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ENVIRONMENTAL IMPACT OF WIND POWER STATIONS IN THE REPORT OF THE POLISH SUPREME AUDIT OFFICE AND IN COMPARISON WITH GERMAN STANDARDS

Summary
This paper elaborates on the problems of operation of wind power stations in Poland, their environmental impact and the evaluation of current wind power stations legal status concerning protection against emissions. In the final section of the paper the author formulates conclusions regarding the need to adjust the existing Polish regulations.

Keywords*: environmental law, protection against emissions, wind power stations, environmental impact, renewable energy sources*.

Introduction

The reason for the considerations presented below was the information published by the Polish Supreme Audit Office[1] on 16th July 2016 entitled: *Location and construction of local wind farms*[2]. The analysis of this report proves beyond reasonable doubts that certain legal changes should be introduced. The changes ought to concern the issue of generating electrical energy by means of wind energy. Due to the fact that the information provided by the Polish Supreme Audit Office does not recommend certain legal solutions, this paper present German standards as a model. The standards relate to: noise emission, infrasound, shadow flicker and so called stroboscopic effect, as phenomena affecting the environment. Citation of the regulation in force in the Federal Republic of Germany is deliberate. The regulations on protection against

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[1]Further referred to as SAO.
[2]Information provided by SAO on 16 July 2014 on the inspection results: *Location and construction of land wind farms*, registration No. 131/2014/P/13/189/LWR.

harmful emissions are extremely precise and have been binding since 1998. Germany benefits from the experiences they have gathered about protection against harmful emissions and is one of the leaders in generating wind power energy. That is the reason why the legal regulations in the Federal Republic of Germany were chosen for contrastive studies.

1. Issues of wind power

Producing energy from renewable sources, including wind power, is a significant element of the implementation of the provisions of Kyoto Protocol decided in 1997 during the United Nations Framework Convention on Climate Change. The necessity to implement the provisions of Directive 2009/28/ EC of 23 April 2009 on the promotion of the use of energy from renewable sources influences the directions of the future consumption of electrical energy from renewable sources.

The commitments which were undertaken by Poland make popular "windmills" a part of local landscape. Landscape interference is not the aspect people generally protest against. The environmental impact of wind farms has been an emotional topic for many years. It is a certain paradox because such installations are supposed to contribute to reducing the emission of harmful gases into atmosphere, they are environmentally beneficial. All the same, human beings also constitute a relevant part of the environment as results from the unwritten law of nature and as stipulated in the Environmental Protection Act[3], however this fact seem to be frequently overlooked what is confirmed by numerous protests and demonstrations of people living in vicinities of wind farms as well as by findings of the Polish Supreme Audit Office's reports.

On one hand the necessity to increase the contribution of the energy from renewable sources in the electricity market justifies the construction of such wind power stations. During 2009-2013 the number of wind power stations in Poland increased by 277%, i.e. from 301 to 835 generating units[4]. The total installed power increased then from 724,657

[3]Act of 27 April 2001 – the Environmental Protection Act (Journal of Laws of 2001 No. 62, item 627).

[4]After the chairman of the Energy Regulatory Authority: by source/installation (WIL) one generating unit (a wind power station) is meant or a set of generating units (a few wind power stations) – information for SAO of 7 April 2014, reference No.: DSW-076-6(2)/2014/MGu.

MW to 3389,541 MW, i.e. almost 5-times[5]. According to the data provided by the Polish Wind Energy Association, approximately 2500 wind turbines of a total power over 3700 MW have been installed in Poland. On the other hand a question of safety of the installations generating energy form wind should be raised. Local communities which function in the neighbourhood of wind farms usually complain about the impact of those installations. The causes of complaints are: generating monotonous noise by the turbines of a low sound power which can have a bad influence on the human psyche, phenomena of light i.e. reflexions of sun light against rotor blades (stroboscopic effect) shadow cast by rotor blades and the bad influence of infrasound. The report of the Polish Supreme Audit Office of July 2014 seems to confirm the legitimacy of the opinion of the population in area affected by the wind power stations.

Not only local people who live near such installations complain about their location and impact. The investors also complain about current legal status. According to the Polish Supreme Audit Office this situation is caused by legislation which is poorly defined for such economic performance and case law and doctrine which are not consistent. It should be emphasized that Polish law does not guarantee the safe location and structure of wind power stations and reduction of the arduousness of farms for local people[6].

