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Visual Impact to Landscape of Wind Turbine

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Determining the Nature, Significance and Contrast of the Visual Impact to Landscape of Wind Turbines in Šilutė District

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Visual impact of wind farms located in the region of Šilutė is analyzed in the paper. In seeking to assess the impact of wind turbines based in Šilutė region on the landscape, the analysis of cartography material was carried out and the inventory of all wind turbines was made (GIS data base). Two wind farms (of six and seventeen wind turbines) are built in the territory under analysis. During the research in situ, photofixation was carried out, and the nature, significance and degree of contrast of the impact on the landscape have been determined from the selected ten observation decks (table 2).

The major factors of visual impact of wind farms are atmospheric conditions, vertical natural and anthropogenic objects (forests, buildings, etc.). There are proposed such intervals of zones of visual influence: 0-1 km; 1-3 km; 3-5 km; 5-7 km; 7-10 km; 10-13 km; 13-16 km; 16-20 km; >20 km. At a distance of 0-3 km wind turbines usually dominate in landscape, at a distance of 4-7 km – they become accents, at a distance of 8-10 km – subdominants and at a distance of >10 km – background elements.

KEYWORDS: wind farm, the influence of wind farms on environment, zones of visual impact.

Introduction

The world is experiencing rapid development of wind turbine construction. Up until 2008, the European continent was in the lead according to the installed capacity of wind power. At a later period (and now), new wind power has been mostly installed in Asia. At the end of 2013, the total capacity of wind turbines installed worldwide reached 318,105 MW. Although the total amount of wind energy installed in Lithuania is not relatively high (amounted to 279 MW at the beginning of 2014), and amounts to only about 4% of the total electricity consumption, the big wind turbines and their farms are concentrated in the western Lithuania (LITGRID 2014; Wind in power 2013). The majority of wind turbines were built in Kretinga (69 pcs.), Šilutė (33 pcs.), and Tauragė (24 pcs.) district areas. Although this region has important protected areas, resorts (Palanga, Neringa), intensive tourist routes, as many as six wind farms operate in Kretinga district alone (which borders the municipality of Palanga).

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Due to their visual - spatial parameters, these sites are becoming dominant verticals thus changing the local landscape and its visual quality, which in turn determines the quality of the living environment. In order to preserve the identity and sustainable of the regional landscape, it is important to estimate the potential impact of both existing and planned wind turbines on the landscape.

Visual impact of wind turbines depends on a number of features: the size, colour and shape of the turbine, observation distance, landscape diversity, time of day, and many other factors (University of Newcastle 2002).

Two wind farms, built in Šilutė district, between Klaipėda – Šilutė Road (no. 141) and the Curonian lagoon, are visible from the adjacent major recreational areas and tourist roads. The wind turbines influence and change the local landscape due to their visual-spatial parameters (blade-tip height 150 m) and their number (23 pcs.).

THE AIM OF THE RESEARCH is to determine the nature, significance and degree of contrast of the visual impact of wind turbines, located in Šilutė district, on the landscape.

THE OBJECT OF THE RESEARCH: two wind farms near Klaipėda – Šilutė Road (no. 141), located in Šilutė district. **(Fig. 1).**

The third wind farm (of ten wind turbines) was built in the district. The wind turbines are set out along Didšiliai, Gnybalai and Rudynai rural areas; the distance to the town of Šilutė is about 6-8 km. The wind turbines were built away from major roads; in the level of highlights – subdominants,

