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RESEARCH OF EQUIVALENT AND MAXIMUM VALUE OF NOISE GENERATED BY WIND POWER PLANTS

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Abstract. According to the Directive 2009/28EC of European Parliament and Council, dated April 23, 2009, Lithuania should strive for the part of renewable energy sources in the balance of electric energy to reach no less than 23% in the year 2020. The most favorable condition for development of wind energy in Lithuania is on a 50 km width zone by the seaside. Parks of wind power plants are expanding fast, but there is a lack of data about noise generated by wind turbines. The noise generated by the wind power plants is known to fluctuate and may spread up to 2 km beyond the wind power park.
Research of noise generated by wind power plants was performed in the western part of Lithuania, near Rudaiciai village (Kretinga district) at the park of four wind power plants. Measurements were performed in cold and warm seasons when different wind speed, environment humidity and air temperatures dominated. The sound pressure levels of noise generated by wind power plants were established. The noise spread in the wind parks and beyond was evaluated according to hygiene norm HN 33:2007 "Acoustic noise. Noise value limits in the residential and public buildings and their surroundings".

Keywords: noise, wind turbine, wind power plant.

1. Introduction

The growing demand for energy increases environmental pollution, therefore more attention is being paid to renewable energy sources. Wind power plants are not only of great economic and environmental benefit but can also bring damage to landscape, with the turning blades casting shadows and spreading noise. Wind energy and wind power plant construction leads to increasing public protests because of lack of data and information about wind power plants' impact on the surrounding environment (Jaskelevičius, Užpelkienė 2008).

In Lithuania, as in other countries, efforts have been made to reduce the surrounding noise and avoid its adverse impact on human health and environment (Baltrėnas *et al.* 2010), but many discussions concerning the noise of surrounding plants still arise. The noise generated by wind power plants is of mechanical and aerodynamic nature (Dumitrescu *et al.* 2010; Vargas 2008; Vargas *et al.* 2009). Aerodynamic noise is raised by turbulent air flow moving around the wind power plant's blades (Kamperman, Dearborn 2008; Rogers *et al*. 2006). Depending on the type of turbine, the maximum speed of rotating is regulated by angling plants' blade angle towards the wind (Muljadi, Butterfield 2001). When the wind is strong the turbines are stopped automatically to prevent construction damage (Pao, Johnson 2009).

Until now, according to the hygiene standards sounds have been distinguished as having low, middle and high frequencies (Baltrėnas *et al.* 2009). Literature sources (Pereira, Branco 2007; Van den Berg 2006; Jakobsen 2005) indicate that wind power plants generate infrasound and low frequency sounds, but the level of the noise generated and the way it spreads have not been completely investigated

Considering the meteorological conditions Lithuanian seaside is the most favorable place for construction of wind power plants (Jaskelevičius, Užpelkienė 2008). The dominating average annual wind speed in this region is 6.4 m/s at the height of 50 m over the ground surface. (Birgiolas, Katinas 2006). Before starting the construction of wind power plants their impact on the environment should be evaluated and the limits of sanitary protection zone should be calculated. At the moment the size of wind power plants' sanitary protection zone (SPZ) has not been established. SPZ is determined by calculations according to hygiene norm HN 33:2007 *"Acoustic noise: Noise value limits in the residential and public buildings and their surroundings"* and the data presented by manufacturers of wind power plants concerning the sound pressure level generated by the wind turbines. In this hygiene norm limitary values are indicated just for equivalent and maximum sound levels, and frequentative characteristics of noise are currently not evaluated.

One of the biggest European manufacturers of wind power plants "Enercon" indicates that the level of sound pressure generated by wind power plants with different rotor diameters is 96–104 dBA (Enercon WindBlatt... 2007).

The purpose of the research was to determine equivalent and maximum values of the noise generated by wind power plants' park inside and outside Rudaiciai village in Western Lithuania during the cold and warm seasons.

2. Object and method of research

The object of the research was four wind power plants in the agricultural territory of Rudaiciai village in western Lithuania (Fig. 1). The four Enercon E70 wind plants of 250 kW nominal power each had been constructed in the park. The northern part of Rudaiciai village borders with Joskaudai forest, with arable lands in the east and west and regional road Kretinga – Rudaiciai – Zibininkai in the southern part. In the east, beyond the arable land, the buildings of agricultural industry of Rudaiciai village are situated. In the north, at a distance of 400 m from the wind park, there is a farm. The relief of the territory is relatively flat with small mounds. When measurements were performed in the warm season, tall grass dominated, rustle of trees could be heard at places of measurement, whereas in winter the ground was covered with a thick layer of snow up to 50 cm, and trees were leafless.

The noise research in the wind park was performed in the warm season on 22–24 July, 2009, and cold season on January 28, 2010.

