wind turbines developed as part of this programme set a number of world records in terms of diameter and output power. In the 1980s and early 1990s, the low oil prices threatened to make electricity economically unviable, i.e. a poor competitor to the fossil fuel energy. However, this did not happen and the 1980s saw a boom in win power in California, partly due to the federal and state tax incentives for renewable energy sources. These incentives financed the first large-scale use of electricity-generating wind farms (Righter, 2008).

Around the time, Europe as well saw efforts to improve the wind power technology, in part due to environmental concerns, as a response to the scientific studies which pointed to the potential changes in the global climate if fossil fuel use continued to increase. Germans, Italians, and the Spanish contributed to the development of wind power. However, the dominant position was held by the Dutch (manufacturing wind turbine propellers) and the Danish (manufacturing wind turbines). At the time, Danish exports to the USA was increasing sharply. For example, in 1981 they exported 21 wind turbines, in 1983 as many as 356, and two years later 3,100 wind turbines.

With ups and downs mostly related to the rise and fall of oil prices, the development picks up the pace after 2000, with a steady increase in oil prices. In the new century, fossil fuels are still comparatively cheap, but growing concerns over energy security, global warming and a possible fossil fuel decrease have resulted in the expansion of interest in all available forms of renewable energy. The industry related to wind power started to expand at a dynamic growth rate of about 25 per cent per year, owing to the availability of large-scale wind farms and the reduction of costs stemming from improvements in the technology and wind management (Renewable energy world, 2009).

Technological innovations, which result in progress in computer engineering (Hewitt et al, 2017) continue to impact upon the developmental processes in wind power (Clive, 2018; 2014). As of 2015 the biggest wind turbine was VMV-V164 with the capacity of 8MW, for use in off-shore wind farms, and the biggest wind farm was Gansu Wind Farm in the province of Gansu, China, with the installed power of 6,000MW and a planned increase to 20,000MW by 2020 (Source: Forbes, 2017). Wind power use is the fastest-growing segment of renewable energy generation today and one which deserves special attention. Chapter 3 of this book provides a more detailed discussion of the tendencies and growth trends in this branch of energy industry.

The wind turbine industry has been developing in the past thirty years at almost the same rate as the computer equipment industry, and is considered very stable and promising in the present day. According to the views of many experts, a further intensive growth of installed capacities is expected, and the trends of a further increase in economic viability, as well as a worsening state of the environment, confirm such assumptions (Wind Energy Foundation, 2016).

2.2. Trends in wind power use

2.2.1. Using wind power globally

The previous chapter provided a historical overview of wind power use, also hinting at the global trends in wind power at the start of the 21^{st} century. Wind power certainly is a fast-growing portion of the renewables sector and its potential and importance in environmental protection are recognized globally by an increasing number of states. This has resulted in large investments in the development of wind power and technological research which could improve wind power utilization. As wind power use grows, the cost of electricity generation in wind farms goes down, making wind power increasingly more competitive than fossil fuels, which then stimulated the development of the wind power sector. All this has an impact on the direction that certain states take, especially the more economically developed among them, which can have a significant contribution to the growth trend, resulting in the construction of more and more wind farms and efforts to produce increasing amounts of electricity from wind power.

If the previous statements are translated into figures, the wind power growth tend looks as follows. By the end of 2001, around 56,000 wind turbines had been installed with the capacity of 25GW, while in 2014 the capacity increased by 55 per cent. Wind electricity production increased fivefold between 2000 and 2007, with the global wind farm capacity standing at 94GW at the end of 2007. This still constituted as little as 1 per cent of the total global electricity production. As early as 2009, wind farm capacity rose globally to 158GW, with half a million employed in this sector. By 2014, there were over 240,000 commercial-dimension wind turbines around the world, participating in global electricity generation by 4 per cent. The total installed capacities exceeded 371GW by the end of 2014, with China, United States, Germany, Spain, and Italy in the lead. By the end of 2016, the installed wind farm capacity stood at nearly 487GW, and it is projected that by the end of 2017 these figures would reach 540GW (source: WWEA, 2017). Below is an illustration of the global wind power trends.

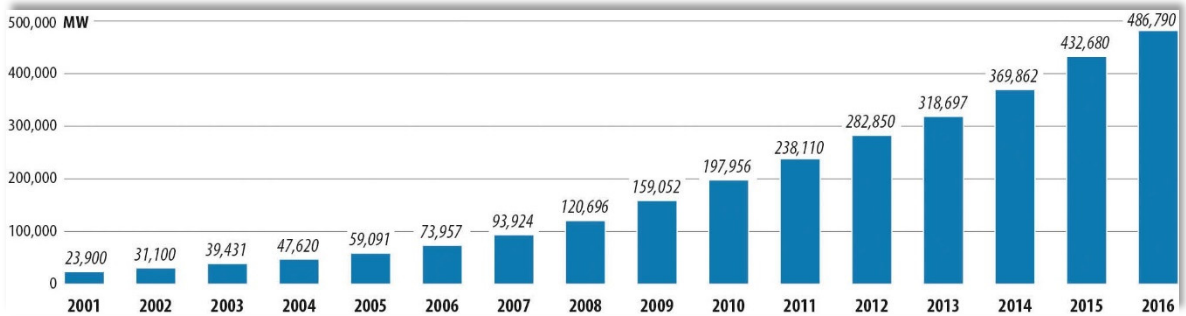


Figure 4. *The total wind farm capacity at the global level for the period 2001–2016 (Source: GWEC, 2017).*

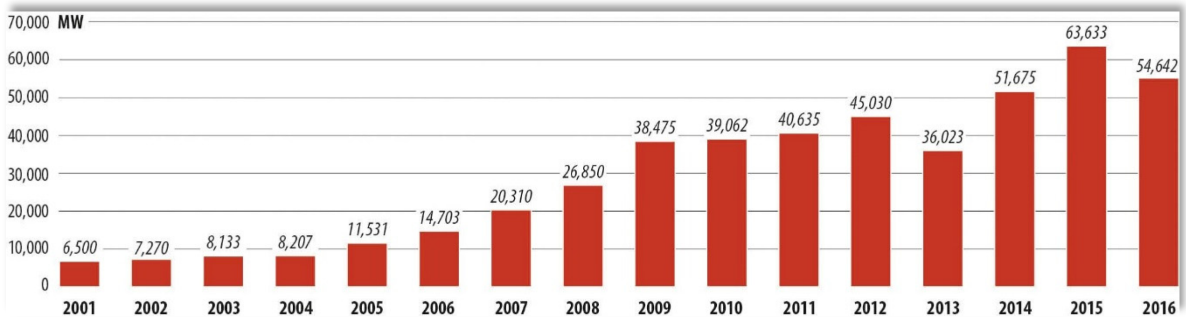


Figure 5. *The annual installed wind farm capacity at the global level for the period 2001-2016 (Source: GWEC, 2017).*

Considering the trends of capacity increase in wind farms (total and annual) in the last 145 years, it is straightforward to conclude that the global trends have a constant and dynamic growth and that subtle fluctuations in these trends depend on diverse economic and environmental circumstances which have a bearing on wind power industry as 'external' factors of sort. However, these fluctuations are noticeable at the annual level, but they do not impact on the constant growth of total capacity globally and in the long term.

In order to track the global percentage growth and increase in the installed capacity in the area of wind power, while at the same time ensuring a reliable picture of the quantitative parameters of this growth, the 2012-2017 period was used. This five-year period was selected as it is precisely the time when wind power has had the greatest growth up until the present day, with record-breaking values of all the parameters relevant to the growth assessment. Based on this, it is possible to make predictions for future trends, but only for the comparatively certain short term (Figure 6).

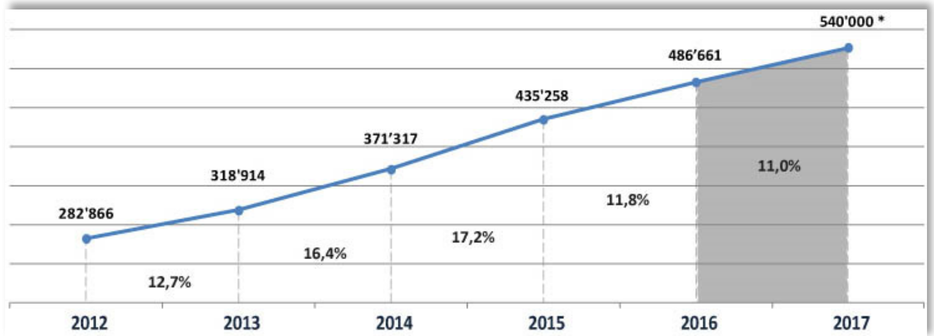


Figure 6. *The trend of installed wind farm capacity growth for the period 2012-2017 (Source: WWEA, 2017).*

As can be seen in Figure 6, and based on the data provided by the World Wind Energy Association (WWEA), the global installed wind farm capacity reached 486.661MW by the end of 2016, of which 63.690MW in 2015, and 54.846MW in 2016. This represents a growth rate of 17.2 per cent in 2015, when the current record was set in terms of new capacities, and 11.8 per cent in 2016. All the wind farms installed around the world by the end of 2016 generate about 5 per cent of the global demand for electricity, and it is predicted that the growth in 2017 will be a further 11 per cent, which means that the total installed wind farm power at the global level will reach 540,000MW at the end of 2017. China and Latin America increased their share in the new installations to 53 per cent in 2016 so the latest data suggest that the share per continent would look like in Figure 7 below:

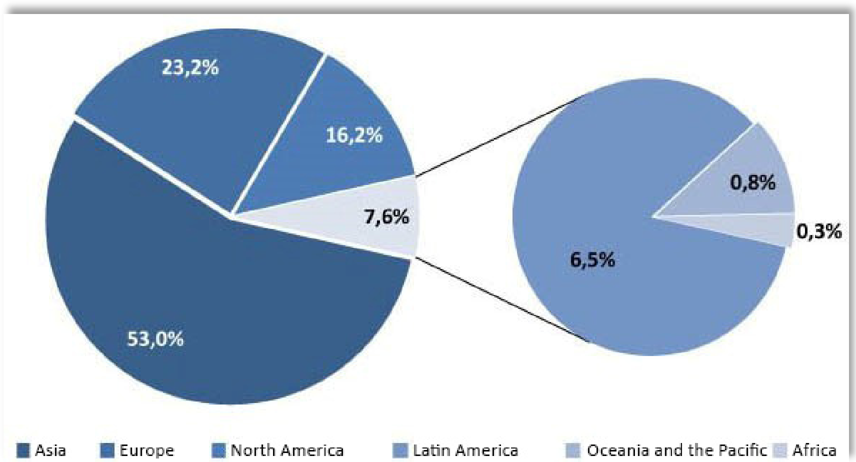
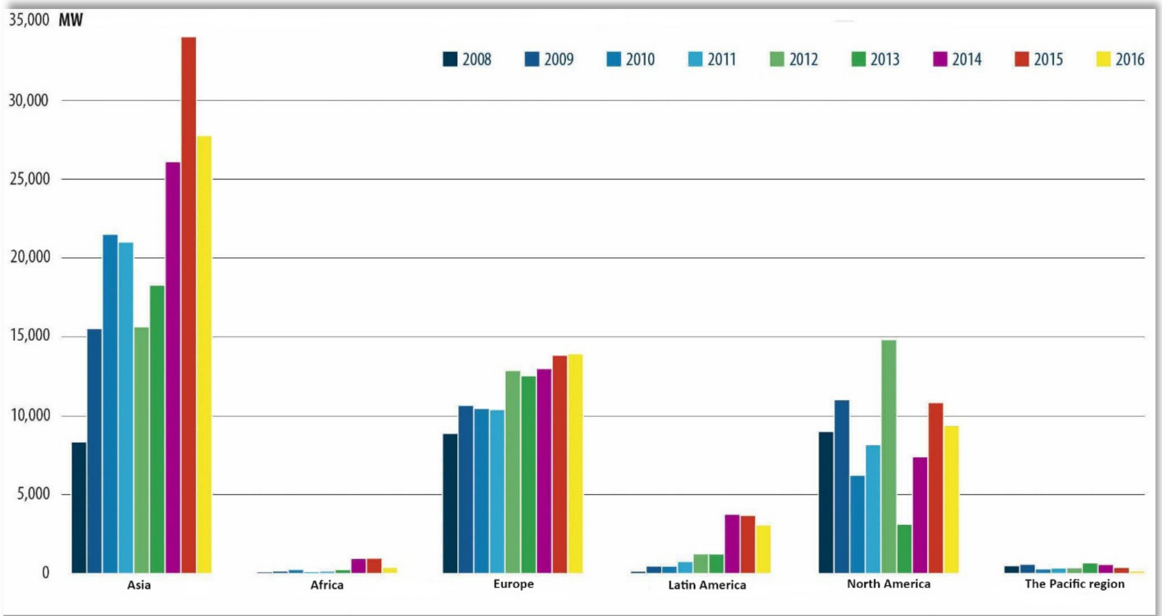


Figure 7. *The share of new capacities in wind farms per region in 2016 (%) (Source: WWEA, 2017).*



	2008	2009	2010	2011	2012	2013	2014	2015	2016
Asia	8,320	15,507	21,481	20,981	15,624	18,252	26,058	33,962	27,721
Africa and the Middle East	96	251	153	8	131	240	934	953	418
Europe	8,851	10,660	10,466	10,393	12,862	12,524	12,988	13,831	13,926
Latin America	128	471	459	771	1,248	1,240	3,744	3,678	3,079
North America	8,969	11,008	6,208	8,137	14,807	3,112	7,382	10,829	9,359
The Pacific region	482	578	294	345	358	655	568	381	140
	28,854	**38,475**	**39,061**	**40,635**	**45,030**	**36,023**	**51,674**	**63,634**	**54,642**

Figure 8. *The annual installed capacity per region for the period 2008-2016 (Source: GWEC, 2017).*

It is interesting to track the changing trends in installed capacity per region, shown in Figure 8 for the period 2008-2016. In 2008, Europe and North America were in the lead in wind power, followed closely by Asia. From 2009 on, Asia had a tremendous growth continuing to the present day, taking the lead in wind power owing first and foremost to China and India. At the same time, Europe maintains a constant development trend, without major fluctuations, in contrast to North America, where the fluctuations are more prominent. Latin America has a noticeable growth from 2014 onwards, while Africa and the Pacific region lag considerably behind the other regions.

Per state, region, or area in which wind power is commercially used (Table 1), two growing trends are evident: (1) The increase in the number of states using wind power commercially; and (2) the increase in the installed capacity per state. Therefore, it can be concluded that the global growth rate in constant on all counts in recent years.

Table 1. *The list of countries using wind power commercially (Source: WWEA, 2016).*

Position in 2016	State/region	Total capacity at end of 2016 (MW)	New capacity in 2016 (MW)	Growth rate in 2016 (%)	Installed capacity per Capita W/person	Installed capacity per km^2 (Kw/km^2)	Total capacity at end of 2015 (MW)
1	China	168,730	23,369	14.0	123.7	18.0	148,000
2	USA	82,033	8,203	8.3	257.7	9.0	73,867
3	Germany	50,019	5,443	10.7	617.7	143.5	45,192
4	India	28,279	3,520	14.2	21.8	9.5	24,759
5	Spain	23,020	34	0.1	495.3	46.0	22,987
6	United Kingdom	14,512	898	6.6	224.8	60.0	13,614
7	France	12,065	1,772	17.2	182.2	22.0	10,293
8	Canada	11,898	693	6.2	334.7	1.3	11,205
9	Brazil	10,800	2,085	23.9	52.4	1.3	8,715
10	Italy	9,257	282	3.3	152.3	31.5	8,958
11	Sweden	6,493	464	7.7	669.6	15.9	6,029
12	Turkey	6,081	1,363	28.9	80.1	7.9	4,718
13	Poland	5,782	682	13.4	152.1	18.9	5,100
14	Portugal	5,316	268	5.3	509.5	57.9	5,050
15	Denmark	5,227	220	3.2	927.0	123.2	5,064
16	The Netherlands	4,328	887	26.1	256.6	128.5	3,431
17	Australia	4,326	140	3.3	184.3	0.6	4,186
18	Mexico	3,709	426	13.0	29.6	1.9	3,283
19	Japan	3,234	196	6.4	25.4	8.9	3,038
20	Romania	3,028	52	1.8	152.1	13.2	2,976
21	Ireland	2,830	384	13.7	613.1	41.1	2,489
22	Austria	2,632	228	9.1	308.0	31.9	2,412
23	Belgium	2,386	117	7.1	212.4	78.8	2,229
24	Greece	2,374	239	10.3	218.4	18.4	2,152
25	Finland	1,539	570	53.1	281.8	5.1	1,005
26	South Africa	1,471	418	39.7	27.2	1.2	1,053
27	Chile	1,424	491	52.6	80.2	1.9	933
28	Uruguay	1,210	354	41.4	353.9	6.9	856
29	South Korea	1,031	198	23.6	20.4	10.6	834
30	Norway	838	16	-	16.6	2.3	838
31	Egypt	810	-	-	6.9	0.6	810
32	Morocco	795	-	-	23.4	1.8	795
33	Bulgaria	691	-	-	95.7	6.4	691
34	Chinese Taipei	682	35	5.4	29.1	18.8	647
35	New Zealand	623	-	-	138.1	2.4	623

Position in 2016	State/region	Total capacity at end of 2016 (MW)	New capacity in 2016 (MW)	Growth rate in 2016 (%)	Installed capacity per Capita W/person	Installed capacity per km^2 (Kw/km^2)	Total capacity at end of 2015 (MW)
36	Pakistan	591	335	130.9	3.2	0.8	256
37	Ukraine	559	45	8.8	12.3	1.0	514
38	Lithuania	493	69	16.2	168.1	7.9	424
39	Croatia	423	34	-	99.7	7.6	423
40	Hungary	329	-	-	33.4	3.6	329
41	Ethiopia	324	-	-	3.3	0.3	324
42	Estonia	310	7	2.3	236.1	7.3	303
43	Costa Rica	297	29	10.8	62.4	5.8	268
44	Czech Republic	282	-	-	26.7	3.6	282
45	Argentina	279	-	-	6.5	0.1	279
46	Panama	270	-	-	69.8	3.6	270
47	Tunisia	245	-	-	22.3	1.6	245
48	Peru	245	97	65.5	7.9	0.2	148
49	Thailand	223	-	-	3.3	0.4	223
50	Philippines	216	-	-	2.2	0.7	216
51	Nicaragua	186	-	-	30.9	1.5	186
52	Honduras	176	-	-	22.1	1.6	176
53	Cyprus	158	-	-	136.5	17.0	158
54	Vietnam	151	16	11.9	0.4	0.1	135
55	Dominican Republic	135	50	58.0	13.0	2.8	85
56	Puerto Rico	125	-	-	35.2	14.1	125
57	Jordan	119	-	-	17.9	1.3	119
58	Iran	118	-	-	1.5	0.1	118
59	Guatemala	76	26	51.8	4.7	0.7	50
60	Switzerland	75	20	24.4	9.2	1.9	60
61	Jamaica	72	24	50.3	26.4	6.6	48
62	Latvia	68	-	-	34.1	1.1	68
63	Sri Lanka	63	-	-	3.0	1.0	63
64	Luxembourg	58	-	-	104.3	22.4	58
65	Mongolia	51	-	-	17.5	-	51
66	New Caledonia	38	-	-	143.6	2.1	38
67	Macedonia	37	-	-	17.8	1.4	37
68	Aruba	30	-	-	290.0	166.7	30
69	Venezuela	30	-	-	1.0	-	30
70	Bolivia	27	27	-	-	-	0

Position in 2016	State/region	Total capacity at end of 2016 (MW)	New capacity in 2016 (MW)	Growth rate in 2016 (%)	Installed capacity per Capita W/person	Installed capacity per km^2 (Kw/km^2)	Total capacity at end of 2015 (MW)
71	Guadalupe	27	-	-	66.4	16.5	27
72	Cape Verde	26	-	-	49.6	6.3	26
73	Reunion Island	23	-	-	27.7	9.3	23
74	Georgia	21	21	-	-	-	-
75	Colombia	20	-	-	0.4	-	20
76	Ecuador	19	-	-	1.2	0.1	19
77	Faroe Islands	18	-	-	379.5	13.1	18
78	Russia	17	-	-	0.1	-	17
79	Guyana	14	-	-	17.7	0.1	14
80	Curaçao	12	-	-	77.0	27.0	12
81	Cuna	12	-	-	1.0	0.1	12
82	Bonaire	11	-	-	620.4	36.7	11
83	Mauritius	11	-	-	7.9	5.1	11
84	Algeria	10	-	-	0.3	-	10
85	Fiji	10	-	-	11.3	0.5	10
86	Serbia	9.9	-	-	1.4	0.1	9.9
87	Dominica	7.2	-	-	99.5	9.6	7.2
88	Israel	6.0	-	-	0.7	0.3	6.0
89	Slovenia	3.4	-	-	1.6	0.2	3.4
90	Belarus	3.4	-	-	0.4	-	3.4
91	Nigeria	3.2	-	-	-	-	3.2
92	Island	3.0	-	-	9.2	-	3.0
93	Slovakia	3.0	-	-	0.6	0.1	3.0
94	Vanuatu	3.0	-	-	11.6	0.2	3.0
95	Saint Kitts and Nevis	2.2	-	-	40.0	8.5	2.2
96	Bangladesh	2.0	-	-	-	-	2.0
97	Azerbaijan	2.0	-	-	0.2	-	2.0
98	Kazakhstan	2.0	-	-	0.1	-	2.0
99	Antarctica	1.6	-	-	-	-	1.6
100	Indonesia	1.4	-	-	-	-	1.4
101	Madagascar	1.2	-	-	0.1	-	1.2
102	Martinique	1.1	-	-	2.7	1.0	1.1
103	Falkland Islands	1.0	-	-	341.1	0.1	1.0
104	UAE	0.9	-	-	0.1	-	0.9
105	Eritrea	0.8	-	-	0.2	-	0.8

Position in 2016	State/region	Total capacity at end of 2016 (MW)	New capacity in 2016 (MW)	Growth rate in 2016 (%)	Installed capacity per Capita W/person	Installed capacity per km^2 (Kw/km^2)	Total capacity at end of 2015 (MW)
106	Grenada	0.7	-	-	6.6	2.1	0.7
107	St Pierre and Miquelon	0.6	-	-	98.7	2.5	0.6
108	Syria	0.6	-	-	-	-	0.6
109	Samoa	0.5	-	-	2.6	0.2	0.5
110	Namibia	0.2	-	-	0.1	-	0.2
111	North Korea	0.2	-	-	-	-	0.2
112	Afghanistan	0.1	-	-	-	-	0.1
113	Nepal	0.1	-	-	-	-	0.1
	Total	**486,661**	**54,846.2**	**11.8**			**435,258.1**

Among the 15 leading countries in terms of installed wind farm capacity (Table 2), the following countries had the greatest growth rate, standing at over 10 per cent in 2016: Turkey (28.9%), Brazil (23.9%), France (17.2%), India (14.2%), China (14%), Poland (13.4%), and Germany (10.7%). As regards new capacity in 2016, the order is slightly different: China is in the lead, with what is by far the greatest installed capacity (23.369MW), followed by: USA (8,203MW), Germany (5,443MW), India (3,520MW), France (1,772MW) and Turkey (1,363MW). It is evident that China has confirmed its role of global leader in wind farm use, with nearly 29% of the total power produced in wind farms around the world. On the other hand, Spain, which used to be one of the leading countries in the wind power industry, stands apart in this list by its exceptionally low growth rate of only 0.1 per cent, which means 34MW in terms new 2016 capacities.

Table 2 also shows that the 15 leading countries in terms of installed wind farm capacity produce around 90 per cent of the total wind farm power, and that the growth in 2016 nears 11 per cent in these leading states.

Table 2. *The list of 15 countries with the greatest installed wind farm capacity (Source: WWEA, 2016).*

Position in 2016	State/Region	Total capacity at end of 2016 (MW)	New capacity in 2016 (MW)	Growth rate in 2016 (%)	Total capacity at end of 2015 (MW)
1	China	168,730	23,369	14.0	148,000
2	USA	82,033	8,203	8.3	73,867
3	Germany	50,019	5,443	10.7	45,192
4	India	28,279	3,520	14.2	24,759
5	Spain	23,020	34	0.1	22,987
6	UK	14,512	898	6.6	13,614

Position in 2016	State/Region	Total capacity at end of 2016 (MW)	New capacity in 2016 (MW)	Growth rate in 2016 (%)	Total capacity at end of 2015 (MW)
7	France	12,065	1,772	17.2	10,293
8	Canada	11,898	693	6.2	11,205
9	Brazil	10,800	2,085	23.9	8,715
10	Italy	9,257	282	3.3	8,958
11	Sweden	6,493	464	7.7	6,029
12	Turkey	6,081	1,363	28.9	4,718
13	Poland	5,782	682	13.4	5,100
14	Portugal	5,316	268	5.3	5,050
15	Denmark	5,227	220	3.2	5,064
Total		**439,512**	**49,296**	**10.86**	**393,551**
The rest of the world		**47,149**	**5,550.2**	**11.8**	**41,707.1**

Such a dynamic growth of the wind power sector is accompanied by the development of technologies used in wind farms. Today, individual wind turbines with the capacity of 2, 3, 4, 5, 6 MW … (up to 8MW for offshore wind farms) are in commercial use and are most widespread in the wind farm market. They are mounted in large wind farms and thus enable the production and connection to the national transport grids of over 1GW of electricity per wind farm (Wind Energy Foundation, 2016). Table 3 provides a list of the biggest wind farms in the world, citing their installed power.

Table 3. *Some of the biggest wind farms in the world (Source: Forbes, 2017).*

No.	Name of wind farm	Location	Installed power (MW)
1	Gansu Find Farm	Gansu province, China	6.000
2	Muppandal Wind Farm	Tamil Nadu, India	1.500
3	Shepherds Flat	Gilliam and Morrow, Oregon	845
4	Roscoe Wind Farm	Roscoe, Texas	782
5	Horse Hollow Wind Energy Center	Taylor and Nolan, Texas	735
6	Alta Wind Energy Center	Kern County, California	720
7	Capricorn Ridge Wind Farm	Sterling and Coke, Texas	662
8	London Array Offshore	Thames estuary, UK	630
9	San Gorgonio Pass Wind Farm	Riverside County, California	615
10	Fowler Ridge Wind Farm	Benton County, Indiana	600
11	Sweetwater Wind Farm	South Texas	585
12	Whitelee Wind Farm	East Renfewshire, Scotland	539
13	Buffalo Gap Wind Farm	Taylor and Nolan, Texas	523
14	Dabancheng Wind farm	Xinjiang province, China	500

If we take a look at the share of wind power in the total production of electricity from renewable sources, it is noticeable that this sort of analysis may lead us to conclude that this sector has a significant role to play, the sort of role attained in 2016 as part of projects using different forms of renewable energy. The share of power produced in wind farms reached 4 per cent in 2016 (Figure 9), and all projections point to the likelihood of this percentage increasing considerably in the near future.

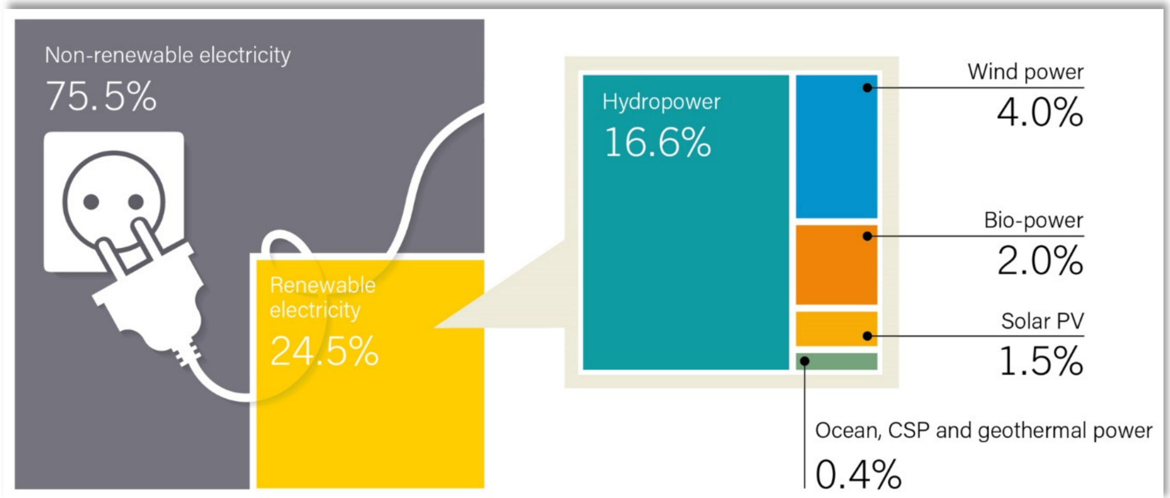


Figure 9. *The share of wind power in the total global production of power from renewables (Source: REN21, 2017).*

By way of summary of the global trends in wind power use, it could be said that the wind power sector has become globally very important and relevant in recent years. While Asian countries (especially China) are leading the way, USA and Germany are right behind them. This is good news not just for the member states of the European Union and the US, but also for the developing nations who should be access and use this form of energy more easily in the upcoming period. This can certainly be achieved through projects like SWERA[1], combined with financial support, which may turn poor states towards renewables, such as wind power.

[1] The UN have been in the development of wind power through the SWERA project (*Solar Wind and Energy Resource Assessment*), which is geared towards locating the areas suitable for using wind power and creating maps of possible areas where wind and solar power can be used in 13 developing nation around the world. This project has already identified a number of suitable areas with a potential of several thousand megawatts in Africa, Asia, and South America. Among the most suitable states is the African state of Ghana, which has locations for wind power use with a potential of over 2,000MW. Steps are also being taken in states such as Kenya, Nepal, Ethiopia, Brazil and many other. If the UN programmes result in the construction of wind farms, this would be very important not just from the standpoint of energy, but also the environment. All these things together should direct the developing nations towards renewables and so reduce the pressure on fossil fuels.

2.2.2. Using wind power in Europe

Wind power had humble beginnings in Europe, with the 'pioneer-countries' (Denmark, Spain, Germany, etc.) using it over 30 years ago. The 1990s and early 2000s saw wind power use spreading across Europe, helped by the 2002 European Parliament Directive (2001/77/EC), which stimulated the use of renewables, especially wind power, in an increasing number of European countries. The renewables directive lays down the general policy for the production and promotion of renewable energy in the EU. It requires that the EU member-states (as well as the states that see themselves as future EU members) cover a minimum of 20 per cent of their total energy needs from renewable energy sources by 2020, and that this goal is attained by reaching individual national objectives. All EU states must also ensure that a minimum of 10 per cent of their transport fuel comes from renewable energy sources by 2020. This Directive also envisages the duty of the electricity transmission and distribution grid operators to guarantee access to renewable energy producers, i.e. that these producers must be prioritized in joining the transmission and distribution grid (Wind Europe, 2017).

Directive No. 2009/28/EC of the European Parliament and Council, dated 23 April 2009, on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, establishes a framework for the promotion of energy form renewable sources. This Directive defines mandatory national objectives regarding the share of renewable energy in the total final energy consumption as well as the share of renewable energy in transport. It sets the rules for the statistical transfers between member states, joint projects between member states and those implemented with third countries, the guarantees of origin, administrative procedures, information on transport and access to electricity grids for energy from renewable sources. Directive No. 2009/98/EC has been in effect since 1 January 2012.

On 30 November 2016, the European Commission announced the draft of the revised directive on renewable energy sources, according to which the EU should reach the goal of producing 27 per cent of total power from renewable sources by 2030.

Today, 10.4 per cent of energy in the EU is obtained from wind power, with higher percentages in several countries (Denmark 42 per cent, Spain 20 per cent, Germany 13 per cent). Wind power is becoming more competitive in terms of installed capacity as well, compared to other forms of energy, but also economically, which additionally stimulates the development of the energy sector.

The current share of total installed capacity in Europe at the global level is shown in Figures 7 and 8. The trends indicate that the rise in global installed capacity has put Europe in second place, immediately following Asia, with growth standing at 23.2 per cent in 2016.

As many as ten European countries can be found in the fifteen leading countries in terms of installed wind farm capacity, with the total installed capacity at 137.772 MW at the of 2016 – around 35 per cent of the total installed capacity at the global level (Table 4).

Table 4. *The list of European countries which are in the 15 countries with the greatest installed wind farm capacity in the world (Source: WWEA, 2016).*

Position in 2016	State/region	Total capacity at end of 2016 (MW)	New capacity in 2016 (MW)	2016 growth rate (%)	Total capacity at end of 2015 (MW)
1	Germany	50,019	5,443	10.7	45,192
2	Spain	23,020	34	0.1	22,987
3	United Kingdom	14,512	898	6.6	13,614
4	France	12,065	1,772	17.2	10,293
5	Italy	9,257	282	3.3	8,958
6	Sweden	6,493	464	7.7	6,029
7	Turkey	6,081	1,363	28.9	4,718
8	Poland	5,782	682	13.4	5,100
9	Portugal	5,316	268	5.3	5,050
10	Denmark	5,227	220	3.2	5,064
Total		**137,772**	**11,426**	**9.64**	**127,005**

As Table 4 indicates, the European leaders in terms of installed capacity are: Germany (50,019MW), Spain (23,020MW), United Kingdom (14,512MW), France (12,065MW) and Italy (9,257MW).

The European states with the highest rate of installed capacity growth: Germany (5,443MW), France (1,772MW), Turkey (1,363MW) and the Netherlands (887MW).

According to the most recent available data for 2016 (Wind Power – 2016 European Statistics, 2017), as much as 12.5 GW has been installed in the new wind farms. These figures reveal that wind farms have been installed more than any other electricity producing facility in Europe in 2016. Wind farms made up 51 per cent of the total installed capacity and in this way contributed significantly to the 86 per cent-share that renewable energy has in the total number of new power plants in the EU in 2016: 21.1 GW of the 24.5 GW total new capacities. With nearly 300 TWh generated in 2016, wind power covers 10.4 per cent of the demand for electricity in the EU. There are currently 153.7 GW installed in wind farms.

Although growing trends in the European energy sector are evident and constant[2], and are at their most constant as regards continents and regions in the last decade (Figure 8), a question can be asked whether Europe can keep up with the wind power sector development trends in other continents. The reason for this is primarily that Europe does not have available locations for new wind farms, or locations with complementary activities in the surroundings (at the micro-location level), unlike most other continents and regions. However, this is not the case with wind farm equipment industry, in which the following states still play an important role: Denmark, which features one of the leading wind turbine industries (Vestas and Siemens); Germany (Enercon); and Spain (Gamesa). Together, these states make up one third of the global wind turbine market. The assumption is that European wind turbine industry will continue to develop and be a world leader, alongside China.

2.2.3. Using wind power in the Republic of Serbia

The energy deficit and the inevitability of using ecologically clean energy sources, as well as adherence to the duties following from European directives and other international obligations in this sector, have slowly been pushing Serbia towards investments in the development and exploitation of wind power. The energy development strategy of the Republic of Serbia by 2025, with projections until 2030 (The Official Gazette of the Republic of Serbia, No.101/25), followed by the Regulation on the Programme of Implementation of the Energy Development Strategy of the Republic of Serbia by 2025 with projections until 2030 (The Official Gazette of the Republic of Serbia, No. 104/17) provide enough space for wind power (and renewable energy source in general) and create the conditions for an accelerated development of this energy sector. Specifically, the Regulation on the Programme of Implementation of the Energy Development Strategy pays special attention to the project of constructing new wind farms with the total power of up to 500MW in the Republic of Serbia as a priority project in the area of renewable energy sources, to be implemented in a six-year period (by 2023). The installed wind farm power of 500 MW in the Republic of Serbia would push Serbia up from its 86th place in the world, with 9.9 MW installed. The potentials for this are discussed below.

[2] European wind power sector has demonstrated in the last decade its ability to grow at a high rate, maintaining the annual market of +10GW since 2009, with an average annual market at 11.3 GW. After a possible 2017 record (14 GW), growth might continue at 12.6 GW on average in the next four years.

2.2.3.1. The potential and suitable locations for using wind power in Serbia

Serbia is classified as a region with an energy potential. Earlier research of the energy potential of wind were mostly based on data from weather measuring stations. Based on investigations and wind measurements carried out by the Republic Hydrometeorological Institute of Serbia, areas with a good potential for wind power as well as suitable locations for wind farms in Serbia are the mountainous regions of South and East Serbia, especially the Kossava area of the Pannonian Plain. The Pannonian Plain, north of the Danube, with around 2,000 km^2, is suitable for the construction of wind farms, as it has developed road and electricity generation and distribution systems in addition to the wind power potential.

This comparatively favourable assessment of the wind power potential has led to further exploration of the wind farm (solar power plant) construction potential. As a result, the Study of the Energy Potential of Serbia for Utilizing Solar Radiation and Wind Energy was drawn up (NPEE, record No. EE704-1052A), ordered by the Ministry of Science and Environmental Protection, and implementer the Centre for Multidisciplinary Studies of the University of Belgrade in November 2004.

The results of this study, obtained through a precise analysis of the available measurement data and assessments, show that Serbia has above-average wind power and solar radiation resources, as compared with the countries of continental Europe. The results also demonstrate that Serbia has the advantage of the complementarity of the wind power time distribution, which is very important for covering ‘spikes’ in the general electricity consumption.

Based on the results obtained, a mapping of the area was carried out as part of the study, indicating the energy potential of the Republic of Serbia in the area of wind power. Wind strength and energy maps (Figures 10 to 13) were made for January, July, and the entire year for the territory of the Republic of Serbia.

The map-making methodology followed those in the European Wind Atlas (CEC, 1989), based on synoptic climatology. The effects of topography are included here indirectly only, to the extent to which it affects the measurement data, as maps only reflect the data collected by weather measurement stations, found primarily at low altitudes.

As the wind measurements were made at 10m, the values at 100m above ground level were calculated using the wind profile equation and the data on the surface asperity. The wind data are from the period 1971-1990. Below are the results of the 2004 study.