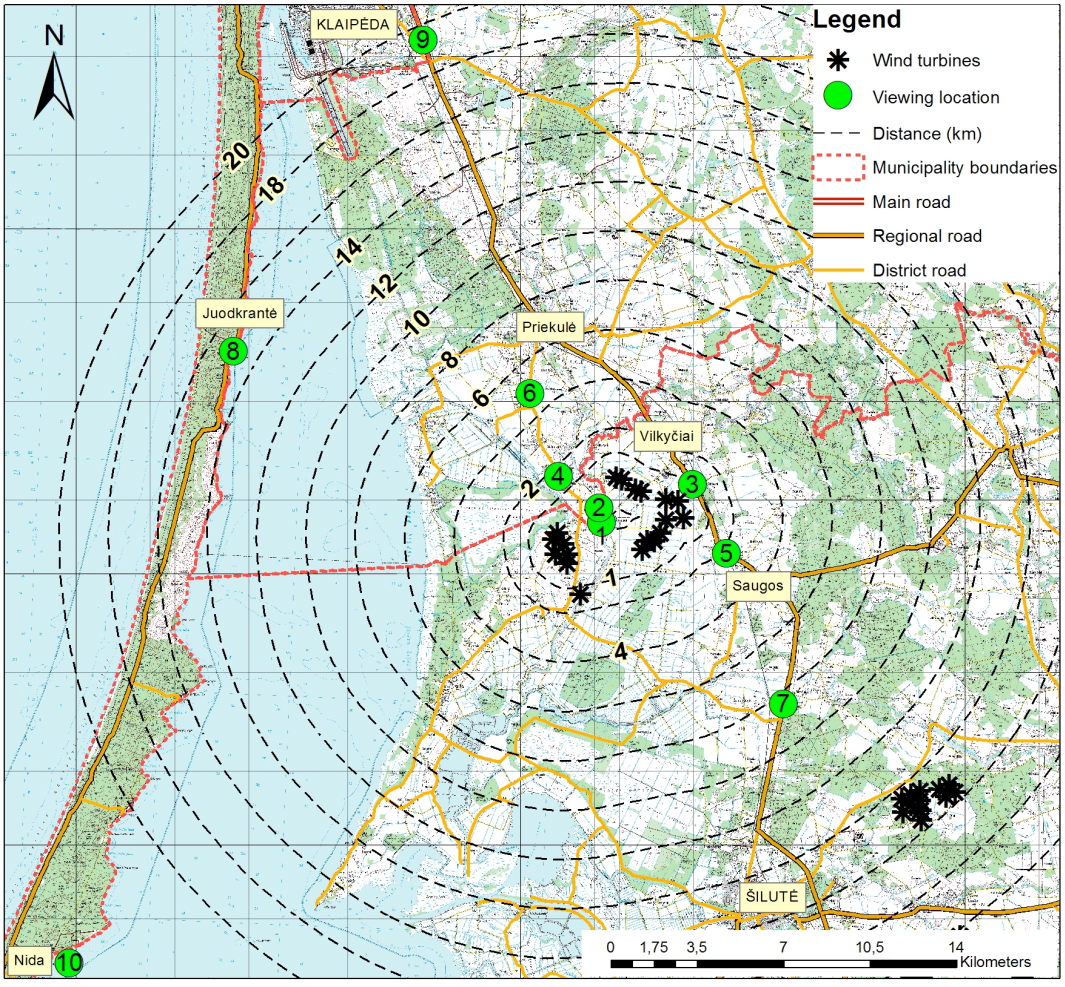

Fig. 1

Locations of wind turbines and viewing points (cartographic base LTDBK50LT Nacionalinė žemės tarnyba)

they are visible while driving the country road Saugos – Šilutė (no. 141) and Šilutė – Žemaičių Naumiestis (no. 165). The impact on the landscape is insignificant, and thus withdrawn from any further examination due to forest arrays around the wind turbine area, sufficient distances to larger villages, and the above-mentioned roads.

Methods

The nature, significance and degree of contrast of the impact have been evaluated during the assessment of the impact of wind turbines in Šilutė district. Visual influence of the wind farms were evaluated from ten the selected observation points. The visual influence of the wind farms was evaluated on 27 June 2013, at 10 am – 6 pm. The day was sunny, and the visibility of wind turbines was very good.

The two analyzed wind farms are situated near the villages of Vilkyčiai, Lankupiai, Čiuteliai and Mockiai in Šilutė region. The first wind farm consisting of 6 wind turbines was constructed in 2010. The second wind farm consisting of 17 wind turbines was constructed in 2012. The turbines of the both wind farms are of the same type Enercon E-82 (2 MW capacity each). The height of their towers is 85 m, the length of their blades is 34 m, and the total diameter of the set of blades is 82 m; the total height of wind turbine with one of the blades at the top position is 150 m.