The places of measurement were chosen depending on dominating wind direction and with the consideration of rotor positions of power plants. On July 22, 2009 and January 28, 2010 they were situated in one straight line forming a perpendicular angle with the rotor planes. On July 22, 2009 during the noise spread measurements, the west-north wind was prevailing, and on July 24 the direction changed to the southwest. On January 28, 2010 the east-southwest wind dominated. The framework of the situation of measurement places of the noise generated by wind power plants, according to wind directions which dominated during measurements, is presented in Fig. 2.

As seen in Fig. 2, the power plants are located in one line. The wind direction on July 22, 2009 and January 28, 2010 was in parallel with this line.

In performing the research on July 22, 2009, the places of measurement were situated at a distance of 20 m, 40 m, and 100 m from the wind power plants and between the wind power plants (V3 – V30). On July 24, 2009 when the wind direction changed, the points of measurement were situated in one line, which extended from wind power plant VJ13 in the north-east direction, with the sound level being measured every 50 m in 14 places (V31 – V44). Performing research during the cold season, the points of measurement were chosen in the middle between wind power plants and at a distance of 150 m, 300 m and 450 m, downwind, beyond the park. (V1, V2, V3, V10, V17, V24). Measurements of every point lasted 10 minutes. Sound level measurements were repeated 3 times.

Equipment

The procedure was created following normative documents LST ISO 1996-1:2005 "Acoustics. Description, measurement and assessment of environmental noise. Part 1. Basic quantities and assessment procedure" and LST ISO 1996-2:2008 "Acoustics. Description, measurement and assessment of environmental noise. Part 2: Determination of environmental noise levels".

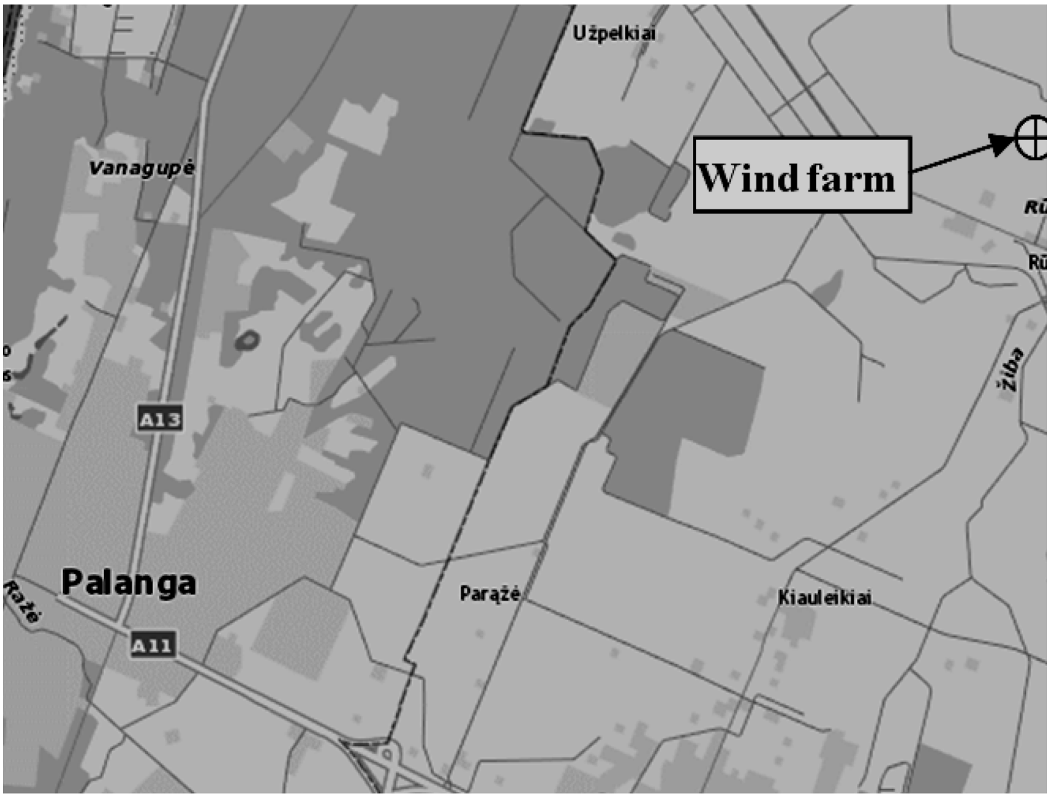

Fig. 1. Geographical situation of Rudaiciai wind power plants' park (UAB HNIT – BALTIC 2011)