2. Characteristics of legal status on wind power station

Wind power stations are located in accordance with Act of 27 March 2003 on Spatial Planning[7]. The Local Spatial Development Plan is the basic document which enables communes to shape a spatial plan. Such plan is approved via the resolution of the municipal council. If such a plan setting forth the manner in which the area may be developed does not exist, the land development conditions are determined via a decision on land development and management conditions. When it comes to an enterprise relating to an implementation of an installation which uses wind power to generate electricity, the assessment of the environmental

[5] On the basis of the information for SAO provided by the chairman of the Energy Regulatory Authority, Warsaw 2014.
[6]Registration No. 131/2014/P/13/189/LWR, p. 8.
[7] Act of 27 March 2003 on Spatial Planning (Journal of Laws 2003 No. 80, item. 717 as amended).

impact should be made[8]. The authority of a commune which issues the decision on the environmental conditions is obliged to assess, on the basis of the documents collected, if the wind power station to be implemented will comply with the standards provided in the decree of the Minister of Environment of 1 October 2012 on permissible levels of noise in the environment. After having received a positive assessment of environmental impact, the competent starost grants a building permission pursuant to Construction Law Act[9]. The supervision over the construction works and putting such buildings into operation was specified in the provision of the Act on Construction Law and entrusted to construction supervision authorities.

3. Conclusions drawn from the assessment by the Polish Supreme Audit Office

In its report the Polish Supreme Audit Office notes that the challenge for the Polish legislator is to create conditions which will allow the harmonious development of this energy sector, on the other hand to introduce the relevant mechanisms of social interest protection and follow the principles of balanced development. The term principles of balanced development implies not only the protection of the environment but also care about the social development and the development of civilization connected with the need to build a suitable infrastructure.

Due to all the above, the Polish Supreme Audit Office applied to the Prime Minister for considering legislative initiative on:

- amendment of art. 55 of the Act of 7 July 1994 Construction Law[10], by implementation of the requirement to obtain a final decision containing a permission to use the wind power station prior to using it;
- complete the Annex No. 1 to the Act of 7 July 1994 Construction Law with classification of wind power stations according to the category of building object, coefficient of the object category (c), coefficient of the object size (s);

[8] § 2 section 1 point 5 and § 3 section 1 point 6 Decree of the Councils of Ministers of 9 November 2010 on the activities of a significant environmental impact (Journal of Laws of 2010 No. 213, item. 1397 as amended).
[9] Act of 7 July 1994 – Construction Law (Journal of Laws 1994 No. 89, item 414).
[10] Act of 7 July 1994 – Construction Law (Journal of Laws 1994 No. 89, item 414 as amended).

- specification of minimum permissible distance between wind farms and human premises.

The Polish Supreme Audit Office applied to the Minister of the Environment for considering a legislative initiative on:

- implementation of the amendment of the Minister of the Environment resolution of 14 June 2007 on permissible noise limits in the environment by specifying the limit of permissible infrasound noise in the environment;
- specification of the methodology of assessment of the noise level emitted by the wind power station during their optimal exploitation.

4. Location of the enterprise as the key issue

In its report the Polish Supreme Audit Office emphasizes the need to clarify certain regulations, especially those which concern minimum permissible distance between wind farms and human premises. This report does not give any recommendation on principles of the location of the wind power stations. The SAO cited the standards of location of such objects applicable in some EU member countries which, however, were not uniform. The SAO provides some examples of minimum permissible distance between wind farms and human premises in the following countries:

- Denmark: minimum four times the total height of turbine;
- Italy (e.g. Kalabria): 20 - times the height of turbine, in practice approximately 2 km from the turbine;
- Sweden: local building councils decide on the location of wind farms on the basis of the principles similar to the current rules in Poland;
- Scotland: the recommended distance is 2 km from towns, cities and villages;
- Wales: 500 m from houses;
- England: the recommended distance is one height of a turbine plus 10% of its height in case it collapses.

The solutions to the problem of the distance between the wind turbines and human premises specified in the unit of length are criticised. The opponents of such solutions claim that fixed limits of minimal distance from buildings do not convey place specificity in a correct way and do not always ensure an optimal location of an investment.

Furthermore, limits which are not flexible, especially depending on the power or height of a turbine, paradoxically, may have a negative impact on the environment, e. g. when it comes to short turbines, low volumes of power and technology which in the age of dynamic development is regarded as obsolete.

