Wind energy in nowadays is a necessity that helps to transform the energy economy towards the sustainable energy developments. Some difficulties that wind power plant expansion faces is related to community acceptance. It is now clear that annoyance from wind turbine noise occurs to a higher degree at low noise levels than noise annoyance from other sources of community. Therefore, it should be analyzed in more details the cases when wind plant impact is related to other impacts of human activities. The aim of the study is to analyze noise impact of road traffic flow to the noise levels in the vicinity of wind plant. For the study was chosen wind plant near Vydmantai and the road A11 Šiauliai- Palanga. Noise levels were measured downwind from the wind plant and upright to the road. Then traffic noise was modeled using GIS-based traffic noise prediction software MapNoise and Computer Aided Noise Assessment software CadnaA. It is shown that the wind plant noise at the distance around 200 m decreases to the background level whereas the road traffic noise is the main factor of noise at the selected area. Modeling was applied for the traffic noise calculation for different traffic flow. It is shown that the area in the very vicinage around the Vydmantai plant tower is masked by traffic noise when traffic flow exceeds 5000 vehicles per day. Also it is shown that because of nature of wind turbine noise, it is difficult to adjust measured sound pressure values to community annoyance.

**Key words:** wind plant noise, road traffic noise, noise level forecast

**Introduction**

Wind turbine noise is the one of important factors on which community concerns are related. Wind farm impact assessment and monitoring of noise levels show that noise does not exceed specified exposure criterion levels but this little influence to public opinion. Some studies indicate that annoyance from wind turbine noise occurs to a higher degree at low noise levels than noise annoyance from other sources of community. Annoyance also is affected by the turbines visual impact on the landscape. Due to wind turbine characteristics it is not easily masked by background noise.

Contrary to wind turbine noise the impact of traffic noise is studied well and regulations are able to manage various scenarios important to human health and safety. Road traffic noise is one of the major environmental concerns of densely populated areas all over the world. Road vehicles are by virtue of their number, their travelling speeds and their power output a potent sound source. Transport noise is an increasingly prominent feature of the urban environment, making the noise pollution an important environmental public health issue. In order do not everestimate the noise impact of farm noise in the cases when windfarm is located near a road it is required to investigate the impact of both noise sources in more details.

Therefore, in presented work it is analyzed the noise impact of road traffic flow to the noise levels in the vicinity of wind plant. For the study wind plant near Vydmantai was chosen which is located near the road A11 Šiauliai- Palanga. Noise levels were measured downwind from the wind plant and upright to the road. Then the traffic noise was modeled. The obtained results show the wind plant noise at the distance around 200 m decreases to the background level whereas the road traffic noise is the main factor of noise. Modeling was applied for the traffic noise calculation for different traffic flow, day and night time, different wind farm noise power.

**Research object:** the impact of noise from various sources near wind warm

**Research goal:** to analyze the noise impact of road traffic flow to the noise levels in the vicinity of wind plant

**The noise of wind turbine and vehicle flow**

Wind turbines generate two types of noise: aerodynamic and mechanical. A turbine’s sound power is the combined power of both. Aerodynamic noise is generated by the blades passing through the air. The power of aerodynamic noise is related to the ratio of the blade tip speed to wind speed. Manufacturer specs for today’s 100 m, 1.5-2 megawatt wind turbines indicate that the “source level” of their noise emissions is generally 98-104dB, roughly the same loudness as a chain saw. However, this noise source is not at ground

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level, it emanates from high above the ground, therefore, it dissipates quickly with a direct, unobstructed path to a very large surrounding area. Therefore, at ground level noise levels exceeding 60 dBA possible only in the very proximity of wind plant in the direction opposite to the wind.

Although vehicle noise and vibration have been reduced over the years, traffic noise remains a problem because of the continuing increase in the numbers of vehicles. In addition, most evidence suggests that the exterior noise of most new cars, except in first gear, is dominated in normal operation by rolling noise (defined here as tire/road interaction noise together with aerodynamic noise), which becomes increasingly important at high speed and exceeds power train noise (usually defined as engine, air inlet, exhaust, cooling system, and transmission). Rolling noise has a negligible effect on the noise produced by heavy vehicles at low speed, but at speeds above 20 km/h for cars and 80 km/h for heavy vehicles, rolling noise contributes significantly to the overall noise level. At speeds above 60 km/h for cars, rolling noise becomes the dominant noise source.

Research methods

Research consists of two parts: noise measurements in the vicinity of wind plant and modeling of noise propagation. For noise measurements analyzer BruelKjaer-2250 was used. Modeling was carried out using GIS based software application MapNoise and Computer Aided Noise Assessment software CadnaA. After several testing trials the results of CadnaA were chosen to present in this work since this software package allows to model the noise from several sound sources in the simpler way.

Results

For the comparison of the impact of various noise sources in the vicinity of wind plant “Vydmantai” wind plant was chosen. Geographical location of this wind plant is indicated (black point) in Fig. 1. This wind plant is located near the road Šiauliai – Palanga, therefore, it suits best for the analysis of noise impact. At this location is installed Enercon E-70 wind power plant. The power of this plant is 630 kW.