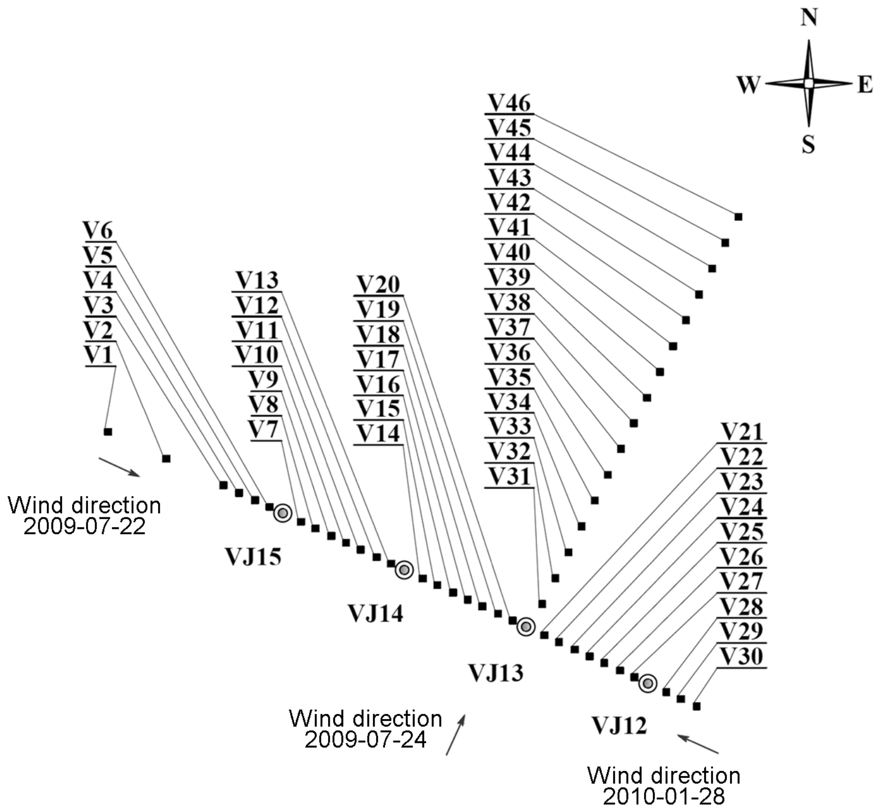

Fig. 2. Framework of situation of measurement places of spreading noise by wind power plants.
▪ V1-V44 – measurement places; ◎ VJ12-VJ15 – numbers of wind power plants

In order to establish the equivalent and maximum sound levels, a measuring device of the Danish company Bruel & Kjaer was used (Fig. 3).

Fig. 3. Precise sound analyzer and vibration gauge Bruel & Kjaer mediator 2260

When the sound level is measured with Bruel & Kjaer mediator 2260, comparative measurement error is equal to ± 1.5%. It is one of the most modern devices manufactured by this company. The device is used to measure parameters of equivalent and broadband sound; additional external supplement for vibration measurement may also be used. Two microphones can be applied to measure noise parameters. This device may register noise in the range of frequency from 6.3 Hz till 20 kHz. Bruel & Kjaer mediator 2260 noise analyzer may be used to measure effective noise level, described by A, B or C characteristics or in separate octaves, which are distinguished by standardized filters. A frequentative characteristic filter was used in this work.

During noise level measurement, meteorological indeces of environment were registered with the device Testo 400 at the height of 1.5 m from the ground surface: air temperature (°C), relative humidity (%), and wind speed (m/s).

Measurements are impossible when it is raining snowing or in thick fog. The microphone of the measurement device should be placed at 1.2–1.5 m height from the ground surface and directed to the noise source, the wind power plant. During measurements the microphone was covered with a special protective screen.

In measuring the noise generated by wind power plants, the most important directions are those oriented towards rotor planes (Fig. 4). Therefore, the directions such as "windward", "downwind", "in one plane with the rotor", etc. are taken into consideration. The reason for this is the fact that the noise level depends on observer's position with regard to the rotor, and the latter is always turned to the wind.

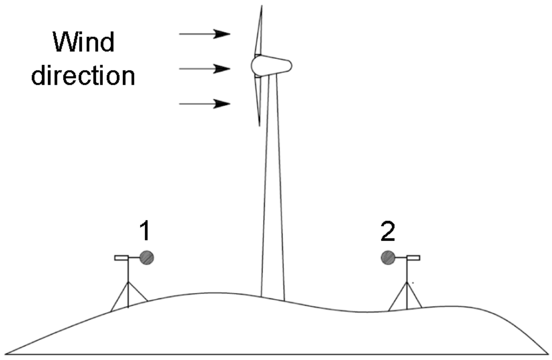

Fig. 4. Measurement description of noise generated by wind power plants: 1 – microphone turned downwind; 2 – microphone turned windward

3. Results

When performing research of noise level in the park of wind power plants, meteorological data were established.

On July 22, 2009 the air humidity changed from 52 to almost 60%. During measurement the temperature of atmosphere was 21 °C, the wind speed was 3–3.8 m/s with gusts of 8 m/s. West and north-west winds dominated.

On July 24, 2009 air humidity changed from 95.5 to 99.9%. During measurement the temperature of atmosphere was 20 °C, the wind speed was 3.8–8.4 m/s with 14 m/s in gusts. The south-west wind dominated.

On January 28, 2010 the air humidity was 35.0%. During measurement the temperature of atmosphere was 15 °C, the wind speed was 9–10 m/s with the gusts of 12 m/s. East-south winds dominated. The results of measurement are given in Table 1.