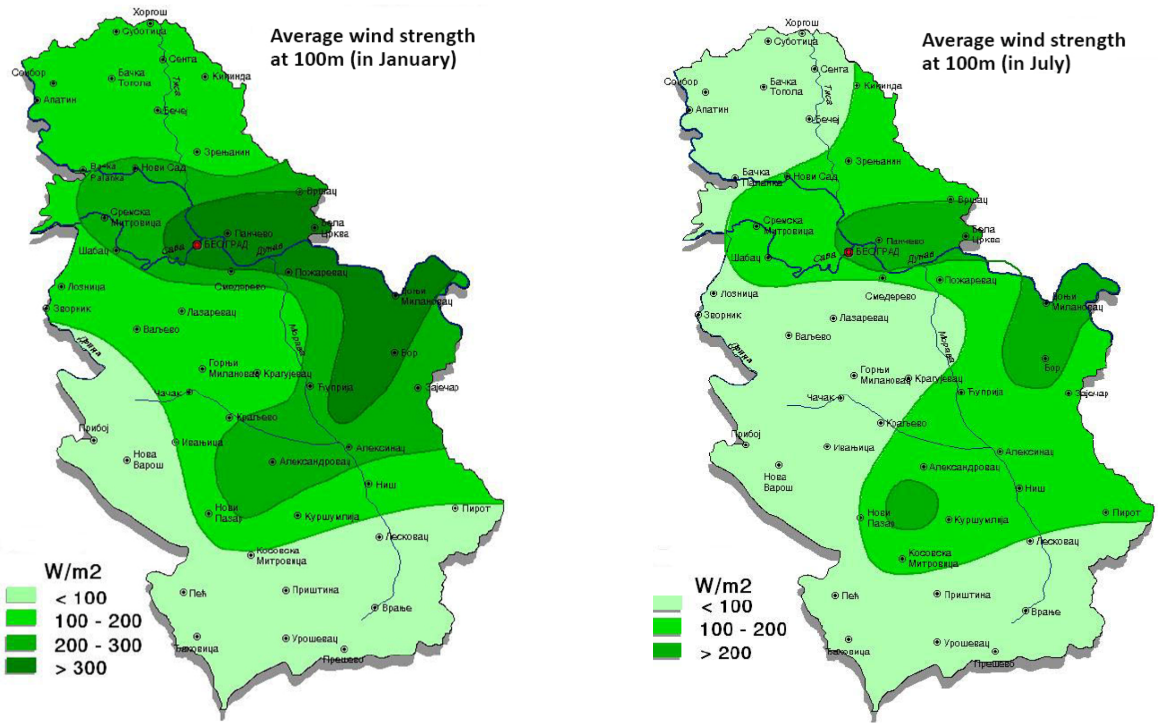


Figure 10. *The average wind strength (W/m^2) at 100m in January and July (Source: SEPS, 2004).*

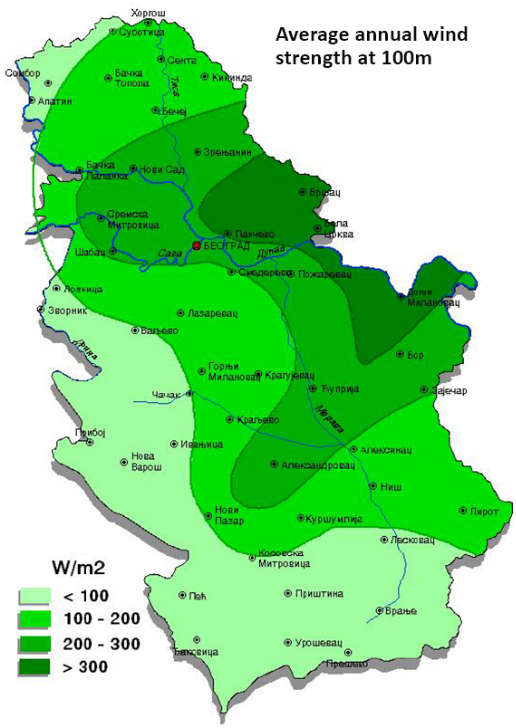


Figure 11. *The average wind strength (W/m^2) at 100m for the entire year (Source: SEPS, 2004).*

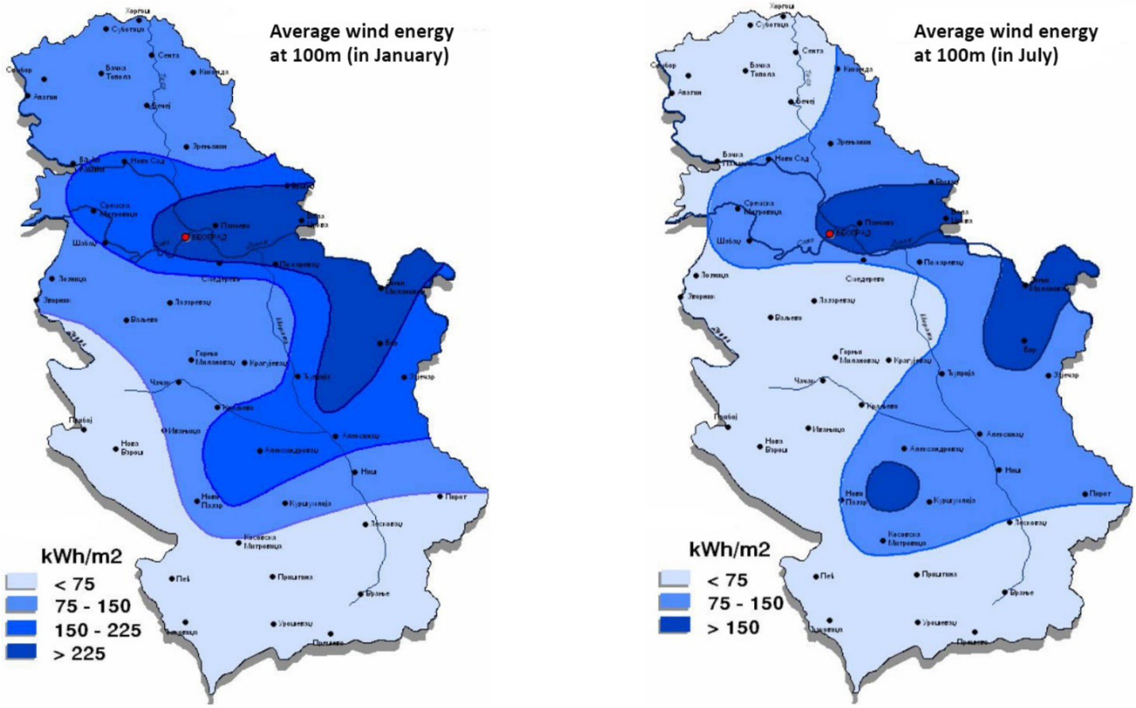


Figure 12. *The average wind energy (kWh/m^2) at 100m in January and July (Source: SEPS, 2004)*

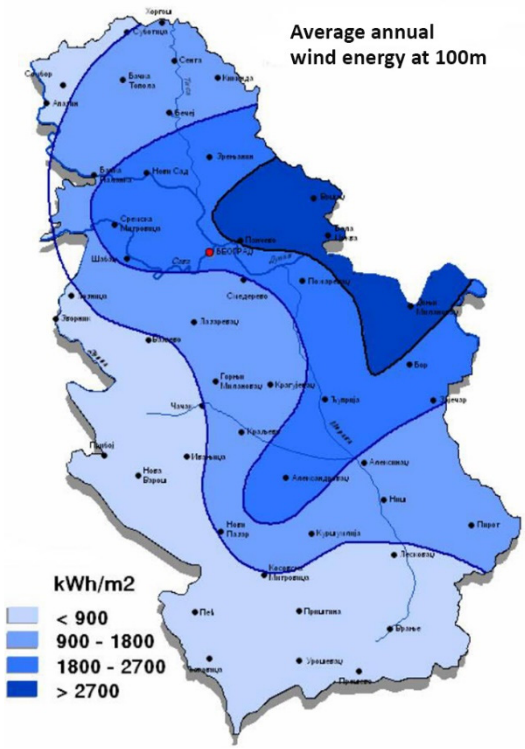


Figure 13. *The average annual wind energy (kWh/m^2) at 100m (Source: SEPS, 2004).*

Figure 10 shows that the maximal wind strength values in January in the lower Danube Basin and East Serbia. Specifically, the areas covered by the isoline 300W/m^2 include South Banat, the southern bank of the Danube from Belgrade to Negotin, as well as the Timok valley with the surrounding mountains. July is similar to January, but with lower values. The 200W/m^2 isoline has a similar shape as the 300W/m^2 in January, except that the Kopaonik area stands out due to the values higher than its immediate surroundings.

As regards the average annual wind strength (W/m^2) at 100m, it is less than in January, so the annual 300W/m^2 isoline does not include the city of Belgrade, or the towns of Požarevac and Bor, as is the case in January (Figure 11).

Figure 12 shows the average total wind energy (kWh/m^2) for January and July, also at 100m above ground level. The maximal values of the total wind energy in January can be seen in the lower Danube Basin area and East Serbia. The area covered by the 225 kWh/m^2 isoline includes South Banat, the south bank of the Danube from Belgrade to Negotin, and the Timok valley with the surrounding mountains. July is similar to January, but with lower values. The 150 kWh/m^2 isoline has a similar shape to the 300 kWh/m^2 line in January, except that the Kopaonik area stands out due to the higher values than its immediate surroundings.

Figure 13 shows the total annual wind energy (kWh W/m^2) at 100m above ground level. The annual value is a sum of 12 monthly energy sums. The annual isoline of 2700kWh/m^2 does not include Belgrade, Požarevac, and Bor, but it is in close proximity.

The results of the Study of the Energy Potential of Serbia for Utilizing Solar Radiation and Wind Energy (SEPS) served as the basis for a great many investors to start conducting precise measurements by mounting anemometers (wind measurement devices) on specific micro-locations found in areas assessed as favourable as per the results of the Study, where wind farm construction is planned.

2.2.3.2. Problems in implementing wind farm projects in Serbia

Problems in implementing wind farm projects in Serbia are many, and the present author has opted for tacking them descriptively, focusing on key problems, and based on the experience gained in implementing a great many projects in the Republic of Serbia as well as the region. It is not the intention of the author to criticise, but to delineate a personal view of the issues in good faith, and to point out the problems that slow down the wind power development dynamic in Serbia. The aim is to remove these problems in the future, speeding up the investments in this energy sector. Further, it is possible that some of the problems are already being solved (overcome), or that they were removed while this book was in publication.

Although at first it may appear that implementing a wind farm is simple, as it does not include traditional construction, but the mounting of equipment already manufactured elsewhere, this is not the case in Serbia. The root of all problems is a complicated procedure for issuing the necessary documentation (planning and technical) and permits, and the inefficacy of the administration.

According to the report of the World Bank (2017), Serbia has risen by four places in the Doing Business list (2017) and is now in the 43rd place. It is also in the first 34 countries in the list to improve its business environment in three or more areas in 2016 and 2017. For example, the DTF (distance to frontier) of Serbia has gone up to 73.13 points, compared to last year's 72.87, as starting a business in the country has become easier and the administration system has been improved, facilitating entering into contracts, the World Bank report states. Serbia is in the 10th place in terms of obtaining construction permits, rising by 150 places in the Doing Business list of the World Bank in the past three years, as per the construction permit issuance criterion.

However, the procedure of issuing the necessary documentation, the competent institutions' requirements, and permits still takes too long, and can be unpredictable and complicated, with many steps whose outcome is often uncertain. This is why all investors – those who have already started their projects, as well as those who are planning to – have a long and tiring road ahead of them, without any guarantee that the construction will be approved. Although this problem has long since been recognized by all the parties involved, the political structures, the administration, and investors, not enough has been done to resolve it.

Below are the most important problems in implementing wind farm projects in Serbia, divided into several groups:

1. Planning/urbanistic documentation;
2. Project (technical documentation);
3. Issuance of the relevant institutions' requirements;
4. Resolution of the legal property status of the land lot

<u>1. Planning/urbanistic documentation</u> – Preparing the planning documentation as the basis for implementing a wind farm project can be used as an example of the problems in wind farm projects in Serbia. As the sort of documentation that often needs to be drawn up separately for the purposes of implementing a wind farm, it involves a complex and lengthy procedure defined under the Law on Planning and Construction. Specifically, in many Serbian municipalities the existing spatial plans are inadequate for the construction of wind farms and renewable energy sources. This aspect is often treated only in the context of identifying the

potential for using renewable energy sources. This situation is often implied by the following: insufficient staffing in local self-governments, as a result of which the needs and possibilities for the development of a certain space are left unexplored; the impossibility for the planners and urbanists to identify the actual needs and possible difficulties in implementing wind farm projects; etc. As a result of this approach, often direct implementation is impossible based on planning/urbanistic documentation, as there are not enough elements for something like that. Consequently, in order to construct wind farms, investors must obtain the planning requirement for project implementation, by preparing a separate urban plan, which requires more time and funds, provided by the investor as a rule.

2. Project (technical documentation) – The procedure of preparing project documentation is conditional on finalizing the procedure of preparing and adopting the planning/urbanistic documentation and cannot be formally initiated before that. This project implementation phase includes a number of formal procedures and actions, as well as document preparation which can take a certain period of time. The procedure for the Study on Project Environmental Impact can be used as an illustrative example of a lengthy procedure, relevant as it is for the topic of the present volume. This study is a component part of the technical documentation and is prepared in line with the provisions of the following: The Law on Environmental Protection (The Official Gazette of the Republic of Serbia, No. 135/04, 36/09, 72/09 – 43/11 – Constitutional Court, and 14/2016); The Law on Environmental Impact Assessment (The Official Gazette of the Republic of Serbia, No. 135/04 and 36/09); and The Regulation on determining the list of projects for which an impact assessment is mandatory and the list of projects for which an environmental impact assessment can be required (The Official Gazette of the Republic of Serbia, No. 114/08). For wind farm projects, the Study on Project Environmental Impact is developed for wind farms whose installed power exceeds 10MW and is an integral part of the documentation required for obtaining a construction permit (The Law on Planning and Construction, The Official Gazette of the Republic of Serbia, No. 72/2009, 81/2009 – corr., 64/2010 – CC decision, 24/2011, 121/2012, 42/2013 – CC decision, 50/2013 – CC decision, 98/2013 – CC decision, 132-2014 and 145/2014). It entails the implementation of three (minimally two) procedural phases in preparing this document, with the transparent participation of institutional stakeholders, the general public, and the non-governmental sector. Conducting these procedures takes, from the experience of the present author, gained in preparing tens of such studies, no less than four months, although the law envisages as much as a year (The Law on Environmental Impact Assessment). If the fact that preparing this document depends on preparing the preliminary design is taken into account, it is clear that the length of this procedure is not something that investors interested in wind power would be happy about.

In addition, a separate problem in implementing wind farm projects is an inefficient and inappropriate procedure of obtaining the construction permit. This procedure does not treat wind turbines as typed devices, equipment and installations, for which certificates issued by international certification bodies or EU states would be accepted. Instead, according to the Law on Planning and Construction, due to the dimensions of the tower wind turbines are classified as building structures over 50m tall, which means that the project documentation must include the project for the tower, with all the calculations and checks in line with the bylaws of the Republic of Serbia. In objective terms, the tower as well as the other part and components of wind turbines, except the foundations and cabling, are not designed in Serbia, making it impossible for investors to obtain all the relevant data from the manufacturers in order for the projects to provide the required content in line with the rulebooks on technical document preparation. This is understandable, as there is quite a bit of profit-driven competition in the global market among wind turbine manufacturers. As a result, manufacturers tend to design and make increasingly taller towers, with longer propellers, and to use ever more powerful generators in order to utilize better the areas with less wind potential. By virtue of this very fact, the technical solutions, details, and calculations are a secret closely guarded from competitors and are mostly unavailable to investors working on projects.

<u>3. Issuance of the relevant institutions’ requirements</u> – In preparing the planning and technical documentation, it is necessary to carry out the procedures of obtaining the relevant institutions’ requirements. A problem arises related to the time needed to issue requirements, in itself a result of a complicated and lengthy procedure of issuing requirements by public enterprises in Serbia, in place as a rule for line objects such as overhead power lines or cables connecting wind turbines or wind farms to the transmission and distribution system. The procedure itself, wherein an authorized specialist draws up the requirements that the directors of various public enterprise sectors – often unavailable due to the nature of their work - need to then sign, causes delays and increases the length of time needed to obtain the requirements. Furthermore, most public enterprises request that the requirements for planning documentation be obtained separately, although they are roughly the same; nonetheless, the investor needs to tread the same ground twice. In addition, state agencies and public enterprises often go over the deadlines set under the law, and the investors and companies cannot speed up the procedure by contacting the public enterprise staff. Also, public enterprise and government ministry staffers often are not motivated by additional incentives to work more efficiently. The cause is sometimes objective and is to do with the lack of staff working on permit issuance. Taking into consideration the fact that obtaining relevant institutions’ requirements is carried out separately in the planning and designing processes, it is evident that this sort of approach poses great challenges for wind farm project investors.

4. Resolution of the legal property status of the land lot – Investors often face difficulties in establishing ownership over land lots and, as a result, in resolving the legal property status of the land in question, which is a condition for wind farm project implementation. The causes are many, ranging from the many years of not transferring ownership by private individuals in the inheritance procedure or in sales, to incorrect data in the land registry.

In addition to the above main problems in implementing wind farm projects in Serbia, there are problems related to the following: paying numerous taxes during project implementation; project funding; the possibility of obtaining the status of privileged manufacturer, etc., which touches on economics and would require a separate analysis well outside the scope of this book.

At any rate, all the problems listed above have long since been recognized by all the actors in the wind farm project implementation process (as well as in the process of implementing other investment projects) and are publicly discussed. This is certainly a good starting point for resolving most of these problems, which would go a considerable distance towards creating a better investment climate in the Serbian wind power sector.

3. THE IMPACT OF WIND FARMS ON THE ENVIRONMENT

Wind farms have an impact on the environment. The impact can be both positive and negative. In order to discuss possible impacts of wind farms on the environment, it is necessary to first understand how they operate.

3.1. Operation of wind farms

The wind farm complex (Figure 14) consists of the following functional subunits: wind turbine (wind mill), consisting of the generator unit (wind rotor/propeller, generator, tower, and foundation), the internal cabling network (underground cable lines), the substation with the command and control building (through which the wind farm is connected to the national distribution grid for delivering the produced electricity and from where the wind farm is operated) and access roads (physical access for the purposes of equipment transport, and wind turbine and substation construction and mounting; it can overlap with the internal cabling network in part or in full).

In this connection, it can be said that the wind farm complex consists of infrastructural facilities for the production of electricity (wind turbines), electricity transport facilities (the internal cabling network and the substation with the command and control building) and transport facilities (access roads).

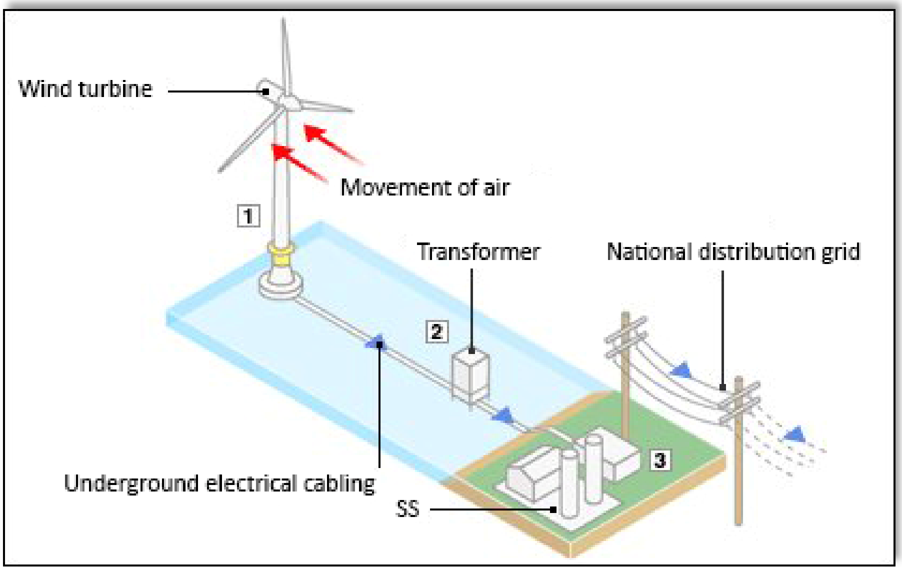


Figure 14. *The diagram representing wind farm operation.*

Each of the functional units of a wind farm has its role and special significance in the operation of the wind farm system, but the most spatially dominant, due to their size, are wind turbines. This makes them very important in terms of possible effects on the environment as well, which is important for the topic of the present volume. In this connection, special attention will be paid to the description of their operation in the text below. The appearance of a modern, commercially used wind turbine, with all the component parts, is shown in Figure 19.

Wind turbines consist of four main components:

1. Wind rotor/propeller;
2. Generator;
3. Tower, and
4. Foundation.

1. Wind rotors, i.e. wind turbine propellers generate kinetic energy by spinning due to the force of wind. The kinetic energy is then converted in the generator into mechanical energy. The wind turbine propellers can be several tens of meters long, depending on wind turbine power and manufacturer. The propeller tips can rotate at the speeds as high as nearly 200km/h, which points to great possibilities and potentials in the transformation of wind power. Essentially, wind turbines can move any type of a three-phase generator. The most common generator types are: synchronous with permanent rotor magnets and asynchronous with cage or wound rotors. Nominal generator voltage typically stands at 400 V or 690 V.

2. Generator is the most important functional unit of the wind turbine. It is a complex device (machine) for converting the kinetic energy of wind into mechanical energy. If mechanical energy is used directly in machines such as pumps or grain milling devices, they are referred to as windmills. If mechanical energy is converted into electricity, as is the case with wind turbines, they are referred to as generators. The conversion of wind power into electricity is done by means of the generator located in the nacelle (Figure 15). The generator converts the kinetic energy of the air created by the movement of the rotor blades (wind rotor/propeller), the transmission mechanism and the generator into electricity. The amount of energy the wind delivers to the rotor depends on a number of factors: air density; rotor surface area; wind speed; the propeller position with respect to the wind; propeller dimensions, i.e. its length.

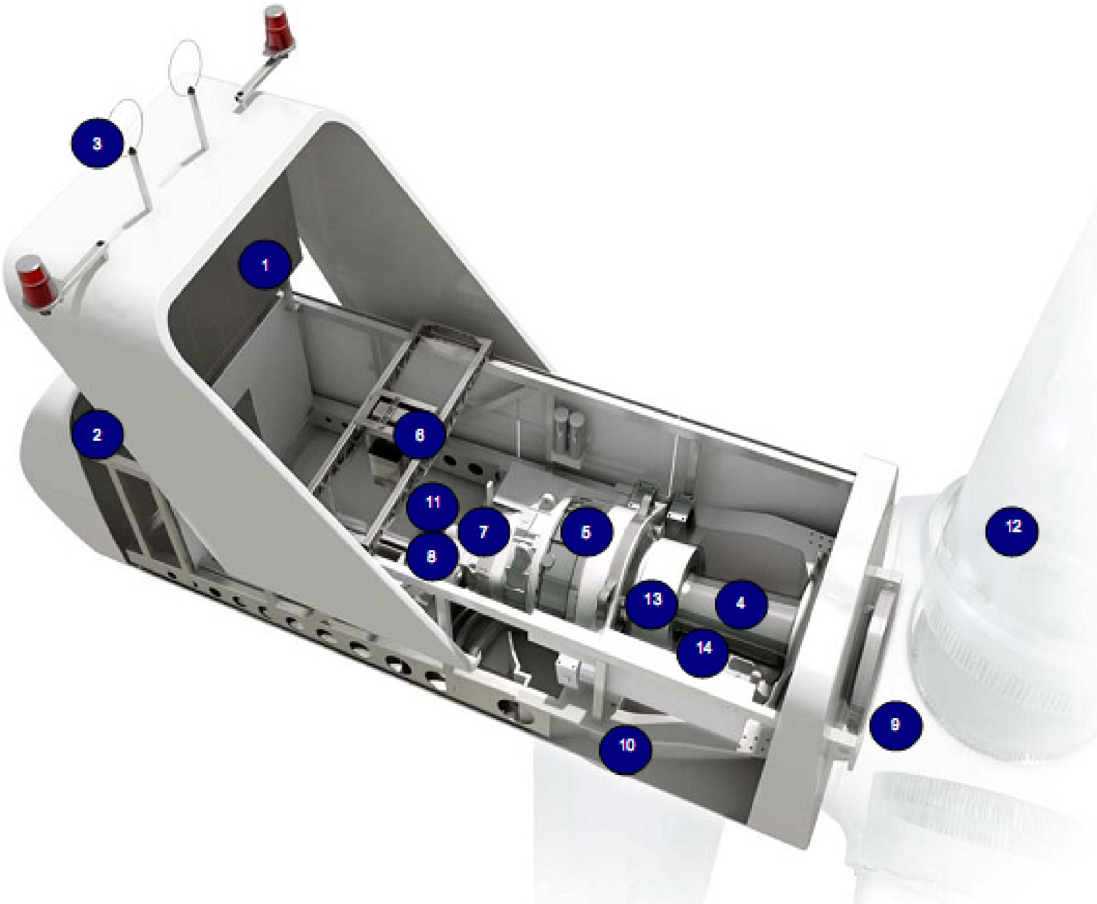


Figure 15. *A typical equipment layout in the nacelle – Vestas V112-3MW.*

The parts and functions of the generator shown in Figure 15 are as follows:

1. Heat exchanger.
2. Transformer. It is installed because of low nominal generator voltage and has the role of adapting the wind farm output voltage for connecting to the distribution system or for connecting the wind turbine generator to the substation (SS), in wind farms with a higher installed power (usually over 10MW).
3. Ultrasonic wind sensors/anemometer. It is used for measuring wind speed and direction, which is necessary for every wind farm in order to ensure efficient operation and control.

4. The main shaft (turbine shaft). The rotor of wind turbines in commercial use today consists of the propeller with three blades and the central cogwheel. The rotor cogwheel transfers the weight from the blades to the main bearing and contains bearings and hydro cylinders for resting and rotating the blades. The cogwheel is made from a steel cast. The rotor shaft transfers torque to the gearbox (multiplier). The shaft rests on the main bearings, oiled using a special automatic oiling system.
5. Gearbox/Multiplier – It allows for the low rotation speed of the wind propeller to be adapted to the high rotation speed of the generator. In multipole generators the gearbox can be omitted. The conversion ratio ranges from 30 to 200. The main issue generators have is lubrication – the same lubricant viscosity must be ensured in all weather conditions, which requires additional cooling and heating devices.
6. Service elevator. It is mounted in the wind turbine tower and used for transporting staff and materials inside the wind turbine, as well as in mounting, inspecting and repairing the wind turbine.
7. The brake assembly. It is used in planned wind farm (wind turbine) operation stops in high wind conditions (usually 25m/s and above, due to the high dynamic load) or in incidents. There are several types of brakes: aerodynamic, disk brakes, electromagnetic, etc. Braking is effected by selecting the angle of the blade with respect to wind speed and direction. Disk brakes are the most common brake systems (operated in modern devices via a microprocessor) and is located on the slow-rotating shaft in front of the gearbox, or on the fast-rotating generator shaft. In selecting the number of brake elements on the brake disk, the focus is on avoiding the imbalance of the angular forces of braking and ensuring propeller load via the braking moment only. They can be electromagnetic or hydraulic, and they are activated by a generator signal (due to grid connection loss, i.e. circuit interruption) or a signal from a device measuring the generator rotation speed.
8. Connector. It is used to transfer torque weight from the gearbox to the generator. A low-speed connector is a standard cone-shaped disk ensuring the necessary contact pressure in the overlapping axle connection, in order to transfer the torque and bending moment from the main axle to the gearbox.
9. Propeller/rotor cogwheel. It is used for transferring the weight from the blades to the main bearing and contains bearings and hydro cylinders for resting and rotating blades. Cogwheels are made from steel casts. The rotor shaft transfers torque to the gearbox (multiplier). The shaft rests on the main bearings, oiled using a special automatic oiling system.
10. The equipment supporting structure - nacelle.

11. Converter. It manages the conversion of am alternating frequency power at the generator into an AC power constant frequency, reaching the desired level of the active and reactive power which is suitable for the grid (at the point of connection).
12. Propeller blade – it is made from plastic-reinforced fiberglass (polyester or epoxy). Carbon fibres and Kevlar can also be used as reinforcements. They can be several tens of meters long, and their length depends on the wind turbine (propeller) strength and the equipment manufacturer.
13. Disk.
14. Hydraulic station. It provides pressure for the yaw drive and the braking assembly.

3. Tower. Wind turbine tower carries the nacelle, i.e. the wind turbine and its propellers. There is a tendency in the market to increase the height of the tower (typically over 100m) as wind speed rises in step with height. By applying this sort of conception, the number of suitable areas for the construction of wind farms goes up, as the areas with a relatively low wind intensity become economically viable for construction. Towers can be steel tubular, concrete, or hybrid; lattice towers are rare (used for lower-height towers). The steel tubular ones are delivered in conical sections (they become narrower towards the top), 20-30 m in length, with flanges at either end to fasten them to the other tower sections at the place of mounting. Using concrete is more recent, and it brings lower cost of production and transport. Many manufacturers also offer hybrid towers, concrete between 60 and 80m, and then steel tubular or even wholly concrete. Inside the tower there are ladders which can be used to go from the bottom to the top, where the nacelle is located. In addition to ladders, a wind turbine tower can also have a service elevator, which enables a faster transport of staff and material to the nacelle. The lower parts of the tower are often painted in shades of green or blue, in order to blend in with the environment.

4. Foundation. Wind turbine foundation must ensure the stability of the wind turbine for the duration of its use. A wind turbine foundation is often shaped like a hollow truncated cone and is made from stainless steel. The total dimensions of the wind turbine foundation ranges within up to 30 X 30m, which is determined after detailed static analyses and identifying the characteristics of the soil on which the wind turbine is constructed. The tower can be connected to the foundation in multiple ways: one solution is a flanged steel pipe, built into the concrete base; another is a ‘steel cage’, where many long anchors are built into the concrete.

Figure 16. *An example of building a foundation for the wind turbine tower.*

When the construction is complete, the foundations are covered by earth so that they remain unnoticeable, i.e. without any visual effect on the location at which they have been constructed.

Generally speaking, wind turbines can be divided into two main groups:

1. With a vertical axis (Figure 17) and
2. With a horizontal axis (Figure 18).

Most wind turbines in commercial use in wind farms today belong to the second category (with a horizontal axis), as the vertical axis turbines cannot start moving by themselves and require an additional mechanism; further, the rotor blades have an aerodynamic dead zone and because of this have a low utilization level, which is economically unsuitable as well.

Figure 17. *Vertical axis generators.*

Figure 18. *Generators with a horizontal axis and three blades.*

Owing to the use of modern materials and technologies, modern wind turbines are very reliable and mechanically safe. The wind turbines conception comprising three blades and a rotatable horizontal axis (Figure 18) is in wide use, allowing the tracking of the wind direction. The rotor diameter depends on the designed power and rages between 30 meters for 300KW propellers to 140 meters for highest-power propellers. Such wind turbines are mounted on a vertical tower, which can be over 130 meters in height, depending on the rotor diameter.

Regarding rotation work speeds, wind turbines can have fixed or variable speed.

Fixed speed turbines maintain constant rotor speed in the entire wind speed range. Rotor speed is determined by the grid frequency, the construction of the generator, and the transference of the gearbox. They are designed for maximal use at a designated wind speed. Changes in wind speed translate into the mechanical load of the shaft, which affects the output power. Depending on the network configuration, these output power fluctuations can result in a drastic deterioration in voltage quality at the end user, as well as in network loss increase.

Variable speed turbines can be implemented in several considerably different ways. One such way is the so-called *direct drive* (no gearbox) system, which operates naturally in a wide range of wind speeds. The second, ‘conventional approach’, includes the use of gearboxes and energy electronics, i.e. grid connection converters. The power at generator output has a variable frequency which depends on rotor speed. The converter then adapts the frequency to the frequency of the grid, allowing operation in a broad range of wind speeds. The advantages of this type of wind turbine are greater utilization, better quality of the produced electricity, and less mechanical strain of the mechanical parts of the generator.

Modern wind turbines start to produce power already at the speeds of around 2.5m/s (*cut-in speed*) and stop at the speed of around 25m/s (*cut-out speed*) from safety reasons. At such speeds, the generator is halted by means of brakes. Although it is possible to design wind turbines for active operation at speeds greater than 25m/s, it was established that it is not economically viable to design such wind turbines, as winds of such speeds occur rarely and last briefly. The generator reaches maximum power at the speed of wind of over 10-12m/s (*rated wind speed*). Moreover, wind farms are designed to withstand extremely high wind speeds, reaching up to 80km/h (*survival wind speed*) (Lazarević, 2005).

Except in the technological advancement in wind turbines, the current development of wind power use, as discussed above, tends towards a sort of group construction of several wind turbines and linking them into wind farms (the so-called windmill farms).

The concept of linking wind turbines into wind farms (Figure 19) allows connecting individual wind turbines in such a manner as to enable connecting the wind farm to the electricity grid. Conceptualized in this way, wind turbines are used in the most economically viable fashion, which is very important for the development of the win power sector.

Figure 19. *An example of a wind farm (Source: sourceable.net).*

The efficiency of this sort of wind turbine grouping is increasing every day. Despite an increase in overall efficiency, the problem of finding suitable or free locations remains, as a great surface area is required with relatively strong and, even more importantly, constant winds.

Wind farms can have hundreds of wind turbines whose aggregate installed power can exceed 1,000MW.

There are also extreme examples, such as the biggest wind farm in the world - *Gansu Wind Farm* (Gansu province, China), made up of 3,500 individual wind turbines with the aggregate installed power of 6,000MW, and characterized by an exceptionally dynamic development which includes mounting new wind turbines daily (Zhang et al, 2016).

Figure 20. *The world's biggest wind farm - Gansu Wind Farm, China (Source: CECEP, 2015).*

3.2. The impact of wind farms on the environment

Global environmental problems are tied to the global energy crisis, and these two problems are now treated as a single issue contained in the concept of obtaining environmentally clean energy (or *green energy*). The environmental advantages of producing electricity from renewables on the one hand, and increased awareness of the populace regarding the need to protect the environment, on the other, form a solid basis for a dynamic development of projects in the area of applying environmentally clean energy based on the application of renewable energy sources. This is certainly helped along by the continued development of technologies in this area, which then contribute to the competitiveness of such projects in the electricity market (Josimović, Pucar, 2010).

However, the global production of electricity is still predominantly based on fossil fuels, with all the negative implications this has. This results the depletion of natural resources and degradation of the environment, which jeopardized sustainable development (Adhikari et. al, 2008).

Furthermore, burning fossil fuels leads to a slew of global environmental problems which are mostly linked to climate change and global warming.

In point of fact, the energy sector is one of the biggest polluters of the environment in terms of pollutant emissions and the waste generated in production. The harmful effects of electricity production on the environment can be divided into three groups (Pucar, Josimović, 2010):

1. Harmful gas emissions (excluding CO_2),
2. Harmful greenhouse gases (primarily CO_2),
3. Waste generated in the production process (radioactive waste, ash, gypsum, oils and methane - CH_4, which is twenty times more toxic than CO_2).

In order to reduce the adverse effects of the energy sector on the environment, while at the same time making profit – in itself an essential condition – the investors and the big energy companies opt in planning new capacities for the construction of power plants using renewable energy sources. The reasons are therefore twofold:

1. The construction of power plants using renewables makes ecological sense. This is in line with the raising of awareness of the importance of environmental protection on the one hand, and ensuring harmonization with the numerous and important international agreements related to environmental protection and climate change, on the other. Each kWh of electricity produced from renewables replaces the same amount of energy which should be produced in fossil fuel power plants. As a result, adverse effects on the environment are reduced, especially the emission of CO_2 into the atmosphere (Esco, 2017). The analysis of the data on CO_2 emissions in the production of electricity from various primary sources leads to the conclusion that the renewable energy sources are incomparably more acceptable than fossil fuels with respect to the environment;
2. The production of electricity in power plans using renewables ensures significant revenues. These revenues initially needed to be incited by a preferential price the investors get from the state as a form of incitement for such electricity consumption. As the renewables market develops, i.e. as the equipment prices drop in step with an increased use of renewable energy sources, these incitements are needed less and less, and investments are directed towards the market economy principles.

Among all renewables, wind power is ranked as one of the cheapest options for reducing CO_2 emissions (Reeder, 2017) as well as for reducing the emissions of other pollutants and environmental pollution in general. This fact confirms the above claims regarding the economic and ecological benefits of suing renewable energy sources.

Special attention will be paid below to the impact of wind farms on the environment, which is the subject-matter of the present volume. The economic aspect of wind power use will not be tackled, important as it may be in the development of the energy sector, as it is not the focus of the present author's research.

Although it is a 'clean technology' or the so-called green energy, projects in the area of renewables have a twofold impact on the environment: positive effects as well as negative. The situation is the same with wind farm projects. The present author intends to analyse both types of effects and to be as objective as possible in his research. Special attention will be paid to just those negative effects of wind farms on the environment. Specifically, the positive effects are always desirable, and it is enough to simply acknowledge them. The negative effects, on the other hand, are not desirable but can be eliminated or minimized. The aim of the present volume is precisely to identify and assess the negative effects (spatial/territorial) of wind farms on the environment, as well as to discuss the ways in which these negative effects can be minimized or eliminated.

This section of the book is a suitable place to define the term 'environment', which is contained in the title of this book as well. The term environment is often conflated with the term natural environment. However, the two are different as the environment also includes human beings as well as all elements of human actions and objects created by them. The environment cannot be seen as the social environment in the narrow sense of the word, as the relationships in it are regulated by social as well as natural laws. The environment represents a qualitatively new category of the geographic space, based on the complex of relations holding between the natural and social environments and the natural and social elements within them.

One of the definitions of the term 'environment' is that it is a system of natural and anthropogenic objects and phenomena in which humans work, live and rest. The term 'environment' includes the social, natural, and artificially created elements, as well as the physical, chemical, and biological factors of living, i.e. everything that impacts on the human life and activities (Čok, 1973).

In addition to abiotic elements (soil, water, air) and biotic elements (living beings), the term 'environment' also includes the society in which human beings live, as well as the products of human labour. Therefore, it is clear that this is a complex concept which includes virtually all the domains of the world (Lješević, 1997).

The present author would venture to formulate what is perhaps the most comprehensive and acceptable definition of the term ‘the environment’: ***The environment is a collection of natural and anthropogenic phenomena and processes, whose complex mutual interactions make up the surroundings, i.e. the living space and conditions.***

All the above analyses, explorations, and conclusions provided below and are related to the environment, are contextually provided formulations (definitions) of the term ‘the environment’.

3.2.1. Positive effects of wind power use

The ecological advantages of producing electricity from wind power and the technological advancements in this area ensure that the wind power sector is increasingly dynamic and significant in an era of mounting problems and challenges in the environment. The latter are caused on the one hand by an exponential growth of the global populations, and on the other by an ever-greater need for energy (a causal link).

The most prominent effects should be seen in the wider context, which goes beyond individual projects, the local, or the regional, as it is has a global significance. One of them is certainly the production of electricity without emissions of pollutants, including greenhouse gases[3]. This fact is uncontested, and this positive effect contributes significantly to the quality of the environment globally and in the long term. As stated earlier, each kW of electricity obtained in this way in wind farms has an effect down the line on the reduction of the same production power from the traditional (non-renewable) energy sources. This should reduce in the near future the need for thermal power station energy and air pollution and greenhouse gas emission. If these assumptions materialize, this would justify fully the reasons for which power plants using renewable energy sources joined the energy sector and became its integral part. At the present stage of development already, wind farms are becoming competitors to the classical sources and the production of electricity from traditional (non-renewable) sources, both in terms of price and the quality of produced energy. Ecologically speaking, the comparison would be inappropriate. Specifically, the modern 3MW wind turbines would result during their service life in the reduction of emissions at around 100,000

[3] If we were to engage in a traditional life scycle assessment, this claim could also be relativized: It would be very interesting to obtain the data energy consumption and possible effects on the environment of the exploitation and production of the materials for manufacturning equipment used in wind farms, as well as the production of wind farm equipment, the transport of the equipment to the mounting location, etc. Also, the assessment might include the transport of the equipment from the location, its treatment in specific recycling facilities, etc. A number of negative effects would certainly be identifies in this sort of analysis, which would then be useful for developing a more detailed picture of all possible effects. But, if we limit the analysis to the wind farm service life, which is the case in the present volume, then the claim can in no way be minimized or called into question.

to 150,000 tonnes of pollutants, depending on specific local conditions, the capacity utilization ratio, and windiness (Gronnel, 2015). Bearing in mind the existing wind farm capacities and the development dynamic of the wind farm sector at the global level, one can only assume how important this would have in the environmental protection around the globe.

Global climate change is one of the most serious effects of fossil fuel use. When coal, oil, and natural gas burn, greenhouse gases are released, which results in global warming. When the wind turbine production and construction phases are complete, the generation of electricity from wind power does not produce greenhouse gases and is therefore an important step towards climate 'stabilization'. By way of illustrating this scenario, it might be opportune to take a look at the results of a recent study conducted by the National Renewable Energy Laboratory (NREL) in the USA. The study concludes that a 25 per cent increase in the use of renewables would reduce greenhouse gas emissions by 30 per cent. Therefore, the positive effect on slowing down climate change is another important and positive effect of wind power use.

A global reduction of pollutant emissions will certainly have a beneficial effect on general population health, and this is the next positive effect of wind power use. The positive effect is related to the reduction in the number of respiratory tract diseases and other threats to human health which occur in the operation of the complex fossil fuel power plant system. Replacing these with renewable source power plants, including wind farms, makes the beneficial effect realistic and expected.