After the wind turbine visual impact zones in different countries have been analysed and the situation in Lithuania taken in, the table of wind turbine visual impact hypothetical degrees has been made up. To determine visual impact degrees' precision, the prospecting in situ has been done, with results then having been compared with theoretical-hypothetical visual impact degrees (a comparative analysis has been done).

On the territory of the wind farms landscape of littoral plains with slight vertical dispersion exists. Entirely open agricultural visual spaces prevail. There are several small areas of forest (Kavaliauskas 2006). The distance between the wind turbines and Curonian Lagoon is 7 km. The wind turbines are visible from Curonian Spit and therefore the observation points are selected in Juodkrantė and Nida.

Results

Visual impact zones.

When analyzing the wind turbine's visual impact zones, its observation point (and the number of them) is used as the base and benchmark for visual evaluation. Degree of visual impact is determined considering the distance and visibility of a wind turbine. It is necessary to mention that adjacent zones (further from the wind turbine) differ from each other by visual impact degree only slightly. At a distance of 0–3 km wind turbines usually dominate in landscape, at a distance of 4–7 km – they become accents, at a distance of 7–10 km – subdominants and at a distance of >10 km – background elements **(table 3)**. (Möller 2006; Homewood 2011; Kamičaitytė, Abromas 2012).

The wind turbines have a visual effect on the landscape at a distance of up to 15-20 km (background elements of the landscape). However, when observing the turbines from the roads (in this case from a dynamic position), the turbines situated nearer the road produce a significantly bigger effect. The turbines situated farther from the observer (10-20 km), make an impact on the landscape only when they are visible on the axis of the road perspective. Apart from the roads, where the turbines are clearly visible, not only intensive traffic roads, but also auto tourism roads are important (Jallouli, Moreau 2000; Tsoutsos et al. 2009; Dominigo-Santos et al. 2011).

After discussing the assessment methodologies of different countries, and their relevance to Lithuania, **principles for determining the contrast of the surrounding area (low, medium, high)** have been distinguished. Significance of the principles lies in their determination based on the **factors relevant to the assessment:**

- DISTANCE: the bigger the distance, the weaker is the perceived contrast. For a smaller distance, the wind turbines look dominating in the landscape. For a bigger distance, the impact becomes less significant.
- OBSERVATION TIME: the longer the turbines are observed, the stronger is the visual impact.
- Relative size or scale: visual impact is directly dependent on the size and scale of the object. The relative size of wind turbines in the landscape is described by three main parameters: hub height, blade-tip height and rotor diameter.
- OBSERVATION SEASON: in determining the contrast, physical conditions of the period of the most intensive visual usage must be evaluated. The visibility of wind turbines is differently affected by winter season. Since the tower and the rotor of almost all the turbines are of a white or grey color, they merge with the color of the environment.
- ILLUMINATION CONDITIONS: while visibility in the daylight is the best, it is worsened when getting dark. At night time only the signal lights of the turbines are visible.
- SPATIAL RELATIONS: since wind turbines are dominating in the landscape due to their big height, they simultaneously become a vertical landmark. The cumulative impact (of several turbines or farms) is also possible.
- ATMOSPHERIC CONDITIONS: at differing weather conditions, different contrast between the turbine and the sky background is formed. For cloudy conditions, wind turbines are less visible. In some cases, the turbine blades can be absolutely invisible against a cloudy background.
- MOVEMENT: the movement in the landscape attracts attention and increases contrast. It is important when observing the wind turbines, since the rotor is a dynamic element. The rotor in movement attracts attention, especially when the turbine is visible on the perspective axis of the road (Bureau of Land Management 2012; Arakawa et al. 2002; Environmental Resource Management 2009).

Determination of the visual significance of the impact of wind turbines on the landscape is based on the following criteria: visual insignificance, slightly significant impact (slight impact), the average impact, and substantial impact (The Landscape Institute 2005) (table 1).

Table 1

Visual significance of the impact of wind turbines on the landscape

Landscape Visual Sensitivity	Magnitude of Landscape Visual Change				
		Negligible	Low	Medium	High
	High	Visual insignificance	The average impact/ Slight impact	Substantial impact/ The average impact	Substantial impact
	Medium	Visual insignificance	Slight impact	The average impact	Substantial impact/ The average impact
	Low	Visual insignificance	Slight impact	Slight impact	The average impact/ Slight impact

The nature of the visual impact has been identified as a description of the change of landscape in terms of quality by levels of visual impact zone.