Table 1. Indexes of atmosphere conditions

Time	Relative humidity, %	Temperature, °C	Wind speed, m/s	Wind direction
22/07/2009				
12:15	60,7	21.0	3.8	W-NW
14:30	59.1	21.1	3.0	
18:40	52.7	21.5	3.3	
24/07/2009				
10.00	99.9	18.9	8.4	SW
12.00	99.7	18.8	6.4	
12.40	95.5	19.1	3.8	
28/01/2010				
11:00	35.5	–15.0	9.5	E-SE
13:00	35.0	–15.0	10.0	
16:00	35.1	–14.0	9.0	

Results of measurement of equivalent and maximum noise generated by wind power plants

The results of measurement have shown the dependence of noise level generated by wind power plant on the distance from the noise source. It is also necessary to mention that near the wind power plant, i.e. at a distance of 50 m, the noise of generator and other mechanical equipment of the plant is well heard. With the distance from the power plant increasing, "wind roaring" can be well heard. The maximum noise level was registered at the shortest distance between the place of measurement and the wind power plants.

During the research performed on July 22, 2009 the maximum noise levels were established in V7, V13 and V20 places of measurement, which are nearest to the wind power plants.

The maximum equivalent noise levels measured reached 41–42 dBA, with the maximum noise levels ranging from 50 dBA to 57 dBA. The maximum equivalent noise levels measured reached only 33–35 dBA in measurement places V3, V23 and V25. The results of measurement are given in Fig. 5.

As can be seen in Fig. 5, at the point of measurement V6 the equivalent noise level is 40 dBA, and at measurement point V7 it is 42 dBA. This difference of 2 dBA may be explained by the fact that at measurement point V6 the noise was measured downwind, and at measurement point V7 windward. However, analyzing the measured equivalent noise levels at points V13, V14, V20, V21, V27 and V28, which are closest to wind power plants, it can be seen that noise level opposite wind power plants, when the microphone of the noise analyzer was turned downwind, was bigger than the noise level measured behind wind power plants when the noise analyzer was turned windward. Respectively, next to the wind power plant VJ14 it was 41 dBA and 38 dBA, at VJ13 it was 42 dBA and 39 dBA, and at VJ12 it was 39 dBA and 37 dBA. Evaluating the data it is possible to make a conclusion that the position of noise analyzer with respect to wind direction affects the results of measurement. The equivalent sound level when measured downwind varies consistently: opposite VJ15 wind power plant at a distance of 100 m it is 38 dBA, at a distance of 40 m it is 38 dBA, at a distance of 20 m it is established to be 40 dBA; opposite 14VJ wind power plant at a distance of 100 m it is 38 dBA, at a distance of 40 m it is 36 dBA, at a distance of 20 m it is 41 dBA; opposite VJ13 wind power plant at a distance 100 m it is 36 dBA, at a distance 40 m it is 39 dBA, at a distance 20 m it is 42 dBA; opposite VJ12 at a distance of 100 m it is 35 dBA, at a distance of 40 m it is 38 dBA, at a distance of 20 m it is 39 dBA. The equivalent sound level when measured downward behind VJ15 wind power station at a distance of 20 m is 42 dBA, at a distance of 40 m it is 36 dBA, and at a distance of 100 m it is 38 dBA; behind VJ14 wind power stations at a distance of 20 m it is 38 dBA, at a distance of 40 m it is 34 dBA, and at a distance of 100 m it is 40 dBA; behind VJ13 wind power station at a distance of 20 m it is 39 dBA, at a distance of 40 m it is 41 dBA, and at a distance of 100 m it is 35 dBA; behind VJ12 wind power station at a distance of 20 m it is 37 dBA, at a distance of 40 m it is 37 dBA, and at a distance of 100 m it is 38 dBA.

Such uneven distribution of data may have been caused by the lee of the tower of the wind power stations, therefore behind the wind power stations at VJ14, VJ13 and VJ12, in measurement points at a distance of 20 m from the wind power station, the reduction of noise level was observed when the analyzer was turned windward at.