Another advantage of using wind power over fossil fuels is energy efficiency. The extraction and processing of fossil fuels is costly. Moreover, enormous amounts of energy are used to transport fossil fuels from remote locations to the place of use. On the other hand, wind-generated electricity is delivered efficiently via transmission lines to the place of use, without additional processing, transport etc. This aspect of the positive effect of wind farms on the environment is also a result of a comparison with the fossil fuel power plants.

In evaluating a technology, the land that is necessary for its application is an important parameter. For example, the thermal power plant operation system requires large areas of land for the purposes of exploiting raw materials, facilities, waste removal, etc. As regards dam-based hydroelectric power plants, large areas of often very arable land are flooded and so lost for agriculture. The situation is very different with wind farms. Wind turbines are laced at considerable heights (usually at over 100m), which allows a multipurpose use of land in the locations where they are mounted. Agriculture is an oft-cited example. In many locations around the world, wind turbines are placed on arable land and pastures, which continue to be used in the same way after the wind farm is constructed. This ensures great economic viability in terms of mand utilization – as much as 99 per cent of wind farm land can be used for agricultural production during its services life (Reeder, 2017). This fact can be considered a positive effect of wind farms on the environment, especially in the wider context (energy is produced with a negligible use of land).

3.2.2. Possible negative effects in the construction and operation of wind farms

Although the positive effects of wind power use on the environment dominate the discussions, there are some negative effects of wind farms on the environment. One may be left with an impression that this subject is somehow avoided in the scientific and professional circles. Leaving aside a conservationist approach to protection according to which 'nothing is allowed', the present author wishes to analyse in a fully objective way the potential negative effects of wind farms on the environment, as he is convinced that only an objective, problem-based approach can ultimately yield an objective assessment of a problem, phenomenon, or process, and offer high-quality solutions based on the conducted analyses.

However, it is not simple to present the negative effects of wind farms on the environment in in a straightforward way and as an isolated problem. Even such effects of wind farms that we are justified in considering negative can be seen as positive once we compare them to the effects of other types of power plants (especially those using non-renewable sources). Such a comparative analysis might lead us to conclude that even some negative effects of wind farms on the environment are relative as, in a wider context, they result in positive trends in the environment and energy.

It is generally accepted that the possible negative effects of wind farms on the environment exist, but that they are negligible compared to the positive effects. However, they cannot or should not be neglected, especially the following effects:

1. Effects on ornithofauna and chiropterofauna,
2. Effects on increase of noise and vibration levels,
3. Effects of shadow flicker,
4. Effects on the surroundings,
5. Effects in the event of accidents.

In addition to the these, there are other possible negative effects which depend on the characteristics of the specific location where a wind farm is constructed, e.g. the possible effect on the immovable cultural goods, as well as brief and temporary effects, technical in nature, which occur during wind farm construction – air or soil pollution as a result of the operation of construction machines, for instance. The present author will not be concerned with such effects in this book, as they have no continuous and strategically important territorial impact.

3.2.2.1. Effects on ornithofauna and chiropterofauna

The effects of wind farms on ornithofauna (birds) and chiropterofauna (bats) is considered one of the prevalent effects of wind farms on the environment and its component parts. This aspect of the possible effects of wind farms are discussed and written about the most in the literature on the subject. Harley (2001); Langston (2003); Percival (2003); Bright et al. (2008); Paunović et al. (2011); Bernard (2014); Marques et al. (2014); Amos (2016); are only some of the great many authors who tackle this topic. The conclusions of these studies range from almost apocalyptic, all the way to very optimistic ones, depending on the perceptions of the author and the approach taken in understanding the subject-matter. They all agree, however, that the effects of wind farms on ornithofauna and chiropterofauna are possible, important, and that they should be given special attention in wind farm project implementation.

Building hundreds of wind farms in various part of the world has made it necessary to assess the impact of wind farms on the volant fauna (Kunz et al, 2007). Such studies indicate the possibility of birds colliding with wind turbine towers and propellers, which results in the death of the volant fauna (Arnett et al, 2008; Baerwald and Barclay, 2009; Hayes, 2013). The wind turbine tower can reach the height of a 30-storey building, the turbine propeller covers large areas when it moves (over 130m), while bigger wind turbines can affect the air space of migratory bats (Barclay et al, 2007; Voigt et al, 2012). Some studies and certain authors point out that the frequency and magnitude of volant fauna collisions is very high (Arnett et al, 2008).

The impact of wind farms on ornithofauna and chiropterofauna is especially significant given the large numbers of (internationally) protected species, which is why these effects can be considered internationally relevant (the so-called cross-border effect). It is for this reason that today there are many laws and international contracts and agreements which are related to these effects, promoting the importance and the need for protection of biodiversity. The following are the most relevant ones:

The Bonne Convention on the Conservation of Migratory Species of Wild Animals is concerned with migratory species and those regularly crossing international (administrative) borders. It prescribes the collective action of all the countries within whose border migratory birds spend any part of their life cycle, as it acknowledges that endangered migratory species can be appropriately protected only if the protection measures are implemented on the entire migratory species route (The Law on the Ratification of the Bonne Convention on the Conservation of Migratory Species of Wild Animals, The Official Gazette of the Republic of Serbia, No. 102/2007).

The Bern Convention on the Conservation of European Wildlife and Natural Habitats is concerned with the conservation and protection of plant and animal life and their natural habitats, especially those that require international cooperation (The Law on the Ratification of the Bern Convention on the Conservation of European Wildlife and Natural Habitats, The Official Gazette of the Republic of Serbia, No. 102/2007).

The Rio Convention on Biological Diversity obligates all signatories to undertake measures in the rehabilitation and reconstruction of the degraded eco-systems, promote the recovery of endangered species, contribute to the development and implementation of plans and other management strategies for the conservation and sustainable use of biodiversity (The Law on the Ratification of the Rio Convention on Biological Diversity, The Official Gazette of the Republic of Serbia, No. 11/2001).

The Paris Convention for the Protection of Birds obligates the signatories to protect the endangered species of birds from extinction or endangerment, especially the migratory ones. The reason for this is their importance for the protection of nature, science, and economy of all states, because of which some species of birds must be internationally protected (The Law on the Ratification of the Paris Convention for the Protection of Birds, The Official Gazette of the Republic of Serbia, No. 6/73).

All the above international agreements, alongside others not listed here, point to an extraordinary (international) importance of volant fauna, as well as to the fact that the impact of wind farms on birds and bats Is recognized by many relevant international organizations, which have drafted in the recent years a number of documents providing instructions and guidelines for this problem area.

Of these documents, those which are most important for Europe and the Republic of Serbia are the European Commission guidelines (European Commission, 2010), encompassing birds and bats, the report of the Council of Europe and the Bern Convention (Langston and Pullan, 2003; Gove et al. 2013) for birds, and the EUROBATS guidelines for bats (Rodrigues et al. 2008, 2015).

Given possible effects of wind farms on the volant fauna, this aspect needs to be explored thoroughly.

Therefore, the effects of wind farms on ornithofauna and chiropterofauna are twofold:

1. The first is related to a potential collision with the wind turbine tower and propeller, which may result in death or injury of birds and bats. What is particularly dangerous is the spinning of the propeller at great speed, which is when there could be a collision with the volant fauna, in which case the propeller might be fatal for them. This is especially important for the species of birds which use warm air currents in flight and hunting (the so-called thermals), as they are focused on observing the ground looking for prey, and not on the flight trajectory. In such cases, a collision with a turbine propeller is not a rare occurrence if the flight is carried out in the vicinity. Something similar is possible in the evening or at night, when whole flocks of birds can collide with the propeller (or tower) of a wind turbine, which are difficult to notice in night conditions. It is precisely the deaths of birds caused by collisions with the wind turbine propellers that is one of the main ecological problems that wind farms have. The data on the factors impacting on the risk of collision and death of birds is comprehensive but what is missing is its integration. The risks in most cases have to do with the following factors resulting in volant fauna deaths: the species characteristics (morphology, sensory perception, phenology, behaviour or marks); the location characteristics (landscape, flight paths, availability of food, and weather conditions), and the wind farm characteristics (type and configuration of the wind turbine and lighting). The risk of death of volant fauna is a result of complex interactions of these factors (Marques, 2014). Due to this complexity, a simple formula cannot be used widely as part of the strategy of impact mitigation. The best option for mitigating the impact is a combination of various measures, adopted to the specificities of each location, the wind farm, and the target species. In spatial terms, the application of the concept of preventive protection is the most important, including as it does the optimal planning of the number and spatial layout of the wind turbines within the wind farm complex.

2. The second has to do with the alteration of the habitat and its conditions, as well as the alteration of the characteristics of the hunting territories. These effects are also very important with respect to the effects of wind farms on volant fauna. Volant fauna represents a functional element of the space and landscape, with all the causal links and interdependencies in space. Changing one element affects another. Specifically, international change or removal of some forest stands at the location of the wind farm directly affects the change of habits and behaviours of specific volant fauna at that location. As with previously discussed effects, the principle of preventive protection is very important for this group of effects as well. This principle includes the optimal planning of the wind farm complex and the space in which it is constructed. The

optimal layout of the location makes it possible to minimize the negative effects of wind farms on this aspect of possible effects.

Figure 21. *Birds flying in the vicinity of the wind turbine (Source: Power Technology, 2017).*

In order to preventively protect the volant fauna at the location of the future wind farm – a most efficient approach to protection – it is necessary to plan the optimal position of individual wind turbines.

To do that, it is essential to conduct detailed observations of the volant fauna for no less than one year, and to include in the observations at least two migratory periods. The observations should include the identification of species, their habit, and numbers, as well as their habitat, hunting territories, and migratory corridors. Based on the observations, it is possible to develop an optimal plan for the number and layout of wind turbines with the aim of providing preventive protection of the volant fauna. The technical characteristics of the wind turbine must also be considered in order to define the appropriate flight height range within which there is a risk of wind turbine collision.

In addition to preventive planning, there are technical protective measures, which are applied in the process of wind farm exploitation and are mostly to do with the following: break in operation of the wind farm during bird flock flyovers or the flyovers of important species and individual birds; adequate marking of wind turbine towers and propellers, using a number of light or colour elements, etc.

3.2.2.2. Effects on increase of noise levels

Increase in noise levels is one of the possible negative effects (Josimović et al, 2016) of wind farms, discussed by many authors recently (Baath, 2013; Arezes et al, 2014; Onakpoya et al, 2015; Liu, 2017; and many others).

The problem of noise, often cited as the most serious negative effect of wind farm operation on the environment, is prominent in older constructions. However, in modern wind turbines, the use of the so-called *optispeed* generator has enabled the constancy of the angular speed of the wind turbine (typically 16 rpm) in a wide range of wind speeds and resulted in a considerable reduction in noise levels.

This generator is a multispeed asynchronous generator with a wound rotor and double power source. Such a construction enables stable and steady operation of the wind propeller, which rotated at a relatively low and stable angular speed even at great wind speed variations.

Bearing in mind the above, it can be concluded that modern wind turbines generate a certain level of noise by the propeller travelling through the air, while the noise of the wind turbine itself is not especially significant.

However, even noise created in this way is not negligible although efforts are being made to reduce it as well by optimizing the construction of the wind turbine propeller and its aerodynamic features (Liu, 2017). This is evident from the illustration in Figure 22 below.

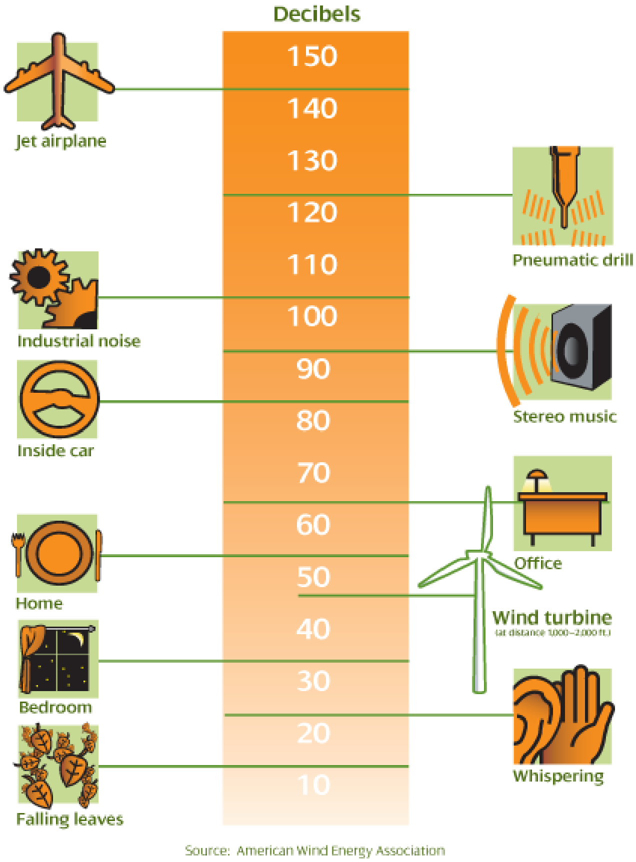


Figure 22. *The diagram showing the comparative values of environmental noise levels (Source: American Wind Energy Association, 2016).*

The figure above indicates that individual wind turbines produce noise of around 55dB at the source (at the distance of 40-50m from the wind turbine). This value varies depending on the wind turbine type and manufacturer, as well as the number of wind turbines (synergic impact), but the listed value is the average intensity of noise for individual wind turbines.

Spatial dispersion of noise made by wind turbine operation is an especially important aspect in analysing the effects of wind farms on the increase in noise levels. It implies the reduction in noise intensity as the distance from the wind turbine (the source of noise) increases.

The spatial dispersion of noise also depends on wind turbine type and the number of wind turbines, the terrain configuration (topography), the existence of physical barriers (natural or anthropogenic) between the noise source and receiver. The average values of noise intensity relative to the distance from the wind turbine are shown in the diagram below (Figure 23).

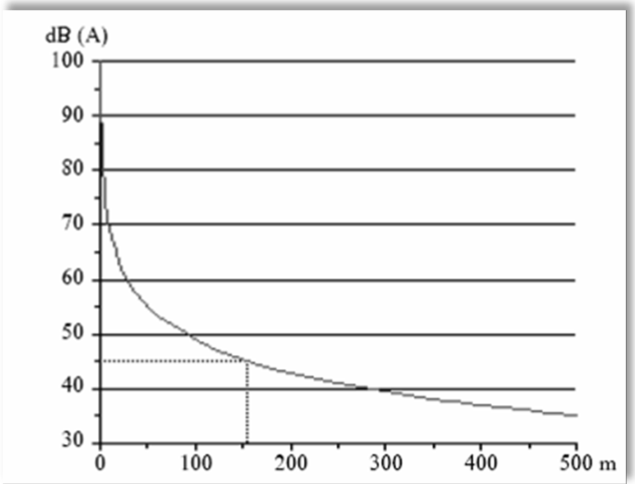


Figure 23. *The drop in noise intensity relative to the distance from the wind turbine*

The spatial dispersion of noise intensity relative to the distance from the wind turbine is an especially important aspect of analysing this wind farm effect. As shown in the diagram in Figure 23, the increase in the distance from the wind turbine results in a significant noise intensity drop.

If we compare the diagram values to the permitted noise levels per land use zone (Table 5), as prescribed by the legislation of the Republic of Serbia, which is taken as an example (The Rulebook on the Permitted Environmental Noise Levels, The Official Gazette of the Republic of Serbia, No. 54/92), it can be concluded that the noise intensity at 300m from the wind turbine are within the value bands acceptable even for vulnerable structures.

Table 5. *Permitted noise levels per land use zones.*

Land use zones	Permitted communal noise levels (dBA) L_{eq}	
	Day	Night
I Rest and recreation areas, hospitals, big parks	50	40
II Tourist areas, small towns and villages, camps and school zones	50	45
III Purely residential areas	55	45
IV Commercial-residential areas, playgrounds	60	50
V City centre, zones by highways, regional roads and city streets	65	55
VI Industrial zones	70	70

Wind farms are most often constructed on farming land with nearby villages. In this connection, the land use zone marked II (Table 5) and the permitted noise values listed there are of special importance. According to the diagram in Figure 23, these values are attained already at a distance of less than 200m, on flat terrains.

This is a very important fact in planning wind farm locations as, given the existing uses at a specific location, it is possible to make a prediction ahead of time regarding possible wind turbine noise levels and determine the smallest necessary distance between the wind turbine and specific structures based on the results. To this end various simulation models are used which take into account the key elements: type and number of wind turbines; wind speed; the speed of wind turbine propeller rotation; and terrain topography (Staffell and Green, 2014; Benmedjahed et al, 2017).

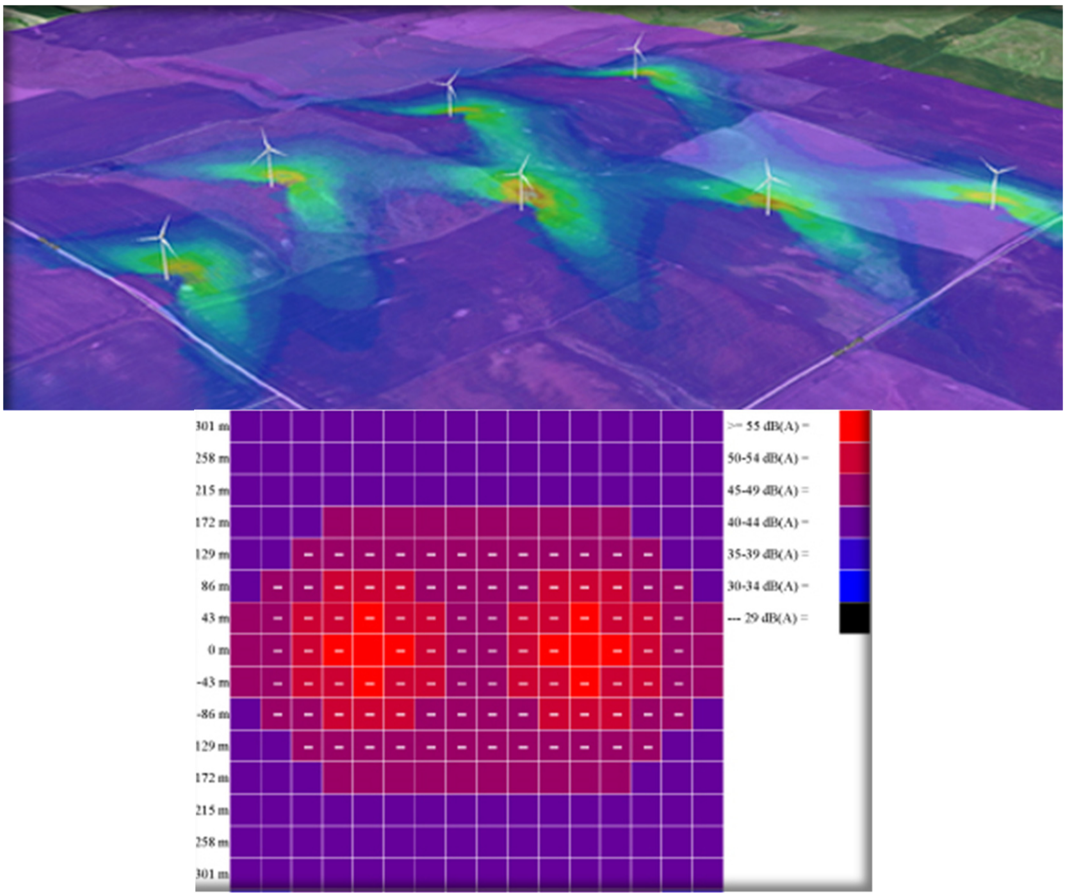


Figure 24. *An example of modelling noise for a wind farm with aggregated wind turbines (Source: Danish Wind Industry Association, 2016).*

Figure 24 shows an illustration of the modelling noise produced by a wind farm with a great number of wind turbines. Using simulation models, it is possible to analyse the synergic effects of a number of wind turbines making up a single wind farm. It is also possible to overlay the obtained simulation models on top of *Google* maps, adding value to these models as in this way it is easier to analyse the effects of wind farm noise on the existing land uses in a specific space (Figure 25).

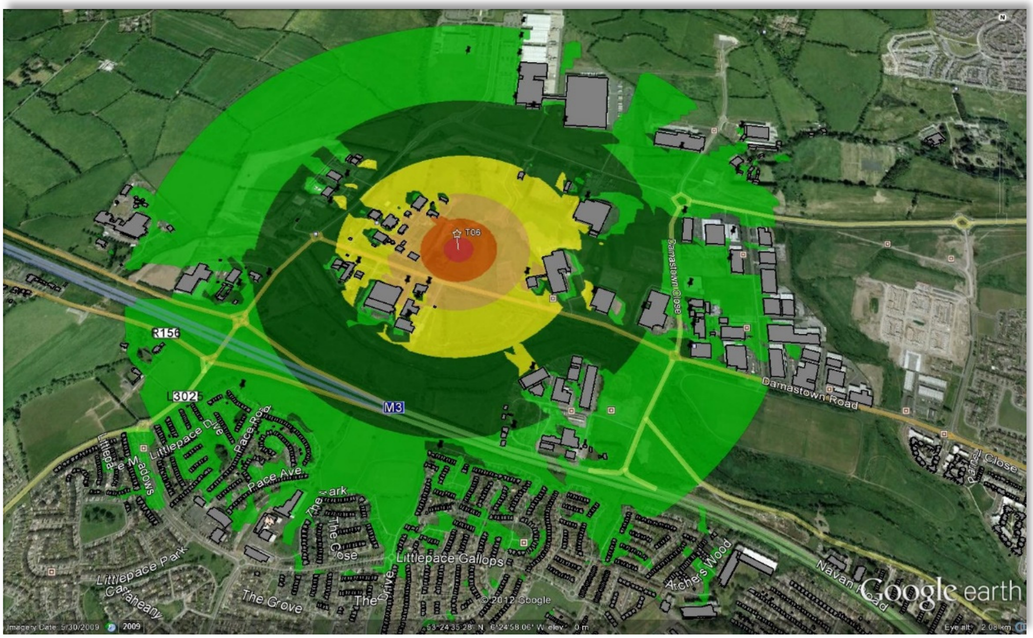


Figure 25. *Overlaying a wind turbine noise prediction model on top of a Google Earth map (Source: AWNConsulting, Dublin, 2017).*

Noise increase as a result of wind farm operation is therefore possible, but spatially limited. Still, in order to avoid the negative effects of this phenomenon on the health of the population (the psychological effect) on the one hand (Pierpont, 2008), and the fauna in the wind farm location, on the other, it is necessary to apply the same principle of preventive protection as in the case of the protection of ornithofauna and chiropterofauna. This includes responsible planning of wind farm location, taking into account all its characteristics, the existing and planned land uses, and using all the available techniques and software technologies (models) for noise modelling. Only such an approach can result in the prevention of spatial conflicts.

All the above claims point to the importance of analysing the spatial aspect of the impact of wind farms on the environment and its factors, which the topic of the present volume.

3.2.2.3. Effects of shadow flicker

Mounting wind turbines can impact on the shadow and reflection of wind turbines, often termed the ‘wind turbine syndrome’ in the literature. As wind turbines can be quite tall, they can block the light, i.e. cast a shadow in the environment. When they are in operation, an unpleasant shadow flicker can occur due to the rotation of the propeller which can be noticed in the morning and evening (the lowest position of the sun) at distances of up to 10 rotor diameters (Pierpont, 2008). Of course, this depends on the terrain configuration, the orientation of the wind turbine with respect to the existing structure in its proximity, and the path of the sun in concrete circumstances.

Figure 26. *Wind turbine shadow.*

The impact of shadow flicker can have a psychological effect on the population, and in order to prevent this negative phenomenon in wind farm operation, it is necessary to apply the preventive planning principle. To this end, as in the case of noise, various simulation models (software packages) are used, allowing predictions for the area of space in which shadow flicker can occur, and optimal planning of the spatial micro-location of wind farm turbines.

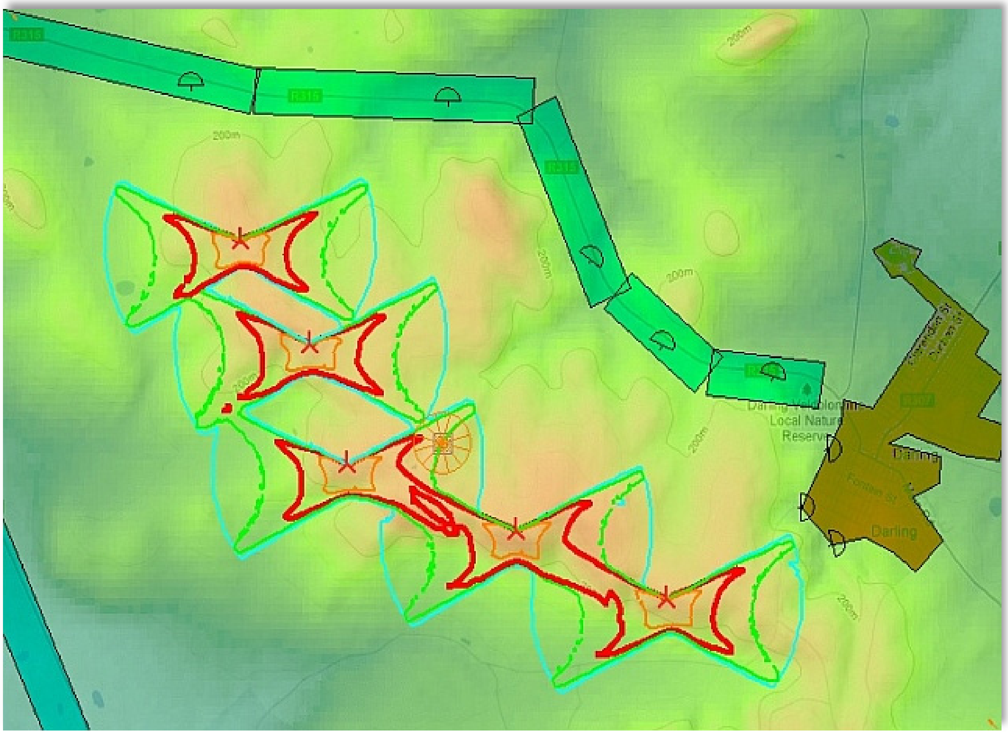


Figure 27. *An example of a shadow flicker simulation (Source: Solid Winds, 2017).*

The simulation in Figure 27 shows the average annual spread of shadow flicker, taking into account the generic wind farm configuration, seasonal sun paths, as well as other parameters. Each wind farm tower generates a field resembling the shape of a butterfly with a projected environmental impact.

In this way the annual number of shadow hours and the benchmark points of unfavourable impact are obtained. Such a simulation is a good basis for optimal planning of the spatial layout of wind farms and their environments.

3.2.2.4. Effects on the surroundings

Landscape characteristics are a subjective category which is not easy to quantify. The visual impact on the environment is a subjective impression which depends, besides the perception of the observer, on the landscape type and specific visual characteristics (Josimović and Crnčević, 2012).

The concept of landscape is very rich and complex, and defining it is not an easy task. Testifying to this are a great many definitions from various areas such as the arts, geography, natural sciences, architecture, or economy. According to the European Landscape Convention (2000), landscape designates an area whose character is a result of the actions and interactions of natural and/or anthropogenic factors. Landscapes are not static as they change over time with respect to the anthropogenic and environmental development.

Wind farms are structures that dominate space. The reason for this is wind turbine dimensions and what is almost a rule that wind farms are located in the free space without other forms of construction, such as mountain ridges, farming land (arable land and pastures), steppes, etc. As a result, wind farms have a considerable impact on the landscape. However, this impact can be positive for one observer as it provides space with a specific visual identity, and negative for another, as it changes the appearance of natural landscapes.

In this context, wind turbine visibility is one of the subjective factors affecting the decision on a possible location for the construction of the wind farm. The visual impact of wind turbines is usually noticeable in a wide area. It is recommended that in the analysis of the impact on the landscape, i.e. the visibility of the wind turbine which is 150m tall, the area 12-15 km from the wind turbine is included, as these are the distances from which wind turbines can be noticed (Wróżyński et al, 2016).

However, wind turbine visibility drops as distance increases, which directly correlates the distance of the observer from the wind turbine and the drop in its visual impact.

Furthermore, visual impact also depends on the following:

- Terrain topography,
- Physical barriers (natural and anthropogenic) between the observer and the wind turbine;
- Weather conditions at the wind farm location and the surrounding area;
- The number of wind turbines making up a wind farm;
- The size of the wind turbine and its architectural shaping (material, colour, etc.).

Figure 28 shows an example of visual impact (visibility) of a wind turbine from different observation distances (1km, 2km, 3km, 4km, and 5km). This illustration confirms the previous claims regarding the drop in visual impact following from an increase in the observation distance.

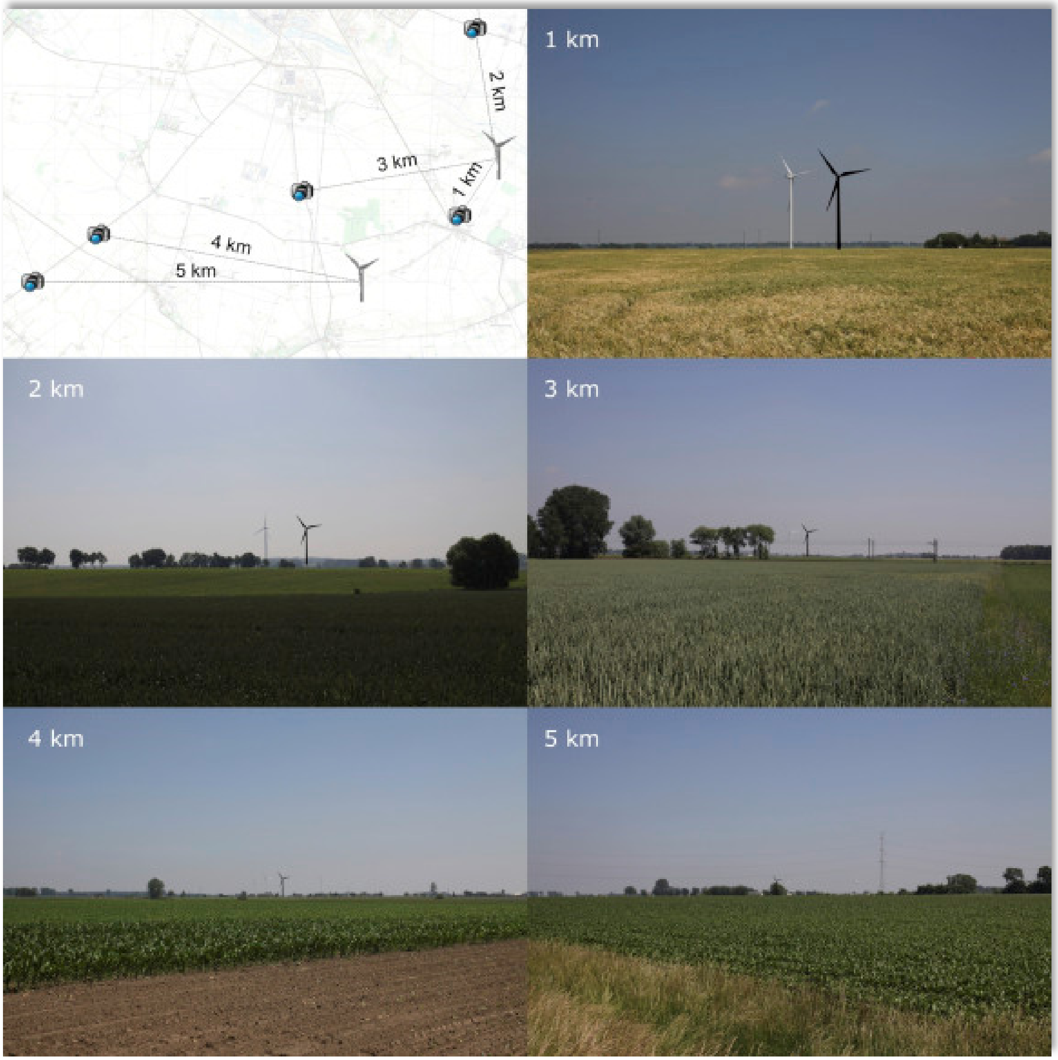


Figure 28. *Visual impact of a wind turbine relative to the observer distance (Source: Wróżyński et al, 2016).*

There are various approaches to the analysis and assessment of the impact of wind turbines on the landscape, but most authors agree that an assessment must be conducted using different instruments, models, and methods for simulating and visualizing possible effects (Mirasgedis et al, 2014; Sánchez-Lozano et al, 2016; Latinopoulos and Kechagia, 2016; Grieken and Dower, 2017; Sklenicka and Zouhara, 2018; etc.). Various software packages can be used, as well as GIS technologies, photo editing, and other methods for predicting the impact of a planned wind farm on the landscape and for visualizing and simulating wind turbine visibility before constructing it in concrete space (Figure 29).

***Figure 29.** A simulation for predicting wind farm impact on the landscape (Source: greenrhinoenergy, 2017).*

Figure 29 illustrates one of the possible examples of simulation (photo editing) used for predicting wind farm impact on the landscape. The planned wind turbine positions are entered into a concrete location from a specific vantage point, which can be a house or a road or any other visually salient point. In this way it is possible to show the status of the future project and its visibility from a visually salient vantage point, as well as to analyse the visual impact of all the wind turbines. The result of this simulation can be a correction of the spatial layout of wind turbines, in order to reduce the visual impact.

It is certainly true that wind farm effects on the landscape cannot be quantified or calculated, but is also true that it is possible to reduce the effect of its visibility during planning and designing, from the salient vantage point by using specific standard principles (Tsoutsos, 2009):

- Wind turbines ordered into rows fit in well with flat terrains;
- A smaller number of bigger wind turbines is better than a larger number of smaller wind turbines in one wind farm;
- The appearance of wind turbines needs to be brought into line with the characteristics of a concrete location and the salience of the landscape at it;
- Wind farms should be located at a sufficient distance from the visually salient points;
- Wind turbines towers should be coloured in such a way to match a concrete space;
- Anti-reflective colours should be chosen as they have a soothing effect on the landscape;
- Light signals (if necessary) should only be mounted onto exposed wind turbines.

3.2.2.5. Effects in the event of accidents

Although wind farm equipment manufacturers invariably take appropriate technical measures for the protection against accidents, there still are situations in which these situations are possible. Below is a list of potential wind turbine accidents:

- The danger of fire in the generator,
- The danger of a thunder strike,
- The danger of ice gathering on wind turbine propellers,
- The danger of bits breaking off propellers in extremely high winds,
- The danger of wind turbine tower snapping.

Figure 30. *Possible wind turbine accidents (fire: top left; thunder strike and the tower snapping in half: top right; ice on the propeller: bottom left; the propeller snapping: bottom right) (Source: PEI, 2017).*

Some of the accidents are a consequence of extreme weather conditions, while others of technical problems which can arise in operation or the production of wind turbines and their component parts.

Wind turbine accidents are not frequent, so it is not surprising that such accidents with more serious environmental consequences have not been recorded anywhere in the world (Garcia and Bruschi, 2016). This is because the impact of wind farm accidents is limited to individual wind turbines, without a significant spatial dispersion which could have serious consequences on the environment and its components factors. In addition, given that wind farms are as a rule located in spaces which are not overloaded with other forms of construction, there is no great danger of effects on anthropogenic factors in space.

However, in certain circumstances, although the spatial dispersion of effects in wind turbine accidents is insignificant, there is nonetheless a danger to lives if wind turbines are located in places where there is movement of people. This is related first and foremost to the proximity of roads (local, municipal, regional, etc.). In this context, as well as in analysing other effects of wind farms on environmental factors, it is especially important to optimally position wind turbines, in such a way as to ensure that conflicts in space are avoided and negative effects on the environment are minimized.

3.3. Environmental protection instruments in planning and designing wind farms

A great many instruments for the assessment of impact of plans, programmes, policies, and projects on the environment are in use today.

Specific instruments, such as the traditional Life Cycle Assessment (LCA), include the entire product (project) development, from the extraction of raw materials, through material processing, production, distribution, use, repair and maintenance, to disposal and/or recycling as the final phase, which takes place after the exploitation period. The basic idea is to analyse energy consumption in making a product relative to the time needed to 'return' that energy in work or exploitation. In terms of the application of LCA for wind farm projects, this would entail quantifying all the effects in the range of wind farm construction power use (the cumulative effect) and the possibility of re-producing that power as quickly as possible. It is the task of the LCA to demonstrate that a specific technology or project produces more power than it expends, because otherwise there would be no useful contribution of a wind farm to the energy system. The shorter the return period of the invested power, the better the LCA results. In such considerations, a comparative analysis of the conventional power production systems, based on fossil fuel use, would be a very important part of the process, and would allow drawing conclusions regarding the benefits or shortcomings of wind power use (Al-Behadili and Ostab, 2015).

In addition to a comprehensive approach that characterizes LCA, there are diametrically opposite approaches, based on the assessment of impact of individual environmental elements (water, air, soil, noise, landscape etc.). In the context of wind farm projects, this so-called partial[4] impact assessment can be conducted as a specific impact assessment regarding the following:

- noise,
- landscape,
- risk of accident,
- ornithofauna,
- chiropterofauna,
- habitat risk.

Given the dynamic development of the wind power sector at the global level, it is no surprise that much has been written in the scientific literature recently on the partial assessment of wind farm effects on individual elements of the environment (Zohbi et al, 2015; Garcia and Bruschi, 2016; Gallo et al, 2016; Lenchine, 2016; Sklenicka and Zouhar, 2017; Zhang et al, 2017; Malov et al, 2017; Newson et al, 2017; Farfánet al, 2017; Roemer et al, 2017; Parisé and Walkera, 2017; etc).

However, the present author thinks that a partial assessment geared towards individual elements of the environment is justifies only if it is part and parcel of a unified impact assessment within which a holistic approach to assessing the impact of wind farms on the environment is implemented (see the definition of the term ‘environment’ on page 48).

In this way, we arrive at two instruments for the protection of the environment which are globally most widespread in assessing environmental impact, for wind farms as much as for all other development plans, policies and projects. They are:

- Strategic Environmental Assessment – SEA; and
- Environmental Impact Assessment – EIA.

What characterizes these two instruments is the application of the holistic approach in analysing the interactions of the existing and planned uses in a certain space. The difference

[4] The present author uses the term ‘partial’ for all the assessments, analysing wind farm impact on just one element (factor) of the environment.

between these two instruments lies in the purpose and approach to impact assessment. While the strategic environmental assessment is applied at the strategic planning level, the environmental impact assessment is applied at the level of concrete investment projects.

SEA is a key instrument for assessing the spatial/territorial effects of wind farms on the environment. Bearing this in mind, as well as the topic and title of the present volume, it is clear that SEA deserves special attention (chapter) in the present volume.

This is why only a short overview of the Environmental Impact Assessment (EIA) is provided below. The history of the application of this instrument goes back to the late 1960s, when a law was adopted in the USA related to environmental protection policy. At the time, EIA was not formulated as such, but the adoption of this law was the watershed moment for the development of this, as well as the other instruments for assessing the impact of various activities on the environment. From that point onwards, the interest in the development of environmental impact assessment instruments has been steadily growing.

One of the first definitions of EIA was articulated in the late 1970s (Munn, 1979): 'The term environmental impact assessment includes the techniques and process in which the information on the environmental impact of projects is collected by the project implementer and other stakeholders and presented to the decision-makers in the form of an assessment of the acceptability/unacceptability of the project.'

Therefore, this instrument helps in resolving the environmental, social, and economic problems which may arise as a result of implementing public and private investment projects in a certain space. This instrument is a tool for managing the environment and is used at the level of concrete projects. It contains a systematic, documented, periodic, and objective assessment of the degree in which pollution control and environment management systems can be attained in the operation of a specific system (Muralikrishna and Manickam, 2017).

EIA was introduced in the European practice in 1985, by adopting the EU Directive on the assessment of the effects of certain public and private projects on the environment (EIA Directive 85/337/EEC). This directive was amended three times:

1. In 1997, it was amended in line with the principles of the convention (ESPOO) on cross-border cooperation (Directive 97/11/EC);
2. In 2003, it was amended in line with the principles of the Aarhus Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (Directive 2003/35/EC);

3. In 2009, it was amended by adding projects related to the transport, capture and storage of carbon-dioxide (CO_2) (Directive 2009/31/EC).