Fig. 1. Geographical location of wind plant (black point) used for the present research.

Noise measurements in the vicinity of “Vydmantai” wind plant were carried out in 2007. The investigation started at about 11 AM, it was sunny day; wind speed at 1.5 m height was 2 m/s. At 10 m height wind speed was about 2.5 - 3 m/s, at the height of the wind turbine’s shaft (78 m) the wind speed was 3.5 – 4 m/s. According to noise assessment of Enercon E70 the noise at described conditions is equal to 85 dB.

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dB. This value was used for wind plant noise modeling. Measured sound pressure levels (A weighted) in dB for two directions from wind plant are presented in Fig. 2. The wind was blowing to the east south direction; the direction towards the road makes some angle pointing to the northeast. Each measurement took 5 minutes.

![Graph](image)

**Fig. 2.** Sound pressure level in the vicinity of wind plant “Vydmantai” for two directions: towards the road and downwind. Positions of wind plant and the road are shown in graph by arrows.

The background noise measured at a distance of over 1.5 km from the road was 38 dB. This means that all features seen in Fig. 2 are determined by the propagation over the area of traffic induced noise. The increase of SPL in the downwind direction can be explained by the surface relief – at the distance 200 m downwind there is a slight valley, and then the surface goes slightly up.

It is clearly evident that traffic noise determines noise conditions in the vicinity of wind power plant. In order to get more clear view of traffic noise importance the experimental situation was modeled using software application CadnaA (Computer Aided Noise Assessment). During the modeling the sets of noise distribution maps were obtained for different sets of conditions. The conditions used as a parameters were: 1) the noise pressure level of wind plant; 2) the period of day and night; 3) the traffic flow. In present work only selected set of noise distributions is chosen to illustrate the noisiness of the environment in the area under the investigation.

Results of modeling of noise distribution over the area are presented in Fig. 3. Each picture represents noise distribution for different traffic flow, vehicles per day: a) 500, b) 1000, c) 5000, d) 9000. As it was mentioned above, at the meteorological conditions during the measurements sound pressure level generated by wind plant is 85 dB.

![Map](image)

a) b)
Fig. 3. Modeled sound pressure level in the vicinity of wind power plant “Vydmantai” for different traffic flow, vehicles per day: a) 500, b) 1000, c) 5000, d) 9000. The noise pressure level generated by wind plant is 85 dBA at the wind conditions during the measurements.

According to the color scale guide of SPL one can see, that wind plant noise can be assumed as a main noise source in environment only in the case when traffic flow is less than 1000 vehicles per day. It can be concluded that, first of all, the area affected by wind turbine noise is limited around to 200 m distance from wind plant tower. Second, it follows from the results of modeling, that even this area is masked by traffic noise, when the traffic flow is larger than 5000 vehicle per day at analyzed conditions.

More clear evidence of traffic noise impact presents the cases shown in Fig 3 c) and d). The average traffic flow at the location under research is 6596 vehicles per day. At the investigation time the traffic flow was measured just for reference and obtained value was 412 vehicles per hour.

In order to compare measurement and modeling results sound pressure level dependences on distance towards the road and downwind were drawn. The results are presented in Fig. 4. It is seen, that measurements corresponds the results of simulations for the case, when traffic flow is equal to 3000 vehicles per day. For more exact adequacy the measurements should be carried out in more details, particularly, the traffic flow during the measurement should be determined.

Fig. 4. Sound pressure level dependence on distance from wind plant towards the road (a) and downwind (b) at different traffic flow. The noise pressure level generated by wind plant is 85 dBA.

The obtained results show clearly that in the case when in the vicinage of operating wind farm there are additional noise sources, particularly, sources of high noise intensity like a road with significant traffic, the impact of wind turbine generated impact may sometimes be misinterpreted. The sound pressure level

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generated by wind plant usually is smaller than the level of other noise sources. However, it should be noted, the nature of the sounds made by wind turbines make it especially difficult to rely on reassuring “noise limits”. Noise propagation varies greatly with changing wind and atmospheric conditions; there are many different ways to average noise recordings. The pulsing nature of turbine noise is inherently more attention-grabbing and more easily disruptive than road or industrial noises. Therefore, the investigation should be carried out considering variations of wind plant power, meteorological conditions and the attitudes of community that is living near the wind power plant.

Conclusions

In present work the noise impact of road traffic flow to the noise levels in the vicinity of wind plant near Vydmantai is analyzed. It is shown that the area affected by wind turbine noise is limited around to 200 m distance from wind plant tower. At larger distances sound pressure levels approach background noise levels. It follows from the results of modeling that the area in the very vicinage around the Vydmantai plant tower is masked by traffic noise when traffic flow exceeds 5000 vehicles per day. Since the nature of turbine noise depends on atmospheric conditions, wind speed, power of wind plant, more investigation should be done to account these factors.

References