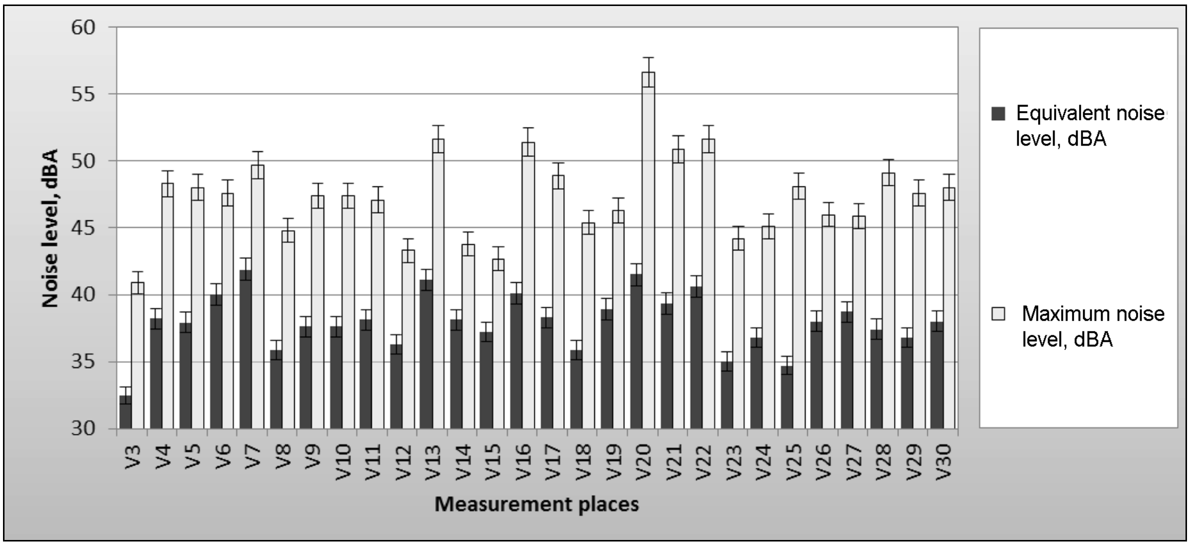

Fig. 5. Levels of equivalent and maximum noise generated by wind power plants in measurement places V3-V30, on July 22, 2009

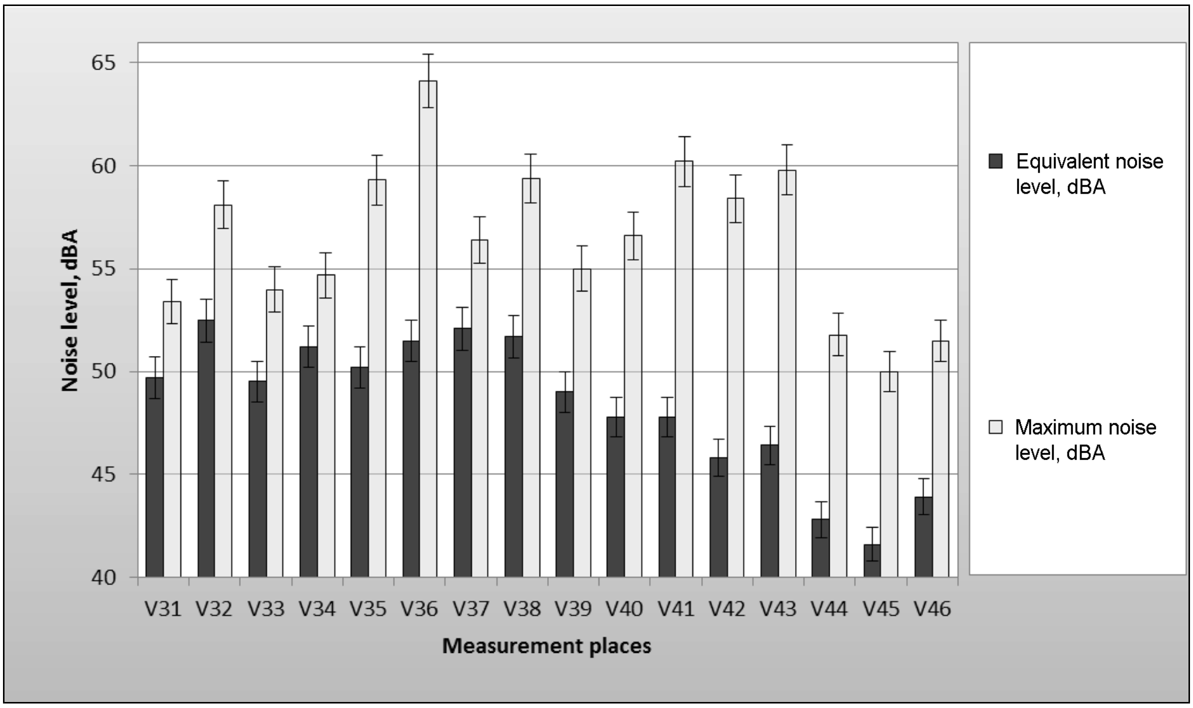

Fig. 6. Levels of equivalent and maximum noise generated by wind power plants in measurement places V31–V46 on July 24, 2009

the moment of measurement. Since sound waves traveling windward bend upwards, consequently "silence" zones occur to which direct sound does not pass, so noise can decrease up to 20 dBA

On July 24, 2009 when the direction and the speed of wind had changed, the equivalent sound level in measurement places changed from 42 dBA to 53 dBA. Maximum sound levels in measurement places changed from 50 to 64 dBA. The smallest measured levels of equivalent noise reached 42–44 dBA, in measurement places V44 – V46. The results of measurement are given in Fig. 6.

