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VISUAL IMPACT ASSESSMENT OF WIND TURBINES AND THEIR FARMS ON LANDSCAPE OF KRETINGA REGION (LITHUANIA) AND GROBINA TOWNSCAPE (LATVIA)

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Abstract. Early in 2013 as many as 5 wind farms were in operation in Kretinga region and the sixth was under construction. The wind farms are concentrated within two territories, i.e. in the south-west part of the region (between Kretinga and Palanga towns) and in the north-west (between Darbėnai and the Senoji Įpiltis villages). The region also houses seven individual wind turbines, the total number being 58 units. In seeking to assess the impact of wind turbines based in Kretinga region on the landscape and the villages, the analysis of cartography material was carried out and the inventory of all wind turbines was made (GIS data base). On assessing the importance of the roads with regard to the intensity of traffic and tourist flows, the observation places were established and photo fixation was performed. The impact was assessed from eleven observation places (all the places were close to the roads). During the study, the nature, importance and degree of contrast of the visual impact of wind turbines were assessed. In assessing the visual impact of wind turbines on the landscape, it was found that woodlands and villages make a significant impact on the visibility of turbines. The wind turbines seen on the axis of the road perspective are not only observed for some length of time, but often serve as a landmark. The investigation results were compared with the situation in western Latvia region (Grobina case).

Keywords: wind turbines, environmental impact assessment, the influence of wind turbines on environment.

Introduction

In recent years, new dynamic visually bulky elements of the landscape, of parameters not typical to the environment, i.e. wind turbines, have emerged in West Lithuania. Their construction in that territory has been initiated by the average annual wind speed amounting to 6–7 m/sec. (Katinas *et al.* 2007; Vaidogas, Juocevičius 2011; Marčiukaitis *et al.* 2008). Even though that region contains major protected territories, health resorts (Palanga, Neringa) and intensive tourist routes, in Kretinga region alone, with Palanga in the neighborhood, 5 wind parks are in operation. Due to these aspects it is of great importance to assess the possible impact of the wind farms, operating and to be operated, on the landscape.

The installed power of wind energy in the European Union at the end of 2012 amounted to 105696 MW, and wind turbines power accounted for 26% of all newly installed electric power (The European Wind Energy Association 2013; Michalak, Zimny 2011; Mostafaeipour 2010).

In Lithuania, until the year 2013, wind turbines of 250 MW total capacity were planned to be built. At the beginning of 2013, the total capacity of wind turbines was 220 MW.

Until 2013, as many as 125 major wind turbines (over 350 kW) were built in Lithuania. The total number of turbines (including minor ones) amounts to 200 units.

The biggest number of wind turbines are constructed in Kretinga (58 units), Šilutė (33 units) and Tauragė

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(24 units) regions. In Kretinga region almost all the wind turbines are located in two areas, i.e. south-west (between Kretinga and Palanga towns) and north-west part (between Darbėnai and the Senoji Įpiltis villages) of the region. Due to intensive traffic and the present resort territory, Kretinga–Palanga habitat is visually the most important. The total height of the turbines built in this part (15 units, Enercon E-70) amounts to 121.5 m. (Fig. 4), and the height of the turbine Enercon E-82 built in 2011 near Vydmantai village is 150 m. Due to these aspects, wind turbines are becoming a dominant vertical in the landscape. This is relevant for the observers from the motorways. While driving, wind turbines and other contrasting objects in the landscape draw attention and are able to make a positive or a negative effect (Ode *et al.* 2010; Söderholm *et al.* 2007). Owing to the turbines built near the motorway, the landscape may become attractive or vice versa.

Wind turbines by their scale or shape can enrich the landscape (Vries *et al.* 2012). The object of this kind may be the first demonstration – industrial wind turbine built close to Vydmantai village which diversifies the plain and monotonous landscape. Therefore, determination of the visual impact of the turbines as visual dominants on the landscape is becoming of the utmost importance.