Such arguments were the grounds for different, more flexible legal solutions where the distance limits are not imposed, but the distance is determined by the permissible noise standards. The level of noise emission is directly linked to the distance from the source to the receiver of the emission. The representatives of the sector of wind energy in Poland claim that current legal regulations providing the requirement to obtain a positive assessment of the impact of the enterprise on the environment are the most precise method of determining if a given investment in a certain location does not exceed the legally permissible limits of the impact on the environment (including people). The windmills location should be based on the noise propagation analysis. The limits permissible under law is the key expression that represents the attitude of the sector.

The principle of location of wind power stations on the basis of the criterion of permissible noise standards applies, among the others, to the following countries: Germany, Holland, Portugal and theoretically also to Poland. Theoretically, because the regulations of the methodology of the noise emission measurement do not guarantee a reliable assessment of the arduousness of such devices. This was emphasized by SAO report and it will be proved in the further part of this paper as the example of German system. Due to the lack of fixed regulations and the absence of suitable methodology of performing relevant measurements of noise level, in Poland *de facto* there are no clear and reliable principles of location of the enterprises in question. The measurements performed for the need of organizational units of communes to issue an environmental decision on the basis of current standards, contrary to the belief of representatives of wind energy sector, are significantly different from the factual level of noise emission. Due to the lack of appropriate methodology of measurement, lack of suitable apparatus – which is also noted by SAO – the assessment of noise impact may be the subject of manipulation.

5. Issue of methodology of noise level measurement

Location of a wind power station is linked to certain arduousness (mainly noise) for the people who live in the neighbourhood of turbines. The following factors influence directly the minimal distance form wind farms to the neighbouring building:

- enterprise scale (number of turbines– accumulated impact),
- level of acoustic power of turbines (the level of noise),
- the height of tower where the turbine is placed,
- landform.

The main source of the noise emission of wind installations is aerodynamic noise, generated by rotor blades and mechanical noise made by operation of generator and gearboxes. Such noise is characterised by "aligned spectrum characteristics without dominating tonal components[11]". Other elements of turbines also produce noise to a lesser or not perceptible extent.

The Voivideship Environmental Protection Inspectors are institutions entitled to measure the noise level in the environment. The measurement of noise emitted to the environment is performed on the basis of reference methodology of performing periodic measurements of noise generated by installations or devices in the environment, specified in the decree of the Minister of the Environment of 4 November 2008. Auditing the methodology of performing measurements, SAO cited the letter of the Minister of the Environment of 11 April 2013[12] and the letter of the Minister of Economy of 5 June 2013[13] concerning the requirements for performing the measurements of the amount of emission and the amount of water uptake. The methodology noted that such measurements should be performed when certain meteorological conditions are fulfilled i.e. first of all at the average wind speed up to 5 m/s.

According to SAO attention should be paid to the fact that permissible noise levels incorporated in Polish legislation do not include directly the noise generated by wind turbines. The sources of noise for which the legislation determines permissible values are linear facilities

[11]W. Ziółkowski, *Hałas elektrowni wiatrowych*, online, according to the condition of 01.12.2015: http://tempus-halas.pl/2010/11/raporty-oddzialywaniahalas-elektrowni/
[12]Reference No. DOPpek-074-3/14157/13/WM.
[13]Reference No. DEO-I-0702-4/11/13.

such as: roads, railways, electro energetic lines and objects qualified as airports. Wind turbines which, similar to the above mentioned kinds of infrastructures, emit noise to the environment were not included. It should be noted that the majority of the objects mentioned does not cause constant noise. Moreover, when the audit was carried out by SAO and currently in legislation in force there are no regulations concerning wind power stations, which establish permissible infrasound noise level and regulations related to the issue of the flickering effect and stroboscopic effect. As SAO states e.g. in Suwałki Voivodeship Environmental Protection Inspector tested neither the level of infrasound, magnetic field, shadow flickering (stroboscopic effect) nor the impact of wind power stations on the plants and animals habitat due to lack of research methodology and the fact that law does not define permissible standards. Another example of lack of reliable measurements, which results from the absence of suitable regulations is the information given to SAO by the Voivodeship Environmental Protection Inspectors in Łódź, Delegation in Sieradz concerning the motion put forward by the residents of Wróblew commune (Voivodeship of Łódź) to intervene in the issue – checking the level of noise generated by the wind power station in Tworkowizna village. The motion said: measurements of the noise emission should be performed at high electric power generator's capacity, which occurs when the wind's speed is above 5 m/s. Under the reference methodology in force the measurements of noise in the environment should not be performed during such a wind (…) The Voivideship Environmental Protection Inspector is not capable of performing such measurements in accordance with reference methodology and with standard measurement apparatus (…) In a situation when in certain conditions the results cannot be obtained by means of direct measurements, the test is carried out by a calculation method. (…) For the need of issuing a decision on environmental circumstances the assessment of acoustic impact was made by calculation method. It showed that the planned enterprise will not exceed permissible noise level which requires protection against noise[14].