Maximum noise levels were determined in measurement place V32, which was at a distance of 50 m from the wind power plants; here the fixed equivalent noise level was 53 dBA and in measurement place V37, which was farther away from the wind power plants at a distance of 300 m, the fixed equivalent noise level was 52 dBA. As can be seen in Fig. 6, the noise level changes inconsistently at a distance of 50–150 m from the wind power plant. In the measurement place V31 the equivalent noise level was 50 dBA, in measurement place V32 it was 53 dBA, and in measurement place V33 diminished again up to 49 dBA. As in previous measurements, this change could be determined by the lee of the towers. At further measurement points V32 – V37 the equivalent sound level changed in the range of 50 dBA to 53 dBA. At measurement points V38 – V45 the equivalent noise level diminished coherently from 52 to 42 dBA. At measurement point V46, 44 dBA equivalent noise level was registered. This change could have been caused by

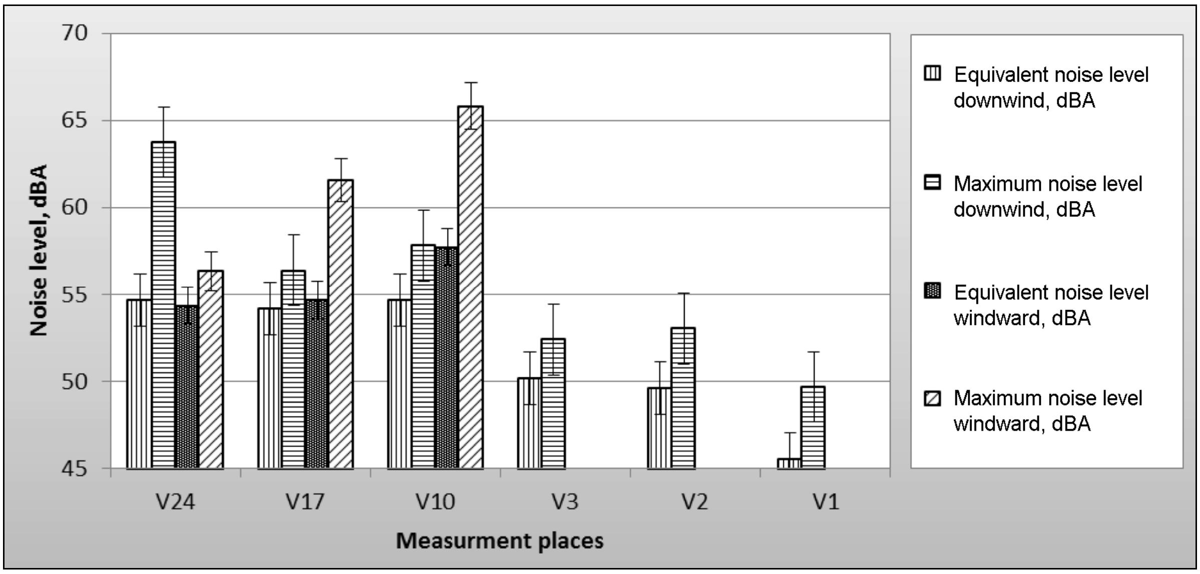

Fig. 7. Levels of equivalent and maximum noise generated by wind power plants in measurement places V1, V2, V3, V10, V17, V24 on January 28, 2010

tree rustle. Considering that measurements were performed moving from VJ13 wind power plant, in measurement places V31, V32, V33 the fixed levels of equivalent sound pressure corresponded to the noise level of this wind power plant. In measurement place V31 the distance to wind power plant VJ13 was 50 m, and to VJ12 or VJ14 it was 300 m, respectively this distance was 6 times larger. In measurement place V46 the distance to the wind power plant VJ13 was 750 m, and to VJ12 or VJ14 it was 800 m, these distances were relatively equal, so the data received from the more distant measurement places may be interpreted as the noise generated by the park of wind power plants.

On January 28, 2010 the equivalent noise level in measurement places varied from 45 dBA to 58 dBA. The results of measurement are presented in Fig. 7.

Maximum noise levels in all measurement places varied from 50 to 66 dBA. Maximum noise levels were established between wind power plants, while moving from the park of wind power plants the noise level decreased gradually, and in measurement place at a distance of 450 m from VJ15 the smallest equivalent noise level was 45 dBA.

The equivalent noise levels established when measuring windward and downwind between wind power plants VJ12 and VJ13, and VJ13 and VJ14 varied marginally, the difference being less than 1 dBA. In measurement place V10, the equivalent noise level measured downwind was 55 dBA, and measured windward it was 58 dBA. The difference between maximum momentary noise levels was 8 dB.

It had been supposed that wind power plants affect each other and the noise level on July 22, 2009 would be bigger at VJ12 wind power plant, and on February 28, 2010 it would be the greatest at VJ15. With the wind speed 9–10 m/s, measured on February 28, 2010, our presumption was confirmed since next to VJ15 at measurement point V5, both equivalent and maximum noise levels were registered as the largest and reached 47 dB. However, on July 22, 2009 the equivalent noise levels at wind power plants VJ15, VJ14, VJ13 were on average 2–3 dBA higher than at VJ12 wind power plant. It is likely that wind speed of 3 to 4 m/s is too weak for air whirlwind, formed behind wind power plant, to affect another wind power plant located downwind.