Nowadays EIA is one of the most widespread instruments for assessing environmental impact. It is used globally given that it is used in the whole world.

As regards methodology, a great many methodological approaches and methods are used today in environmental impact assessment (MCA - Multi-criteria Analysis; MCDM - Multi-criteria Decision-Making; LM – Leopold Matrix, etc.) and a good many authors have been concerned with this topic (Glasson et al, 2005; Jay et al, 2007; Josimović et al, 2014; Podimata, 2016; Kalnins et al, 2016; etc.). All the methods listed here are based on the application of sophisticated mathematical simulation methods, based on which it is possible to render the expected effects (positive and negative) of project on the environment objectively and in quantitative terms. Such an approach provides relevant data on the types and amounts of materials, energy, and products, as well as their movement in the process of project construction and exploitation, which is used as an input in the above methods for assessing environmental impact within EIA.

Since it was introduced, the EIA process has been criticised and modified with a view to resolving the issues stemming from its widespread use. In this connection, one of the most active debates focuses on the need for a more serious analysis of the social impact of project implementation. As a result, social impact assessment (SIA) started to be used, but it has long since been viewed as one component subordinated to the EIA process. Continuing this debate, the Environmental and Social Impact Assessment (ESIA) has been increasingly used in recent times. Since its inception, ESIA has been increasingly used in cases where projects are funded by international agencies and private creditors, given that it allows an integral analysis of all the consequences of project implementation and so an assessment of the implementation risks.

At any rate, since the early 2000s, the trend has been the transformation of EIA into ESIA, i.e. an integrated assessment of environmental and social development impact, in order to gain a better understanding of the interconnections between nature and society on the one hand, and investment project implementation on the other (Smart et al, 2014).

Globally and widely used, EIA has found its applications in wind farm projects as well. Its task is to assess the environmental impacts which can occur:

- During wind farm construction;
- In wind farm exploitation; and
- After it is shut down.

The impact is assessed based on the following:

- Precise data on the characteristics of the environment (natural and anthropogenic) at a specific location;
- Precise data on all project segments, including wind turbine type and manufacturer;
- Precise data on the execution of construction and other works in the construction of a wind farm;
- Detailed plans on the transport of equipment to the micro-locations of all individual wind turbines within the wind farm.

As can be seen, what is characteristic for EIA is that it is conducted based on precise and detailed data on the location and project that has entered the pre-implementation/construction phase. This level of detail and precision sets EIA apart from other instruments for environmental impact assessment. The holistic approach and quantitative terms in which the results are expressed, based on precise data (input), indicate the reasons why EIA is positioned as a go-to instrument both for wind farm projects and globally.

As pointed out earlier, it is possible to apply different methodological approaches and methods for the assessment of wind farm impact on the environment within EIA. Many academic papers discuss this very topic (Josimović et al, 2014; Valença and Bernard, 2015; Phillips, 2015; Lintott, 2016; Sağlam, 2017; Silva et al, 2017; etc.).

Regardless of which approach to impact assessment is taken up, special attention should be paid to the following within EIA:

- Avoiding rough assessments, predictions, and evaluations based solely on textual comments;
- Impact assessment which would not be based solely on identifying impact magnitude but also on analysing various aspects of possible impacts.

In this context, the application of combined methodological approaches and methods should be considered, as well as the upgrading of existing methodological approaches and methods, in order to ensure the best results in EIA based on concrete cases (Crnčević et al, 2011).

In his previous research, the present author concerned himself with the analysis of the possibility of upgrading the existing methods in assessing environmental impact. Specifically, for the example of an EIA for Serbian wind farms, the author presented the possibility of upgrading the Leopold matrix method[5]. In a previously published paper (Josimović et al, 2014), the author and his collaborators presented the results of this research, confirming the advantages of this kind of apporoach in assessing the envrionmental impact of wind farms. It was revealed that the main advantage of upgrading the existing model lies in creating preconditions for a comprehensive impact assessment adapted to specific conditions. This approach seems to suggets that for each individual project an original methodology is developed, which them yields the best possible results.

All assessment instruments listed in this chapter are technical and are applied at the level of individual projects. The next chapter presents the only instrument for assessing spatial/territorial effects, used at the level of strategic planning and providing preventive protection in the proper sense of the word.

[5] The Leopold matrix (LM) is one of the pioneering and widely used approaches to impact assessment. It the first comprehensive method in the sense of analysing environmental and socio-economic factors. The LM was conceived by Luna B. Leopold with colleagues in 1971, in response to the 1969 US law on environmental protection which did not provide clear guidance for Federal Government agencies on how to prepare reports on the environmental effects of projects planned by an agency. LM responsed to the challenge by ’providing a system for the analysis and numerical presentation of the impact’. According to the LM method, an EIA should contain three main components: a) the list of effects on the environment that the proposed project might have; b) an assessment of the importance of each of the listed effects (e.g. local and regional); and c) a brief assessment, which is a combination of magnitude and importance assessments. The LM format evolves into around 8,800 possible interactions, as the number of activities listed on the horizontal axis in the sample matrix stands at 100, and the number of environmental factors listed in the vertical axis of this matrix stands at 88. However, as the authors of this method point out, only some of the interactions merit a comprehensive treatment due to a significant magnitude and importance, varying between 25 and 50 interactions on average for a typical project. In order to maximise matrix efficiency, the starting point is to check for any significant action listed on the horizontal axis. Experience indicates that ’only about ten action will be important. Each checked action is assessed within the matrix in terms of the magnitude of the effect on the environmental factors listed on the vertical axis. Although most matrices are developed for a specific purpose, LM is quite a general method. This is another reason for its wide application, as well as the fact that the method can use both quantitative and qualitative data. The Leopold matrix is a framework method of assessing project impact, which allows its creative upgrading and development. In addition, LM is widely applicable in drawing up the EIA for various types of projects, and the basic principles are known in the scientific and professional communities owing to many decades of use, which in turn makes the elaboration of the results understandable to large numbers of scientists and experts. The presentation of results can be appropriate to overcoming the existing problems in wind farm project implementation, as descriptive and oftentimes approximate assessments of possible impacts are avoided in drafting EIAs.

4. STRATEGIC IMPACT ASSESSMENT AS AN INSTRUMENT FOR ASSESSING SPATIAL EFFECTS OF DEVELOPMENT PLANS ON THE ENVIRONMENT

4.1. On the strategic environmental assessment

A long-standing need for a legally regulated analysis of the impact of plans, policies, and programmes on the environment was first addressed in the late 1960s, when the US National Environmental Policy Act (NEPA) laid the foundations of strategic environment assessment (SEA). This law did not distinguish between plans, policies, and programmes on the one hand, and projects on the other, i.e. between the strategic and project-level decision making; rather, it referred generally to actions (Fischer, 2002; Dalal-Clayton and Sadler, 2005).

The notion of strategic impact assessment was formulated in 1989 in the United Kingdom and stemmed from a project-oriented assessment of environmental impact (EIA). The assessment principles in SEA and EIA were the same at the time. Over time, the scope of SEA interpretations expanded and started being used for other types of assessment as well – the types that differed from the ones based on project EIA principles. From that period onwards, a definition is often used according to which the SEA is a formalized, systematic and comprehensive process which assesses the effects on the environment of plans, policies, and programmes, considers alternatives, and contains a written report on the assessment based on which decisions are made in a public procedure (Therivel and Partidario, 1996).

Out of a large number of definitions of SEA, the one that can be considered as the most general and comprehensive defines SEA as ‘a part of the systematic process for assessing the consequences for the environment of a proposed policy, plan, or programme, in order to ensure that they have been fully included and appropriately processed at the earliest possible decision-making phase, on an equal footing with the economic and social considerations’ (Partidario, 1996).

Based on the considerations of international experiences and own practice in the area of SEA, the World Bank is of the opinion that the SEA is a ‘participatory approach to increasing the impact of social and environmental issues on the processes of developmental planning, decision making, and implementation at the strategic level’ (Mercier and Ahmed, 2004; Dalal-Clayton and Sadler, 2005).

Today SEA is one of the most important instruments for assessing territorial effects of a proposed policy on the environment, and for implementing a sustainable development strategy in formulating spatial development policy in the areas of strategic planning, spatial and urban planning, sector policy planning, etc. The main aim of SEA is to facilitate the timely and systematic consideration of possible effect on the environment, based on which decisions are made on development policies at the strategic level, as well as on their acceptability in terms of sustainability (Josimović et al, 2015).

Since the mid-1990s, many authors have discussed the role and significance of SEA in policy making in various social domains, as well as the role of this instrument in the decision making process (Therivel and Partidario, 1996; Nilsson and Dalkmann, 2001; Nilsson et al, 2005; Maričić and Josimović 2005; Josimović and Crnčević, 2009; Josimović and Crnčević, 2010; White and Noble 2013; Nenković et al, 2014; Josimović et al, 2016; Krunić et al, 2017; etc). All these authors agree that the importance of applying SEA is extraordinary in making spatial development policy and optimal decisions on spatial development. This is further bolstered by the fact that an increasing number of international institutions, such as the European Commission, World Bank, UNDP, UNEP, and USAID, are introducing SEA application requirements in order to increase the number of development initiatives in line with the environmental and sustainable development principles (Chaker et al, 2006; Dalal-Clayton and Sadler, 2005).

The above authors are mostly from Europe, so it is no surprise that much attention is paid to the application of SEA in the European[6] practice of planning and spatial development, evident in European legislation as well. There are two legal documents which provide guidance on the application of SEA in the countries of the European Union:

- The EU directive on the assessment of the effects of certain plans and programmes on the environment (The EU Directive on SEA)
- The Protocol on Strategic Environmental Assessment (The SEA Protocol).

Both have been adopted with the aim of ensuring a high level of environmental protection and improving sustainable development in all EU member states, including all environmentally relevant factors in the process of preparing and adopting plans and programmes.

The European Strategic Environmental Assessment Directive 2001/42/EC, adopted on 27 June 2001, relates to the plans and programmes:

[6] The present author’s research work and results in the application of SIA are based on the European experience. This is why the author has opted to present in this section of the book the European practice in applying SIA, without wishing to diminish in this way the importance and role of SIA in spatial development planning elsewhere. The present author does not intend to favour the European practice in applyong SIA relative to the experiences from other parts of teh world, or to carry out a comparative analysis; rather, the intention is linked solely to the territorial detemination in applying SIA, which ithe author is familiar and comfortable with.

- Prepared and/or adopted by authorities at the national, regional, or local level;
- Adopted based on regulations;
- In the following areas: agriculture, forestry, fishing, **energy**[7], industry, transport, waste management, water management, telecommunications, tourism, urban planning or land use, which provide a framework for issuing permits for future development projects,
- Which are subject to environmental impact assessment given the possibility of impact in the implementation environment;
- Which envisage the use of smaller plots at the local level, or a modification of the adopted plans and programmes; they are subject to environmental impact assessment only if it is established that they can have significant environmental effects.

The Protocol on Strategic Environmental Assessment, legally binding, was adopted in 2003 at the ministerial conference Environment for Europe in Kiev and developed as a supplement to the Convention on Environmental Impact Assessment in a Transboundary Context (ESPOO). It requires all states that have ratified it to assess the draft plans and programmes in terms of environmental consequences. Unlike the SEA Directive, the Protocol puts more emphasis on the need for a clear and transparent participation of the public, activated as early as the decision-making process regarding the scope of SEA.

Current controversies regarding the nature and scope of SEA are approached in two different ways. The advocates of the first approach argue for the process to focus primarily on issues of environmental protection, whereas those advocating the second approach think that SEA must have incorporate sustainability, i.e. address economic and social aspects alongside environmental protection.

The present author believes that neither approach is formulated in objective terms. Specifically, if we go back to the definition of the term ‘environment’ (see page 48) and accept that in addition to the natural environment this terms also includes human beings and their (anthropogenic) activities, and if we analyse the symbiosis of all phenomena and processes unfolding continually in the environment, it is evident that social and economic aspects cannot be separated/abstracted from the environment.

[7] The provision of the EU SEA Directive, indicating the necessity of conducting the SEA procedure in the energy sector, provide a link to the need for implementing SEA in wind farm planning as well. Although the Directive does not make explicit mention of power plants using renewables, they must be included in the SEA procedure as an integral part of the energy sector, which implies significant (mostly negative) environmental effects.

Therefore, SEA cannot only include the environment seen by some authors as natural environment only (the ecological aspect), which is advocated by the proponents of the first approach. However, the formulation that the environment is separated from the social and economic topics in a space, advocated by the proponents of the second approach, cannot be accepted either (although the second approach is conceptually convincing).

In the context of the above claims, the present author thinks that SEA should engage the environment by analysing the symbiosis of all the phenomena and processes in it within a certain space. Any other approach, which would conceptualize a certain space selectively and partially, would be wide of the mark.

The point of applying SEA is directing the planning process towards defined goals of sustainable development on the one hand, and assessing and identifying the strategically important territorial effects of a certain policy, based on which spatial development decisions are made, on the other.

By applying SEA in spatial development planning through various development documents, it is possible to analyse the consequences of proposed development concepts and spatial modifications, while taking into account spatial capacity and the possibility of avoiding overload of this space, as well as including the public in all the phases of preparing and adopting the SEA.

In this context, it is evident that based on all the information obtained in the complex procedure of SEA implementation, a significant contribution is made to the decision-making process regarding the future development of a space (Salhofer et al, 2007).

SEA can be divided based on the use it can have:

- sectoral – assessing the impact of sectoral development policies in the areas of energy, transport, water industry, agriculture, waste management, forestry, etc.
- spatial – assessing spatial and urban plans at the state, regional, and local level, as well as at the level of special use area;
- indirect – assessing scientific programmes, public enterprise privatization plans and similar concepts, in terms of their effects on the environment and spatial development.

Compared to other environmental impact assessment methods and instruments, which are mostly project-oriented (EIA, ESIA, LCA, etc) and assume projects are near implementation (there is no uncertainty about the spatial micro-location determination of the project), SEA

contributes to impact integration at the strategic planning level. This allows the use of preventive protection in the full sense of the word.
If the results elaborated in chapter 3.2.2. of the present volume are analysed in detail, they indicate the need for/necessity of preventive protection in order to minimize in the best possible way or, ideally, eliminate fully, the possible negative effects of a development policy on the environment and its individual elements.

Applying the principle of preventive protection is only possible in the phase preceding designing and implementation (construction) of concrete investment projects, i.e. the phase in which the planned spatial activities are spatially determined. This is the phase and process of spatial development.

4.2. The strategic environmental assessment methodology

Methodologically speaking, unlike the diverse, precise, and highly operative software tools used in an engineering environment (when project-oriented environmental impact assessments are typically applied), the concept of SEA methodology remains quite unclear (Liou et al, 2005). Some authors (Brown and Therivel, 2000; Partidario, 2000; Therivel, 1996) claim that there is no generalized SEA methodology that is applied to all plans and development policies. Moreover, in a direct sense, the techniques and methodologies of SEA should be treated as a collection of tools in a single 'software package', from which each user can pick their own tools depending on their specific needs (Brown and Therivel, 2000; Partidario, 2002).

Based on the above discussion, SEA becomes an interdisciplinary intersectoral area, which underscores integration and teamwork. Generally speaking, SEA techniques and methodologies stem from the traditional environment impact assessment studies (EIA) as well as policy/plan assessments (Sheate et al, 2001; Partidario, 2002), ensuring that the methodologies do not hinder the institutional promotion of SEA (UNEP, 2002). Possible different techniques for conducting different SEA steps are further analysed and discussed in the literature (DHV, 1994; Sadler, 1996; Partidario, 2002; UNEP, 2002; Therivel 2004). Besides, Marsden (2002) points out that in terms of methodologies, SEA depends more on qualitative investigations techniques than on the traditional environmental impact assessment and that therefore expert assessment is key.

The question of the choice of appropriate techniques and assessment methodologies for any particular case must refer back to the corresponding implementation experiences accumulated through comparative studies of previously prepared methodologies, which have had good results in application (Liou et al, 2005; Josimović et al, 2015).

There are two approaches in the current practice (Josimović and Crnčević, 2009):

1. Technical: it applies the extended EIA methodology to plans and programmes, where EIA principles can be applied as the plans have a small spatial extent, and there is no complex interaction of planned activities and conditions at the location with the planned development conceptions for that space.
2. Planning-related: it requires a substantially different methodology, for the reasons below:
    - Plans are concerned with strategic issues and have less detailed information on the environment and processes and projects to be implemented in the plan area; due to this, it is difficult to analyse the effects arising from developing the planning document at lower planning hierarchy levels;
    - Due to structure and process complexity, as well as the cumulative and synergistic effects, sophisticated mathematical simulation methods are not applicable;
    - Strategic plans have multiple variants/development scenarios, which need to be assessed in terms of acceptability before making a decision on which development variant to accept based on sustainability;
    - In making decisions, the stakeholders' and general public's influence is greater, because of which the methods applied and assessment results must be understandable to the assessment participants, and presented clearly and simply.

    For these reasons, in SEA practice qualitative expert methods are most often used, such as: control lists and questionnaires, matrices, multicriterial analysis and evaluation, spatial analysis, SWOT analysis, the Delphi method, environmental capacity assessment, causal chain analysis, vulnerability assessment, risk assessment, etc. As a result of applying any method, matrices are used to explore the changes that implementing a development concept and the chosen spatial development variant would cause. Matrices are formed by establishing relations between spatial development policy goals, planning solutions, and strategic assessment goals which determine the relevant indicators.

The procedural and methodological frame of the application of SEA is detailed in the EU Directive on SEA and the national legislations of EU countries; it included four mandatory phases in the SEA procedure:

1. Defining strategic action goals;
2. Formulating strategic action options;
3. Environmental impact assessment;
4. Analysis of information, conclusions, guidelines, and the presentation of SEA.

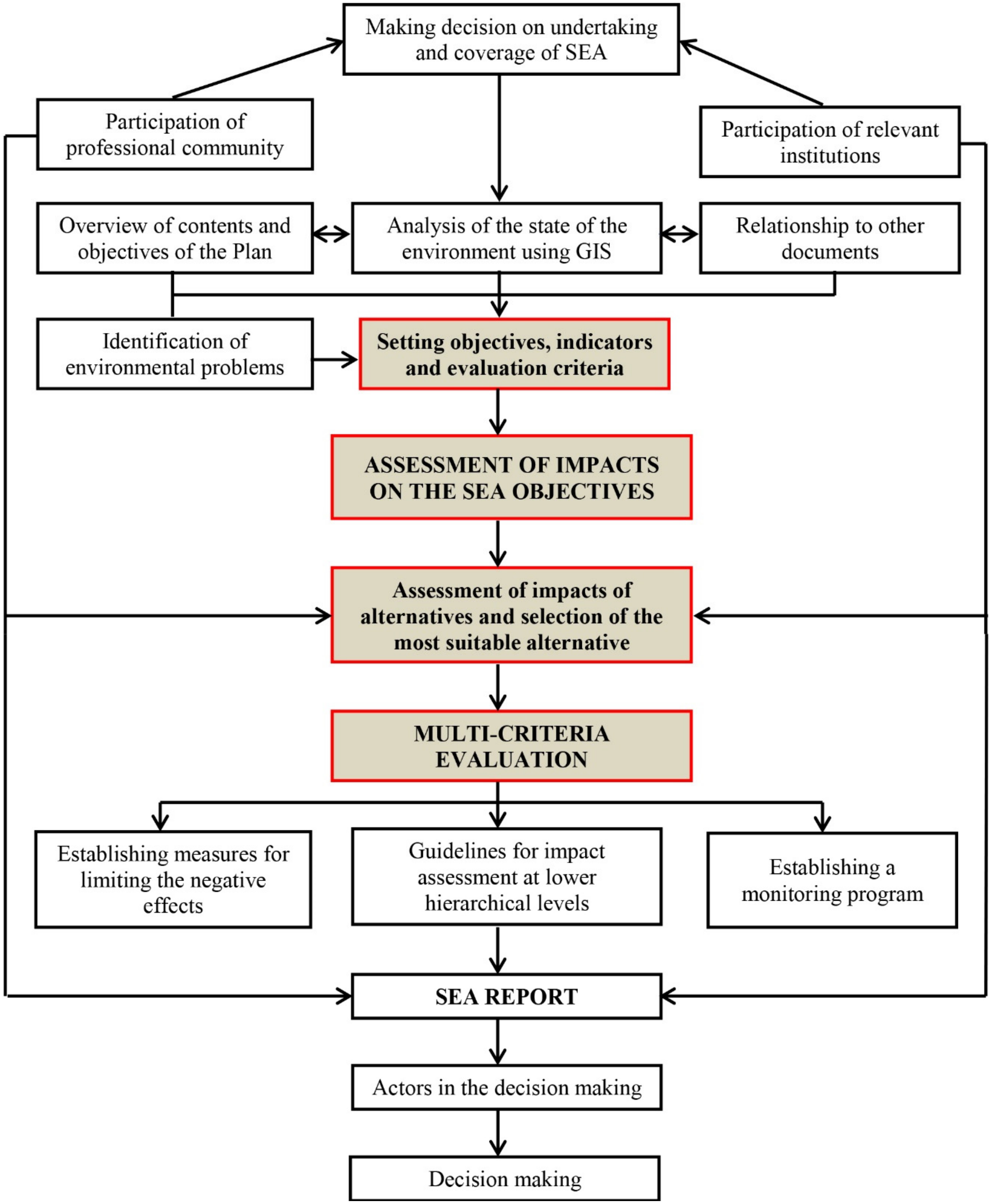


Figure 31. *The procedural and methodological framework for SEA application*

Figure 31 shows the procedural and methodological framework for the application of SEA, based on the provisions of the EU SEA directive. All the steps in the SEA procedure have their significance and an important role.

The methodological approach in impact assessment, i.e. the method used in impact assessment as part of SEA (the red boxes in the figure) receives a lot of attention from researchers, and it is not defined wither in the SEA Directive, nor is it possible to define it in national legislation.

There is no doubt that the SEA impact assessment stems from approaches based on expert qualitative methods, which is perfectly understandable given the scope and detail of the information available at the level of strategic planning. This opens up many possibilities for the methodological approach to impact assessment at SEA level to be adapted to specific circumstances, as well as to combine different methodological approaches and methods for impact assessment to obtain the best results – the kinds of results which should be the basis for making appropriate decisions on spatial planning in specific cases.

Given that qualitative expert methods are characterized by subjectivity, it is necessary to apply the techniques and tools allowing the greatest possible objectivity in impact assessment. In this context, the present author underscores the role and importance of GIS technology in this procedure (Josimović and Krunić, 2008); other authors discuss this as well (Grassi et al, 2014; Campo, 2017; García-Ayllón, 2017; Pedro et al, 2017).

4.2.1. Applying the multi-criteria evaluation method in impact assessment

One of the most widely used impact assessment method in SEA, dominant in the research and specialist work of the present author, is the multi-criteria method (MCE) of evaluating planning conceptions.

The MCE method was developed in the early 1970s and is now considered a well-developed scientific field, supported by a great number of scientific references (Figueira et al, 2005; Kangas and Kangas, 2005; Ananda and Heralth, 2009; etc.).

When it was first developed, the MCE method was characterized by a methodological principle of deciding based on several criteria with a modest participation of the public or without it (Zionts, 1979; Zionts and Vallenius, 1976). The primary goal was to obtain clear information for decision-making, and then to solve a well-structured problem using mathematical algorithms. Over time, the ideas of procedural rationality (Simon, 1976) and constructive or creative approach (Roy, 1985) led to the development of the MCE method to the level where the whole application concept was geared towards making optimal decisions, which entails including the public in the MCE process (Banville et al., 1998; De Marchi and coll., 2000; Proctor, 2004). In this context, appropriate consideration is a precondition for ensuring the outcome of process quality.

The MCE method is often recommended today as a suitable support in decision-making, due to its capacity to indicate in many ways the manifold development alternatives based on criteria assessment related to the environment and the socio-economic aspects of sustainable development (Josimović et al, 2015).

4.3. The possibility of using SEA in wind farm planning

Impact assessment in wind farm planning has its specificities which affect the specificities of assessing their impact on the environment in the planning process. The specificity can be seen in the following facts:

- A planning document usually only includes one project (one wind farm);
- Most technical details regarding the project are known in advance;
- Although only one wind farm is typically planned, the space needed for constructing a wind farm is considerable, which requires significant spatial analyses.

The facts above indicate that there are elements in wind farm planning which may lead one to assume that it is enough to conduct an EIA and not a SEA (one project – one location – technical details of the project known). This is always an attractive option for wind farm investors, who always want to save time. Getting straight to the EIA, without a SEA, seems like a good opportunity to do just that.

However, there are two key arguments for conducting a SEA in wind farm planning:

1. Implementing the concept of preventive protection is possible only if wind farm planning and drafting a SEA affects the spatial micro-locational determination of wind farm structures; and
2. Credit institutions providing funds for the investor to implement a wind farm project pay special attention to just the environmental impact of a project (financial risk assessment) and applying the preventive protection principle appears to be the only right way. Applying SEA in wind farm planning can make possible environmental impacts of a project acceptable to creditors (the economic argument is often crucial in selecting the appropriate approach to project implementation).

If based on the facts above we accept that SEA is an essential instrument in wind farm planning – and the present author is of that view – a further analysis is possible which would look at which circumstances are possible in wind farm planning and the application of SEA in this process.

The first and most beneficial circumstance is planning the wind power sector development at the national or regional level. In this case, SEA can reach its full capacity at the level of strategic planning by analysing the spatial capacities of many wind farms at the national or regional level, with all the implications for space and the environment. By applying this principle, it is also possible to analyse the cumulative and synergic effects of wind farms and their interactions, as well as the interactions with the existing activities in the explored space, which is a traditionally important contribution of SEA. The results of a SEA conducted in this way would be an extraordinary contribution to determining the optimal number and layout of wind farms at the national or regional level. Although it is not rare for the wind power development strategy to be formulated at the national level, it is usually incorporated in the national energy development strategies, or only individual spatial aspects are analysed (e.g. *Spatial Planning for Onshore Wind Turbines – natural heritage Considerations, 2015*), without spatial analyses for wind farm positioning. However, there are cases where the concepts of spatial planning of the wind power sector are applied, but based on the analysis of the relationship between planned wind farms (not micro-locationally determined) and specific environmental elements (protected natural reserves, landscape, etc.) without applying SEA as a control instrument in the planning process (e.g. Spatial planning of wind turbine developments in Wales, 2002). This circumstance is not unusual given that wind farm construction depends on individual initiatives which are not known to the spatial developers at the national and regional level. Specifically, it is difficult to know the capacities of these wind farms, and so this circumstance appears to be only a good idea.

The second circumstance is planning wind farm at the local level, for the needs of a specific project, which is the sort of case which as a rule can be found in practice. In this case, all the circumstances for the application of SEA in planning are known (micro-location, capacities, number of wind turbines). In these circumstances, the main role of SEA in the planning process is to micro-locationally determine individual wind turbines relative to spatial relations, phenomena, and processes at a specific location. Although it may appear that this other circumstance is limiting for the application of SEA and its full contribution, the situation is actually different. By applying SEA in planning individual wind farms it is possible to encompass all SEA areas, including the analysis of variant solutions which in this case can relate to, for example, the number of wind turbines (a higher number of smaller wind turbines or a smaller number of bigger ones) or phasing in construction (which leaves space for the adaptations of wild life at the location to new circumstances, the so-called adaptiveness).

Irrespective of the circumstances discussed above, the application of SEA in wind farm planning is based on the guidelines for selecting the optimal options for minimizing or eliminating potential conflicts in space which can arise as a result of a correlation between a wind farm and the environmental elements described in section 3.2.2. of this book. Optimal options are sought in the analysis of the spatial relations of a wind farm to ornithofauna and chiropterofauna, structures and settlements (effects of noise, effects on the landscape with the effect of shadow flicker, effects in the case of an accident), infrastructure (effects in the case of an accident). In this context, SEA stands out as an ideal instrument for the assessment of spatial/territorial effects of wind farms on the environment.

From a methodological perspective, the application of SEA in wind farm planning allows the application of various qualitative expert methods (described in section 4.2) combined with quantitative methods applied in partial impact assessments (described in section 3.3.). In other words, due to the specificity of wind farm project planning, it is possible and desirable to combine the technical and the planning approach to SEA, i.e. to apply a semi-quantitative method of multi-criteria evaluation that the author of the present volume has written much about in his papers, some of which can be found in the list of references at the end of the book.

5. APPLYING SEA IN THE PLANNING OF THE WIND FARM BELA ANTA IN DOLOVO – A CASE STUDY

Unlike the previous chapters, which were dedicated to theoretical considerations of various aspects of wind power and focused on the assessment of possible effects of wind farms on the environment, this chapter is concerned with applications. It will use a concrete example to present the application of SEA in planning wind farms in the Republic of Serbia[8]. As previously stated, the author of the present volume has gained a considerable experience in assessing the impact of wind farms on the environment by preparing over ten SEA and EIA for wind farms in Serbia and Montenegro. The author wishes to present this experience to the readership interested in expanding or improving their knowledge in this area.

The example presented in this book section is the wind farm project Bela Anta in Dolovo (the town of Pančevo, Serbia) for a couple of reasons:

- This is a big project (60 wind turbines with the installed power of around 200MW) for whose implementation it is necessary to analyse a larger space; this is why the role of SEA is bigger due to analysing a greater number of interactions in the given space.
- There is phasing in project implementation (35 + 25 wind turbines), which is why a spatial analysis and impact assessment was done for both phases individually, ensuring greater level of detail and data precision in SEA;
- There were two approaches to planning the project implementation phase, which made the project more interesting. The first approach included defining the spatial micro-locational determination of the wind turbines, while the second included defining the zone of future wind turbines;
- Applying SEA resulted in a more significant modification of the initial spatial micro-locational determination of the wind turbines, confirming the important contribution of SEA in preventive environmental protection;
- The project investor, Energohelis Group d.o.o., demonstrated an exceptional attitude towards the environment by putting in efforts to conduct all the procedures ensuring preventive environmental protection.

[8] SEA was introduced in the planning practice in Serbia by the adoption of the Law on Environment Protection (The Official Gazette of the Republic of Serbia, No. 135/2004, 36/09, and 72/09 – 43/11 – the Constitutional Court). According to Article 35 of this law, 'The strategic environmental assessment is conducted for plans, programmes and bases in the area of spatial and urban planning or land use, energy, industry, transport, waste management, water management and other areas, and is an integral part of a plan, programme, or basis.' A separate Law on Strategic Environmental Assessment was adopted at the same time as this system law (The Official Gazette of the Republic of Serbia, No. 135/2004 and 88/2010).

In addition to the Bela Anta wind farm project, the same complex saw the planning of a biomass power plant project, which makes this space a unique complex for applying renewable sources of energy.

Although these projects and their component parts (transport infrastructure, substation, transmission network, etc.) are included in a single SEA, this chapter only shows the segments of SEA relating to the wind farm. The overview focuses on the methodological approach and certain important results sufficient for getting a general idea of the application of SEA in wind farm planning. The SEA details, in part a business secret, are not elaborated in the present volume.

The SEA in the planning of the wind farm Bela Anta is provide in several sections:

- The starting assumptions with an overview of the planning concept;
- Analysis of the research space environment;
- Applying the semi-quantitative multi-criteria evaluation method;
- The plan implementation guidelines.

These sections contain all the key elements of the application of SEA in wind farm planning.

5.1. The starting assumptions with an overview of the planning concept

Recognizing the importance and need for the protection of the environment which can be affected by the planned wind farm, and based on the Opinion of the Secretariat for the Environment, the Secretariat for Urban Planning, Construction, Housing and Utilities of the Town of Pančevo adopted the Decision on initiating the preparation of the Report on Strategic Environmental Assessment of the Detailed Regulation Plan (DRP) of the infrastructural complex for renewable energy sources (RES) in the Bela Anta area in Dolovo (2016). This created a planning basis for the preparation of the SEA in line with the provision of the Law on Strategic Environmental Assessment (The Official Gazette of the Republic of Serbia, No. 135/04 and 88/10).

According to the decision above, the task of the SEA is to assess all possible effects of the planning concept of development defined under the DRP, define the guidelines for minimizing or eliminating the negative DRP environmental effects, and present the results in a simple and unambiguous way, making it possible to make a decision on the acceptability of the DRP and the wind farm Bela Anta project.

The DRP solutions are such that their implementation should create planning assumptions for the construction of multiple functional units for electricity production from renewables. Of interest for this book is the section in the DRP and SEA relating to the wind farm. In this connection, Bela Anta wind farm is planned to be constructed as several independent wind farms (wind turbine fields). Initially, based on a technical and economic analysis, the Bela Anta wind farm was planned to have the total power of around 120MW (about 35 wind turbines); based on an additional technical and economic analysis for the purposes of preparing the DRP, a use was set for the expanded space for the WF Bela Anta 2, with the total power of around 80 MW (around 25 wind turbines).

The spatial extent of the facility for the production of electricity from renewables in the Bela Anta energy complex is shown in Figure 32.

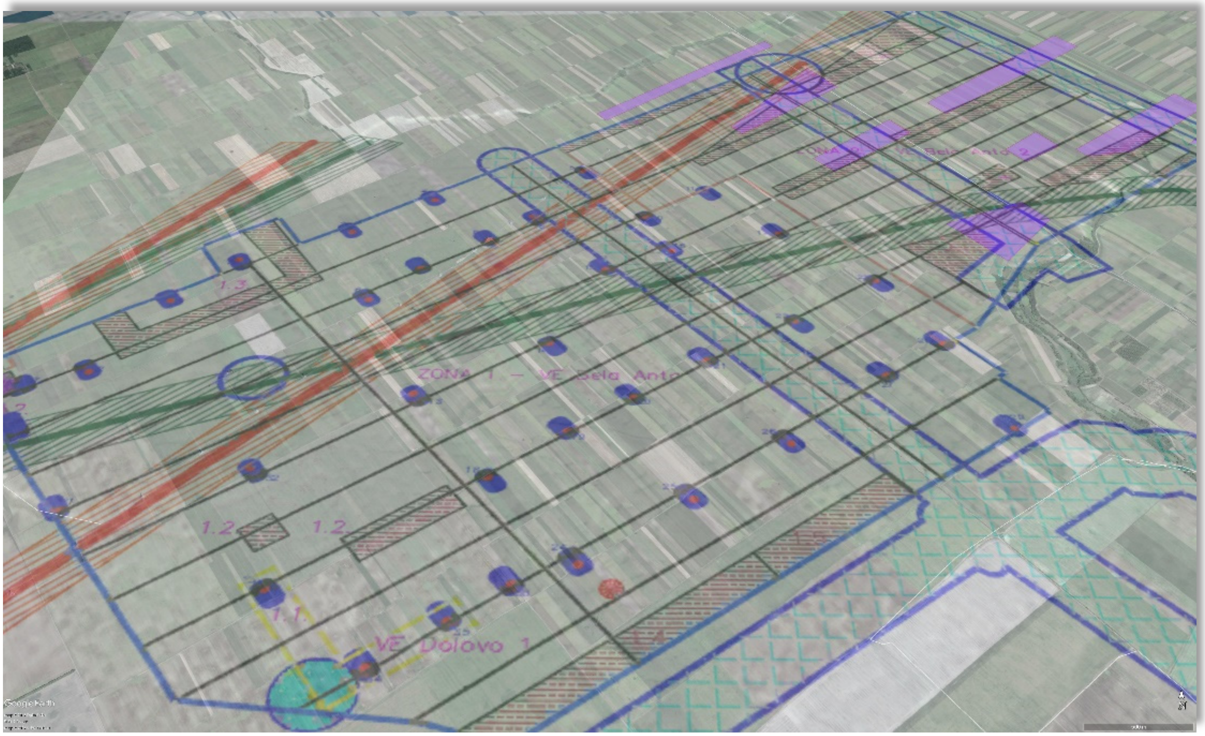


Figure 32. *Land use in the Bela Anta RES complex*

These independent wind farms in the Bela Anta RES complex are divided in line with the DRP into the following spatial units:

ZONE 1 (WF Bela Anta)

This refers to the part of the DRP extent for the wind farm consisting of 35 wind turbines, for which a spatial micro-locational determination was proposed relative to the possible effects on the environment and the corresponding wind potential.

A number of subzones are planned within Zone 1:

- Subzone 1.1 (WF Dolovo 1) - 3 wind turbines (power up to 10 MW) and
- Subzones 1.2 – 1.5 (WF Dolovo 2 to WF Dolovo 5) **–** 3 wind turbines each (power up to 10 MW).

The creation of subzones is conditional on project funding, which is important to the investor, but not relative to environmental protection as all these subunits are treated in a unified fashion in the SEA.

ZONE 2 (WF Bela Anta 2)

The plan is to construct roughly 25 wind turbines (with power around 80 MW), located in the expanded section of the initially envisaged wind farm Bela Anta (Zone 1). In this zone, spatial micro-locational determination of the wind farm Bela Anta (Zone 1) was not envisaged; rather, zones were provided (9 in total) within which the exact number and spatial layout of wind turbines would be determined at a later stage of project development (during the preparation of technical documentation). The wind farm Bela Anta 2 (Zone 2) was planned to be constructed in phases, in line with the same principle as in Zone 1.

In addition to establishing land use, DRP lists as one of the main goals the importance of the protection of the environment and its factors. The decision to apply the SEA in the earliest phase of development of the project/complex for the application of RES was construed as positive – in conceptual terms – by the local authorities which adopted the Decision on the drawing up of the SEA, as well as by the investor who showed initiative regarding environmental protection even before the Decision was made by embarking on a one-year observation of the ornithofauna and chiropterofauna.

5.2. The characteristics of the exploration space environment

The current state of the environment is a basis for defining the SEA goals and the associated indicators, which are then used in the process of multi-criteria evaluations of planning solutions (treated in section 5.3). In this context, special attention is paid in this analysis within the SEA to the analysis of all the elements of the environment which could be affected by all the planned activities within the RES-utilizing complex.

This section presents a selection of the characteristics of the environment which are important solely in terms of identifying the spatial/territorial effects of the Bela Anta wind farm on the environment; specifically:

- The physical-geographic spatial characteristics;
- Data on the ornithofauna in ZONE 1 of WF Bela Anta
- Data on the ornithofauna in ZONE 2 of WF Bela Anta
- Data on the chiropterofauna in ZONE 1 of WF Bela Anta
- Data on the chiropterofauna in ZONE 2 of WF Bela Anta
- The anthropogenic spatial characteristics

The analysis of the characteristics of these environmental elements is a basis for defining the relevant goals, indicators and criteria to be included in the process of multi-criteria evaluation of the planned developmental concepts within the SEA.

5.2.1. The physical geographic characteristics of the space

In assessing the territorial/spatial effects of a specific planning document on the environment, it is necessary to analyse the wider context. This is why it is not enough to analyse only the space determined by the planning document boundary, but also the space outside the planning document. This is especially important if it is estimated that it is possible to expect the effects of future activities, planned in the planning document, on the environmental factors outside the boundaries of the plan area.

In the case of the planning of Bela Anta wind farm, this included the analysis of the area of the town of Pančevo, whose territory contains the village of Dolovo. A wind farm is planned in the village's wider area, and the analysis focused on the physical geographic characteristics (geographic position, climate conditions, etc.), landscape characteristics, and the visibility of the wind tubines at greater distances, as well as on the issue of effects on the ornithofauna and chiropterofauna, for which detemining the plan area is practically insignificant.

Geographic position

The town of Pančevo is situated in the south of the Autonomous Province of Vojvodina and includes the territory of southwestern Banat in the delta of the Danube, Tamiš and Nadel (Figure 33). In the north it borders on the municipalities of Opovo and Kovačica, in the northeast with the municipality of Alibunar, and in the east with the municipality of Kovin.

The south and west border are made up of the rivers Tamiš and Dunav, which is at the same time a natural border separating the Autonomous Province of Vojvodina and Serbia proper.