SAO noted that the measurements were carried out in two other communes at a very low speed of wind, in commune Kleczew (Wielkopolskie Voivodship), two wind power stations of a total power of 1,2 MW, during the day at the wind speed 3 m/s, at night – the wind

[14]Registration No. 131/2014/P/13/189/LWR, p. 23.

speed: 2,2 m/s; in commune Babiak (Wielkopolskie Voivodship), wind power stations in Zakrzew of a power 1,6 MW, wind power 2,7-2,8 m/s.

The problem of the methodology of measurement of noise emission in Poland is that it does not apply to the specificity of such objects as wind power stations. The measurements may be performed in compliance with the requirements in force at the speed of wind higher than 5 m/s. However, in Germany the measurement of wind noise have to be performed in possibly reliable conditions, i.e. at 95% of nominal power of the installation, reached at the wind speed of 10 to 12 m/s at the height of a hub**.** Relation of the level of noise to the speed of the wind is not coincidental. This is a critical value. The noise level below this value obviously goes down. However, if the wind speed exceeds 10-12 m/s, the natural wind sound drowns down the sound generated by the rotary movement of blades. In the light of the above it should be acknowledged that the decisions on the impact of wind power stations by noise generation which have been issued so far have been affected by a significant underestimation of the level of emission of noise to the environment.

The SAO drew attention to the necessity to develop a unified methodology of the measurement of the emission of noise generated by the wind power stations[15].

Table No. 1. Measurement of the impact of wind power stations during the period: 2009-2013

Specification		Number of the users of land wind farms checked				
		2009	2010	2011	2012	2013
Measurement of the noise level in the environment	Total	0	3	3	8	10
	Including complaints	0	1	2	8	7
Measurement of noise level of infrasound in environment		0	0	0	0	0
Measurement of electromagnetic fields levels in an environment and areas accessible to people		0	0	0	0	1
Occurrence of stroboscopic effect (shadow flickering), generated by the operation of blades		0	0	0	0	0

Source: Information of the Voivideship Environmental Protection Inspector for SAO, Warsaw 2014, following the information in the findings of inspection of 16 July 2014 *Location and structure of land wind farms* (The reference number 131/2014/P/13/189/LWR).

[15]Ibidem, p. 11, point 2.2. letter b.

6. Noise level

Typical noise levels at source (wind power station) oscillate between 95 dB in the case of smaller installation and 107 dB in the case of huge installations. The noise level of old biplane rotors reaches much higher values[16]. For comparison the noise level of the modern installation measured 500 metres away from the source is 42 dB. This means that location of wind power stations in the distance of 0.5 km from the nearest buildings makes a real protection against noise provided that the installation is technologically advanced. For comparison SAO findings on location of wind power stations in three out of ten communes, which were audited, can be cited. The wind power stations which were the most closely located were as follows: in Kleczew commune (205 metres) and Babiak commune (230 metres). The location of wind power station was established in a distance of only 55 metres away from buildings in Żurawica commune (Podkarpackie Voivodeship).

In Poland, in accordance with the decree of the Minister of the Environment, permissible level of noise is 45 dB. It is doubtful if the wind power stations situated in the communes mentioned above comply with law regulations. Similar situation may take place in a case of wind power stations situated further than 500 metres away from the buildings when the technologies applied do not meet the highest standards of noise emission.

In Germany this level varies depending on the use of neighbouring sites and on time of the day. For residential buildings sites this level is lower than in Poland. However, in the industrial areas and the sites of economic use higher emission standards are permissible. Pursuant to the Act on protection against emission and the implementing provisions in the Federal Republic of Germany the following maximum standards of the noise level outside the buildings apply:

- in the industrial areas 70 dB,
- in the areas used for economic performance during the day: 65 dB, at night 50 dB,
- in rural areas and mixed areas[17] during the day 60 dB, at night 45 dB,

[16] E. Hau, Windkraftanlagen: Grundlagen, Technik, Einsatz, Wirtschaftlichkeit, Berlin/ Heidelberg 2008, p. 609 and next.
[17]Mixed areas e.g.: single agricultural holding in a non-built-up area.