Visibility of wind turbines is different when observing them in a static or a dynamic state. While observing them from a static position, the picture of the turbine does not change with time. But when studying the movement of transport and in a dynamic position of the observer, a visual relation between wind turbines and the landscape changes permanently. The sight may be partially limited by physical possibilities (e.g. the size of the car window) to observe the turbines from the inside of the vehicle (Jerpåsen, Larsen 2011; Bishop, Stock 2010).

The aim of the paper is to make an inventory of wind farms and single wind turbines in Kretinga region, to discuss visual significance of wind turbines and contrast-determining factors as well as to evaluate the impact of the turbines on the landscape when observing them from the selected observation place.

1. Materials and methods

In seeking to assess the impact of the wind turbines located in Kretinga region on the landscape and villages, all cartography material was analyzed and the inventory of all wind turbines was made (GIS data of turbines location was worked out). On assessing the importance of the roads in situ, the importance of the impact of the wind turbines was grouped in terms of degrees (Fig. 1):

– Visually dominating (about 0–1 km). Wind turbines dominate in the observation area due to

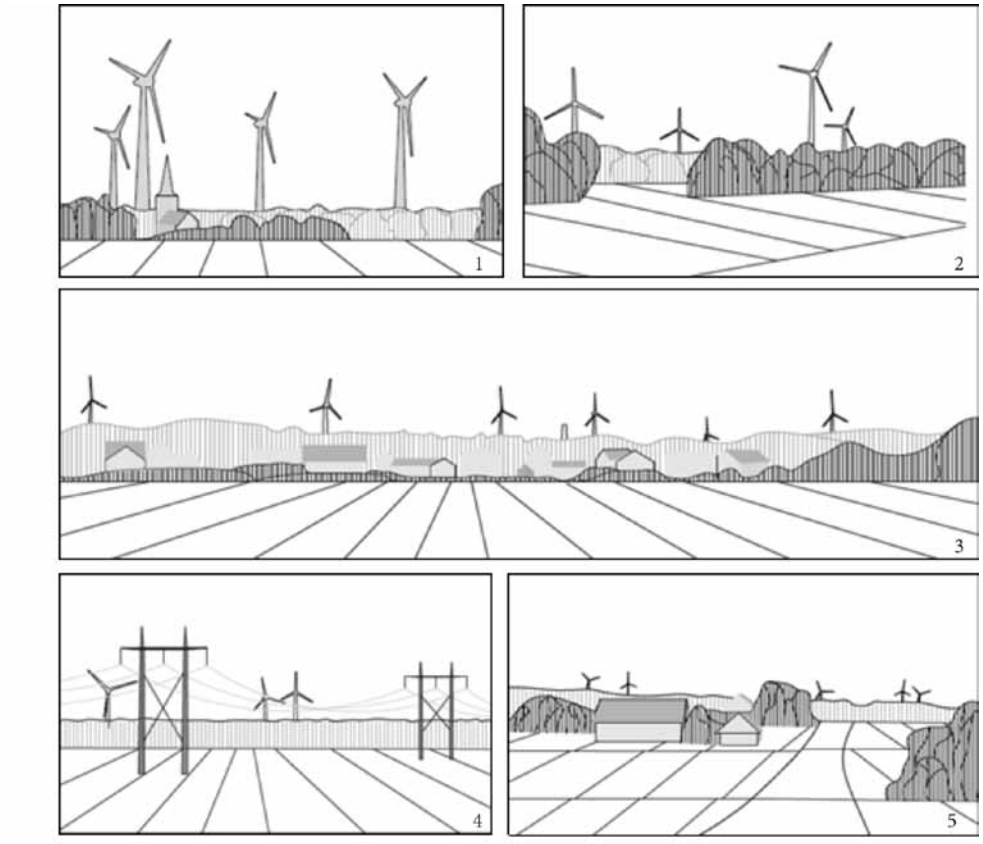

Fig. 1. Diagrams of the significance of the impact of the wind turbines in terms of degrees:
1 – visually dominating, 2 – generally dominating, 3 – accents, 4 – subdominants,
5 – background elements (author of the schemes: J. Abromas, 2013)