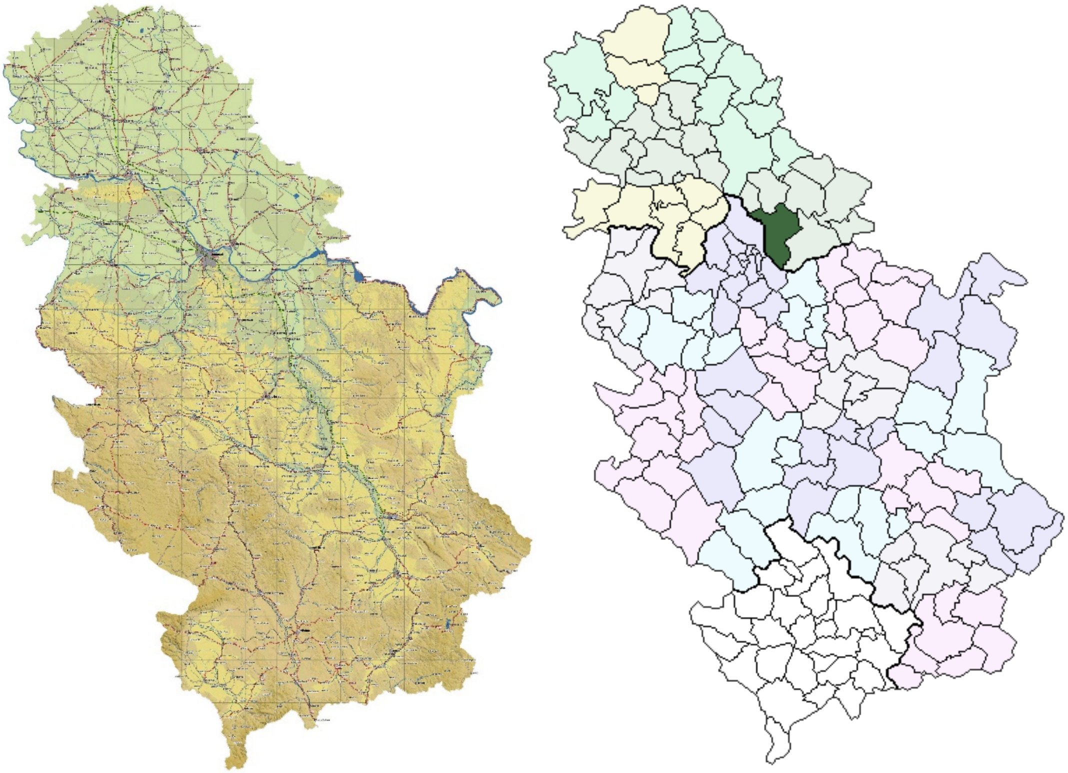


Figure 33. *The geographic position of the town of Pančevo*

Although Pančevo is geographically peripheral in Vojvodina, its position is exceptionally good as it is only 17 km away from Belgrade. Besides having a direct connection to the Danube and Tamiš, several national roads run through its territory (Belgrade-Zrenjanin; Belgrade-Vršac; Pančevo-Kovin) and two important rail lines (Belgrade-Kikinda and Belgrade-Bucharest). This is very beneficial for transporting equipment used to construct the wind farm which due to its size requires specific transportation norms,

The location of the Bela Anta RES complex (Fig. 34) is east of Pančevo, at about the mid-point between Pančevo and the Special Nature Reserve Deliblato Sands (at about 10km), and west of the village of Dolovo (distance of nearest towers to the nearest residential structures is app. 1,500m). The space included in the DRP is located in farmland to the west and north of the village of Dolovo and the Deliblato Sands Reserve.

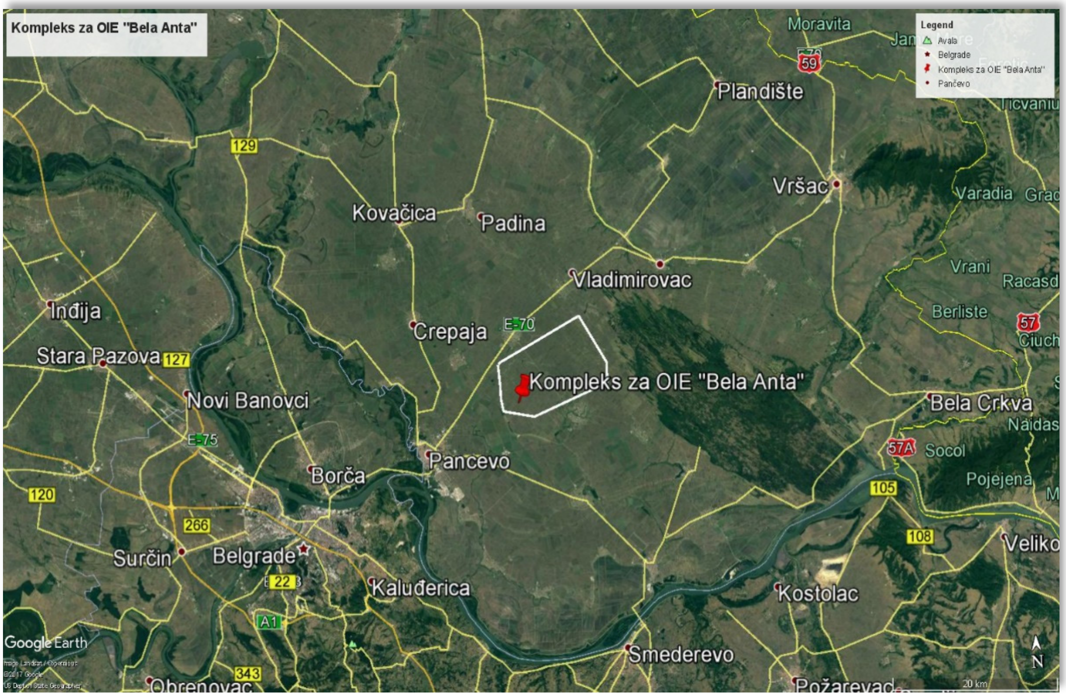


Figure 34. *The position of the Bela Anta RES complex relative to the wider area (Source: Google Earth, modified)*

<u>Terrain topography</u>

The terrain topography is important in terms of the visibility of the wind turbines as a factor in assessing the impact of wind turbines on the landscape.

Geomorphologically, the location of the planned complex is situated in the South Banat (Deliblato) loess plateau, at the very border with the South Banat (Pančevo) loess terrace.

The terrain topography is gently undulating and stands at 105 masl on average. The approximate levels of the terrain in the Bela Anta RES complex range from 90 to 125 masl. The loess terrace lying eastwards and southwards from the location is a gently undulating plain at an obviously lower altitude (figure 35), on average around 10m lower than the location. The loess plateau containing the location has, in addition to higher altitudes, a more undulating relief (Figure 36), with characteristic morphology – loess dunes, loess sinkholes and loess valleys.

Figure 35. *A view from the location to the lower neighbouring area of the South Banat loess terrace (Photo by: Branko Karapandža, original).*

Figure 36. *The characteristically undulating loess plateau terrain at the location (Photo by: Milan Paunović, original).*

Biogeographic characteristics

Biogeographic characteristics are especially important for determining the potential of a location for forming habitats and the identification of hunting areas of some ornithofauna and chiropterofauna. This is why their analysis is important for the impact assessment in the SEA.

Biogeographically speaking, the space in which the Bela Anta wind farm is planned is situated in the Pannonian province of the Pontic biogeographical region, characterized originally by forest-steppe vegetation and moderate continental climate, with noticeable central-European and Mediterranean influences. Due to many centuries of anthropogenic activities, the original vegetation and indigenous eco-systems are very reduced, fragmented and transformed in the entire province, for the most part into agrobiocenoses. These processes are continuing.

The very location of the Bela Anta wind farm, taken as a whole, has very sparse indigenous forest-steppe vegetation, but its fragments and elements are still there, mostly by some field roads (Figure 37).

Figure 37. *Sparse elements of the indigenous forest-steppe vegetation at the location appear mostly by some field roads (Photo by: Branko Karapandža, original).*

Much bigger fragments and elements of the relatively preserved forest-steppe vegetation appear in the immediate vicinity of the location, especially in the loess valleys along the south-eastern and western borders of the DRP. The biggest such unit includes the loess valley lying along the south-eastern and eastern border of the plan from south-west to north-east, connecting the micro-sites Male šumice, Volarska Bara, and Ciganska dolina (Figure 38).

Figure 38. *The most important complex of the indigenous forest-steppe and marsh vegetation in the immediate vicinity of the location, in the zone of the Ciganska Dolina site zone. (Photo by: Branko Karapandža, original).*

Figure 39. *Sparse elements of the indigenous forest-steppe vegetation and marsh vegetation at the location appear in small loess valleys. (Photo by: Vukašin Josipović, original).*

The specific location where the Bela Anta RES complex is planned has very sparse indigenous forest-steppe and marsh vegetation as a whole, but its fragments and elements do exist, mostly in some parts of the loess valleys stretching along the location (Figure 39).

The only bigger forest fragment is found at the very north-western border of the location (Figure 40) and occupies around 17 ha, while five smaller fragments take up 0.5 ha each at maximum. Each fragment is very densely structured, difficult to pass through or completely impassable, consisting of a mixture of indigenous plants and cultivated acacia.

These fragments are important as shelter for the local populations of hunted mammal species (does, rabbits, pheasants, badgers, foxes) and birds, as well as other numerous animal species, which feed in the surrounding agricultural habitats.

Figure 40. *A view from the location to the southern and eastern edge of the biggest forest fragment at the location of the Bela Anta RES complex (Photo: Branko Karapandža, original).*

With the exception of the forest fragments above, in most of the location the wood and brush vegetation is sparse and consists for the most part of individual trees and shrubbery, most often next to field roads, and only by some parts of the Prvi preki put, and of smaller fragmented and/or sparse linear elements – lines of tress (Figure 41).

Figure 41. *Sparse linear wood and bush vegetation next to the Prvi Preki Put road (Photo by: Branko Karapandža, original).*

The presence of mosaic-shaped fragments and linear elements of wood and relatively preserved indigenous habitats, especially in the great expanses of the agroecosystems of the plains, contributes to the preservation of biodiversity and the ecological stability of the entire, mostly agricultural eco-system.

The priority of such fragments for the protection of biodiversity is recognized by the Law on Environmental Protection (The Official Gazette of the Republic of Serbia, No. 36/2009, 88/2010), whose Article 18, par. 6 states: 'The preservation of the biological and landscape diversity of habitats within agroecosystems and other non-autonomous and semi-autonomous ecosystems is conducted primarily by preserving and protecting the edge habitats, hedges, borders, individual trees, groups of trees, wetlands, and meadow belts, as well as other ecosystems with a preserved or partially altered wood, brush, meadow or marsh vegetation.

Although ecologically very important, the forest-steppe and forest fragments and linear elements make up no more than around 0.5 per cent of the surface area of the location where Bela Anta wind farm is planned. As a whole, the Bela Anta location is a compact spatial unit situated in the agricultural landscape. It includes almost exclusively farmland with intensively farmed fields sown with crop monocultures, between which there are no overgrown borders, hedges, or tree lines. The presence of non-crop agricultures and deserted fields is small, almost negligible. The entire location and the surroundings are covered with a dense grid of field and earth roads, only partially causewayed or macadamed, used for accessing agricultural plots. In the immediate vicinity of the location, at about 0.5km from the southern border of the plan, lies the asphalt road Pančevo–Dolovo.

The electricity infrastructure (high voltage power line) runs through the far northern parts of the location south-west to north-east, and dominates the landscape visually, which is relevant to the assessment of the impact of the Bela Anta wind farm on the landscape.

In addition, the location where the wind farm is planned does not include the zone of surrounding towns and villages. However, surrounding the location are the country house area near the village of Dolovo at about 0.5km south of the plan border, the village of Dolovo (Fig. 42) at around 1km southeast, and the village of Stari Tamiš at around 2.5km southwest of the location. Although the DRP border is near the two populated areas, the nearest wind turbine positions are more than 1 km away from them, which is relevant to the assessment of visibility of the future wind farm and to the noise impact assessment.

Figure 42. *Dolovo, the village closest to the location – a view from the location (Photo: Branko Karapandža, original).*

The SNR Deliblato Sands is located at around 7.5km east of the location. This space is protected under the law as 'the biggest European area made up of sediments of aeolian sand with prominent dune relief shapes and characteristic sandstone, steppe, and forest ecosystems, with a unique mosaic of animal groups and typical and specific representatives of flora and fauna. Many of them are natural rarities and species important as per international criteria' (The Official Gazette of the Republic of Serbia, No. 3/2002, 81/2008). The SNR is also an IBA - Important Bird and Biodiversity Area, i.e. an area important for as many as 180 recorded bird species and 22 bat species. It is one of the most important centres of bird and bat fauna diversity in Serbia and bat fauna diversity in the AP Vojvodina. This is especially relevant in planning the wind farm given that the potential impact of the wind farm on the volant fauna is considered the most prevalent.

Further, at around 13 km south-east of the location is the Special Nature Reserve Kraljevac (The Official Gazette of the Republic of Serbia, No. 14/2009), a marsh habitat protected for the purposes of ‘preserving the geomorphological and hydrological characteristics of this space and […] the habitat of natural rarities.’ The SNR Kraljevac is also an important hunting territory for many species of bat. At around 12 km south-east of the location lies the Tamiš river valley, and at between 13 and 30 km the location is partially hemmed in by a stretch of the Danube. The Tamiš and Danube valleys are important European migration corridors for birds and bats in the spring and autumn season. This is why their waterways and bank areas are protected by law as environmental corridors of international significance and parts of Serbia's environmental network (The Official Gazette of the Republic of Serbia, No. 102/2010). A part of the Danube river valley, at around 15 km south of the location, belongs to the Lower Danube Delta, protected by the Spatial Plan of the Republic of Serbia by 2020 (The Official Gazette of the Republic of Serbia, No. 88/2010). Still, due to the geographic and ecological separation from the location, the expected impact of these important natural resources on the bird fauna is small, and negligible for the bat fauna.

<u>Climate conditions</u>

The most important climate factors impacting on the characteristics of the Pančevo area are latitude, distance from the Mediterranean Sea and the Atlantic Ocean, as well as the isolation of the Pannonian Basin, surrounded as it is by the Alps, the Carpathians, the Dinarides, and the Rhodopes. Another important factor are the active centres of air pressure, both permanent and seasonal, the Azores Anticyclone, the Asian winter anticyclone, and the Atlantic and Mediterranean depression-cyclone. The effects of the Azores Anticyclone are manifested in increased air pressure, which results in longer spells of stable weather, intensive heating of the earth and air, as well as in prominently ascending air.

The climate factors with a significant impact on the climate characteristics of the space planned for the Bela Anta wind farm include altitude and terrain, rivers, various soil types and plant life. Small absolute altitudes in the town of Pančevo, less prominent relief structure, Danube and Tamiš waterways, gallery forests on the Danube banks, the thin forest strip around the river Tamiš, the forests of the Banat sands in the immediate vicinity of the town of Pančevo and other low vegetation can only affect micro-climate differences, which are not important for the municipality as a whole.

Windiness and cloud cover are also important in planning the Bela Anta wind farm and assessing its potential impact, especially on ornithofauna and chiropterofauna. The data shown below relate to windiness and have been retrieved from the web page meteoblue.com, from the climate diagrams contain there. The meteoblue.com climate diagrams based on 30-year hourly weather models, available for all locations around the world. The simulated weather data have the spatial resolution of around 30 km and may not show all local weather effects but remain relevant at the DRP and SEA processing levels.

Windiness

Winds have a very important effect on the climate of the town of Pančevo, and thus on the organic world and main human activities. In addition, windiness is key for the project assessed in this SEA as the wind potential affects wind farm production estimates and operation, as well as the impact on ornithofauna and chiropterofauna.

The analysis of annual wind frequencies shows that the south-eastern wind Kossava is dominant and appearing mostly in October, November, February and March. It is most frequent in autumn and winter, less so in spring, and least frequent in summer.

Wind	S	SI	I	JI	J	JZ	Z	SZ	None
Winter	105	82	55	212	161	55	136	128	66
Spring	140	81	47	202	133	68	116	142	71
Summer	131	91	48	148	96	61	136	177	112
Autumn	91	84	64	264	145	59	105	112	76
Year	117	84	53	207	134	61	123	140	81

Table 6. *Mean wind and calm weather frequency (%).*

The mean wind speed per direction analysis shows that south-eastern and south winds reach greatest speeds annually and seasonally. Still, the greatest mean speeds are reached in spring and winter. The mean number of days with high winds (speeds over 12.3 m/s or 44.3 km/h) per year is 45.3, mostly between October and April. In monthly terms, most days with high winds are found in November (5.8) and March (5.7), and fewest in August (2.1).

Wind	S	SI	I	JI	J	JZ	Z	SZ
Winter	2.82	1.96	1.80	4.87	3.38	1.91	2.29	2.95
Spring	3.48	2.48	2.26	5.28	3.62	2.52	2.83	3.38
Summer	3.03	2.21	1.88	3.19	3.03	2.57	2.78	3.26
Autumn	2.91	2.01	1.69	4.67	3.48	2.01	2.45	3.82
Year	3.10	2.17	1.88	4.58	3.40	2.27	2.59	3.13

Table 7. *Mean wind speed (m/s).*

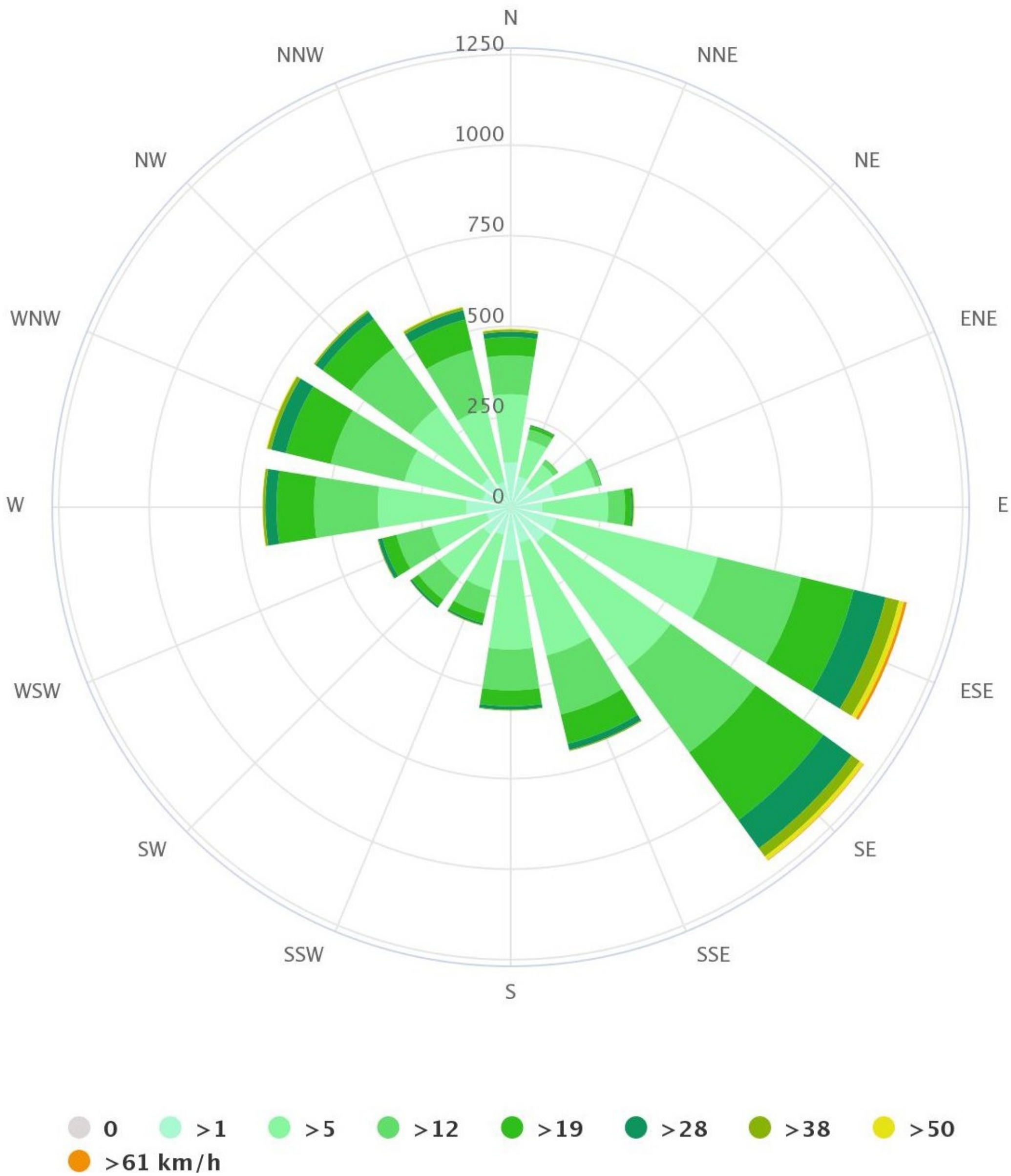


Figure 43. *The wind rose for the town of Pančevo (Source: meteoblue.com).*

Cloud cover

Cloud cover is an important climate modifier affecting solar radiation intensity, sunshine duration, irradiation, the earth temperature and the temperature of air above it, fog – which is also important for the wind farm impact on ornithofauna. The cloud cover in Pančevo is greatest in December (73%), January (70%), February (67%) and November (66%).

The smallest mean cloud cover is seen in August (34%), September (37%), and July (38%). The remaining months have an average cloud cover ranging from 44 to 59% annually. Cloud cover fluctuations are very high, standing at 39%.

Hydrology

The hydrological characteristics of the planned wind farm area are also important in terms of possible impacts on the ornithofauna and chiropterofauna. In this connection, water surfaces are important as they attract volant fauna and can also be a migration corridor in case of big waterways, such as the Danube. Wind farm planning must be carefully conducted in such circumstances, with detailed observations of the volant fauna.

There are many surface waterways in the Pančevo territory. Surface waterways can be divided into natural (Dunav, Tamiš, Nadela and Poljavica) and artificial (melioration channels and artificial lakes).

For a 30-km stretch the Danube constitutes the border of the town of Pančevo. It enters the municipality near the confluence of the Tamiš and leaves it in the area of Banatski Brestovac, 5 km upstream from Grocka. At the very entrance into the Pančevo municipality, it meanders prominently towards the north. There are two bigger and two smaller waterways here, with the river islands of Forkontumac, Štefanac and Čakljanac between them. Around two kilometers upstream from the Tamiš confluence is Starčevačka ada (holm), situated along the left bank and bordering on the east a river branch at whose entrance is a stone barrier built in 1907. The second Danube river branch is situated near Ivanovo, hemming in the island with the same name. The Nadela flows into this river branch. Downstream from Pančevo the average width of the Danube is 600-700m. In medium and low water levels, the depth increases by 2-7m and width by as much as 50m.

Water	J	F	M	A	M	J	J	A	S	O	N	D	Ann
Low	153	198	242	334	304	273	215	145	108	81	100	157	193
Medium	254	291	350	414	384	336	283	211	178	174	202	252	277
High	343	390	442	485	453	388	352	289	236	212	286	341	351

Table 8. *The typical water level of the Danube at Pančevo (cm)*
(Source: data of the Pančevo water gauging station).

The Danube has a complex hydrographic regime, which changes depending on the climate conditions in the upstream portion of the basin. The regulation works had an important impact on determining the Danube water regime, especially in the lower section of the basin, which Pančevo is part of as well. The surface waterways of the Danube and Tamiš have a twofold impact on the bank area. At low water levels, rivers serve for drainage and ground waters, at their lowest then, move toward them. At high water levels, the river is higher than the banks, which results in the inverse movement of ground waters. Bearing in mind that the high water levels of the Danube exceed the altitude of 74 masl and that the altitude of large areas of arable land stands at 70 to 72 masl, what occurs is a systematic saltification of large areas of arable land.

The Nadela's spring is in the south Banat terrace east of Crepaja, and it flows southwards with two prominent meanders – at Jabuka and east of Pančevo down to where it flows into the Danube. It is 36km long. The Nadela flows down one of the abandoned Tamiš waterways, and its valley is 200m wide on average. It is the deepest at Starčevo, standing at 2.5m. The highest water levels occur in the spring, due to the rain and the melting of snow. The secondary maximum, a result of autumn rain, occures in late autumn, while the lowest water levels occur in late summer due to intensive evaporation.

The plan scope does not envisage a canal network, and the ground waters flow through the soil by natural collation into the wider area, in which water removal is regulated by a system of canals connected to the channelled waterways, with a string of pumping stations which maintain the design flood levels of the water.

<u>Vegetation</u>

The plant and animal life in the Pančevo territory is largely degraded and altered by the anthropogenic factor. Natural vegetation has been replaced with agricultures which have created new ecological conditions. This has resulted in the reduction of the total forest area, comprising around 5.5% of the Pančevo territory, as compared to the 4.9% of meadows and pastures, according to the data of the Statistical Office of the Republic of Serbia.

The natural vegetation is still found only in small areas, by rivers and canals, along roads and in marshland. The most prevalent are indigenous and artificial marsh forests. Thick shrubbery is found between trees, and meadows and pastures occupy open spaces. Some of the mineral water springs were forested in the 1980s using the fast-growing Canadian poplars. Large farmland areas are jeopardized by the construction of the Đerdap hydroelectric power plant, rising ground water, and periodic flooding.

The town of Pančevo's forest cover is very small with respect to its total area and is unfavourable concentrated in the thin inundation strip close to river streams. The forest structure is dominated by poplar monocultures, while mixed forests are bad, which has an additional adverse effect.

Protected natural values

The space contained in the DRP, where the Bela Anta wind farm is planned, there are no protected nature sections. However, given the fact that the future RES complex Bela Anta is in the 'impactful area' spatial unit, outside of the protected natural resource whose boundary is determined by the Regulation on the Protection of the SNR Deliblato Sands, special attention must be paid to the conception of spatial development in order to minimize the possible negative effects on the SNR area.

5.2.2. The ornithofauna and chiropterofauna of the broader area

In order to obtain clear and detailed data on the numbers and types of the volant fauna in the explored space, identify their habitats, their habits and hunting territories, and as part of the planning process for the Bela Anta wind farm and the preparation of the SEA, observations of the ornithofauna and chiropterofauna were carried out in the plan area and its surroundings. The impact of wind farms on volant fauna is considered the highest in projects of this type, so the data obtained in detailed observation of the volant fauna have a direct bearing on the number and position of the wind turbines within a wind farm.

One-year observations of ornithofauna and chiropterofauna were carried out separately for ZONE 1 of the DRP – the Bela Anta wind farm (January to December 2013) and for ZONE 2 of the DRP – the Bela Anta 2 wind farm (July 2015-July 2016)[9]. This section of the book will present only the summary of the observations carried out by the authors: Dr Milan Paunović and Milan Karapandža.

The observations of the ornithofauna and chiropterofauna were carried out in the space which originally belongs to the forest-steppe areas, long since altered into farmland and cultivated steppe.

At the location, forest vegetation and elements of the original forest-steppe vegetation are present in a small space (up to 1% of the location area), and humid habitats do not exist; near the location are larger and more important habitats, with a relatively well-preserved forest-steppe vegetation, as well as marsh vegetation, preserved in a lesser degree.

[9] This section of the book presents an summary of the observaitons of ornithofauna and chiropterofauna carried out by the authors: Dr Milan Paunović and Milan Karapandža. Detailed one-year observations (monitoring) were carried out in the form of 500-page long studies, with tables and diagrams. The present author wishes to thank the authors of these studies for agreeing to allow some of their research to be presented here.

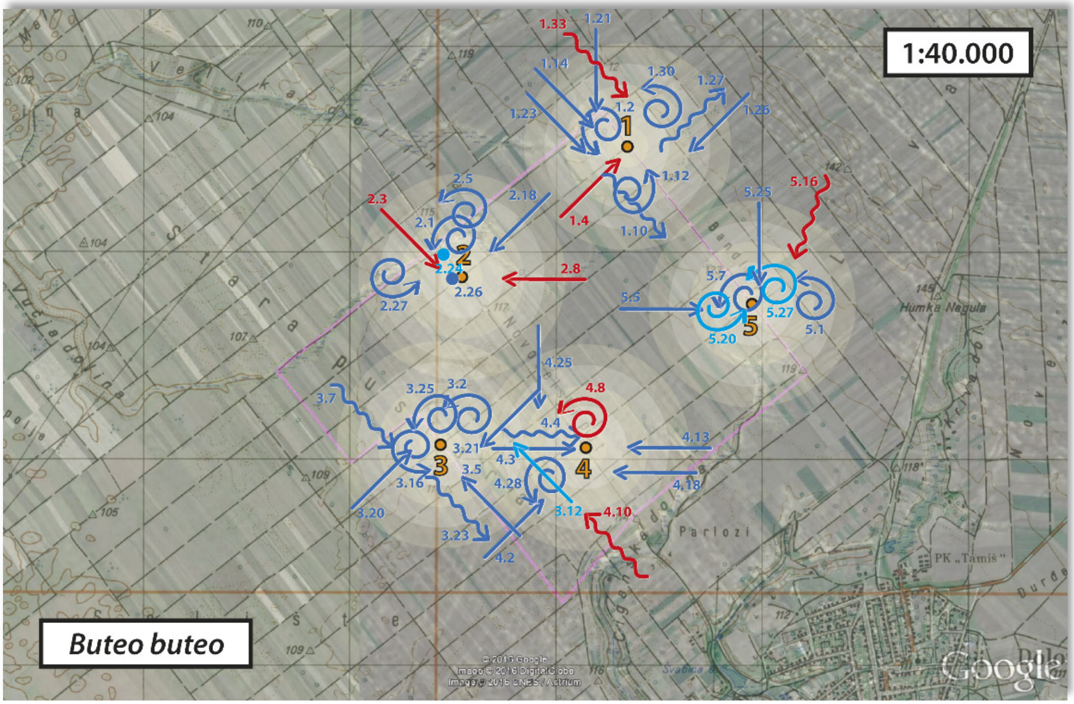


Figure 44. *An illustration of the observation of the species Buteo buteo (Source: Paunović, Karapandža)*

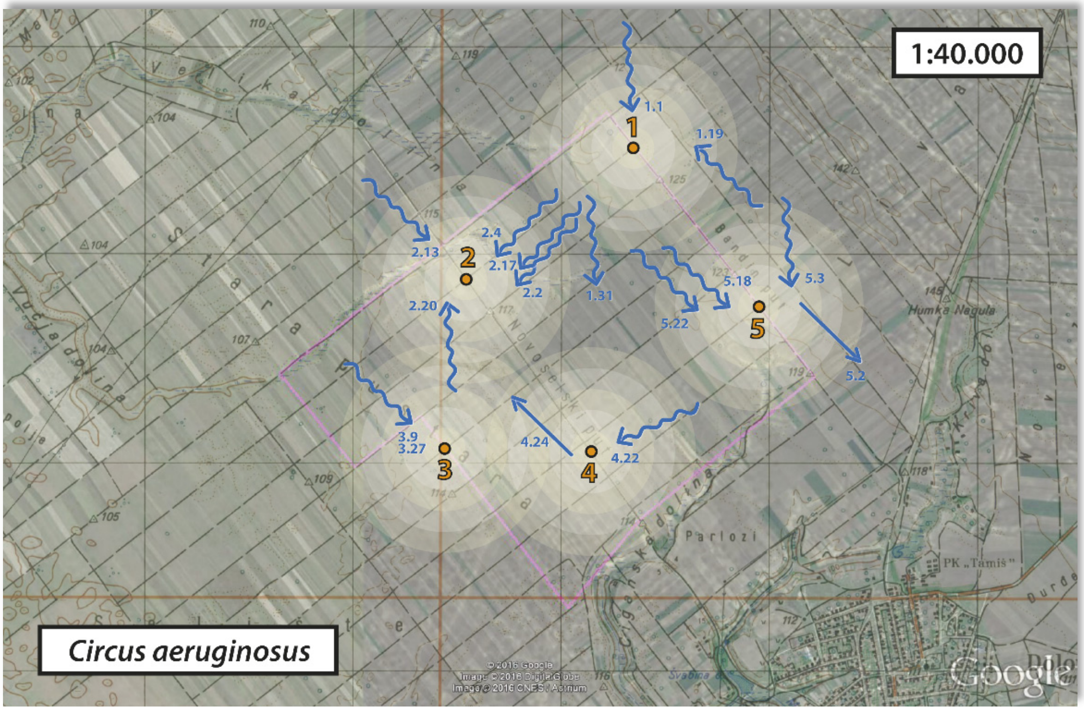


Figure 45. *An illustration of the observation of the species Circus aerugiosus (Source: Paunović, Karapandža)*

A very small section of the location soil is permanently uncultivated and covered in weed, with the mosaic habitat of cultivated steppe comprising around 99% of the location area. In such habitats, anthropogenic activities, i.e. intensive farming accompanied by the use of pesticides, result as a rule in sparsity of trophic and cryptic resources, for birds and bats as much as for other animal species. This is especially prominent during the colder part of the year, as the barren fields are left without sparse vegetation, leaving animals protectionless and without necessary shelter.

However, it is well-known that the presence of mosaic-like layouts of fragments and linear elements of forest and indigenous habitats (relatively well-preserved), contributes in its present modest form to the biodiversity of the largely agricultural ecosystem. This is why before the field research started the location was expected to feature the bird and bat fauna, but not in large numbers and with great diversity, due to the expected sparsity of the trophic and cryptic resources.

Although there are important bat habitats in the vicinity, especially the SNR Deliblato Sands, as well as the internationally significant environmental corridors of the Danube and Tamiš, this was seen as not having a great impact as these habitats, unlike the wind farm location, do have the ecological resources to meet the all the needs of the bird and bats.

In the 2013, 2015, and 2016 observation of the Bela Anta RES complex area, concrete data was obtained on the numbers and types of the volant fauna in the complex and the surroundings.

It was established that there are 107 species of birds and no less than 16 species of bats at the location and in the surrounding area. Although many of them were recorded in very small numbers and peripherally, such a result can be seen as expected as well as relevant to the fauna studies.

In the area proper, the dominant species are those benefiting from the open, cultivated steppe and field habitats, without larger pieces of brush and forest vegetation.

This chapter provides concrete data on the findings for bird and bat fauna elements between January and December 2013, and June 2015 and June 2016, in the explored areas of the future wind farm and its surroundings.

5.2.2.1. The data on the ornithofauna in ZONE 1 of the WF Bela Anta

The results of the observations presented below were obtained in 2013 for the needs of ZONE 1, planned in the DRP as the site for the Bela Anta wind farm, i.e. the western part of the planned RES complex Bela Anta.

The analysis of the satellite imagery, topographical maps and plans, and preliminary terrain survey, potential environmental functions of the habitat elements and location areas for birds were identified at the wind farm location. Bird monitoring was largely carried out using the point census method and, to a lesser extent, the limited transect method. Standard equipment for visual detection and bird species identification was used. Census was carried out at observation points marked in Figure 46 with numbers 1 through 4, covering the planned wind farm space.

Figure 46. *The layout of observation points in the explored area relative to the initial wind turbine position (Source: Milan Paunović).*

The data was sent to the investor monthly in the form of lists of all the species, with details on their numbers, as well as lists of target species with the details on the observed numbers, length of observation and stay, height and direction of their flight, and the weather conditions.

In the space planned for the Bela Anta wind farm, between January and December 2013 a total of 107 bird species were recorded (Table 9), with the target species highlighted (greyed out and **in bold**). Many species were recorded in very small numbers. Of the total number of species, 20 were classed as target species given their national and international significance and preservation and protection status, as well as based on the susceptibility to the risk of wind turbine collision due to their specific bionomy, behaviour, flight manner and height, and possible habitat disruption by constructing the wind farm.

Table 9. *The list of birds recorded at the location per observation point.*

No	Species	OP1	OP2	OP3	OP4
1	*Phalacrocorax carbo*	+	+	+	+
2	***Egretta garzetta***	+	+		+
3	*Ardea cinerea*	+	+	+	+
4	***Ardea purpurea***		+		
5	***Ciconia ciconia***	+	+	+	+
6	***Anser fabalis***	+	+		
7	***Anser albifrons***			+	
8	***Anser anser***				+
9	*Anas platyrhynchos*	+		+	
10	***Circus aeruginosus***	+	+	+	+
11	***Circus cyaneus***	+	+	+	+
12	***Circus pygargus***	+	+	+	+
13	***Accipiter gentilis***	+	+	+	+
14	***Accipiter nisus***	+	+	+	+
15	***Buteo buteo***	+	+	+	+
16	***Falco tinnunculus***	+	+	+	+
17	***Falco vespertinus***	+			+
18	***Falco columbarius***			+	+
19	***Falco subbuteo***	+	+	+	
20	***Falco cherrug***			+	+
21	*Perdix perdix*	+	+	+	+
22	*Coturnix coturnix*	+	+	+	+
23	*Phasianus colchicus*	+	+	+	+
24	***Grus grus***	+	+	+	+
25	*Charadrius dubius*				+
26	***Vanellus vanellus***	+		+	+
27	*Larus ridibundus*	+	+	+	+

No	Species	OP1	OP2	OP3	OP4
28	*Larus cachinnans*	+	+	+	+
29	*Columba livia f. domestica*	+	+	+	+
30	*Columba palumbus*	+	+	+	+
31	*Streptopelia decaocto*	+	+	+	+
32	*Streptopelia turtur*	+	+	+	+
33	*Cuculus canorus*	+	+	+	+
34	*Asio otus*		+		+
35	*Apus apus*	+	+		
36	*Merops apiaster*	+	+	+	+
37	***Coracias garrulus***		+	+	
38	*Upupa epops*	+	+	+	+
39	*Picus viridis*	+	+		+
40	*Dendrocopos major*	+	+	+	+
41	*Dryobates minor*			+	
42	*Calandrella brachydactyla*	+			
43	*Galerida cristata*	+	+	+	+
44	*Alauda arvensis*	+	+	+	+
45	*Riparia riparia*	+	+	+	+
46	*Hirundo rustica*	+	+	+	+
47	*Delichon urbicum*	+	+	+	
48	*Anthus campestris*	+	+	+	+
49	*Anthus trivialis*	+	+	+	+
50	*Anthus pratensis*	+			
51	*Motacilla flava*	+	+	+	+
52	*Motacilla feldegg*			+	+
53	*Motacilla alba*	+	+	+	+
54	*Troglodytes troglodytes*	+			+
55	*Erithacus rubecula*	+	+	+	+
56	*Luscinia megarhynchos*	+	+	+	+
57	*Phoenicurus ochruros*		+	+	+
58	*Phoenicurus phoenicurus*	+			+
59	*Saxicola rubetra*	+	+	+	+
60	*Saxicola rubicola*	+	+	+	+
61	*Oenanthe oenanthe*	+	+		+
62	*Turdus merula*	+	+	+	+

No	Species	OP1	OP2	OP3	OP4
63	*Turdus pilaris*	+	+	+	+
64	*Turdus philomelos*	+	+	+	+
65	*Turdus iliacus*		+		+
66	*Turdus viscivorus*		+		+
67	*Acrocephalus palustris*	+			
68	*Sylvia curruca*	+	+	+	+
69	*Sylvia communis*	+	+	+	+
70	*Sylvia borin*	+	+		+
71	*Sylvia atricapilla*		+	+	+
72	*Phylloscopus sibilatrix*		+		
73	*Phylloscopus collybita*	+	+	+	+
74	*Phylloscopus trochilus*			+	
75	*Muscicapa striata*	+	+	+	+
76	*Ficedula parva*				+
77	*Ficedula hypoleuca*	+		+	+
78	*Aegithalos caudatus*	+	+	+	+
79	*Parus palustris*	+		+	
80	*Parus caeruleus*	+	+	+	
81	*Parus major*	+	+	+	+
82	*Sitta europaea*		+	+	+
83	*Oriolus oriolus*		+		
84	*Lanius collurio*	+	+	+	+
85	*Lanius minor*	+		+	
86	*Lanius excubitor*		+	+	+
87	*Garrulus glandarius*	+	+	+	+
88	*Pica pica*	+	+	+	+
89	*Coloeus monedula*	+	+	+	+
90	*Corvus frugilegus*	+	+	+	+
91	*Corvus corone/cornix*	+	+	+	+
92	*Corvus corax*	+	+	+	+
93	*Sturnus vulgaris*	+	+	+	+
94	*Passer domesticus*	+	+	+	+
95	*Passer montanus*	+	+	+	+
96	*Fringilla coelebs*	+	+	+	+
97	*Fringilla montifringilla*		+		

No	Species	OP1	OP2	OP3	OP4
98	*Serinus serinus*	+	+		+
99	*Carduelis chloris*	+	+	+	+
100	*Carduelis carduelis*	+	+	+	+
101	*Carduelis spinus*	+	+	+	+
102	*Carduelis cannabina*	+	+	+	+
103	*Coccothraustes coccothraustes*	+	+	+	+
104	*Emberiza citrinella*	+	+	+	+
105	*Emberiza hortulana*				+
106	*Emberiza schoeniclus*	+	+	+	+
107	*Emberiza calandra*	+	+	+	+
	Total number of species	**86**	**86**	**83**	**88**
	Total number of target species	**14**	**14**	**15**	**15**

The bottom of Table 9 shows the total number of all species and target species recorded per observation point (OP) in the exploration period. It is evident that the species are equally present, with a minimum of 83 recorded at OP3, and a maximum of 88 recorded at OP 4. The number of recorded target species is also balanced and revealing a similar trend.