Table 2

Assessment of the significance of visual impact of wind turbines and the degree of contrast as well as the nature of the impact from the observation places

No. and observation place	Visually influenced villages	Distance to the wind turbines (km)	Nature of visual impact	Visual significance (VS) and contrast degree (CD)
1 Village Lankupiai	Lankupiai	1	Wind farm consisting of 6 wind turbines is located in the western part of Lankupiai village, and in the eastern part there is wind park consisting of 17 wind turbines. The distance between the wind turbines and the village is 1 – 3 km. Observing from the selected viewing point six wind turbines **dominate** visually in the visual space. Due to the vegetation situated in front of the wind turbines the lower part of their towers cannot be seen.	Substantial/ the average impact (VS). Strong (due to observation distance and relative size) (CD)
2 Village Lankupiai	Lankupiai	1	Four wind turbines are seen looking to the east. Though the observing distance is 1 km the wind turbines **lose their dominance** in the landscape. This is determined by mature trees existing between the wind turbines and observer which screen the turbines and pylons of air electric line (Fig. 2).	The average impact (due to the magnitude of the impact on the landscape) (VS). Medium (due to spatial relations) (CD)
3 Village Čiūteliai	Čiūteliai, Vilkyčiai	2	A 17-wind-turbine farm dominates in the foreground. Further away, the second six-wind-turbine farm can be seen. All parts of wind turbines, located closer, can be clearly visible, while the blades of the rest of wind turbines (6 km distant) partially "disappear" in the background of darker clouds.	The average impact (VS). Strong/medium (due to observation distance ir weather conditions) (CD)
4 Road Priekulė-Kintai (No. 2201)	Lankupiai	2	The observation point is specific because both wind farms can be seen from it in the context of agrarian landscape. The nearby wood situated in front of the turbines partially screens their towers. Wind turbines **dominate** in the landscape.	The average impact (VS). Medium (due to spatial relations) (CD)
5 Road Klaipėda-Šilutė (No. 141)	Saugos	2,5	Though a lot of elements of anthropogenic activity can be seen in visual space (rail roadbed, electric pylons and lines, road, single structures) the wind turbines obviously **dominate** in the contextual environment	Substantial/ the average impact (VS). Strong (due to observation distance and relative size) (CD)
6 Road Priekulė-Kintai (No. 2201)	Venskai	5	Agrarian landscape dominates in the viewing field. The wind turbines are seen clearly. The movement of blades is also seen but partially disappears in the background of clouds. The wind turbines become landscape **accents.**	The average/ slight impact (VS). Medium (due to observation distance) (CD)
7 Road Klaipėda-Šilutė (No. 141)	Saugos	8,5	Due to the nearby wood, half/ two thirds of the lower part of turbines towers cannot be seen. Due to the air electric lines which are near the observer the wind turbines become **subdominants.**	Slight impact (VS). Medium/weak (due to observation distance and spatial relations) (CD)

8 Village Juodkrantė	Juodkarantė	15	Due to the favorable observing conditions (Curonian Lagoon in front of the observer) the closer wind farm consisting of 6 wind turbines becomes a visual **accent.** The lower part of the towers of turbines is screened by the wood. The movement of blades is seen. The further wind farm consisting of 17 wind turbines (distance from the observer is 17-19 km) cannot be seen clearly **(background element).**	Substantial/ the average impact (due to the magnitude of the impact on the landscape) (VS). Weak (due to observation distance) (CD)
9 Road Klaipėda-Šilutė (No. 141) (near Klaipėda city)	Dituva	19,5	The wind turbines are seen from the road Klaipėda – Šilutė from this observation point. Electric lines, pylons, and vegetation dominate in the visual space. Due to the observing distance and the mentioned visual obstacles visual impact of the turbines becomes **insignificant.** The movement of blades can be seen partially.	Visual insignificance (due to visual sensitivity of the landscape) (VS). Weak (due to observation distance and spatial relations) (CD)
10 Village Nida	Nida	28	The wind turbines are seen but visual impact is **insignificant.**	Slight impact (VS). Weak (due to observation distance) (CD)