On July 24, 2009 measurement places V33, V36 and V39 were located at a distance of 150m, 300 m and 450 m from VJ13 wind power plant; here equivalent noise levels were determined respectively as 49 dBA, 51 dBA and 49 dBA. On January 28, 2010 measurement places V3, V2 and V1 were also located at a distance of 150 m, 300 m and 450m from VJ15 wind power plant; here the established equivalent noise levels were respectively 50 dBA, 49 dBA and 45 dBA. On January 28, 2010 when measuring was being performed, the wind was 3 m/s stronger than that during measurements on July 24, 2009, and air humidity was three times lower. As is known from literature, the noise spread can be reduced by humid air. But on July 24, 2009 the equivalent noise level was bigger by 2 to 6 dBA than that on January 28, 2010. The greater formation of noise could have been caused by the environment: rustle of deciduous forest and the rye field nearby around the wind power plants. Though, when the ground surface is flat, sound waves travel farther, and the background noise also makes strong impact.

The equivalent sound level beyond sanitary protection zone did not exceed 65 dBA, therefore in the environment of residential houses and public buildings the noise level met the requirements set by hygiene standard HN 33-2007. The research in the park of wind power plants has shown that the noise generated by wind power plants is varied both in winter and in summer. The difference between equivalent and maximum sound levels in places reach 15 dB, this inconsistency could have been caused by varied noise generated by the blades of the wind power plants. This noise could be defined as impulsive or fluctuating. Analyzing data about the noise generated by the wind power plants, collected during research, it is difficult to establish the nature of variable noise. The noise generated by wind power plants is not limited to the sounds of average and high frequencies. In the noise generated by wind power plants sounds of low frequency dominate, therefore, evaluation of the sound generated by wind power plants requires an extensive investigation into evaluation of the validity of sanitary protection zones.

4. Conclusion

1. During the research performed in warm season, equivalent noise level in measurement places varied from 42 dBA to 53 dBA. Maximum momentary noise level was determined in measurement place V36, at a distance of 300 m from the wind power plant VJ13 and it was 64 dB.
2. During the research performed in cold season, equivalent noise level in measurement places varied from 45 dBA to 58 dBA. The maximum momentary noise level was established in measurement place V10 at a distance of 150 m from wind power plant VJ13 and was 66 dB.
3. When wind speed was 6–8 m/s, noise level generated by wind power plants did not exceed marginal values indicated by hygiene norm HN 33-2007 and varied in the range of 5 dB.
4. The lee of the tower of the wind power plant may have influenced the noise spread at a distance of 100 m beyond the wind power plant.
5. When the wind speed was low (3 to 4 m/s), the turbulent flow that formed behind wind power plants did not influence another wind power plant.
6. Results of measurement are strongly affected by wind direction, so at the chosen measurement points the level of noise should be measured in several directions.

References

Baltrėnas, P.; Petraitis, E.; Januševičius, T. 2010. Noise level study and assessment in the southern part of Panevėžys, *Journal of Environmental Engineering and Landscape Management* 18(4): 271–280. http://dx.doi.org/10.3846/jeelm.2010.31

Baltrėnas, P.; Puzinas, D. 2009. Jūrų uosto teritorijos ir gyvenamosios zonos triukšmo sklaidos modeliavimas taikant programą CadnaA, *Journal of Environmental Engineering and Landscape Management* 17(3): 148–153. http://dx.doi.org/10.3846/1648-6897.2009.17.148-153

Birgiolas, E.; Katinas, V. 2006. Vėjo srauto parametrų kitimo dėsningumų tyrimas Lietuvos pajūryje, *Energetika* 2: 29–33.

Directive 2009/28/EC of the European parliament and of the council of 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] [online]. 2009 [cited 17 March 2011]. Available from Internet: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:01:LT:HTML

Dumitrescu, H.; Cardos, V.; Dumitrache, A.; Frunzulica, F. 2010. Low-frequency noise prediction of vertical axis wind turbines, *Proceedings of the Romanian Academy* 11(1): 47–54.

Enercon WindBlatt Magazine [online]. June 2007 [cited 17 March 2011]. Available from Internet: http://www.enercon. de/ p/downloads/WB-0207-en.pdf

Jakobsen, J. 2005. Infrasound emission from wind turbines, *Journal of Low Frequency Noise, Vibration and Active Control* 24(3): 145–155. http://dx.doi.org/10.1260/026309205775374451

Jaskelevičius, B., Užpelkienė, N. 2008. Research and Assessment of Wind Turbine‘s Noise in Vydmantai, *Journal of Environmental Engineering and Landscape Management* 16(2): 76–82. http://dx.doi.org/10.3846/1648-6897.2008.16.76-82

Kamperman, G.; Dearborn, R. 2008. Simple guidelines for siting wind turbines to prevent health risks, *Noisecon*, 28–31.

Muljadi, E.; Butterfield, C. 2001. Pitch-controlled variable-speed wind turbine generation, *Transactions on Industry Applications* 37(1): 240–246.