Of the 107 species, 98 can be found in the Addenda to the Bern Convention (The Official Gazette of the Republic of Serbia No. 102/2007): 64 in Addendum II – strictly prohibited species, and 35 in Addendum III – protected species. In the Bern Convention (The Official Gazette of the Republic of Serbia No. 102/2007) 34 species are listed in Addendum II. In the EU Directive on Birds 09/147/EC, Addendum I lists 20 species, Addendum II 22, and Addendum III 5. Of 107 registered species, the legislation of the Republic of Serbia in the area of environmental protection lists 83 as strictly protected, and 23 as protected (The Official Gazette of the Republic of Serbia No. 5/2010). The total of 14 species is classified as game protected by hunting bans in specific periods (The Official Gazette of the Republic of Serbia No. 75/2010).

Although 107 bird species can be seen as significant in terms of fauna studies, the number of recorded birds is relatively small. Of the ecological bird groups which can collide with wind turbines (necessitating additional attention and being classified as the so-called target groups), storks and herons (*Ciconiiformes*), floaters (*Anseriformes*), and diurnal birds of prey (*Falconiformes*) should be mentioned separately. Due to a lack of water and humid habitats, the location is not beneficial for the first two ecological groups, as habitats are missing for their feeding, hiding, and nesting. This is why there are so few herons, storks, and floaters and why they are so rarely recorded. This is especially interesting for migratory flocks of geese, few in number and rarely recorded. Herons and storks were recorded sporadically, whether as individual birds or in small groups. In contrast, diurnal birds of prey have a regular presence at the location. This can be explained by the fact that the space in question has a significant trophic base for the birds in this ecological group, above all mous-like rodents (*Rodentia*) as an important element of agricultural habitat fauna. It is for this reason that the most numerous birs at the location are the common buzzard (*Buteo buteo*), common kestrel (*Falco tinnunculus*), and seasonal and other birds of prey, such as the harrier (*Circus* sp.) and falcon (*Falco* sp.).

A wider range of prey is available to the northern goshawk (*Accipiter gentilis*) and the Eurasian sparrowhawk (*Accipiter nisus*), but these species were recorded in very small numbers.

The findings for the saker falcon (*Falco cherrug*) are the fewest but most important, observed in passing on a few occasions.

From the remaining target bird species, small flocks of the common crane (*Grus grus*) had few seasonal overflights during migration, without descending to the location and at high altitude; also, small groups of northern lapwings (*Vanellus vanellus*) were recorded, also in migratory periods. European rollers (*Coracias garrulus*) were recorded rarely and individually only during roaming in the summer months, while the European bee-eater (*Merops apiaster*) was more frequent. Many species of singing birds were recorded, but their numbers were small so that the wind farm would not affect them greatly. Still, important findings include numerous individual birds and flocks of Eurasian skylarks (*Alauda arvensis*), common starlings (*Sturnus vulgaris*), many species of thrushes and three species of swallows.

Each of the species can be exposed to the wind farm in different ways, but being categorized as less endangered, their positive population trends, and considerable numbers present no cause for concern, based on a preliminary assessment. The other singing birds are still less endangered, due to their ecological status and habitat use.

5.2.2.2. The data on the ornithofauna in ZONE 2 of the WF Bela Anta

This section presents the results of a one-year monitoring of the ornithofauna and chiropterofauna, carried out between July 2015 and July 2016 in the Bela Anta 2 wind farm infrastructural complex area, in ZONE 2 of the DRP (eastern and north-eastern part of the future RES complex Bela Anta).

This part of the RES complex Bela Anta is located in farmland north-west of the village of Dolovo and west of the SNR Deliblato Sands. The census was carried out at 5 observation points. The observation points were set at easily accessible locales, on local and/or field roads (Figure 47).

Figure 47. *The location of the Bela Anta wind farm, with the observation point positions (Sources: modified Google Earth 2015, Branko Karapandža).*

The points have been selected in such a way as to cover all the important natural units at the location, as well as to allow the detection of natural units outside of the future wind farm area that were estimated as potentially important for the bird fauna at the location.

In the smaller space planned for wind farm construction, 74 bird species were recorded (Table 10), with the target species highlighted (greyed out and in bold). Many species were recorded in very small numbers. Of the listed species, 14 were classed as target species given their national and international significance, protection and preservation status, and susceptibility to the risk of collision with wind turbines due to their specific bionomy, behaviour, flight manner and height, as well as potential habitat disruption by wind turbine infrastructure construction. Based solely on the number of registered species, the species diversity of bird fauna at the Bela Anta 2 wind farm location can be characterized as moderate and considerably lower than at the phase one location (the construction of the Bela Anta wind farm – ZONE 1 of the DRP), with 107 species. Also, as for a great many species only a small number of specimens/overflights were recorded, this result in not surprising in terms of fauna studies, especially given the uniformity of the agricultural habitats dominated by monocultures.

Table 10. *The list of bird species at Bela Anta 2 per observation point.*

No	Species	OP1	OP2	OP3	OP4	OP5
1	***Ciconia ciconia***	+	+	+	+	+
2	***Anser* sp. (*fabalis /anser*)**			+		+
3	***Anser albifrons***		+	+		
4	***Circus aeruginosus***	+	+	+	+	+
5	***Circus cyaneus***		+	+		+
6	***Circus pygargus***	+	+	+	+	+
7	***Accipiter gentilis***	+	+		+	+
8	***Accipiter nisus***	+	+			+
9	***Buteo buteo***	+	+	+	+	+
10	***Falco tinnunculus***	+	+	+	+	+
11	*Perdix perdix*		+	+		
12	*Coturnix coturnix*	+	+	+		
13	*Phasianus colchicus*	+	+	+	+	+
14	***Grus grus***			+	+	+
15	***Vanellus vanellus***	+	+	+	+	
16	*Larus ridibundus*		+			
17	*Larus cachinnans*			+	+	
18	*Columba palumbus*	+	+	+		+
19	*Streptopelia decaocto*	+	+	+	+	
20	*Streptopelia turtur*		+	+		+
21	*Cuculus canorus*	+	+	+	+	+
22	***Athene noctua***		+	+	+	
23	***Asio otus***		+		+	
24	*Merops apiaster*	+	+	+	+	+
25	*Upupa epops*		+			
26	*Galerida cristata*		+		+	+
27	*Lullula arborea*					+
28	*Alauda arvensis*	+	+	+	+	+

No	Species	OP1	OP2	OP3	OP4	OP5
29	*Riparia riparia*	+	+	+	+	+
30	*Hirundo rustica*		+	+	+	
31	*Delichon urbicum*			+		+
32	*Anthus campestris*		+		+	
33	*Anthus trivialis*	+				+
34	*Motacilla flava*	+	+			
35	*Motacilla feldegg*		+	+		
36	*Motacilla alba*	+				+
37	*Erithacus rubecula*					+
38	*Phoenicurus ochruros*	+	+	+	+	+
39	*Saxicola rubetra*	+		+		
40	*Saxicola rubicola*		+		+	
41	*Oenanthe oenanthe*	+	+	+	+	+
42	*Turdus merula*	+		+		
43	*Turdus pilaris*	+	+	+	+	+
44	*Turdus philomelos*	+			+	
45	*Sylvia communis*	+	+	+		
46	*Sylvia atricapilla*	+	+	+		+
47	*Phylloscopus collybita*		+			
48	*Phylloscopus trochilus*			+		
49	*Aegithalos caudatus*	+			+	
50	*Parus caeruleus*	+	+	+	+	+
51	*Parus major*	+	+	+	+	+
52	*Oriolus oriolus*	+				+
53	*Lanius collurio*	+	+	+	+	+
54	*Lanius excubitor*	+		+	+	+
55	*Garrulus glandarius*					+
56	*Pica pica*	+	+	+	+	+
57	*Coloeus monedula*	+	+		+	
58	*Corvus frugilegus*	+	+	+	+	+
59	*Corvus corone/cornix*	+	+	+	+	+
60	*Corvus corax*	+	+	+	+	+
61	*Sturnus vulgaris*		+	+		

No	Species	OP1	OP2	OP3	OP4	OP5
62	*Passer domesticus*	+				+
63	*Passer montanus*		+	+	+	+
64	*Fringilla coelebs*	+		+	+	
65	*Fringilla montifringilla*	+		+		
66	*Serinus serinus*				+	+
67	*Carduelis chloris*	+	+	+		+
68	*Carduelis carduelis*	+	+	+		
69	*Carduelis cannabina*	+	+			
70	*Coccothraustes coccothraustes*			+		
71	*Emberiza citrinella*		+	+	+	
72	*Emberiza hortulana*	+		+		
73	*Emberiza melanocephala*		+			+
74	*Emberiza calandra*		+	+		+
Total number of species		**45**	**52**	**51**	**39**	**43**
Total number of target species		**8**	**12**	**11**	**10**	**10**

It is evident from Table 10 that the species have an equal presence at OP, with a minimum of 39 recorded at OP 4, and a maximum of 52 recorded at OP 2. The number of recorded target species is also balanced and with a similar trend.

Based on the data from Table 10, of the 74 recorded species, 66 are listed in the Addenda to the Bern Convention: 45 in Addendum II – strictly protected species; and 21 in Addendum III – protected species.

In the Bern Convention, 14 species are listed in Addendum II. The EU Bird Directive lists 10 species in Addendum I, 21 in Addendum II, and 5 in Addendum III. Of the 74 bird species registered, the Serbian legislation in the area of environmental protection lists 55 as strictly protected species and 19 as protected. A total of 11 species was classified as game protected by hunting bans in specific periods.

Although 74 bird species can be seen as significant in terms of fauna studies, the number of recorded birds is relatively small. Of the ecological bird groups which are sensitive to wind turbines (necessitating additional attention and being classified as the so-called target groups), storks (*Ciconiiformes*), floaters (*Anseriformes*), and diurnal birds of prey (*Falconiformes*) should be mentioned separately. Due to a lack of water and humid habitats, the location is not beneficial for the first two ecological groups, as habitats are missing for their feeding, hiding, and nesting. This is why there are so few storks and floaters and why they are so rarely recorded. This is especially interesting for migratory flocks of geese, few in number and rarely recorded. Storks were recorded sporadically, whether as individual specimens or in small groups, and herons were not recorded at all.

In contrast, diurnal birds of prey have a regular presence at the location. This can be explained by the fact that the space in question has a significant trophic base for the birds in this ecological group, above all mouse-like rodents (*Rodentia*) as an important element of agricultural habitat fauna. It is for this reason that the most numerous birds at this location are the common buzzard (*Buteo buteo*), common kestrel (*Falco tinnunculus*), and seasonal and other birds of prey, such as the harrier (*Circus* sp.); falcons (*Falco* sp.) were not recorded. A wider range of prey is available to the northern goshawk (*Accipiter gentilis*) and the Eurasian sparrowhawk (*Accipiter nisus*), but these species were recorded in very small numbers.

From the remaining target bird species, small flocks of the common crane (*Grus grus*) had few seasonal overflights during migration, without descending to the location and at high altitude, as well as small groups of northern lapwings (Vanellus vanellus) were recorded, also in migratory periods.

Two species of owl were recorded, which used the location intermittently for feeding and hunting purposes. The European bee-eater (*Merops apiaster*) was recorded, but only in overflight at high altitudes, during migration periods, although there are a few smaller loess sections near the location, with small colonies of these birds.

Many species of singing birds were recorded, but their numbers were small so that the wind farm was not estimated as having a great potential effect on them. Still, important findings include numerous individual birds and flocks of Eurasian skylarks (*Alauda arvensis*), common starlings (*Sturnus vulgaris*), many species of thrushes and three species of swallows.

Each of the species can be exposed to the wind farm in different ways, but being categorized as less endangered, their positive population trends, and considerable numbers present no cause for concern. The other singing birds are still less endangered, due to their ecological status and habitat use.

5.2.2.3. The data on the chiropterofauna in ZONE 1 of the WF Bela Anta

Field research during the monitoring of chiropterofauna (bats) was carried out using two main methods and techniques: bat activity detection on transects, and identification and inspection of possible bat shelters.

This monitoring did not include hunting using mist-nets, as it is not suitable for open habitats in which bats fly relatively high, as is the case at the location in question. This method is used as auxiliary in this sort of monitoring, with the aim of establishing the reproductive and phenological status of individual specimens and a more precise identification of species which cannot be reliably differentiated by ultrasonic audio-detection. It can also be used for detecting bats in potential, difficult to access, or inaccessible shelters.

All research aspects are concerned with the entire period and all phenological activity phases of bats at the location in question, for one year. This complies with, and possibly exceeds, the standards prescribed in national and international guidelines, as well as the usual natural protection requirements prescribed by the Regional Environmental Protection Institute, with the authority to issues the requirements for the Bela Anta wind farm.

Exploring bat activities at the Bela Anta wind farm location and the surrounding area was carried out using the ultrasonic audio-detection, with a hand-held detector and using the transect method (combined with the points census), which is suitable for the project type and location characteristics.

Analyses of the satellite imagery, topographic maps, and preliminary terrain survey at the wind farm location have helped identify the potential ecological functions of the habitat and location landscape elements for bats.

Forest and forest-steppe fragments, especially in loess valleys and their immediate vicinity, have been identified as potentially important hunting territories; fields with specific agricultures, especially sunflower, can also be such hunting grounds, depending on the season.

No natural linear landscape elements that bats typically use as summer corridors were registered at the location. Without these typical summer corridors, bats use field roads and noticeable relief elements (at the location of the loess valley, as expected), in landscapes and environmental conditions of the same kind as at the location.

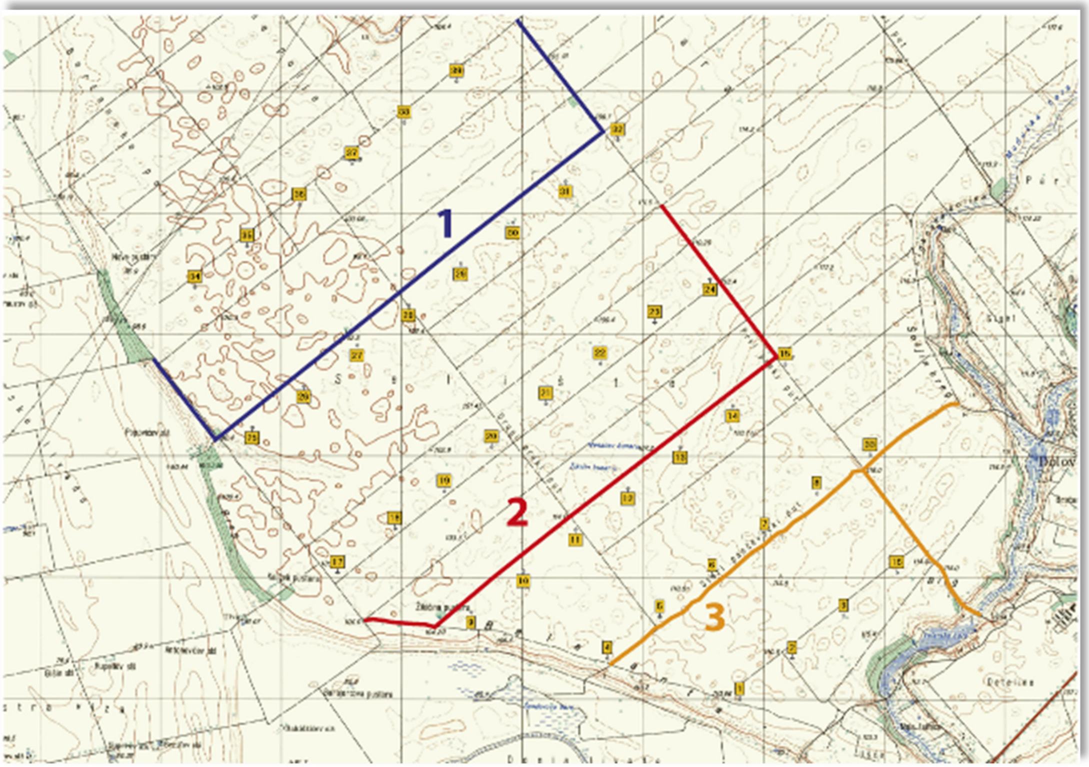


Figure 48. *The transect positions in the preliminary plan of the Bela Anta wind farm.*

Three transects (lines marked by different colours and numbers 1 to 3 in Figure 48) along field roads are defined such that they represent and spatially and ecologically encompass to the fullest extent possible the location space and its ecological elements which are potentially most important for bats. The transect method is combined with the point census method.

Bat activities along transects were registered by audio-detecting their ultrasonic echo-locational signals and calls using the hand-held ultrasonic bat detector *Petterson D240h* (which has *time expansion* and *heterodyne* systems), and by visual detection using a handheld spotlight.

For each registered bat overflight (contact), a (preliminary) identification was made of the species, specimen numbers, duration, location, habitat, and sometimes the direction and altitude of flight and observations on behaviour.

One unique overflight/contact was understood as the total activity of a bat during which it did not leave the audio-visual field of the researcher, in order for the number of overflights/contacts to reflect as accurately as possible the number of present specimens, at least in a short space of time. The flight altitude of the bats was not systematically recorded (it was recorded only in individual cases, when this was considered important), as it would result from the limited audio-visual field of the researcher with the ultrasonic detector and from the specificity of ultrasonic signals of particular species, rather than the actual altitudes at which these species fly. This would make the recorded flight altitudes unrepresentative and irrelevant to the research in question. This is why the view taken is that the flight altitude data collected in the monitoring of chiropterofauna, visual observation during transects and automatic detection at height is more appropriately used in combination with the relevant information on the altitude and flight characteristics of specific bat species collected in systematic research.

Besides on-site identification, the registered ultrasonic bat signals were recorded as the need arose by a digital audio-recorder *Zoom H2* and analysed at a later time on a computer using the specialized software *Bat Sound 4.03* (*©Petterson Elektronik AB*), relevant literature and a comparative collection of recordings owned by the monitoring authors.

Bat activity detection on transects was conducted from April until November 2013, covering the entire period of bat activity at the location in this time interval, as well as all the phenological phases of their activity in this space for one year. Thus, the relevant national standards and usual nature protection requirements prescribed by the Regional Nature Protection Institute were met.

The examination of the satellite imagery and the detailed survey of the terrain at the wind farm site and in the immediate surroundings have helped identify human and natural structures potentially suitable for bat shelters. The human structures suitable for bat shelters were almost non-existent at the wind farm site but were very numerous in the surrounding area, especially in the inhabited area (Dolovo and the country houses). The zones with the shelter potential for dendrophilic bat species, i.e. the old deciduous trees with hollows and cracks used by this species as shelters, were found on site and in the surrounding area, but there were many more in the latter.

The identified potential shelters in structures, on site, and in the surrounding area, were directly visually inspected for bats, but were also inspected for the characteristic ‘swarming’ of bats near the shelter entrance and for entries and exits from the shelter using the ultrasonic bat detector *Petterson D240h* and a handheld spotlight. Bat inspection in dendrophilic shelters was conducted by detecting the copulation calls of males. These calls are characteristic of males of certain species which take certain shelters during mating season (in Serbia usually from late summer to mid-autumn) and call the females, in order to form copulation colonies, the so-called harems, consisting of several to many tens of specimens.

They spend winters in these shelters as well, hibernating. This inspection was also conducted using the ultrasonic bat detector *Petterson D240h* and a handheld spotlight.

This February to November 2013 monitoring established that the wind farm location and the surrounding area have at least 16 different bat species (Table 11). This number alone, though certainly not final, is only 5 species fewer than the number of species registered thus far in the broader South Banat region, making up over 55% of the total bat fauna in Serbia. Therefore, the wind farm location can be described as moderately rich in terms of bat fauna diversity.

As most species were recorded as having a very small number of specimens/overflights and only peripherally or in spatially very limited, ecologically specific zones, this result, although relevant, can be seen as mostly expected in terms of fauna studies.

Ultrasonic audio-detection at the wind farm location registered the activity of 13 species whose specimens can be reliably distinguished only on the basis of echo-location signals: *Rhinolophus ferrumequinum*, *Myotis emarginatus*, *Myotis bechsteinii*, *Barbastella barbastellus*, *Pipistrellus pygmaeus*, *Pipistrellus pipistrellus*, *Pipistrellus kuhlii*, *Pipistrellus nathusii*, *Hypsugo savii, Nyctalus leisleri*, *Nyctalus noctula*, *Vespertilio murinus* and *Eptesicus serotinus*.

In addition to these, the activity of 3 species groups was registered whose members cannot be reliably distinguished based on echo-location signals **–** *Myotis myotis/M.blythii*, *Myotis brandtii/M.mystacinus/M.alcathoe* and *Plecotus sp*. **–** so there is no doubt that at least one member of each of these groups is present at the location, making up a total of 16. However, it is very likely that this number is actually higher – standing at 19 – as a temporary and/or sporadic presence of 6 species from these groups (*M. mystacinus*, *M. alcathoe*, *M. myotis*, *M. blythii*, *Plecotus austriacus* and *Plecotus auritus*) is practically certain, based on their spread and the existence of the appropriate environmental conditions on site and in the surrounding area. The data on the presence of these species in the surrounding area testifies to this.

Besides these, a temporary and/or sporadic presence of the species *Myotis nattereri* is possible at the wind farm location, as this species was recorded in the surrounding area, and the location itself as well as the surrounding area have minimally partially suitable environmental conditions for it. The presence of the remaining two species recorded in South Banta but not at the location in this monitoring – *Myotis daubentonii* and *Myotis dasycneme*, cannot be expected given the lack of suitable water habitats on site.

Table 11. *The list of bat species at the wider location of the Bela Anta wind farm*

Species / sp. group	South Banat	Surrounding area				Location				Rel. numbers	
		shelters	Hunting grounds	Flight corridors	migration	shelters	Hunting grounds	Flight corridors	migration	N	%
Rhinolophus ferrumequinum	+	(+)	+	+						10	0.3
M.brandtii/M.mystacinus/M.alcathoe		(+)	+	+			+	+		32	1.1
M.myotis/M.blythii		(+)	+	+		?	+	+		69	2.3
Myotis bechsteinii	+	(+)	+	+						9	0.3
Myotis emarginatus	+	(+)	+	+			(+)	(+)		11	0.4
Myotis sp.										10	0.3
Plecotus sp.		(+)	+	+		?	+	+		6	0.2
Barbastella barbastellus	+	(+)	+	+						7	0.2
Pipistrellus pygmaeus	+	+	+	+						7	0.2
P.pipistrellus/P.pygmaeus										7	0.2
Pipistrellus pipistrellus	+	(+)	+	+		?	+	+		15	0.5
P.kuhlii/P.pipistrellus										6	0.2
Pipistrellus kuhlii	+	+	+	+			+	+		1412	47.8
P.kuhlii/P.nathusii										337	11.4
Pipistrellus nathusii	+	+	+	+	+	+	+	+	+	365	12.3
Pipistrellus nathusii/Hypsugo savii										113	3.8
Hypsugo savii	+	+	+	+			+	+		63	2.1
Pipistrellus/Hypsugo sp.										24	0.8
Nyctalus leisleri	+	(+)	+	+		?	+	+		58	2.0
N.noctula/N.leisleri										43	1.5
Nyctalus noctula	+	+	+	+	+	+	+	+	+	217	7.3
N.noctula/N.lasiopterus							?	?		6	0.2
V.murinus/N.noctula/N.leisleri										1	<0.1
Vespertilio murinus	+		+	+			+	+		7	0.2
Eptesicus serotinus	+	+	+	+		?	+	+		67	2.3

Species / sp. group	South Banat	Surrounding area				Location				Rel. numbers	
		shelters	Hunting grounds	Flight corridors	migration	shelters	Hunting grounds	Flight corridors	migration	N	%
Vespertilionidae indet.										54	1.8
Total (minimal) no. of species / Σ	21	16				12				2956	100.0

(+ - confirmed, (+) – very likely, ? – hinted but not confirmed)

All bat species are protected in Serbia as strictly protected wildlife species by the Law on Environmental Protection (The Official Gazette of the Republic of Serbia, No. 36/2009) and the Rulebook on the Declaration and Protection of Strictly Protected and Protected Species of Wild Plants, Animals, and Fungi with Addenda containing lists of species as its integral part (The Official Gazette of the Republic of Serbia, No. 5/2010).

Serbia has ratified and for the most part implemented all the conventions that regulate at the international level the protection of bats; some of the most important ones are: The Bern Convention on the Conservation of European Wildlife and Natural Habitats (The Official Gazette of the Republic of Serbia, No. 102/2007); and the Bonne Convention on the Conservation of Migratory Species of Wild (The Official Gazette of the Republic of Serbia, No. 102/2007). All European bat species are listed in the Addendum II of the Bern Convention (strictly protected species), except *Pipistrellus pipistrellus*, which is listed in Addendum III (protected species), and all European bat populations are listed in Addendum II of the Bonne Convention. The implementation mechanism of the Bern Convention for the EU is the EU Directive on the conservation of natural habitats and of wild fauna and flora. All bat species are listed in Addendum II of this directive, and 13 species are listed in Addendum IV, all of which have been recorded in Serbia, and at least 4 at the wind farm location (*Rhinolophus ferrumeduinum*, *Muotis emarginatus*, *Muotus bechsteinii* and *Muotis muotis/M.blithii*).

Despite a considerable number of registered species, it should be pointed out that the majority were recorded during this monitoring in very small numbers, i.e. only a few times compared to 2,956 overflights/contacts recorded on transects. The largest majority, as many as 2,331 – almost 80% of all registered overflights/contacts goes to only 3 species: *Pipistrellus kuhlii*, *Pipistrellus nathusii* and *Nuctalus noctule*; their actual relative numbers are even higher, as a significant share of the additional 247 goes to these species, i.e. 8.4% of overflights/contacts that could not be identified precisely from the level of genus, species group, or family (due to great distances and short duration). All the other species were far less numerous: 2% of overflights/contacts each went to the species/group *Muotis*

muotis/M.bluthii, *Hupsugo savii, Nuctalus leisleri* and *Eptesicus serotinus*, while other species had almost negligible relative numbers – mostly below 1%. Also, although the bat fauna of the explored area as a whole – including the location and the surrounding area – is qualitatively comparatively rich, a significant number of species was registered exclusively or almost exclusively in some small and ecologically specific parts – in the areas surrounding the fragments of forest-steppe and forest vegetation, especially in the zone where Volarska Bara used to be. At least 4 species (*Rhinolophus ferrumequinum*, *Barbastella barbastellus*, *Myotis bechsteinii* and *Pipistrellus pygmaeus*) were registered only in the Volarska Bara zone, i.e. in the immediate vicinity of the location but not at the location. A further 3 species/groups (*Plecotus sp.*, *Myotis emarginatus* and *Pipistrellus pipistrellus*) were registered sporadically at the location (except in the Volarska Bara zone), and exclusively in the vicinity of the forest-steppe and forest vegetation fragments. There were only 8 species/groups at the location: *M.brandtii/M.mystacinus/M.alcathoe*, *M.myotis/M.blythii*, *Pipistrellus kuhlii*, *Pipistrellus nathusii, Hypsugo savii, Nyctalus leisleri*, *Nyctalus noctula* and *Eptesicus serotinus*, but only 3 (*Pipistrellus kuhlii*, *Pipistrellus nathusii and Nuctalus noctula*) in larger numbers. This is why it can be said that with the exception of the micro-location, characterized by the relatively high diversity, the bat fauna at the location is qualitatively poor and considerably less rich than its surrounding area.

The total number of overflights/contacts registered on transects during this monitoring, standing at 2,956 – is not small. However, this number does not reflect the actual state of affairs at the location itself, as over 80% of the total number of overflight/contacts were registered on a single transect – transect 3, therefore during a comparatively short (a bit more than 1/3) total transect duration (whose individual sections are not at the location itself). Furthermore, the majority (around ¾) of all the overflights/contacts on this transect was registered in a very small portion – the segment of the Old Pančevo Road east of the junction with the Prvi Preki Put Road (with about 2/5 of this segment lie outside of the location). This is why the bat fauna at the location, with the exception of the peripheral sections and specific microlocations characterized by larger numbers of bats, can be described in quantitative terms as poor and considerably less rich than the surrounding area.

Bat colonies and shelters at the wind farm location are not numerous, which confirms the initial hypothesis regarding the sparsity of the cryptic conditions at the location. A thorough search for potential shelters, i.e. structures suitable for bat shelters, did not reveal any such human structure; rather, only several suitable older trees were found, mostly within fragments and linear elements of arboreous vegetation. A detailed visual inspection revealed that the only human structure at the location – the anti-hail system, found near the junction of the Prvi Preki Road and the Old Pančevo Road, does not provide even the most basic conditions for bat shelters, and that there are no significant current or potential bat shelters.

This was confirmed in inspecting the entry into/exit from this structure by bats on multiple occasions during bat activity season. The detailed inspection of the potential shelters in old trees and bat activities in their vicinity established that in the period from mid-August until mid-November 2013, six to eight specimens of the species *Nyctalus noctule* and 10-12 specimens of the species *Pipistrellus nathusii* use these shelters fairly regularly. This is indicated for the period in question by the copulation calls of the species members from the shelters in tree hollows and cracks.

The immediate vicinity of the location paints a different picture altogether. The structures potentially suitable as bat shelters are very numerous. In the all surrounding towns and villages, especially in the nearest village of Dolovo and the zone where Volarska Bara used to be – which is of special significance for the study – many old trees and human-built structures were identified (older and decrepit structures who share is significant) which offer a wealth of potential shelters suitable for various bat species. This is why the discovery of colonies and bat shelters in the immediate surroundings of the location can be considered as expected. For the entire period of bat activity, many colonies of the species *Pipistrellus kuhlii* were registered in Dolovo. These colonies were made up of several to a few tens of individual bats located in inaccessible crack-like spaces inside human-built structures. Shelters of the species *Pipistrellus nathusii* (9)*, Hypsugo savii* (2) and *Eptesicus serotinus* (1), with colonies made up of 3 to 12 bats, were registered in the Dolovo structures for the whole period of bat activity. The village and its surroundings, especially the Volarska bara zone, registered a significant number of copulation shelters of the species *Nyctalus noctula* (50-60) and *Pipistrellus nathusii* (60-70). The characteristic male copulation calls of both species were recorded regularly between mid-August and mid-November from old tree shelters, and in three cases in human structures as well. The village area regsistered one copulation shelter of the species *Pipistrellus pygmaeus* in September.

Unline the hypothesis that the cryptic resources were sparse at the location, the same hypothesis regarding trophic resources turned out not to be true during the monitoring. This is indicated clearly by the bats' hunting activity, quite high in some part of the location and in some periods.

In addition, the monitoring in the whole wind farm territory, permanently and during whole nights in favourable weather conditions, especially between June and September, revealed comparatively large numbers and diversity of potential bat prey – flying and non-flying insects active at night (butterflies, mosquitos, flies, beetles, and crickets). This was especially prominent in, but not limited to, the previously mentioned specific micro-locations – elements and fragments of forest-steppe and woody vegetation – where bats were registered occasionally in considerable numbers and engaging in intensive hunting activity. Therefore, the trophic resources for bats in the entire area of the wind farm location during the monitoring period were rich, which can be characterized as expected.

The presence of mosaic-like fragments and linear elements of forest habitats and well-preserved indigenous habitats contributes to this, although modestly given the large total surface area of the location. A further contribution may be a small-scale application of pesticides and other agrotechnical measures, smaller than expected (or with lesser effects due to unusually intensive precipitation in the first half of the year).

5.2.2.4. The data on the chiropterofauna in ZONE 2 of the WF Bela Anta

This section of the book presents the data collected by chiropterofauna monitoring for ZONE 2 of the DRP in the period between July 2015 and July 2016. All the research aspects covered the entire period and all the phenological phases of bat activity in this space for one year. This complies with the standards prescribed by the relevant national and international guidelines and the usual requirements for the protection of nature prescribed by the Regional Environmental Protection Institute.

As regards methodology, the same approach was used as in monitoring ZONE 1 of the DRP.

At the location, two important linear landscape elements were identified which bats typically use as summer corridors – the Novoselski macadam road with linear woody., steppe, and marsh vegetation stretching alongside, as well as small valleys cutting across the location and containing small fragments of marsh and forest-steppe vegetation.

In the landscapes and environmental conditions as those at the location, in the absence sparsity of typical summer corridors, bats use as summer corridors field roads as well. In the immediate vicinity of the location, the potential summer corridors are much more numerous and adequate, especially the bigger valleys with more developed forest-steppe and marsh vegetation.

Two transects (the blue line – Transect 1, and the red line – Transect 2, in Figure 49) alongside the macadam road and fields roads, are defined such that they represent the space of the location as fully as possible, both spatially and ecologically. Special emphasis was given to the location’s ecological elements which are potentially essential for bats.

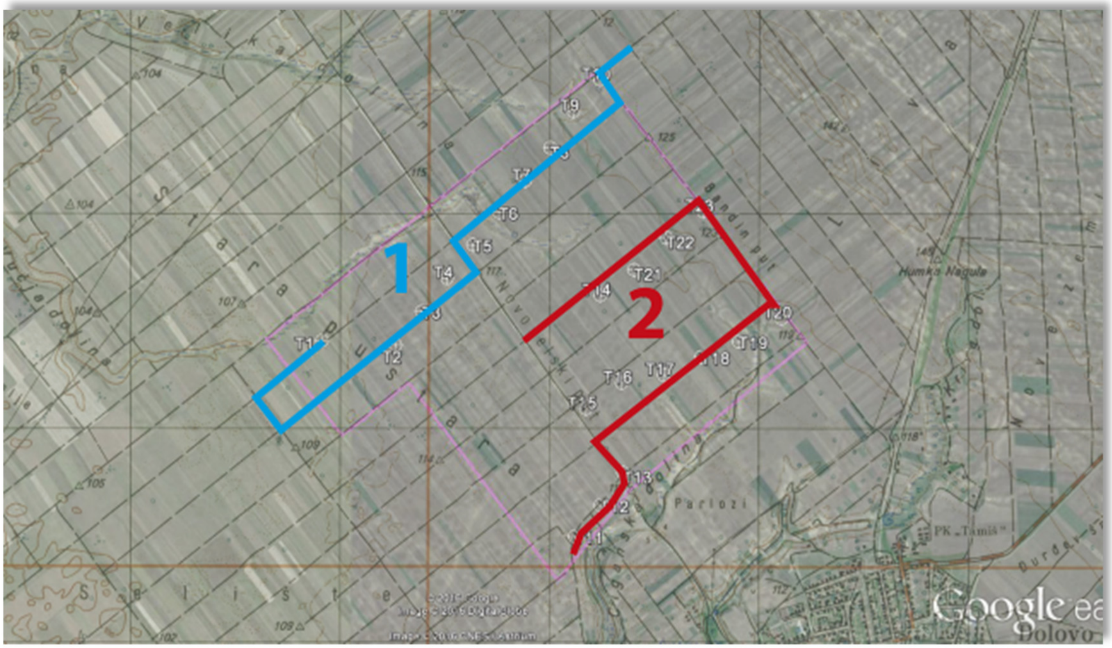


Figure 49. *The transect positions for monitoring bat activities*

This monitoring between July 2015 and July 2016 established that at least 11 bat species are present at the location and the surrounding area. This number of species is half the number of species registered in the wider area of South Banat, making up around 37% of the bat fauna. Therefore, based only on the number of registered species, the species diversity of bats at the Bela Anta 2 wind farm location can be characterized as modest and considerably lower than at the location of the neighbouring Bela Anta wind farm, with as many as 16 species. Further, as for a large majority of species only very small numbers of specimens/overflights were recorded, this result can be characterized as expected in term of fauna studies. The overview of the results of bat fauna monitoring at the location of the future wind farm Bela Anta 2, conducted between July 2015 and July 2016, alongside the previous information on the bat fauna in the wider area of South Banat, is shown in Table 12.

Activities of 8 species was recorded at the wind farm location and in the surrounding area using ultrasonic audio detection; the species members can be reliably distinguished using echo-location signals: *Rhinolophus ferrumequinum*, *Barbastella barbastellus*, *Pipistrellus kuhlii*, *Pipistrellus nathusii*, *Hypsugo savii, Nyctalus leisleri*, *Nyctalus noctula* and *Eptesicus serotinus*. In addition to these, the activity of 3 species was registered whose members cannot be reliably distinguished using echo-location signals - *Myotis myotis/oxygnathus*, *Myotis brandtii/mystacinus/alcathoe* and *Plecotus sp*. **–** so it is beyond doubt that at least of species from each of these groups was present at the location, making up a total of no fewer than 11. However, it is possible that the numbers are actually higher, i.e. 14, as the sporadic and/or temporary presence of 6 species from these groups (*Myotis mystacinus*, *Myotis alcathoe*, *Myotis myotis*, *Myotis oxygnathus*, *Plecotus austriacus* and *Plecotus auritus*) is beyond doubt, based on their wider spread and the existence of at least partially suitable ecological conditions at the location and the surrounding area. The data on the presence of these species in the surrounding area testify to this. In addition, during shelter exploration, besides the species recorded at the location, the presence of *Myotis bechsteinii*, *Myotis emarginatus*, *Myotis nattereri*, *Pipistrellus pygmaeus* and *Pipistrellus pipistrellus* was registered in the surrounding area; therefore, their temporary and/or sporadic presence is potentially possible at the wind farm location as well.