- in the areas of general residential and small housing estate areas during the day 55 dB, at night 40 dB,
- in the areas of residential use exclusively during the day 50 dB, at night 35 dB,
- in resort areas (*Kurgebieten*), for hospital and healthcare centres during the day 45 dB, at night 35 dB.

Moreover, in specific cases noise levels of short duration cannot exceed the noise intensity by 30 dB during the day and by 20 dB at night[18].

Therefore, in line with the regulations quoted, in German law the surroundings of the sites near wind power stations are crucial for the location of such enterprises. The flexibility of implementing regulations show on the one hand care for providing the human environment with suitable conditions for rest (residential zones), on the other hand permits higher standards of the noise emitted by wind power station in the industrial areas. In both cases such legal provisions are rational. The first issue does not require commentary. Higher noise standards near industrial plants result from the simple assumption that they emit the noise themselves (usually oscillating around 70 dB), so the noise from wind power stations is drown out by them.

Moreover, Germany regulated the obligation of the reduction of noise generated by the installations situated near human settlements during the period of higher sensitivity to noise i.e. at night[19]. It seems that such solution favouring the reduction of the noise emission by the installations situated near human settlements should be considered by the Polish legislator during legislative work.

[18] Point 6.1 of the Technical Instruction of 11 August 1998 adopted by means of a regulation by the Federal Council of Ministers (Technische Anleitung zum Schutz gegen Lärm, Sechste Allgemeine Verwaltungsvorschrift zum Bundes-Immisionsschutzgesetz vom Bundeskabinett am 11.08.1998) on the basis of § 48 of the Federal Act on o protection against emissions of 15 March 1974 (Gesetz zum Schutz vor schädlichen Umwelteinwirkungen durch Luftverunreinigungen, Geräusche, Erschütterungen und ähnliche Vorgänge (Bundes-Immissionsschutzgesetz - BImSchG) in der Fassung der Bekanntmachung vom 17. Mai 2013 (BGBl. I S. 1274), das durch Artikel 1 des Gesetzes vom 2. Juli 2013 (BGBl. I S. 1943) geändert worden ist).

[19] From 10 pm to 6 am. See:. E. Hau, Windkraftanlagen: Grundlagen, Technik, Einsatz, Wirtschaftlichkeit, Berlin/ Heidelberg 2008, p. 613.

7. Infrasound

The problem of infrasound seems to be rather of mental nature and do not require the state intervention. However, it requires the attention and control of state institutions. Among scientists there is a strong belief that wind power stations which generate low infrasound are not hazardous for people's health. The paediatrician Nina Pierpont in her (non-scientific paper) published at her own cost, writes about so called "wind power station syndrome", which is noticed in pubic debate[20]. However, in scientific debate the work of Pierpont and its hypothesis is omitted due to methodological errors.

The concern about the invisible impact of new technologies on the environment such as: radiation, radio waves and scents is underpinning the increasing number of reports about poor health condition. For some time there have been suggestions that the wind turbines are the new culprit of non-specific symptoms which are not explained by medicine, so called "wind turbines syndrome"[21]. This syndrome is related to the unreal perception of the noise of the wind turbines and is diagnosed among people who suffer from so called negatively oriented personality[22]. It is characterized by such symptoms as: neuroticism, tendency to negative feelings, frustration and intolerance. The researches carried out in Great Britain revealed unreal perception of noise only by people of a high level of NOP[23].

8. Shadow flickering

The flickering of the rotor blades of wind power stations is perceived as something unpleasant because it does not occur constantly but periodically. This leads to disturbances of sun lighting in the site of location which can be perceived negatively by people. In order to determine the time of flickering the staring point should be the source of emission. This means that how long the effect lasts is not relevant but

[20]N. Pierpont, *Wind Turbine Syndrome*: A Report on a Natural Experiment, 2009.
[21]Ibidem.
[22]NOP – Negatively Oriented Personality.
[23]J. Taylor, C. Eastwick, R. Wilson, C. Lawrence, *The influence of negative oriented personality traits on the effects of wind turbine noise, "Personality and Individual Differences"* 54 (2013), p. 338–343.

how long it affects a given point. Such research is not carried out in Poland due to the absence of legal basis.