Fig. 2

Photos made from observation points No.:2, 4, 5, 9 (photos by J. Abromas, 2013)

Discussion

Evaluating of visual impact in Šilutė region it is noticed that the wind turbines are constructed very close to the settlements of Vilkyčiai and Lankupiai. Considering this aspect two observing points (No. 1 and 2) were selected in Lankupiai village. There are wind farm from 6 turbines to the south west from the village and wind farm from 17 turbines to the east. The distance between the turbines and the village is 1 – 3 km. The wind turbines clearly dominate in the contextual landscape and are seen from many sites in the village. Evaluating visual impact of

wind turbines from Curonian Spit the visual impact of them is enhanced by Curonian Lagoon situated between the observer and visual obstacles as water body which forms a basis of the visual space.

Wood near the observation point has a big influence on the visual impact of the wind farm. This aspect was noticed evaluating visual influence from the observation point No. 3-5, 7, 9-10 (Fig. 2).

Atmospheric conditions such as cloudiness also have a big influence on the visual impact of the wind farm. This aspect was noticed evaluating visual impact of the wind farm from the observation point No. 7, 10. The color of the wind turbines is light grey. When clouds are of the same or similar color the set of blades in some cases can be invisible or on the contrary can be visible more clearly if the clouds are darker. The more anthropogenic objects are in the visual space the more visual impact of the wind farm is decreased. In some cases wind farm can become a background element.

When being at the distance of 0-7 km from the wind farm, it can be noticed that 1-2 km interval is of great importance to the visual impact evaluation. When the distance is greater, the interval of 1-2 km loses its previous importance.

Conclusions

1 The visual nature of landscape and its visual-aesthetic quality is changing due to wind farms and single wind turbines built mostly in the Western Lithuania. There are six wind farms in Kretinga district alone (which borders the municipality of Palanga). The hub height of current wind turbines reaches 80-120 m, while the blade-tip height is 120-160 m. These objects are becoming dominant verticals. The documents of territorial planning already provide for the construction of wind turbines in Šilutė and Pagėgiai district areas with the blade-tip height of 200 m. Under ideal weather conditions, the wind turbines can be seen from up to 25-30 km distance. It is important to group the wind turbines currently under construction into separate farms, and to deploy them away from villages, important preserved areas, recreational zones or observation decks in order to reduce the negative visual impact of wind turbines. It is important to evaluate the impact of both existing and planned wind turbines on the landscape.

2 Even though the blade-tip height of the major wind turbines (up to 120-150 m) are observed at the distance of 30 km at good visibility, the visual effect on the landscape is produced only by background elements located at the distance of 15-20 km. When viewed from the roads and from a dynamic position, a more significant effect is produced by the wind turbines located nearer the roads. The turbines located farther from the observer (at a distance of 10-20 km) make visual influence only when seen on the road perspective axis.

3 The research in situ and the summarized data allowed to distinguish factors mostly determining visual impact of wind turbines: visual-spatial parameters of wind turbines, the local terrain, forest arrays and smaller natural and anthropogenic elements between an observer and wind turbines, village deployment, weather conditions and arrangement of wind turbines in the farm/ group.

4 It was found that wind turbines, analyzed within the landscape of Klaipėda – Šilutė Road (no. 141), become most significant at Saugai village. In this section of the road, wind turbines are clearly dominant due to a large scale, short observation distance, and open spaces; the wind turbines overshadow natural features of the landscape. The visual impact is negative. In other sections of the road, there are different natural-anthropogenic elements (trees, buildings) between the road and wind turbines, which reduce their dominance.

5 The public opinion survey, carried out by the authors during the previous research, confirmed that the respondents usually had identified the change of the landscape as

negative at a short observation distance (where wind turbines dominate/ commonly dominate in the landscape). It was found that Lankupiai, Saugai and Vilkyčiai villages fall into the zones of wind turbine dominance/ common dominance within the territory under analysis. The distance from the mentioned villages to the wind turbines is 1-3 km.

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