Table 12. *The list of bat species at the wider location of the Bela Anta 2 wind farm*

Species/group species	South Banat	Surrounding area				Location				Rel. numbers	
		shelters	Hunting grounds	flight corridors	migration	shelters	Hunting grounds	Flight corridors	migration	N	%
Rhinolophus ferrumequinum	+	+	+	(+)			?	?		2	0.2
Miniopterus schreibersii	+										
Myotis mystacinus	+										
M.brandtii/M.mystacinus/M.alcath		+	+	(+)			+	(+)		6	0.5
Myotis oxygnathus	+										
Myotis myotis	+										
M. myotis/M. oxygnathus		(+)	(+)	(+)			?	?		3	0.3
Myotis bechsteinii	+	?	(+)	(+)							
Myotis emarginatus	+	?	(+)	(+)							
Myotis nattereri	+	?	(+)	(+)							
Myotis daubentonii	+										
Myotis dasycneme	+										
Myotis sp.										4	0.4
Plecotus auritus	+										
Plecotus austriacus	+										
Plecotus sp.		(+)	+	(+)			?	?		1	0.1
Barbastella barbastellus	+	(+)	+	+			?	?		1	0.1
Pipistrellus pygmaeus	+	+	+	+							
Pipistrellus pipistrellus	+	+	+	+							

Species/group species	South Banat	Surrounding area				Location				Rel. numbers	
		shelters	Hunting grounds	flight corridors	migration	shelters	Hunting grounds	Flight corridors	migration	N	%
Pipistrellus kuhlii	+	+	+	+			+	+		684	60.
P.kuhlii/P.nathusii										97	8.6
Pipistrellus nathusii	+	+	+	+	+		+	+	+	155	13.
Pipistrellus nathusii/Hypsugo savii										6	0.5
Hypsugo savii	+	+	+	+			+	+		13	1.1
Pipistrellus/Hypsugo sp.										17	1.5
Nyctalus leisleri	+		+	+	?		(+)	(+)		6	0.5
N.noctula/N.leisleri										6	0.5
Nyctalus noctula	+	+	+	+	+		+	+	+	111	9.8
N.noctula/N.lasiopterus										1	0.1
Vespertilio murinus	+										
Eptesicus serotinus	+	+	+	+			+	(+)		8	0.7
Vespertilionidae *indet.*										12	1.1
Total (minimal) no. of species / Σ	**22**	**16**				**11**				**1133**	**10**

+ - confirmed, (+) – very likely, ? – hinted but not confirmed.

Besides these species, the species *Vespertilio murinus*, registered at the neighbouring wind farm Bela Anta, can also be temporarily/sporadically present at the wind farm location, as the location itself and the surrounding area have at least partially suitable environmental conditions for them

The presence of the species *Miniopterus schreibersii*, although recorded earlier in South Banat, cannot be expected as the location and the surrounding (as well as wider) area do not have appropriate underground shelters. The presence of the remaining two species recorded in South Banat but not in this monitoring - *Myotis daubentonii* and *Myotis dasycneme*, cannot be expected either at the location due to the absence of appropriate water habitats.

Despite a significant number of registered species, it should be mentioned that a large majority of them were recorded in very small numbers in this monitoring, i.e. only a few times compared to 1,133 overflights/contacts total recorded on transects. The biggest majority, as many as 1,047, or 92.4% of all registered overflights/contacts goes to only three species - *Pipistrellus kuhlii*, *Pipistrellus nathusii* and *Nyctalus noctule*, with their actual relative numbers even higher, as a significant share of the additional 42, or 3.7%, of overflights/contacts which could not be identified more precisely than in terms of genus, species group, or family (due to great distances and short duration) goes to the representatives of these species. Furthermore, even among these species, standing at 60.4% (alongside the greatest share of the additional 11.1% of fully unidentified overflights) is *Pipistrellus kuhlii*, so this species can be considered very dominant in the entire location; in contrast, the species *Pipistrellus nathusii,* with 13.7%, and *Nyctalus noctula*m, with 9.8%, are subdominant. All the other species were far less numerous: 1.1% of overflights went to the species *Hypsugo savii*, and all the remaining species/groups, i.e. 7 of them, were recorded with negligible relative numbers – below 1% (4 of them only sporadically, i.e. only 1-3 times for the duration of the monitoring).

Despite the total number of registered species which can be estimated as moderate, due to the domination of one and an almost negligible numbers of a great majority of other species, it can be concluded that the bat fauna at the location is quantitatively poor and that it corresponds in these quantitative terms to the typical agro-systems under monocultures. This is confirmed by the facts that the dominant species, *Pipistrellus kuhlii*, is at the same time the most prominently synanthropized bat species in this part of Europe.

In addition, although the bat fauna at the location is poor seen as a whole in quantitative terms, a significant number of species was registered exclusively or almost exclusively in specific, spatially very small and ecologically specific parts. These ecologically specific parts are surrounding area the small fragments and elements of marsh and forest-steppe vegetation in small valleys cutting across the location and along the Novoselski Road and, especially, in the bigger valleys that approach the location boundaries only peripherally – to the Ciganska Valley along the south border of the location, and Velika Dolina along the north-west border, representing as they do the peripheral parts of much larger such units, located in the valley system surrounding the location. Four species/groups - *Rhinolophus ferrumequinum*, *Plecotus* sp., *Myotis myotis/oxygnathus* and *Nyctalus leisleri*, were registered exclusively, and three almost exclusively in these ecologically specific zones. At the location itself, a wider presence was recorded only by the previously mentioned most numerous species – *Pipistrellus kuhlii*, *Pipistrellus nathusii* and *Nyctalus noctula.*

Based on the above, it can be said that the bat fauna at the location, with the exception of the microlocations characterized by slightly higher diversity, is qualitatively very poor and considerably less rich than the surrounding areas. Both Dolovo and Banatsko Novo Selo saw registrations of many colonies of the species *Pipistrellus kuhlii* throughout the bat activity period. These colonies were made up of several to a few tens of specimens located in inaccessible crack-like spaces inside human structures. In the Dolovo structures, shelters of the species *Pipistrellus nathusii* (7), *Hypsugo savii* (1), *Eptesicus serotinus* (1), *Nyctalus noctula* (2) and *Myotis brandtii/mystacinus/alcathoe* (1) were registered during the entire bat activity period; in Banatsko Novo Selo the shelters of the species *Pipistrellus nathusii* (5), *Pipistrellus pipistrellus* (1), *Eptesicus serotinus* (2) and *Rhinolophus ferrumequinum* (1) were registered, with colonies made up of 2 to 17 bats. A considerable number of copulation shelters were registered in the towns and villages, as well as the surrounding area – in Dolovo the species *Nyctalus noctula* (40-50), *Pipistrellus nathusii* (50-60), *Pipistrellus pipistrellus* and *Pipistrellus pygmaeus* (1), and in Banatsko Novo Selo the species *Nyctalus noctula* (30-35) and *Pipistrellus nathusii* (30-40). A smaller number of copulation shelters were recorded in the valleys outside of the location – in Ciganska Dolina the species *Nyctalus noctula* (4-5) and *Pipistrellus nathusii* (6-7), and in Velika Dolina the species *Nyctalus noctula* (2) and *Pipistrellus nathusii* (2-3). The typical copulation calls of males of the species were recorded regularly from mid-August until mid-November 2015 from old tee shelters, as well as from human-built structures in 5 cases.

5.2.3. The anthropogenic characteristics of the area

The anthropogenic characteristics of the area in which the construction of the wind farm is planned, and the surrounding area are very important in terms of assessing the environmental impact. This importance can be seen in the assessment of the territorial/spatial impacts of the planned wind farm on the following:

- Increase in noise levels – what is important is the exposure of the population to increased noise levels as a result of wind farm operation. In this context, the use of the surface areas in the wind farm space is important, as well as the distance of the nearest structures, especially vulnerable ones, from the wind farm
- Landscape characteristics – the proximity of inhabited areas and structures from which wind turbines are visible are important, as well as the existence of possible physical (anthropogenic) barriers which can affect wind turbine visibility. One should bear in mind the existence of other structures which dominate the space, e.g. power lines whose pylons have a similar visual effect as wind turbines.
- Accidents – the proximity/distance of structures and the transport network to wind turbines are important because of possible danger associated with wind turbine accidents.
- Immovable cultural goods – the distance from the registered and protected immovable cultural goods and archaeological sites is important, as they can be affected by the wind farm.

In line with the importance of the analysis of the anthropogenic characteristics of the area in which the Bela Anta wind farm is planned, and taking into account all of the phases and zones defined under the DRP, the following has been found:

- The nearest village of Dolovo is located south-east of the RES complex Vela Anta, while the villages Banatsko Novo Selo and Kačarevo, located north-west of the RES complex Bela Anta, are at a considerably greater distance from the nearest Bela Anta wind farm turbines.
- The existing surface area use in the location has an open-field rather than urban structure. The existing land use regime is primary agriculture – the Dolovo structures are located at slightly over 1,500m from the nearest wind turbines.
- The plan area does not include the transport infrastructure. The transport network within the DRP is made up of the system of open-field non-categorized roads of different ranks, whose function is accessing farming plots in the surroundings. These are not asphalt roads, they have no road pavement and are of limited width and load. The location of the planned wind farm is accessible via the network of open-field roads which join the existing local-municipal road L-5 Nadel-Dolovo.
- The DRP does not include electricity infrastructure. Such infrastructure does, however, exist in the immediate vicinity of the DRP boundary, near the village of Dolovo. Furthermore, according to the Spatial Plan for the special use area of the infrastructural corridor for the power line 2X400kV SS Pančevo 2 - the Romanian border (The Official Gazette of the AP Vojvodina, No. 3/12) is one of the plan obligations and will be constructed in the upcoming period.
- According to the data from the hierarchically higher plans and those of the surrounding area, relating to the DRP scope, there are no structures within it which have the character of monument legacy, but the following sites with archaeological content have been registered: the site between Vučja Dolina and Nova Pustara; the site Volarska Bara – Vikend Zona; the site Ciganska Dolina; the site Ciglana. This may indicate that within the DRP one can also expect the existence of archaeological remains which should be taken into consideration during the wind farm project implementation.

5.3. Applying the semi-quantitative multi-criteria evaluation method

Chapter 4.2 of this book provides more details on a possible methodological approach to the environmental impact assessment applicable in the SEA.

Also discussed is the prevalent application of expert qualitative methods for evaluating spatial development planning solutions applied in the SEA, as well as the importance and the possibility of application of the semi-quantitative multi-criteria evaluation method, advocated by the present author.

What follows is a presentation of the application of the semi-quantitative multi-criteria evaluation method to the spatial development planning solutions in the process of preparing the SEA for the RES complex Bela Anta DRP, i.e. for the wind farm project within this complex.

The concept of the semi-quantitative method and its presentation in this section of the book is based on several main methodological steps:

- Defining the SEA objectives and indicators;
- Environmental impact assessment:
  - Assessment of variant solutions,
  - Evaluation of the characteristics and importance of the impact of the planning solutions with a defined evaluation criterion,
  - Determining the cumulative and synergic effects.

These steps will be elaborated in turn.

5.3.1. Defining the SEA objectives and indicators

The general and specific objectives of SEA are contained in part in the plans, national strategies and other documents which are hierarchically higher than the DRP for the RES complex Bela Anta (The Spatial Plan of the Republic of Serbia, The Strategy of Energy Development of the Republic of Serbia, The Spatial Plan of the Autonomous Province of Vojvodina, The Spatial Plan of the City of Pančevo, etc.) and in part in the need for protecting a concrete space delineated by the DRP based on the specificities of the planned project and the specificities and characteristics of the environment in that space. The general SEA are defined based on the listed planning and developmental documents, as well as on the analysis of the current state and trends in the future development within the plan area and its wider context, predominantly relating to the following: protection of biodiversity, protection of the main environmental factors, protection of landscape, socio-economic development.

In order to implement the general objectives, the specific SEA objectives are determined in particular areas of protection. The specific SEA objectives are a concrete, partially quantified expression of the general objectives provided in the form of guidelines for change and actions using which these changes will be effected. The specific SEA objectives make up the methodological benchmark through which the effects of the DRP on the environment are checked. They should provide the decision-makers with a clear picture of the essential DRP effects on the environment, based on which it is possible to make decision geared towards environmental protection and achieving sustainable development goals. The specific SEA objectives form a basis for the evaluation of territorial effects of the DRP on the environment.

They are defined based on the general SEA objectives and the DRP spatial scope, planned structures in the DRP area, environmental conditions in the planning and wider area (Table 13).

In addition to the SEA objectives, very important for impact assessment is also defining the indicators relative to which the trends of spatial change and environmental change are assessed and monitored.

For each specific SEA objective one or more associated indicators are set. In the case of the SEA for the RES complex Bela Anta, the indicators were selected from the Basic Set of UN Sustainable Development Indicators, in line with the Instructions issued by the Ministry of Science and Environmental Protection in February 2007 and the Rulebook on the National List of Environmental Protection Indicators (The Official Gazette of the Republic of Serbia, No. 37/2011).

This set of indicators is based on the concept of 'cause-consequence-response'. The 'cause' indicators denote human activities, processes and relations affecting the environment; the 'consequence' indicators denote the state of the environment; and the 'response' indicators define the planning and political options and other responses with the aim of changing the 'consequences' in the environment. This indicator set fully reflects the tenets, principles and goals of sustainable development, and thus it fully fulfils its role in their application in the SEA.

The selection of indicators listed in Table 13 is in line with the planned activities in the area of DRP implementation and their possible effects on the quality of the environment; they have been used in evaluating the planning solutions as part of the SEA.

Table 13. SEA objectives and indicators

Environmental receptors	Specific SEA objectives	Indicators
Protection of biodiversity	**1. Reduce the harmful effects on the ornithofauna**	- The number[10] and status of potentially endangered target bird species as a result of wind farm construction and operation.
	2. Reduce the harmful effects on the chiropterofauna	- The number[11] and status of potentially endangered bat species as a result of wind farm construction and operation

[10] Refers to the assessment of the number of potentially endangered birds as a result of construction and operation of the wind farm in the period of one year, including both migratory periods (spring and autumn).
[11] Refers to the assessment of the number of potentially endangered bats as a result of construction and operation of the wind farm in the period of one year.

Environmental receptors	Specific SEA objectives	Indicators
Protection of basic environmental factors	**3. Preserve air quality**	- The number of days when the ELV are exceeded as a result of wind farm construction and operation
	4. Preserve water quality	- Increased emission limit values for water as a result of wind farm construction and operation
	5. Preserve soil quality	- % of contaminated surfaces as a result of wind farm construction and operation - % surfaces covered under new use
Protection of landscape	**6. Protection of landscape and ambient values**	- The number and spatial layout of planned wind turbines - Location exposure/visibility - The number of structures exposed to shadow flicker
Protection of cultural heritage	**7. Preserve cultural heritage**	- The number of potentially endangered sites containing cultural heritage structures and objects/archaeological remains
Protection from non-ionizing radiation	**8. Reduce non-ionizing radiation**	- The number of sources of non-ionizing radiation and their intensity - Exposure of the population to non-ionizing radiation
Reduction of climate changes	**9. Increase the use of RES**	- The total installed power and share in total RES production in the territory of the city of Pančevo.
Socio-economic development	**10. Reduce noise level**	- The number of residential structures in the zone with higher noise levels
	11. Protection from accidents	- The surface area where accidents might occur. - Exposure of the population, structures, plant life, and animals to accidents.
	12. Stimulate economic growth	- The number of staff in the construction and operation of the wind farm. - The city of Pančevo revenues from implementing RES use projects.

Table 22 lists all the SEA objectives and indicators for the DRP of the Bela Anta RES complex in full. Given that the DRP also includes uses other than wind farm planning (biomass power plants, substation, etc.), the table also lists the objectives relating to all other elements of spatial development of the plan area, not only those directly correlated with the Bela Anta wind farm project.

SEA objectives and indicators are very important in the semi-quantitative multi-criteria method of evaluation. The process of evaluation of planning solutions is conducted with respect to the SEA objectives and the associated indicators. This is achieved by creating matrices where the planning solutions are combined with SEA objectives and the associated indicators, as shown below.

5.3.2. The environmental impact assessment

Efficient environmental protection is one of the foremost social duties today, both globally and regionally/locally. The negative consequences present in the environment today are for the most part a result of inappropriate planning, construction, uncontrolled and inadequate energy use, as well as ignorance of the basic regularities in the area of environmental protection.

In the context of the claims made above, the changes that result from adapting nature to the needs of mankind can be as it expects, but they can also be – and frequently are – very unfavourable for mankind itself. The totality of such changes has very complex consequences, which can have a backwash effect on the initiators of change, leading in this way to new conditions and new consequences.

The SEA aims to analyse all the aspects of potential effects (positive and negative) which can arise in the environment as a result of implementing a specific spatial development policy. The SEA assesses future trends in the environment, envisages guidelines for implementing the planning concept of spatial development which prevents spatial conflicts, and formulates conclusions which serve as the basis for the decisions on future spatial development in a certain space.

The DRP for the Bela Anta RES complex will, among other things, represent a framework for approving the construction of a wind farm whose operational characteristics can have positive effects on the environment but also negative ones, whether on the quality of the environment or some of its elements. In this context, it is necessary to analyse all potential changes in the environment in the SEA procedure.

Further, it should be said that for the most part SEA analyses directly the spatial aspects of potential effects of wind farms on the environment, while some technical aspects of wind farm construction and operation are treated only indirectly and with the aim of analysing the wider context. The analysis of the spatial aspect is initially carried out in the SEA relative to the variant solutions of spatial development (the initial impact assessment), and then the selected variant is assessed against individual planning solutions.

5.3.2.1. Assessment of the variant solutions

Variant plan solution are different ways, means, and measures of implementing plan goals in specific development sectors by considering the possibility of using a particular space for specific purposes and activities. The total plan effects, including environmental effects, can be efficiently established by a comparison with different variant plan solutions and assessing them relative to the SEA objectives and indicators (Table 13).

The legislation does not prescribe what variant plan solutions are which would be subject to a strategic impact assessment, but no fewer than two variants are considered in practice:

- The variant of implementing the plan,
- The variant of not implementing the plan.

In order to assess the effects of variant solutions, matrices are created where the impact of sectoral solutions is assessed in all the existing spatial development variants. An illustration of the matrices for assessing variant solutions in the SEA for the DRP of the Bela Anta RES complex is shown in Table 14.

Table 14. *An illustration of variant solution evaluation in matrix form*

SEA area	Variant solutions	SEA objectives											
		1	2	3	4	5	6	7	8	9	10	11	12
Zone 1 – WF Bela Anta	A	–	–	+	0	–	0	–	0	+	0	0	+
	B	0	0	0	0	0	0	–	0	–	0	0	–
Zone 2 – WF Bela Anta 2	A	–	–	+	0	–	0	–	0	+	0	0	+
	B	0	0	0	0	0	0	–	0	–	0	0	–
⋮	A	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	B	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
n	A	…	…	…	…	…	…	…	…	…	…	…	…
	B	…	…	…	…	…	…	…	…	…	…	…	…

The meaning of the symbols:

+ overall positive effect;
– overall negative effect;
0 no direct effect or effect unclear;
A – the variant of implementing the plan;
B – the variant of not implementing the plan.

Given that on the variant where the DRP for the Bela Anta RES complex is not implemented, there would be no spatial changes relevant to the evaluation, this section of the SEA was geared towards and limited to the concrete DRP variant solutions. The concrete variant solutions were related exclusively to the spatial layout of the wind turbines in the context of the protection of the ornithofauna and chiropterofauna for ZONE 1, for which the planning was at the level of microlocation determination of specific wind turbines. In this context, the 'variant solution' column in Table 15 was replaced with the wind turbine position variants.

As regards ZONE 2 (WF Bela Anta 2), the DRP did not consider the spatial layout of the planned wind turbines but only the zoning of the area for the construction/mounting of wind turbine towers; this was carried out in line with the results of the one-year monitoring of the ornithofauna and chiropterofauna for this part of the future Bela Anta RES complex.

The variant solution assessment had four phases:

- Phase 1 – the initial positioning of the wind turbine towers. The position of the towers in this phase is determined solely based on wind measurements at the location, i.e. on the predictions and estimates of production, without spatial analyses and analyses of potential environmental effects. This phase served as the basis for the Study of the one-year monitoring of ornithofauna and chiropterofauna;
- Phase 2 – the variant of positioning the wind turbines after the one-year monitoring. The spatial layout of the wind farm structures was carried out in this phase after identifying all the required elements and zones which can be a limiting factor in terms of the protection of volant fauna. Relative to the initial position, in this phase the towers were removed from the microlocations at which corridors, habitats, or hunting grounds of volant fauna target species were identified (the protected zones). In this context, and with respect to the initial position of the wind turbines, 15 wind turbines were displaced. The displacement was carried out relative to the 'protected zones'. Nine 'spare' wind turbines were added in this phase relative to the initial wind turbine positioning;
- Phase 3 – the variant of positioning and numbering of wind turbines during consultations with the Regional Institute for Nature Conservation. In this phase, all spare positions from Phase 2 were cancelled in order to minimize the potential negative effects on the volant fauna, and a duty was established to adhere to the results of the one-year monitoring, especially in the sense of omitting the identified 'protected zones' during the final spatial layout of the wind turbines, whose precise position, besides the requirements of protecting the volant fauna, also depend on the possibility of resolving the legal property status of the land lot.
- Phase 4 – the final variant of wind turbine layout relative to the results of the previous phases and the other elements of the environment (towns and villages, infrastructure, the existing used, etc.). In this variant, additional displacement was carried out for four more wind turbines, and as such, this variant was adopted and included in the next impact assessment phase.

Summarizing the above, it can be said that the procedure of evaluation of the SEA variant solutions for the DRP of the Bela Anta RES complex resulted in the final variant of wind turbine positioning in the plan area. In this context, in this phase the principle of preventive protection was applied in the SEA, which should be considered one of the most important contributions in the SEA procedure.

After selecting the most favourable variant solution, based on a general assessment of trends in the environment which can arise as a result of implementing plan propositions, the phase of evaluating individual planning solutions by applying the semi-quantitative method is initiated.

5.3.2.2. Evaluation of the characteristics and importance of the impact of planning solutions, with definitions of the evaluation criteria

After selecting the most favourable variant solution (in this case, the spatial layout of the wind turbines), a multi-criteria evaluation was carried out in the SEA by applying a semi-quantitative method, focusing on the importance, spatial extent, likelihood and duration of impact of the planning solutions relative to the SEA objectives and indicators, with the aim of identifying the possible (strategic) effects of the planning solutions formulated in the DRP.

The multi-criteria evaluation was carried out with respect to the criteria[12] in Table 15, 16, 17 and 18.

Table 15 shows the criteria for evaluating the planning solutions.

[12] The present volume only lists the main groups of criteria based on which the strategic importance of the spatial impact of planning solutions is assessed, without any specific criteria. For each criterion in the main criteria groups, specific criteria for each individual planning solution were set in the SEA for the DRP of the Bela Anta RES complex. For example, in order to ascertain the impact in the context of assessing noise levels as a result of wind farm operation, the relevant criteria included distance from the noise source and noise level values (dB) – the spatial dispersion of noise. Setting specific criteria is conditional on professional discretion that the present author has opted for in consultations with the Bela Anta project investor; on the other hand, it would require a considerably more detailed and comprehensive treatment that the one conceptualized for this book. This statement notwithstanding, the presentation of the evaluation methods and results in this section of the book are based on the application of all the defined specific SEA criteria for the DRP of the Bela Anta RES complex.

Table 15. *The criteria for assessing impact magnitude*

Impact magnitude	Mark	Description
Critical	**- 3**	Overloads space capacity
Greater	**- 2**	Disrupts the environment to a greater degree
Smaller	**- 1**	Disrupts the environment to a smaller degree
No impact	**0**	No impact on the environment
Positive	**+ 1**	Smaller positive changes in the environment
Favourable	**+ 2**	Favourable changes in the quality of the environment
Very favourable	**+ 3**	Changes improve quality of life considerably

Table 16 shows the criteria for evaluating the spatial extent of possible effects.

Table 16. *The criteria for evaluating the spatial extent of possible effects*

Impact significance	Mark	Description
National	**N**	Possible impact at the national level
Regional	**R**	Possible impact at the regional level
Municipal	**G**	Possible impact at the municipal level
Local	**L**	Possible local impact

The likelihood of an assessed impact actually occurring is also an important criterion for the decisions made during plan preparation. The likelihood of impact is determined based on the scale shown in Table 17.

Table 17. *The impact likelihood assessment scale*

Likelihood	Mark	Description
100%	**I**	Impact certain
over 50%	**V**	Impact likely
below 50%	**M**	Impact possible

Furthermore, additional criteria can be derived based on the duration of impact and consequences. It is in this sense that temporary-occasional (P) and long-term (D) effects can be defined.

<u>Adopted</u>: Strategically significant impacts for the DRP of the Bela Anta RES complex are those that have a strong or considerable (positive or negative) impact in the entire plan area or in the space bigger than the one delineated in the DRP (municipal and/or national level) in line with the criteria in Table 18.

Table 18. *The criteria for evaluating impact significance*

Extent	Magnitude		Significant impact mark
National level: N	Strong positive impact	+3	**N +3**
	Considerable positive impact	+2	**N +2**
	Strong negative impact	-3	**N -3**
	Considerable negative impact	-2	**N -2**
Municipal level: G	Strong positive impact	+3	**G +3**
	Considerable positive impact	+2	**G +2**
	Strong negative impact	-3	**G -3**
	Considerable negative impact	-2	**G -2**
Local level: L	Strong positive impact	+3	**L +3**
	Considerable positive impact	+2	**L +2**
	Strong negative impact	-3	**L -3**
	Considerable negative impact	-2	**L -2**

Based on the criteria for magnitude assessment, spatial extent, likelihood estimates and duration of impact of concrete planning solutions from the DRP (Table 19) on the SEA objectives and associated indicators, the procedure of multi-criteria evaluation is conducted the significance of the identified DRP impacts is assessed.

Table 19. *An illustration of the planning solutions included in the impact assessment*

No.	Planning solution
1	ZONE 1 (WF Bela Anta)
2	ZONE 2 (WF Bela Anta 2)
⋮	⋮
n	…

The assessment of the impact on the environment and the elements of sustainable development is carried out in matrices, as shown in Tables 20, 21, and 22.

As the method of elaboration (presentation) of the results obtained by applying the semi-quantitative method of multi-criteria evaluation of the planning solutions is key for making optimal decisions on DRP implementation, it is very important for the presentation of the obtained results to be clearly and unambiguously shown in the SEA.

In this context, graphs (Figure 50) were used to present the results; these graphs fully represent the results obtained in matrices for the multi-criteria evaluation of the planning solutions.

The matrices (Tables 20 and 21) combine the planning solutions with the SEA objectives and produce assessments based on the main criteria groups: for assessing impact magnitude (Table 15) and for the spatial extent of impact (Table 16).

The strategically significant impacts (Table 18) are identified relative to these two main criteria groups; they are then used to determine the value in accordance with the remaining two main criteria groups: impact likelihood (Table 17) and duration/frequency of impact.

An illustration of the matrix-format presentation of the multi-criteria evaluation of the planning solutions is provided in Tables 20 and 21.

SEA objectives

1 Reduce harmful effects on the ornithofauna
2 Reduce harmful effects on the chiropterofauna
3 Preserve air quality
4 Preserve water quality
5 Preserve soil quality
6 Protection of the landscape and ambient values
7 Preserve the cultural heritage
8 Reduce non-ionizing radiation
9 Increase the use of renewable sources of energy
10 Reduce the level of noise
11 Protection from accidents
12 Stimulate economic growth

Table 20. *An illustration of the assessment of impact magnitude of the planning solutions on the environment*

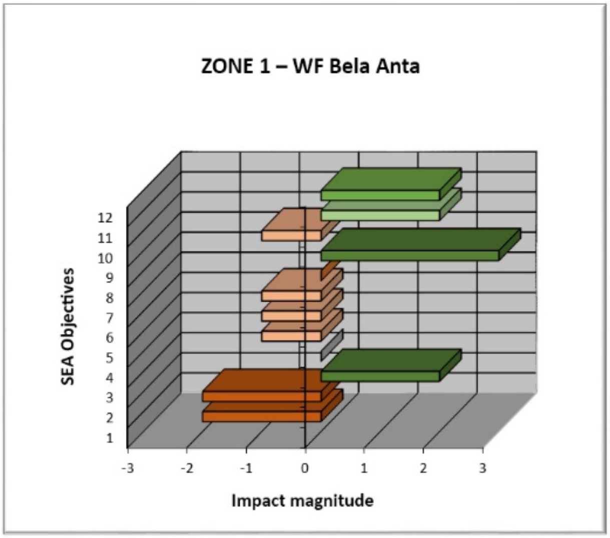
Planning solutions	SEA objectives											
	1	2	3	4	5	6	7	8	9	10	11	12
ZONE 1 (WF Bela Anta)	-2	-2	+2	0	-1	-1	-1	0	+3	-1	+2	+2
ZONE 2 (WF Bela Anta 2)	-1	-1	+2	0	-1	-1	-1	0	+3	-1	+2	+2
⁝	⁝	⁝	⁝	⁝	⁝	⁝	⁝	⁝	⁝	⁝	⁝	⁝
n	…	…	…	…	…	…	…	…	…	…	…	…

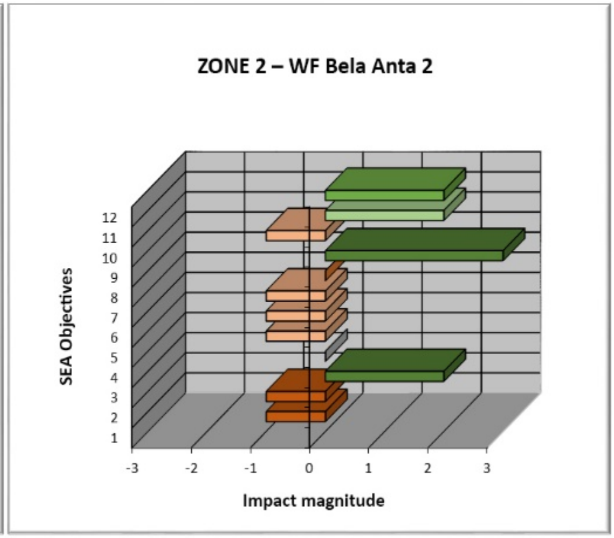
***** **-** criteria according to Table 15.

Table 21. *An illustration of the assessment of the spatial extent of the impact of the planning solutions on the environment*

Planning solutions	SEA objectives											
	1	2	3	4	5	6	7	8	9	10	11	12
ZONE 1 (WF Bela Anta)	N	N	G	/	L	L	L	/	N	L	L	G
ZONE 2 (WF Bela Anta 2)	N	N	G	/	L	L	L	/	N	L	L	G
⁝	⁝	⁝	⁝	⁝	⁝	⁝	⁝	⁝	⁝	⁝	⁝	⁝
n	…	…	…	…	…	…	…	…	…	…	…	…

***** **-** criteria according to Table 16.





Mark (negative)	Impact significance	Mark (positive)
N	National	N
G	Municipal	G
L	Local	L

Figure 50. *Graphs for presenting the results of the impact assessment*

After the multi-criteria evaluation of each individual planning solution and the presentation of the evaluation results in graph form (Figure 50), the identification of strategically significant impacts and other (smaller) potential effects of the DRP on the environment are initiated (Table 22).

All identified strategically significant impacts are ranked in line with all the main criteria groups (Tables 15, 16 and 17) and the criteria for the assessment of impact duration. Impact ranking is determined for each SEA according to which the strategically significant impact is realized (both positive and negative).

The identification of smaller potential impacts, not strategic in nature, is also important for understanding the broad picture of all the implications which may arise in space as a result of implementing the plan propositions. Only a comprehensive analysis of the potential problems makes it possible to define the appropriate guidelines for minimizing or eliminating potential spatial conflicts.

Table 22. *An illustration of the identification of strategically significant and other impacts of the planning solutions on the environment.*

PLANNING SOLUTION	Identification and evaluation of strategic impacts		Explanation	Other (smaller) effects on SEA objectives	Explanation
	SEA objective	Ranking			
ZONE 1 (WF Bela Anta)	1	-2/N/M/P	Negative impacts on the volant fauna are possible due to the size of the wind farm and the number of wind turbines in ZONE 1. All preventive planning measures have been taken in order to minimize all these impacts. The construction of a wind farm in the broader context has positive long-term effects on increasing air quality and CO_2 emission reduction (theoretically, every kW produced from RES means one less kW of electricity produced from non-renewable sources). The implementation of this project stimulates economic growth, as confirmed in the contract concluded between the city of Pančevo and the investor, o % of the revenues that the investor must pay the city by way to tax for the use of the space and resources.	5, 6, 7, 10	Smaller negative effects are expected on the following: the volant fauna in Zone 2, minimized by the optimal layout of the wind turbines; the soil used for building wind turbine towers; the increased level of noise at the very source, which is within the prescribed range relative to the nearest residential structures; the landscape, as wind turbines will dominate the space; the potential archaeological sites during tower foundation digging. The positive effects relate to the protection from accidents in line with optimal planning and equipment specification.
	2	-2/N/M/P			
	3	+2/G/V/D			
	9	+3/N/D/I			
	11	+2/L/V/D			
	12	+2/G/I/D			
ZONE 2 (WF Bela Anta 2)	3	+2/G/V/D		1, 2, 5, 6, 7, 10	
	9	+3/N/I/D			
	11	+2/L/V/D			
	12	+2/G/I/D			
⋮	⋮	⋮	⋮	⋮	⋮
n	…	…	…	…	…

It is clear from Table 22 that both zones in which the DRP of the Bela Anta RES complex envisages the construction of the wind farm have positive and negative effects on the environment and sustainable development elements. However, it is noticeable that the positive effects outrank the identified potential negative effects of DRP implementation.

The effects of the planned wind farm on the environment are elaborated below in the form of environmental impact summaries.

5.3.2.3. The environmental impact summarized

This section of the book focuses on summarizing the impacts relating to the spatial aspect and are conditioned by the spatial organization and spatial relations of the existing and planned activities (the wind farms in ZONE 1 and 2) in the DRP area, discussed in theoretical terms in section 3.2.2 in the present volume.

For the other identified but smaller impacts, only a brief and general assessment is provided which is itself a result of the multi-criteria evaluation of the DRP planning solutions.

Effects on the ornithofauna

Of the total of 372 recorded overflights of target species in ZONE 1, only 76 were in the critical altitude region of 60 to 180m above ground, which is around 20% of the total number of recorded target species overflights. However, the majority of these overflights were by the most frequent and numerous birds of prey in the location – the common buzzard *Buteo buteo* and the common kestrel *Falco tinnunculus*, which cannot be characterized as endangered.

Based on the analysed data on the presence and overflight directions of various bird species, as well as on the wind turbine layout, it can be assumed that the construction and operation of the Bela Anta wind farm will affect in the greatest degree the most numerous and regularly present species such as the common buzzard *Buteo buteo* and the common kestrel *Falco tinnunculus.*

The other target species flying at critical altitudes were few in number, and it can be assessed with a high degree of certainty that the impact of the wind turbines on them will be minor. In addition, the final layout of the wind turbines, itself a result of the recommendations from the monitoring of the ornithofauna and chiropterofauna, is a very satisfactory compromise regarding the volant fauna, which meets the criteria of preventive protection and preservation of the bird fauna.

The birds in the area in question do not have strict and prominent migration corridors, but the wind turbine layout implemented by the investor resulted in the greater scatter of the corridors, increasing the likelihood of safe passage for migratory and diurnal bird overflights.

In ZONE 1 no impact was assessed as strongly negative. Of the target species, the greatest cumulative effect would be suffered by white storks *Ciconia ciconia*, common buzzards *Buteo buteo*, common kestrels *Falco tinnunculus*, as well as geese *Anser* spp., and of the selected other species the European bee-eater *Merops apiaster*, Eurasian skylarks *Alauda arvensis* and common starlings *Sturnus vulgaris*.

It is important to stress that the each of these species' numbers are comparatively small, and that there should be no significant effects on them.

On the other hand, it is necessary to point out the assessment of possible positive impact of the construction and operation of the wind farm and the supporting infrastructure on some bird species. For example, the construction of power lines used by the wind farm as mandatory supporting infrastructure can have a significant effect on the nesting populations of the birds whose nests can be beneficially located there.

As has been established, many species nest on power lines, such as the sparrow *Passer* spp., the common starling S*turnus vulgaris,* the raven *Corvus corax*, the crow *Corvus cornix*, the magpie *Pica pica*. Birds of prey like to use raven nests, e.g. the common kestrel *Falco tinnunculus*, the common buzzard *Buteo buteo*, the Eurasian hobby *Falco subbuteo*, as well as the saker falcon *Falco cherrug*, on rare occasions the Eastern imperial eagle *Aquila heliacal* as well. The latter has not been recorded in the location or the surrounding area.

Maintaining the space around the wind turbine supporting tower bases – mowing the grass, for example – can result in the increase of nesting pairs of species which are averse to tall grass, e.g. the pipit *Anthus* spp. and the lark *Alaudidae*.

In ZONE 2 and the surrounding area, 74 bird species were identified. The biggest reason for the low numbers of the recorded species in the examined area of the Bela Anta wind farm is the pronounced uniformity and the presence of non-optimal habitats. Trees are almost completely missing, as well as mid-storey growth (shrubbery). Species living at ground level are typical of the examined area.

Of all the species which could be put in harm's way by the wind turbines, 14 target species were selected and were specially monitored and recorded. The scope, altitude, and directions of overflights testify to the weak effects and intensity of potential harm.

Certain wind farm operation effects can be assumed for some diurnal birds of prey which were the most numerous and recorded at the critical altitudes, such as the common kestrel *Falco tinnunculus* and the common buzzard *Buteo buteo*.

The other species, such as the Western marsh harrier *Circus aeruginosus*, the Northern goshawk *Accipiter gentilis*, the Eurasian sparrowhawk *Accipiter nisus*, and white stork *Ciconia ciconia*, were considerably fewer in number and flew mostly below 50m, i.e. the altitude out of reach of the planned wind turbines, or above 180m from ground level, again out of reach of the wind turbines.

The most sensitive subjects of the monitoring were birds of prey (*Falconiformes*) which belong to the endangered species, because of which they are mostly strictly protected. Of the 14 target species, nine were diurnal birds of prey. Nesting of the saker falcon *Falco cherrug* and the Eurasian hobby *Falco subbuteo*, and even the more numerous common kestrel *Falco tinnunculus* and common buzzard *Buteo buteo,* was not observed.

The greatest number of overflights were recorded for the common kestrel and buzzard, while the number of other species' overflights was considerably to very small. Generally speaking, the most frequent altitude range in ZONE 2 was between 10 and 50m. Of the total of 151 recorded target species overflights, only 14 were in the critical altitude zone of 60 to 180m above ground level, which is only around 9% of the total number of recorded target species overflights. However, the greatest number of these overflights were by the most frequent and numerous birds of prey at the location – the common kestrel *Falco tinnunculus* and the common buzzard *Buteo buteo*, which cannot be characterized as endangered.

Based on the analysed data on the presence and overflight directions of various bird species, as well as on the wind turbine layout, it can be assumed that the construction and operation of the Bela Anta 2 wind farm will affect in the greatest degree the most numerous and regularly present species such as the common buzzard *Buteo buteo* and the common kestrel *Falco tinnunculus*.

The other target species flying at critical altitudes were few in number, and it can be assessed with a high degree of certainty that the impact of the wind turbines on them will be minor.

At the location in question no impact was assessed as strongly negative. Of the target species, the greatest cumulative effect would be suffered by common kestrels *Falco tinnunculus*, common buzzards *Buteo buteo*, white storks *Ciconia ciconia*, as well as geese *Anser* spp., and of the selected other species the European bee-eater *Merops apiaster*, Eurasian skylarks *Alauda arvensis* and common starlings *Sturnus vulgaris*. It is important to stress that the each of these species' numbers are comparatively small, and that there should be no significant effects on them.

Effects on the chiropterofauna

Based on the data collected in the one-year monitoring of the chiropterofauna in ZONE1 of the DRP and the one-year monitoring of the chiropterofauna in ZONE 2 of the DRP, as well as on the basis of the findings from the literature for the immediate and wider surroundings of the plan area designated for the Bela Anta RES complex, an assessment was made of the impact of the planned wind farm on the bats. Below are the conclusions of the assessment:

<u>ZONE 1</u>

- If in the project implementation phase the infrastructure construction works result in the removal of the woody and brush vegetation by the segment of the Stari Pančevački Road, east of the junction with the Prvi Preki Road, which for the species *Pipistrellus kuhlii* is the most important summer corridor and important hunting grounds, and if such a state of affairs remains during the project, this can lead to the loss of the functions of this road. This would have a moderate impact on the local bat population which has shelters in the Dolovo village area, as only a portion of their hunting grounds are at the wind farm location, and the bigger portion is in the immediate surroundings and cannot be included in this impact.