In German legislation the standards concerning flickering are in a form of recommendations and result from understanding § 3 section 2 and 3 of the federal Act on protection against emissions[24]. The recommendations in that regard were developed by a specially created institution - Federal/ State Working Group for protection against emission matters[25] in a document "Recommendations on measurement, assessment and light emission mitigation"[26].

Pursuant to recommendations of LAI the shadow cast by rotor blades of wind power stations should not have an influence on a household longer than 30 hours a year or 30 minutes a day. If these standards are exceeded by a given wind power station it should be closed down. In such case the actual and maximum time of emission should be taken into account. Such a differentiation is a result of the assumption that the maximum theoretical duration of emission is only possible under certain conditions i.e., *always* when the sky is clear and during constant sunlight, *always* of the constant movement of a rotor and always perpendicular to sun rays. According to the legal definition such circumstances happen very rarely. The actual impact is in reality lower due to changeability of meteorological conditions. It is assumed that in a case of 30 hours, which are theoretically permissible during the year, the actual impact is approximately 8 hours a year. Single objects should be shut down on area of wind farms in order not to exceed the shadow emission standard. It can mean in practice that a given wind power station can only operate

[24]Federal Act of 17 May 2013 on protection against emissions (BGBl. I S. 1274) – Gesetz zum Schutz vor schädlichen Umwelteinwirkungen durch Luftverunreinigungen, Geräusche, Erschütterungen und ähnliche Vorgänge (Bundes-Immissionsschutzgesetz - BImSchG) in der Fassung der Bekanntmachung vom 17. Mai 2013 (BGBl. I S. 1274), das durch Artikel 1 des Gesetzes vom 2. Juli 2013 (BGBl. I S. 1943) geändert worden ist.

[25]Die Bund/Länder-Arbeitsgemeinschaft für Immissionsschutz (LAI) ist ein Arbeitsgremium der Umweltministerkonferenz (UMK). Aufgaben: Mithilfe und Beratung des Bundes bei der Umsetzung europäischer Richtlinien in praxisgerechte nationale Vorschriften, Erarbeitung von Auslegungshinweisen für Länder, die Erarbeitung von technischen Auslegungen zum Themenfeld Luftreinhaltung, Lärm, Verkehr und elektromagnetische Felder, Vorbereitung und Begleitung europäischer Rechtsetzungsverfahren, Information und Meinungsaustausch über immissionsschutzrechtliche Entwicklungen und deren Bewertung.

[26]Hinweise zur Messung, Beurteilung und Minderung von Lichtimmissionen der Bund/Länder-Arbeitsgemeinschaft für Immissionsschutz (LAI).

before noon, another in the afternoon not to exceed the daily emission standard which is 30 minutes. However, as it can be seen from Table 1, as far as shadow flickering phenomena is concerned, for ten cases checked no measurement of shadow flickering was performed.

9. Stroboscopic effect

The SAO report draws attention to the fact that, law regulations did not define permissible standards concerning potential hazards such as: infrasound or the stroboscopic effect. Therefore competent state authorities did not carry out an audit of the impact of wind farms on the environment as it was indicated[27].

Shadow flickering caused by casting shadows by rotor blades at a given point is often wrongly identified with so called stroboscopic effect. The stroboscopic effect is, however, a different phenomenon that results from operation of wind power stations. It appears as a result of rotor blades movement and their rake angle relative to sunlight rays, they are reflected by the surface of the blade of the rotating rotor and light reflexes are shed on a given point. This phenomenon is of short duration but it may cause discomfort and, in extreme cases, be hazardous to people's health. As research has shown in the Federal Republic of Germany, such glints of light are usually the effect of lacquering of the surface of blades rotors. For this reason in new wind power stations in Germany the rotor blades are not covered with lacquer, so the problem is eliminated along with replacing old installations with the modern devices. Unfortunately in Poland due to the absence of suitable regulations protecting against the stroboscopic effect and the absence of relevant limits in import of old installations, a large proportion of wind power stations are technologically obsolete and for that reason they had been withdrawn from use in western countries. As Table 1 shows, in Poland for 24 wind farms which have been audited since 2010 no research concerning stroboscopic effect was carried out.

10. The risk of impact on microclimate

The operation of wide areas of wind farms can also influence local microclimate in the location of wind power stations. Research carried out in the USA shows that a large concentration of wind turbines can cause

[27]Reference No. 131/2014/P/13/189/LWR, p. 21-23.

thermic anomaly characterised by the increase of air temperature at night by approximately 2˚C, and even contribute to the increase of the average wind speed to 2 m/s[28].