Pao, L. Y.; Johnson, K. E. 2009. Tutorial on the Dynamics and Control of Wind Turbines and Wind Farms, in *2009 American Control Conference Hyatt Regency Riverfront, St. Louis, MO, USA June 10-12*, 2076–2089.

Pereira, A. M.; Branco, C. N. A. A. 2007. Public Health and Noise Exposure: The Importance of Low Frequency Noise, in *Proceedings of the Inter-Noise 2007 Conference. Istanbul: Sponsored by the International Institute of Noise Control Engineering (I-INCE) and Organized by the Turkish Acoustical Society. August 28-31.*

Rogers, A. L.; Manwell, J. F.; Wright, S. 2006. *Wind Turbine Acoustic Noise*. Amherst. 215 p.

Van den Berg, G. P. 2006. *The sounds of high winds: the effect of atmospheric stability on wind turbine sound and microphone noise*. Dissertation, University of Groningen, Groningen. 210 p.

Vargas, L. 2008. *Wind Turbine Noise Prediction*. Instituto superior tecnico. Universidade tecnica de Lisboa. Dissertação para obtenção do Grau de Mestre em. Engenharia Aeroespacial. 85 p.

Vargas, L. F. C.; Oliveira, J. M. G. S.; Lau, F. J. 2009. Development of a wind turbine noise prediction model, in *7th EUROMECH Solid Mechanics Conference. Lisbon, Portugal, 7–11 September*. 1–10.

VĖJO JĖGAINIŲ SKLEIDŽIAMO TRIUKŠMO EKVIVALENTINIŲ IR DIDŽIAUSIŲ VERČIŲ TYRIMAI

D. Butkus, R. Grubliauskas, J. Mažuolis

S a n t r a u k a

Remiantis Europos Sąjungos Parlamento ir Tarybos 2009 m. balandžio 23 d. direktyva 2009/28/EB Lietuva turi siekti, kad 2020 m. atsinaujinančiųjų energijos išteklių dalis šalies elektros energijos balanse sudarytų ne mažiau kaip 23 %. Lietuvoje vėjo energetikai plėtoti palankiausios sąlygos yra maždaug 50 km pločio juosta prie jūros pakrantės. Sparčiai plečiantis vėjo jėgainių parkams trūksta duomenų apie vėjo jėgainių skleidžiamą triukšmą. Žinoma, kad triukšmas nuo vėjo jėgainių yra fliuktuojantis bei gali sklisti iki 2 km už vėjo jėgainių parko ribų.
Vėjo jėgainių skleidžiamo triukšmo tyrimai buvo atliekami vakarų Lietuvoje, Rūdaičių k. (Kretingos r.) prieigose esančiame keturių vėjo jėgainių parke. Atlikti žiemos ir vasaros matavimai, vyraujant skirtingiems vėjo greičiams, aplinkos oro drėgniui, oro temperatūrai. Nustatyti vėjo jėgainių parko skleidžiamo triukšmo, garso slėgio lygiai. Pagal higienos normą HN 33:2007 „Akustinis triukšmas. Triukšmo ribiniai dydžiai gyvenamuosiuose ir visuomeninės paskirties pastatuose bei jų aplinkoje“ įvertinta triukšmo sklaida vėjo jėgainių pake ir už jo ribų.

Reikšminiai žodžiai: triukšmas, vėjo jėgainė, vėjo jėgainių parkas.

ИССЛЕДОВАНИЕ ЭКВИВАЛЕНТНЫХ И МАКСИМАЛЬНЫХ ЗНАЧЕНИЙ ШУМА, РАСПРОСТРАНЯЕМОГО ВЕТРЯНЫМИ УСТАНОВКАМИ

Д. Буткус, Р. Грубляускас, Ю. Мажуолис

Р е з ю м е

На основании Директивы 2009/28/УС, принятой 23 апреля 2009 г. Парламентом и Советом Евросоюза, Литва должна стремиться к тому, чтобы к 2020 г. часть возобновляемых источников энергии в электроэнергетическом балансе страны составляла по крайней мере 23%. В Литве наиболее благоприятные условия для получения ветряной энергии могут быть созданы на полосе шириной примерно в 50 км вдоль зоны морского побережъя. В связи с интенсивным развитием парков ветряных установок данных о создаваемом ими шуме не достаточно. Известно, что шум от ветряных турбин флуктирует и может распространяться до 2 км за пределы парков ветряных установок.
Исследования четырех ветряных турбин и создаваемого ими шума проводились в парке ветряных установок на Западе Литвы, в Рудайчяй (Кретингский район). Измерения проводились зимой и летом при разной скорости ветра, влажности и температуре воздуха. Установлены уровни распространяемого ветряными установками шума и звукового давления. На основании гигиенической нормы HN 33:2007 «Акустический шум. Предельные величины шума для жилых зданий, зданий общественного назначения и их среды» установлено распространение шума в парке ветряных установок и за его пределами.

Ключевые слова: шум, ветряная турбина, парк ветряных установок.

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