- Removing the woody and brush vegetation during the project implementation phase and maintaining such conditions during the project, as well as the positioning and operation of the wind turbines or other infrastructural elements in important summer corridors – by the Stari Pančevački Road and the Prvi Preki Road or in their vicinity – would result in a disruption of their function, i.e. the creation of obstacles, disrupting thus the regular daily transitional activity of these species/populations. This would affect them considerably, depending on the degree of disruption of the corridors in question and proportionately to the importance these corridors or parts thereof have for specific species/populations.

- A larger-scale removal of the woody vegetation during wind farm construction, and maintaining such conditions during the project in the zones of the most important registered and potential hunting grounds of the species *Pipistrellus nathusii* at the location would affect the local and migratory population. The effect would not be low as, unless the woody vegetation is completely removed from these zones, the loss of these functions would only be partial, and their more important hunting grounds are not at the location. As the same woody vegetation fragments also contain some of the registered copulation and other potential shelters of the local and migratory populations of the above species as well as *Nyctalus noctule*, removing woody vegetation would also result in the loss of these functions, which would impact on them. The impact would also be low, as a much greater portion of their registered and potential hunting grounds is in the area surrounding the location.

- The local and migratory population of the species *Nyctalus noctule* use the location as a less important transit area, but not as the hunting grounds, while they have important hunting grounds and summer corridors in the immediate vicinity of the location. Also, due to the specificities of the bionomy and ecology of the species, project works cannot substantially disrupt their hunting or their daily transit activity, which take place as a rule at altitudes over 40m within the corridors which are not very strictly spatially defined, as confirmed by the observation made during the monitoring.

- The species *Nyctalus leisleri* were not registered in considerable numbers or in prominent activities for the duration of the monitoring. Their significant ecological functions were not observed at the location and in the surrounding area. On the basis of this it can be concluded with certainty that the wind farm project will not impact on their local population. However, although during the monitoring no significant influx/outflux was recorded, it can be expected that the location zone has at least moderately important summer corridors and hunting grounds, as well as less important shelters of the species migratory population, and consequently at least occasionally moderate to high activity intensity. As due to the specificities of their bionomy this species is among the most frequent victims of wind turbines in Europe, if it turns out that occasionally (during spring and summer migrations) their numbers and activities go to moderate or high levels in the location zone, a higher mortality rate can be expected for the migratory population of this species.

- For the species *Pipistrellus kuhlii* deaths have been recorded as a result of collisions with wind turbines in Europe. As the numbers and activities of this species reach highest levels at the location during the monitoring and the risk of death is high, it can be expected that the direct fatality rate is high too. Nonetheless, as the local population of this species engage much more in their activities outside of the location and are very numerous and dominant (in towns and villages in the immediate and wider surrounding area as well as in all urban habitats in Serbia), even a considerable death rate at the location would not seriously impact on the population of this species.

- The species *Pipistrellus nathusii* and *Nyctalus noctula* are due to the specificities of their bionomy among the most frequent victims of wind turbines in Europe. As, therefore, a high fatality rate can be expected, and the local and migratory populations of both species are present throughout the location, with occasional relatively high numbers and moderate levels of activity, a moderate to high fatality rate can be expected for these populations.

- All other species are registered only sporadically at the location and in very small numbers, most often peripherally. The location does not have a significant function for their local populations, which goes for the potentially present species. Therefore, the wind farm project cannot have a significant impact on the ecological functions of their local populations. Although the risk of death exists for all species recorded as victims of wind turbines, it is negligible.

ZONE 2

- If in the project implementation phase the infrastructure construction works result in the removal of the linear elements (young lines of trees) and forest-steppe and marsh vegetation by the Novoselski and Bandin Road, which for this species/populations are the most important summer corridors and hunting grounds at the location, and if such a state of affairs remains during the project, this can lead to the loss of the functions of this road. In the worst case scenario, this would only have a moderate significance for the populations of these species, which have shelters in the zone of the Dolovo village and the Ciganska Dolina, as under the environmental conditions such as those at the location and in the absence of linear elements, these species follow roads without linear vegetation elements, so a full loss of these functions cannot occur. Further, only a small portion of their hunting grounds/summer corridors is located in the wind farm area, while the more important and bigger ones are in the surrounding area and thus cannot be impacted in this way. Nonetheless, as the wind farm plan does not envisage drastic interventions on these roads, the expected impact of the wind farm on their functions will likely be negligible for these species.

- The local and migratory populations of the species *Nyctalus noctule* use the location almost exclusively as a fairly unimportant transit area. Due to the specificities of the bionomy and ecology of these species, neither the project works nor the operation of the wind farm can substantially disrupt their hunting and diurnal transit activity, which as a rule takes place at altitudes higher than 40m within corridors which are not strictly spatially defined, as confirmed by the observations during this monitoring.

- The species *Hypsugo savii* were not registered during this monitoring in significant numbers or as having significant activities, nor were their significant ecological functions observed at the wind farm site and in the surrounding area. Therefore, they cannot be exposed to the effects of wind farm construction and operation. However, this species has appeared recently in the general area of the location, expanding its habitat and increasing in numbers comparatively fast. This is why it can be expected that in the upcoming years the location zone will see their numbers increase and summer corridors and hunting ground appear, resulting in the increase of their activity as well. As they are registered in Europe as victims of wind turbines, if in the upcoming years their numbers and activities increase significantly in the wind farm zone, a higher death rate can be expected.

- This monitoring did not establish whether the location and the surrounding area contain significant migration corridors for the species *Pipistrellus nathusii* and

Nyctalus noctula. As there is a significant migration influx in both species, and the surrounding area has well-known migration corridors – the Tamiš and Danube river valleys, the possibility that the location area is peripherally included in these corridors cannot be ruled out.

*

The data and analyses above indicate a low level of negative effects on bird fauna – local populations and nesting birds as much as the migratory species. The layout and distance between wind turbines appears favourable for bird survival. In this context, it can be concluded that the principle of preventive protection which has been applied based on the results of the ornithofauna observations has had a significant contribution to bird preservation in the Bela Anta wind farm area.

In order to register, prevent, and reduce potential damage, it is necessary first and foremost to carry out monitoring during wind farm construction, as well as a post-construction monitoring, in order for the potential negative effects on the volant fauna to be prevented by rapid action and adequate protection measures.

The post-construction monitoring tracks the changes in the local bird fauna and its ecological functions at the wind farm site, especially the death rates -which is done by carcass searches with a full application of the relevant guidelines.

Taken as a whole, the wind farm site has a certain – although not high – importance for the preservation of the local bat fauna. This is particularly relevant to the local populations of the species *Pipistrellus kuhlii*, *Pipistrellus nathusii*, *Nyctalus noctula*, and in the near future likely the species *Hypsugo savii,* as well as on the migratory populations of *Pipistrellus nathusii, Nyctalus noctula* and possibly *Nyctalus leisleri,* for which moderate ecological functions exist at the very location, due to which their high or moderate activity and relatively high numbers are recorded here temporarily and/or locally.

Given that the data and analyses from this study indicate that the wind farm project can have an impact on bats which could at least in some cases be qualified as moderately or very harmful, during wind farm planning, implementation, operation, and shut-down, measures must be taken in order to prevent, reduce and/or eliminate potential harmful effects of the project on bats.

Lastly, it can be concluded that in the planning of the Bela Anta RES complex and in the preparation of the DRP and SEA the most efficient principle of prevention and minimizing negative effects of the planned wind farm on the ornithofauna and chiropterofauna was applied – the principle of preventive protection. Contributing to this approach were the methodological approach to the preparation of the SEA, for which detailed observations of the ornithofauna and chiropterofauna were made; and a responsible approach to environmental protection on the part of the investor of the project.

Based on the entire analysis above, elaborated on and argued in detail, the following can be concluded:

- Most measures needed to prevent the negative implications of the Bela Anta wind farm in ZONE 1 and ZONE 2 have already been implemented through the preventive planning of the spatial microlocation determination of wind turbines. The final spatial layout of wind turbines was determined based on the results of the multi-criteria evaluation of the variant solutions within the SEA for the DRP of the Bela Anta RES complex. This should be considered the most important contribution to the SEA and the most important planning measure for the efficient protection of the ornithofauna and chiropterofauna in the plan area;
- All the defined wind turbine positions making up the Bela Anta wind farm in ZONE 1 and 2 were assessed as favourable regarding the impact on the ornithofauna and chiropterofauna. However, it is necessary to apply the requirements so that these positions are optimal during wind farm construction and operation. Only some of the most important requirements to be applied can be provided as examples:
    - During wind farm construction, it is necessary to avoid the removal of woody and brush vegetation which takes he volant fauna away from the wind turbine positions and thus reduces the risk of collision;
    - In order to reduce the risk of direct death of bats and birds during wind farm operation, measures should be taken for the reduction of insect concentrations in their immediate vicinity, and especially: using lighting that does not attract insects; switching off the lighting that has not been prescribed for safety reasons; removal and prevention of growth of woody, brush, and weed vegetation; and ensuring water does not accumulate in the immediate vicinity of a wind turbine.
- After commissioning the wind farm, it is recommended to conduct a post-construction monitoring which would track the changes in the local bird and bat fauna and their ecological functions at the location, and especially the death rates, with special focus on the diurnal birds of prey, storks, and herons, as well as the following bat species: *Hypsugo savii* and *Nyctalus leisleri* (in ZONE 1); and *Pipistrellus kuhlii*, *Pipistrellus nathusii*, *Nyctalus noctula* (in ZONE 2).

Effects on noise levels

Special attention during the planning of the Bela Anta wind farm and the SEA procedure should be paid to the assessment of the possible impact of noise, i.e. the exposure of the population to increased noise levels as a result of wind turbine operation. In this context, one of the specific SEA objectives and the associated indicator (Table 13) is related to analysing this aspect.

Although in modern wind turbines the use of the so-called *optispeed* generator ensures constant angular velocity of the wind propeller (typically at 16rpm) in a wide range of wind speeds, which reduces noise levels considerably, noise is nonetheless made by the operation of wind turbines. Nowadays, the most important source of wind turbine noise is actually the sound created by the turbine propeller as it travels through the air. Given the dimensions (length) of modern wind turbine propellers and the speed at which they travel through the air (the propeller tip can reach the speed of nearly 200 kmh), this sound can be heard from several hundred meters away, depending on the terrain topography.

In addition to the power and dimensions of the wind turbine, an especially important aspect of analysing noise intensity is the spatial aspect. The noise caused by the wind turbine decreases with distance (the spatial dispersion of noise). This fact was taken into account in the assessment of wind turbine noise at the source and the spatial dispersion of noise in the plan area and the surroundings. Noise intensity was modelled for the planned wind farm using the Danish 'wind turbine noise intensity calculator'. Modelling[13] was done for individual wind turbines and for wind turbine groups.

For nearest towns and villages as well as structures, the criteria for Zone 2 were applied (small towns and villages) from the Regulation on Noise Indicators, Limit Values, Methods for Assessing Indicators of Noise, Disturbance, and Harmful Effects of Noise in the Environment (The Official Gazette of the Republic of Serbia, No. 75/10), where the highest permitted level of ambient noise during the day/night is 50 dB and 45 dB respectively (Table 5).

The modelling results indicate that the wind turbine positions ensure the conditions for the protection of the immediate surroundings from noise in line with the regulations prescribed, given that the prescribed noise levels at the location are reached at the average distance of 370m from the wind turbine. Bearing in mind that the nearest structures are 1,500 m away

[13] Section 3.2.2.2 provides a more detailed discussion of the principles of modelling the spatial dispersion of noise from wind turbines. This section only shows the results obtained by modelling the noise produced by the Bela Anta wind farm.

from the wind turbines, there is no doubt that, except for the source, no effects are expected from increased noise levels coming from the wind turbines.

Given that in the spatial layout of the wind farm turbines in the Bela Anta RES complex special attention was paid to the possible effects of wind turbine noise on the nearest residential structures, the model has established that the noise levels from the wind turbines are considerably below the legally prescribed values. In this context, the planned turbine layout is very favourable and has no significant negative effects of noise as a result of wind farm operation.

Effects on the landscape

The landscape characteristics are a subjective category which is not simple to assess. The visual impact on the environment is a subjective impression which depends on the perceptions of the observer as much as on the type of landscape and specific visual characteristics. Analysing the DRP area and its surroundings by applying the model for the analysis of wind turbine visibility (see section 3.2.2.4), it was concluded that, given its prominently flat and monotonous terrain topography, wind turbines will dominate the environment. Based on that it was concluded that the construction of the planned wind farm will considerably change the existing landscape.

However, although the wind turbines will be visible from great distances due to the lack of physical barriers in the plan area, the distance from the nearest structures (no less than 1.5km) indicates that the wind turbines will not be visually prominent (Figure 28). With careful design and colour of the lower portions of the wind turbine towers (shades of green or brown), the visual impact can be additionally minimized.

Furthermore, it was previously mentioned that installing wind turbines can impact on the shadow-casting and reflection of wind turbines. Wind turbines are very big and tall objects, and as such they can block the light and cast a shadow on the surrounding area. When they are operational, the spinning of the wind propeller can cause an unpleasant shadow flicker, which is noticeable at distances up to 10 rotor diameters. Given the planned wind turbine layout in the Bela Anta wind farm and the existing structures in the plan area surroundings, as well as the path of the sun, it can be concluded that such effects will not be big enough to be causing a disturbance.

Summarizing the assessment of the Bela Anta wind farm impact in ZONE 1 and 2, it can be concluded that the project implementation will lend a special visual identity to the plan area and the surroundings, that it will be visible from great distances, but that the distance/visibility of the planned wind turbines relativizes the expected effects.

Effects in the event of accidents

As indicated in section 3.2.2.5, the following are potential accident types occurring in a wind farm:

- The danger of fire in the generator,
- The danger of a thunder strike,
- The danger of ice gathering on wind turbine propellers,
- The danger of bits breaking off propellers in extremely high winds,
- The danger of wind turbine tower snapping.

However, equipment manufacturers invariably implement all the required accident protection measures to keep accidents within theoretical bounds. The protection measures are related to mounting wind turbine shut-off mechanisms in extreme winds, implementing fire protection technical measures, measures for ice gathering on wind propellers, etc. For these reasons the risk of an accident in a wind turbine is very small.

Also important, besides the protection measures implemented by equipment manufacturers, is the exposure of people and structures to accidents. Once again the focus is on the importance of the spatial microlocation determination for individual wind turbines and analysing the spatial aspect of the impact of wind turbines on the environment and its elements.

The spatial analysis conducted with the aim to provide an optimal microlocation layout of wind turbines in the planned Bela Anta wind farm, in both zones envisaged by the DRP, has concluded that there is only a theoretical danger for people, even in the event of the most severe malfunction (the propeller breaking off or the entire wind turbine collapsing).

Residential areas and roads are not found in the vicinity, so the danger of accidents is minimal.

Natural objects (forest complexes or other types of vegetation) are also at a distance which prevents any harm to them in the event of, above all, fire, while the use of the land for farming purposes is an aggravating circumstance for the potential spreading of fire in the plan area.

Other identified effects

In a wider context, the implementation of a wind power (renewable) plant brings about positive long-term effects on improving air quality and reducing CO_2 emissions (theoretically, each kW produced from RES is one less kW of electricity produced from non-renewable sources). This benefit goes beyond local microlocation conditions and the boundary of the plan area, and is characterized as nationally significant impact, given that it affects the improvement of Serbia's portfolio in the area of renewable energy source use. It is also a contribution to the reduction of greenhouse gas emissions – a global problem in this day and age.

The implementation of this project stimulated the economic growth of the local community, as confirmed by the contract concluded between the city of Pančevo regarding the percentage (%) of revenues the investor must pay to the city as a fee for using the space and the resources. This amount will depend on renewable electricity prices in Bela Anta exploitation phase (25 years). Given the capacity and the installed power of the planned wind farm, there is no doubt that the sum to go into the city budget during exploitation will not be negligible. In addition to this benefit, there is also the possibility of hiring local companies in the wind farm construction phase, which would enable these companies to make profit and increase their workload. For these reasons, this (positive) impact is characterized as strategically important.

In addition to the listed positive strategically important effects of the DRP, smaller negative effects are also possible as a result of the wind farm project implementation: on the volant fauna in Zone 2, minimized by the optimal layout of the wind turbines; the use of land for building wind turbine tower foundations; the increased noise levels at the source; the potential archaeological sites during tower foundation digging.

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Summarizing all the effects above (positive and negative) of the planned Bela Anta wind farm on the environment and the sustainable development elements, it can be said that the identified strategically important effects of the planning solutions on the concrete space and wider area (Table 22) are positive. Smaller negative effects, which can be expected during the implementation of the planning solutions, are of limited intensity and spatial extent, as confirmed in the multi-criteria evaluation of the planning solutions. Bearing in mind that project characteristics and the fact that renewable energy is used and green technology applied, it can be said that the project will produce environmentally clean ('green') electricity, which is a special contribution to the quality of the environment and goes beyond the plan.

Smaller negative effects on the ornithofauna and chiropterofauna are possible, but they have been minimized by an adequate selection of microlocations for mounting wind turbines.

In addition, the SEA lists a whole array of other positive effects of the DRP not related to wind turbines, but to other activities envisaged within the Bela Anta RES complex. However, given the decision of the present author to limit the discussion here to just the Bela Anta wind farm, these effects have not been presented.

5.3.2.4. Determining the cumulative and synergistic effects

In line with the Law on Strategic Environmental Assessment (Article 15), the SEA also includes an assessment of cumulative and synergistic effects. These effects arise as a result of interactions between numerous smaller effects of the existing structures and activities, and different planned activities in the plan area

Cumulative effects arise when individual planning solutions do not have a significant impact, but several individual effects can. An example would be air and water pollution, or increased noise levels due to many individual factors (traffic, industry, individual furnaces in heating systems, etc.)

The synergistic effects arise in interactions of individual effects and produce an effect which exceeds the sum of individual effects.

The cumulative and synergistic effects of the DRP are identified partly in the tables/matrices for multi-criteria evaluation (Tables 20 and 21) and partly in section 5.3.2.3 of the present volume, in the segment relating to the effects of multiple wind turbines on noise levels and the landscape.

With more complex strategic plans of spatial development, the cumulative and synergistic effects are usually shown in a table for each SEA area (Table 23).

For the planned Bela Anta wind farm (zones 1 and 2) and with respect to the existing uses and structures, there was no need to analyse the cumulative and synergistic effects, except for those relating to the interactions of multiple wind turbines in the wind farm, as elaborated in the tables relating to the multi-criteria evaluation of the planning solutions.

Table 23. *An illustrative tabular presentation of the approach to determining the cumulative and synergistic effects of the planning solutions with the existing activities in the plan area*

Interaction of priority activities	SEA area
BIODIVERSITY	
SEA objectives (1-n)	*Negative implications (explanation)*
SEA objectives (1-n)	*Positive effects (explanation)*
MAIN ENVIRONMENTAL FACTORS	
SEA objectives (1-n)	*Negative implications (explanation)*
SEA objectives (1-n)	*Positive effects (explanation)*
…	
SEA objectives (1-n)	*Negative implications (explanation)*
SEA objectives (1-n)	*Positive effects (explanation)*
SOCIOECONOMIC DEVELOPMENT	
SEA objectives (1-n)	*Negative implications (explanation)*
SEA objectives (1-n)	*Positive effects (explanation)*

5.4. The plan implementation guidelines

After the multi-criteria evaluation of the planning solutions and identifying all the expected effects (positive and negative), the next step in identifying the plan implementation guidelines.

The plan implementation guidelines are invariably defined in the SEA in the following format:

1. Environmental protection guidelines,
2. Guidelines for the hierarchically lower planning levels and environmental impact assessment, and
3. Guidelines for monitoring environmental conditions

<u>Environmental protection guidelines</u>

In order for the positive planning effects to remain within the projected bounds and so not overload the spatial capacities and minimize or eliminate possible negative effects of the planning solutions, measures must be taken to prevent and limit the negative effects of the plan on the environment, and the identified positive effects should be intensified.

Based on the analysis of the environmental conditions, the spatial relations of the plan area with the surroundings, the planned activities in the plan area, and the results of the application of the semi-quantitative method of multi-criteria evaluation of the planning solutions relating to the implementation of the project of Bela win farm, the effects of implementing the planned use on the environment were assessed and guidelines for environmental protection were set.

Given that the greatest contribution of the SEA for the DRP of the RES complex Bela Anta comes from preventive planning and assessing the impact of variant solutions of the spatial microlocation layout of the wind turbines making up ZONE 1 – WF Bela Anta, as well as from defining the most favourable variants for locating ZONE 2 – WF Bela Anta 2, the environmental protection guidelines had no significance that they would have had in a different case, where no variant solution was considered.

Although the SEA for the DRP of the RES complex Bela Anta itemizes the guidelines for environmental protection that need to be implemented in designing and implementing the planned wind farm, they were mostly based on an interpretation of the duties prescribed by the relevant legislation and the requirements set by the competent institutions, obtained in a regular procedure for the purposes of the DRP preparation.

The defined environmental protection guidelines were based on the spatial aspect of environmental protection. However, due to the specificities of the planning document which envisages the construction of the concrete wind farm (many technical details were known about the project in advance), this section of the SEA defines the guidelines that can impact on project solutions.

Detailed technical/technological and organizational environmental measures are defined during the preparation of the Study on the Environmental Impact of the Bela Anta wind farm (EIA) and during the preparation of the technical project documentation.

Guidelines for the hierarchically lower planning levels and environmental impact assessment

In the hierarchy of spatial/urban plans, the detailed regulation plan (DRP) is at the lowest hierarchical level. With this fact in mind, as well as the fact that the SEA is prepared for spatial, urban plans and other development plans, in this specific case there was no need to provide guidelines for the preparation of the SEA for planning documents at the lower hierarchical level.

However, this was not the case in the environmental impact assessment for individual projects planned within the Beal Anta RES complex. Pursuant to the provisions of the Law on Environmental Impact Assessment (The Official Gazette of the Republic of Serbia No. 135/04 and 36/09), in order to obtain the construction permit for the Bela Anta wind farm project (ZONE 1 and ZONE 2 of the DRP), the SEA indicated the need to prepare a Study on the Environmental Impact Assessment (EUA) so that all possible effects of the project on the environment could be assessed in all the phases of implementation of the wind farm project: construction, exploitation, and post-exploitation. Based on that the technical and organizational measures of environmental protection are defined are the level of detail that goes beyond the SEA.

Guidelines for monitoring environmental conditions

In order to implement the defined plan propositions and guidelines for the protection of the environment, it is necessary to check how they are carried out in all the DRP implementation phases. These checks should be conducted by the relevant institutions for each individual section of the plan, as indicated in the SEA. The guidelines for monitoring environmental conditions are defined for biodiversity and noise.

During the construction of the wind farm, and especially after commissioning it, active monitoring was planned of the conditions and effects of the facility on the bird and bat fauna in the period of one year. In this connection, visits to the facility and the surrounding area (the spatial extent is defined under the SEA) to collect the data on the effects and possible deaths of birds and bats.

The monitoring was to include making records of the numbers and determining the species of the dead or wounded birds and bats as a result of the wind farm operation. In this context, it is necessary to observe separately the space within the 100m radius from each wind turbine every 7 days (1 February -1 May, and 1 August - 1 December) and every 14 days in the remaining part of the year. The monitoring must be carried out by a professional institution, and if the need arises, other competent institutions can be included, which then submit the monitoring report to the Regional Institute for Nature Conservation from Novi Sad.

If during the monitoring wounded specimens are found which belong to the species protected as natural rarities as per the Rulebook on the Declaration and Protection of Strictly Protected and Protected Species of Wild Plants, Animals, and Fungi (The Official Gazette of the Republic of Serbia No 5/10 and 47/11), the investor must fund their transport and treatment at the Shelter for Wild Animals at the Palić zoo.

The further procedure includes the identification of these specimens, dissection, and classification, as well as conservation and retention in the sense of evidence, but also for other professional and scientific purposes. To this end, the support and assistance of the Institute for Nature Conservation and the Natural History Museum in Belgrade, which is authorized to perform such tasks in light of its capacities and expertise as well as under the law.

If the monitoring establishes facts about the effect of a structure and its operation on the examined natural values, the persons conducting the monitoring must notify the project initiators and implementers, as well as the competent authorities, of these developments. In so doing, the measures to remove and prevent possible larger-scale consequences and compensation measures can be taken in a timely fashion.

According to the Law on Environmental Protection, the noise levels in the environment are controlled by systematic noise measurements provided by the municipality. Noise is measured by authorized professional organizations in line with the Law on the Protection from Noise in the Environment and the associated bylaws.

5.5. The SEA conclusions

Recognizing the importance of protecting the natural resources and protected volant fauna which can be affected by the wind farm project, the investor of the project, Energohelis Group from Belgrade initially, before the formal procedures marking the beginning of the preparation of the DRP, hired experts to conduct observations of the volant fauna in the area where the Bela Anta wind farm project was to be implemented.

During the observation of the ornithofauna and chiropterofauna, a procedure was initiated for the preparation of the DRP of the RES complex within which the Bela Anta wind farm was to constructed in ZONE 1 and 2. In this context, based on the opinion of the Secretariat for the Environment and the Regional Secretariat for Urban Planning and Environmental Protection, the Secretariat for Urban Planning, Construction, Housing and Utilities of the City of Pančevo adopted the Decision on the Start of Preparations of the SEA for the DRP of the RES complex in the area of Bela Anta in Dolovo (The Official Gazette of the City of Pančevo, No 2/2016). The legal basis for adopting this decision was the Law on Strategic Environmental Assessment (The Official Gazette of the Republic of Serbia No. 135/04 and 88/10).

Based on the decision on preparing the SEA, the existing environmental conditions were analysed in the area included in the DRP, as well as the importance and characteristics of the DRP, the characteristics of the impact on planned structures and activities and other issues and problems in environmental protection, in line with the criteria for determining the potential significant effects of the DRP on the environment and taking into account the planned uses.

The semi-quantitative method of multi-criteria expert evaluation of planning solutions was used against the set SEA objectives and indicators (based on the main set of UN indicators for sustainable development) to assess the impact.

The effects of the Bela Anta wind farm in ZONE 1 and 2 of the DRP were assessed separately against the 12 SEA objectives and 17 associated indicators.

16 different criteria were used in the evaluation of the planning solutions, and they were divided into 4 criteria groups: impact magnitude assessment; the assessment of the spatial extent of potential impact; impact likelihood assessment; and impact duration assessment.

In evaluating the planning solutions, the focus was on the analysis of their effects on the potentially most sensitive environmental factors in a specific space, and especially the ornithofauna and chiropterofauna. To this end, a one-year monitoring of the wider area was conducted, and the synthesis of the results was included in the SEA in the phase of evaluating the variant solutions for the spatial microlocation determination of the wind turbines.

This type of approach resulted in the preventive protection of the ornithofauna and chiropterofauna, and the optimal number and layout of the wind turbines, which can be considered the most important contribution to the SEA.

Summarizing the effects of the DRP on the environment and the sustainable development elements, the section relating to the wind farm project implementation finds that the majority of the effects of the planning solutions are positive for the specific space and its surrounding area. Smaller negative effects, expected to arise in the implementation of the planning solutions, are of limited intensity and spatial extent.

In order for the positive plan effects to remain within the estimated bounds and not overload the spatial capacities, as well as to minimize the possible negative effects of the planning solutions, the environmental protection guidelines (27 in total) were defined and listed. These guidelines need to be carried out in the DRP implementation process through project documentation and the construction of the Bela Anta RES complex.

In addition, the SEA contains the guidelines for the assessment of impact at the hierarchically lower level, i.e. for the preparation of the EIA for individual projects within the Bela Anta RES complex, as well as the measures for monitoring the environmental conditions and sensitive elements (biodiversity – ornithofauna and chiropterofauna, and noise) which need to be taken during the implementation of the DRP.

Summarizing all of the above, the SEA concludes that the DRP of the Bela Anta RES complex in Dolovo and the SEA analyses all possible effects of the planned uses, envisages the appropriate planning activities, and specifies the measures of technical protection and monitoring, in order for the planned activities to be geared towards the implementation of the sustainable development goals in the space in question. In this context, the SEA assesses that the DRP and the wind farm envisaged in this planning document are considered wholly acceptable in terms of possible environmental effects.

A difficulty in preparing the SEA was the lack of a single methodology for preparing this sort of impact assessment. This necessitated special efforts to conduct the analysis, assessment, and evaluation of the planning solutions in the context of environmental protection, and to apply the model suitable in terms of treatment level in the DRP for the Bela Anta RES complex.

Another problem was the assessment of the wind farm impact on the ornithofauna and chiropterofauna, for two reasons:

1. It is impossible to precisely predict the number and the negative impact on the ornithofauna and chiropterofauna before the wind farm is constructed and before the analysis of negative effects includes the temporal aspect of the monitoring of conditions (the post-construction monitoring), and
2. There is no clearly defined general criterion for which negative effect on the ornithofauna and chiropterofauna are acceptable in the quantitative sense.

In this context, an impact assessment was carried out in the SEA based on the following:

- The experiences of the countries with a great track record in empirically analysing these problems,
- The data in the literature,
- The current state of the ornithofauna and chiropterofauna and their movements, analysed in the one-year monitoring and investigation in the plan area.

6. DISCUSSION AND CONCLUSIONS

The trend of increasing the share of renewable energy sources (RES) is the total electricity production at the global level is evident. The wind power sector is becoming one of the fastest-growing sectors of RES utilization, with global exponential growth in the recent years. This fact is important for several reasons:

- RES have an important role in the reduction of greenhouse gases;
- An increase in the share of RES bumps up the energy sustainability of the system and helps reduce the dependence of imports of energy sources and electricity;
- It is expected that RES will become economically competitive against the conventional energy sources in the mid-term.

A large share of RES in electricity production is a result of environmental awareness on the one hand, and of economic benefits on the other.

Although this is a ‘clean technology’ or so-called ‘green energy’, exactly as projects using other forms of RES, wind power projects have twofold effects on the environment: positive and negative.

The most prominent positive effects of wind power use in wind farms must be analysed in a wider context – beyond individual projects, and local and regional levels, because it is globally important. One of them is certainly electricity production without the emission of pollutants into the air, which includes greenhouse gases. This has an indirect beneficial effect on population health, which is yet another positive effect of wind farm projects. Another advantage to wind power compared to fossil fuel use is energy efficiency. The extraction and processing of fossil fuels is expensive. In addition, enormous amounts of energy are used to transport fossil fuels from remote locations to the point of use. On the other hand, the electricity produced in wind farms is efficiently transported by transmission lines to the point of use, without the additional processing, transport, etc. Lastly, wind farm construction does not necessitate a change of use of the land, as it takes up small surface areas for building wind turbine tower foundations.

Negative effects of wind farms on the environment exist as well, but they are negligible compared to the positive ones. However, they cannot and should not be ignored, especially the following: the effects on the ornithofauna and chiropterofauna; effect of increased noise levels; effects of shadow flicker; effects on the landscape; effects of accidents. In addition to these, there are other potential negative effects which depend on the characteristics of the specific location where a wind farm is constructed, e.g. a possible effect on immovable cultural goods.

A great many different instruments for assessing the impact on the environment is in use today, and they can be applied to wind farm projects. Some of these instruments are comprehensive, e.g. project life cycle assessments, environmental impact assessments, and strategic environmental assessments, while others are based on a partial assessment of impact of individual environmental elements.

As regards wind farm projects, this so-called partial impact assessment can be conducted in the form of a separate impact assessment for noise, accident risk, ornithofauna, chiropterofauna, etc. A partial impact assessment for individual environmental elements is justified only if it is an integral part of a unified impact assessment which employs a holistic approach to the assessment of wind farm impact on the environment.

The SEA instrument that applies the holistic approach in analysing the interactions of the existing and planned uses in a specific location. Given that the SEA is used at the strategic planning level, where it is possible to apply the preventive protection principle, one is left with an impression that the SEA is an ideal instrument for an efficient environmental protection in the planning of wind farm projects.

The application of the preventive protection principle is only possible in the phase preceding designing and implementation (construction) of specific investment projects, as well as in the phase when the planned location activities are spatially determined. This is precisely the phase and process of planning the spatial development focusing on the analysis of the spatial aspect of possible effects on the environment.

Impact assessment in wind farm planning has its specificities that affect in turn the specificities in the assessment of their impact on the environment in the planning process. The specificity can be seen in the following facts

- It is customary for the planning document to include only one project (one wind farm);
- Most technical details of the project are known in advance;
- Although only one wind farm is often planned, the space needed to implement the wind farm is considerable, which requires significant spatial analyses.

These facts indicate that in planning wind farms there are elements which may suggest that it is enough to conduct the EIA procedure (one project – one location – technical project details known), but not the SEA. This is a very attractive option for the wind farm investors, who always wish to save time. Going straight to the EIA, without the SEA procedure, may seem like an excellent opportunity for just that.

However, there are two key arguments for conducting a SEA procedure in wind farm planning:

1. The application of the preventive protection concept is only possible if the spatial microlocation determination of the wind farm is shaped at the wind farm planning and SEA preparation level; and
2. Crediting institutions which secure funds for the investor needed to implement wind farm projects pay special attention to precisely the environmental impact aspect (financial risk assessment). This is why it appears that the application of the preventive protection principle as part of the SEA is the only correct way to go. Applying the SEA in wind farm planning may result in making the possible environmental impact of the project acceptable to the investors (the economic argument is often crucial in selecting the appropriate approach to project implementation).

If based on the facts above we accept that the SEA is an essential instrument in wind farm planning, this can be followed by analysing principles in wind farm planning and SEA applications in this process.

Applying the SEA in wind farm planning is based on the guidelines for the selection of optimal options to minimize or prevent potential spatial conflicts, which may arise in the correlation of the wind farm and environmental elements. Optimal options are sought in the analysis of spatial relations holding between the wind farm and the following: ornithofauna and chiropterofauna; structures, towns and villages (the effects of noise, the effects on the landscape with the shadow flicker effect, the effects of accidents); and infrastructure (the effects of accidents). In this context, the SEA appears to be an ideal instrument for assessing the spatial/territorial effects of wind farms on the environment.

SEA is an interdisciplinary and intersectoral area, in which integration and teamwork are emphasized and in which an impact assessment is based on approached stemming from expert qualitative methods. This is perfectly understandable given the scope and detail of the information available at the strategic planning level. As a result, it becomes eminently possible for a methodological approach to impact assessment at SEA level to be adapted to specific circumstances, as well as to apply a combination of different methodological approaches and methods for impact assessment in order to obtain the best results which should be the basis for making appropriate decisions on spatial development in concrete cases.

Methodologically speaking, the application of the SEA in wind farm planning may include different qualitative expert methods in combination with quantitative methods, which are applied for partial impact assessment. In other words, due to the specificity of wind farm project planning, the combination of the technical and planning approach in the SEA is possible and recommended, as is the application of the semi-quantitative method of multi-criteria evaluation of planning conceptions, discussed in the present volume as a very suitable and widely applicable method.

The application of the semi-quantitative method of multi-criteria expert evaluation in wind farm planning is presented in the book on the concrete example of preparing the SEA for a wind farm, i.e. in applying the preventive protection principles in planning the Bela Anta wind farm in Dolovo. The results of the application of this method of impact assessment were geared towards the decision-making process regarding the spatial development of the wind farm in a concrete space. Theoretical knowledge has thus been given a practical application.

Based on the theoretical assumptions and concrete results of the applied method, it can be concluded that the semi-quantitative method of multi-criteria expert evaluation provides useful support in the following: the assessment of the wind farm impact in the SEA; in the preventive environmental protection in the area designated for the construction of the wind farm; and in the process of making decisions on spatial development. The SEA capacities contribute to this in the sense of indicating in multiple ways the many development alternatives based on the assessment of the criteria relating to the environment and the socio-economic aspects of sustainable development.

A fact that can be negatively connoted in the context of SEA application and the use of the semi-quantitative method of multi-criteria evaluation is the possible bias which can take two forms: 1. In the impact assessment based on the subjectiveness of expert opinions; and 2. In making decisions based on the SEA results. In this context, and given that subjectivity is the main characteristic of qualitative expert methods, it is necessary to apply within the SEA the optimal techniques and tools which would ensure the greatest possible degree of objectivity in assessing the impact of wind farms on the environment (simulation models, GIS technologies, etc.). The subjectivity in making decisions based on the SEA results, this is beyond the control of experts in this area and depends on the political, financial, and other aspects, which can certainly jeopardize the implementation of SEA provisions.

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GLOSSARY

Environmental Impact Assessment – A preventive measure of environmental protection based on studies and consultations with the participation of the general public in the analysis of alternative measures, with the aim of collecting the data and predicting the harmful effects of specific projects on the life and health of people, flora, fauna, soil, water, air, climate and landscape, material and cultural goods and the interactions of these factors, as well as determining and proposing measures to prevent, reduce, or remove the harmful effects, in light of the feasibility of these projects.

Strategic Environmental Assessment (SEA) – A control instrument used for directing the planning process towards environmental protection goals. It is part of the planning documentation and includes the report on the condition of the environment, the consultation procedure, acknowledging the report and the consultation results in the process of decision-making or adopting specific plans and programmes, as well as providing information and data on the conducted procedure. The SEA report is part of the documentation which is submitted together with a plan or programme and contains the identification, description, and assessment of possible significant impacts on the environment due to the implementation of the plan and programme, as well as the variants considered and adopted based on the aims and the spatial scope of the plan and programme. The SEA procedure is conducted for plans, programmes, and strategies in the area of spatial and urban planning or land use, agriculture, forestry, fishing, hunting, energy, industry, transport, waste management, water management, telecommunications, tourism, preservation of natural habitats and wild flora and fauna, by which a framework is established for approving future development projects.

Wind turbine (windmill) – A functional unit of a wind farm used for the production of electricity; it consists of the generator, wind rotor/propeller, tower, and foundation.

Wind farm (wind park, wind power station) – A facility for the production of electricity from wind power; it consists of wind turbines, the electricity transmission system, and the transport infrastructure.

Generator – Represents the most complex functional unit of a wind turbine, in which kinetic energy is converted (transformed) into mechanical energy. The generator turns the kinetic energy of air (wind), created by the movement of the wind propellers on wind turbines, the gearbox, and the generator, into electricity.

Wind rotor (propeller, blade) – A functional unit of a wind turbine whose spinning creates kinetic energy from wind power, which is then converted in the generator into mechanical energy.

Environment – A collection of natural and anthropogenic phenomena and processes, whose complex interactions make up the surroundings, i.e. the space and the living conditions.

SUMMARY

At a time of increasing use of renewable energy sources in the production of electricity, including the expansion of wind energy, there is a need to examine the impact that projects in the field of renewable energy resources have on the environment.

Although it is mainly the positive impact of projects in this field that are spoken and written about, and these are certainly indisputable, there are also certain negative implications of renewable energy projects. This is also the case with projects using green energy in wind farms. For this reason, special attention must be paid to the analysis and assessment of such impacts, as well as to responsible planning and optimal solutions for the spatial organization, by means of which effective environmental protection is achieved. This is where we arrive at the significance of applying strategic environmental assessment (SEA) in the planning and spatial organization of wind farms, with the aim of achieving preventive environmental protection.

With regard to the role and significance of SEA as an instrument for steering the planning process towards the objectives of environmental protection, the application of SEA in the planning of wind farms stands as the optimal solution for the prevention of the negative effects of wind farms on environmental elements. Another argument supporting this statement is the fact that SEA is characterized by a holistic approach in which it is possible to see complex interactions and correlations in the space in which a wind farm project is planned, that is, the approach analyzes the spatial aspects of the impact of wind farms on the environment. This is precisely the theme of the book SPATIAL ASPECTS OF THE IMPACT OF WIND FARMS ON THE ENVIRONMENT.

In addition to analyzing the possibilities and significance of applying SEA in preventive environmental protection when planning wind farms, the book pays special attention to a possible methodological approach in the evaluation of planning propositions. In this context, particular significance is given to the application of the semi-quantitative expert qualitative method for the multi-criteria evaluation of planning solutions, which also integrates so-called partial approaches in evaluating the impact of individual environmental elements, and which can in the case of planning wind farms be based on specific simulation software models.

The theoretical knowledge is applied to a specific example in the second half of the book, which contributes to the applicability of the research.

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