11. De lege ferenda

Currently in Poland there is an ongoing discussion on location of wind power stations. This is an especially important issue from economic, social or even international point of view. This issue has not been regulated in a consistent way in Poland yet. There were various reasons for this – mainly political. The leading party advocates introduction of legal provisions on the location of wind power stations. The most important subject of regulation is the issue of distance of such objects from human settlements which has been specified in a draft legislation of the Law and Justice Political Party as ten times the height of the planned installation (measuring to the place where the rotor is situated). By adopting such a solution the legislator is *de facto* opting for a fixed distance. Another amendment draft of a fixed distance 3 km was put forward in 2014 by the Law and Justice Political Party *PiS*. However, two years ago it turned out that such a radical restriction will not get enough support, therefore the draft fell through. Having analysed the current draft, it can be emphasized that it is less radical than the previous draft, however, not well thought out. If an example of modern efficient and relatively less emissive wind power station 150 metres high and of the power of over 500 kW is taken, it can turn out that the obligatory distance for their location will be 1500 metres from the buildings. As it appears in thorough research studies carried out all over the world, the protective distance of 500 metres is enough. Paradoxically, if the draft amendment comes into force in its proposed form, it will support the investments in low old type installations of a very high level of emission of noise and infrasound, withdrawn form the market in more developed countries. Low, less technologically advanced installations will be situated within 500-700 metres within human settlements. Non-flexible regulation in the age of dynamic development of wind turbines technology is pointless. As studies and guidelines in the Federal Republic of Germany have shown, the application of the newest technology allows location of the wind power stations closer to human settlements, at the

[28]T. Boczar, *Energetyka wiatrowa – aktualne możliwości wykorzystania*, Wydawnictwo Pomiary Automatyka Kontrola, Warsaw 2008, p. 253.

same time limiting to the minimum their negative impact on human environment and animal habitat. In the light of the above, the restriction of import of old wind turbines whose impact level is excessively high but efficiency disproportionately low seems to be a more justified solution.

Fixed, unjustified distance of wind power station from human settlements may be a deterrent for potential investors. It is generally known that the Polish economy based on coal-powered energy requires investments in development of renewable sources of energy. Every misguided restriction could contribute to a smaller attractiveness of the investment and as a consequence slow down the development of such an important alternative among renewable sources. It should be remembered that Poland accepted certain liabilities on the share of energy from renewable sources in the energy market. To 2020 the share will amount to 15% (initially 20%). Currently this share is about 12%. The commitments have almost been implemented but Energy Market Agency estimates that the production of energy from renewable sources fell by 8% during one year[29]. This market, therefore, requires stimulation instead of restrictions.

On the other hand, it is important not to bow to a pressure of wind-energy investors lobby, who usually ring alarm bells in such cases. As it is clear form statistical data covering the period to the end of 2013, in Italy where there are strict regulations on wind power stations sites, production of energy generated from the wind reaches the level of 8,5 GW, whereas in Great Britain, very liberal in terms of wind farms location, 10,5 GW of energy is produced. Middle-liberal Denmark comes last at the ranking list with the result of 4.7 GW of the energy produced [30]. This data shows that the problem of wind energy development lies in the "good will" of the politicians towards the renewable energy sources rather than in regulations on the location of installations that produce energy.

[29] After Internet portal wysokienapięcie.pl – http://wysokienapiecie.pl/oze/1356-produkcja-energii-z-oze-spadla-o-jedna-czwarta, according to the condition of 16 August 2015 .

[30] Compare Charter 4 concerning restrictions. The data set cited comes from the European Wind Energy Association – EWEA) available online at the address: http://www.ewea.org/fileadmin/ files/library/publications/reports/EWEA_Annual_Report_2013.pdf, according to the condition of 16 August 2015.

Conclusions

The analysis of the legal position in the Federal Republic of Germany concerning the impact of wind power stations and the juxtaposition of German solutions with the data gathered by SAO, allows to draw a conclusion that regulations governing the issue of study on noise nuisance connected with the site of wind power station in regard to buildings do not guarantee a safe and socially acceptable location around human settlements.

According to investors and according to some experts, the introduction of fixed distances is not a good solution. In their opinion a reliable study of the nuisance of wind power stations should be carried out first and on the basis of its findings the standards of noise or infrasound ought to be established. Such standard would allow determining the safe location of such investments. It is also indicated that apart form standards established by the state such measurements should be carried out for each investment separately because there are various technologies in a market, including the old installations from secondary market. Thus, one investment can be more onerous and another less. Therefore, it is so important to focus on the question of reliability and honesty of research and creation of more opportunities for relevant institutions to perform measurements of infrasound emission and a level of electromagnetic fields instead of implementation of misguided standards which in the age of rapid technological development of wind power stations will make investment in the energy production sector more difficult.

In the light of the above, taking a look at other countries' legal regulations on location and operation of wind farms is justified because such legal solutions in well developed countries are a result of multiannual experience and social, economical and environmental analysis which - as the report confirms – do not exist in Poland. Such a need has been noticed by M. Banak, who claims that *learning from the experience of countries of more developed sector of wind energy seems beneficiary, where its needs were noticed, also in the area of spatial planning, and methods of combining them with the needs of other sectors, economy, society and environment have been worked out*[31].

[31]M. Banak, *Lokalizacja elektrowni wiatrowych – uwarunkowania środowiskowe i prawne*, Człowiek i Środowisko 34 (3-4) 2010, p. 126.

From the above considerations a few aspects, which should be taken into account while legislative work on function of wind power plants is carried out, could be singled out:

- authorizing location of wind power stations on the basis of the noise measurement and other nuisance emissions,
- creating a consistent methodology of research on noise generated by wind power stations following the example of Germany,
- ensuring a suitable inspection of noise emission by equipping the relevant institutions, responsible for the noise level measurement, with adequate apparatus,
- restriction on import of the elements of wind turbines based on old technologies (of a weak capacity and of a stronger impact on the environment),
- introduction of permissible standards of noise depending on the use of neighbouring areas on the basis of local spatial development plan,
- taking into account night time while establishing the permissible noise levels,
- limitation of the noise level at night time,
- implementation of maximum permissible standards of shadow flickering,
- creation of financial conditions for investors which will enhance the development of wind power stations based on the newest technologies which will guarantee the highest efficiency and the smallest impact on the environment.

Legal acts

[1]. Federal Act on protection against emissions (BGBl. I S. 1274) – Gesetz zum Schutz vor schädlichen Umwelteinwirkungen durch Luftverunreinigungen, Geräusche, Erschütterungen und ähnliche Vorgänge (Bundes-Immissionsschutzgesetz - BImSchG) in der Fassung der Bekanntmachung vom 17. Mai 2013, das durch Artikel 1 des Gesetzes vom 2. Juli 2013 (BGBl. I S. 1943) geändert worden ist.

[2]. Decree of the Council of Ministers on the activities of a significant environmental impact (Journal of Laws of 2010 No. 213, item 1397 as amended).

[3]. Spatial Planning and Land Use Management Act, (Journal of Laws 2003 No. 80, item 717 as amended).

[4]. Act on access to information concerning the environment and its protection, the contribution of society to the protection of environment and assessment of environmental impact (Journal of Laws of 2008 No. 199, item 1227 as amended).

[5]. Construction Law Act (Journal of Laws 1994 No. 89, item. 414 as amended).

Literature

[1]. Banak M., *Lokalizacja elektrowni wiatrowych – uwarunkowania środowiskowe i prawne,* Człowiek i Środowisko 34 (3-4) 2010, p. 117-128.

[2]. Boczar T., *Energetyka wiatrowa – aktualne możliwości wykorzystania*, Wydawnictwo Pomiary Automatyka Kontrola, Warsaw 2008.

[3]. Hau E., *Windkraftanlagen: Grundlagen, Technik, Einsatz, Wirtschaftlichkeit*, Berlin/ Heidelberg 2008.

[4]. Pierpont, N., *Wind Turbine Syndrome: A Report on a Natural Experiment 2009.*

[5]. Stryjecki M., Mielniczuk K., *Wytyczne w zakresie prognozowania oddziaływań na środowisko farm wiatrowych*, Generalna Dyrekcja Ochrony Środowiska, Warsaw 2011.

[6]. Taylor J., Eastwick C., Wilson R., Lawrence C., *The influence of negative oriented personality traits on the effects of wind turbine noise*, Personality and Individual Differences 54 (2013).

[7]. Ziółkowski W., *Hałas elektrowni wiatrowych* (online, according to the conditions as of 30 October 2014).