their bulky size. Essentially change the sight of the neighboring environment. The movement of the rotor is clear;
- Generally dominating (about 1–3 km.). The turbines look bulky and are a significant element of the landscape; however, they do not necessarily dominate in the observation area. The movement of the blade is clearly perceived and attracts attention;
- Noticeable (accents) (about 3–7 km). Wind turbines are clearly visible, but they aren't visually unwanted any more. The wind farm is noticeable as an element of landscape. The movement is noticeable at good visibility. The turbines do not look large in the overall field of view. Some changes in the landscape due to the emergence of the turbines are acceptable. The observation is influenced by weather conditions;
- Subdominants (about 7–10 km). Wind turbines are less clearly visible, the size is visually diminished, but the movement is noticeable. With the increasing distance, wind turbines become general elements of the landscape;
- Remote elements of the landscape (background elements) (>10 km). The turbines are no longer clear, of a small shape and look insignificant. The movement of the blades is generally unnoticeable. The overall size of the turbines is very small (authors of the article, and Jallouli, Moreau 2009).

In carrying out the assessment of the impact of wind turbines on the landscape, the principles of forming the contrast of the objects and the surrounding environment "Bureau of Land Management" (USA) were used:

1) the components and elements forming the contrast are determined;
2) the contrast may be nonexistent, weak, medium or strong;
3) the contrast is nonexistent, when not seen or perceived;
4) a weak contrast is when it is visible, however, does not attract attention;
5) a medium contrast attracts attention and starts dominating in the landscape;
6) a strong contrast is dominating in the landscape and attracts attention (Bureau of Land Management 2012).

The object of study in situ is a visual impact of six wind farms and four wind turbines on the roadscape in Kretinga region.

The visual impact on the roadscape was assessed from eleven selected observation places (all of them are close to the roads). The location of the places was chosen in accordance with the road categories: five were chosen at the highways Šiauliai–Palanga (A11), four near the national roads, two places near the regional roads (Fig. 2). The study in situ was performed on March 9–10, 2012. The day was sunny, hardly cloudy and the visibility of the turbines was excellent.

In the first area under study (south-west part of the region), 15 Enercon E-70 wind farms were built in 2006, and in 2009 seven turbines wind farm of different capacity were built. Also, three turbines located in the neighborhood were assessed. The territory is dominated by the landscape of rural, slightly urbanized nature, plain and sandy curved plateaus with an insignificant vertical scatter (wavy with slanting valleys). Half-open and open visual areas prevail (Kavaliauskas 2006). The dominating objects are wind turbines. The nearest towns are Kretinga and Palanga. In the vicinity there are Kiaupiškės and Palanga forests.

In the second area of study (i.e. north-west part of the region between Darbėnai and the Senoji Įpiltis villages) three wind farms are constructed (the fourth is under construction). The territory is dominated by the scarcely populated agrarian landscape with sandy clayey plains and half-closed areas (in the very territory of the farm half-open/open) with poorly expressed vertical scatter (plain landscape with the videotops of one level). Vertical objects, such as wind turbines and overhead power transmission lines prevail in the spatial structure. The wind farms are located in an open space between the woodlands, except Sudėnų Degsnė forest which partially penetrates into the territory of wind farms.

The visual impact of one minor wind turbine (250 kW capacity) located nearby the Salantai–Kūlupėnai road (No. 226) was also assessed. This turbine is important for the fact that it is situated in a hilly area next to the Salantai regional park. The territory is dominated by agrarian, scarcely urbanized landscape with moraine ridges and a medium vertical scatter (hilly, free of well-marked valleys). Half-open, mostly clearly visible spaces are dominating (Kavaliauskas 2006).

According to the values of the zones of the visual impact of wind turbines determined by the authors of the paper, the major turbines, the blade-tip height of which amounts to 120–150 m, can be visible at a distance of up to 30 km (for clear visibility). The following intervals of zones of visual influence are recommended: 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 3–7 km – they become accents, at a distance of 7–10 km – subdominants and at a distance of >10 km – background elements (Möller 2006; Leung, Yang 2012; Molnarova *et al.* 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

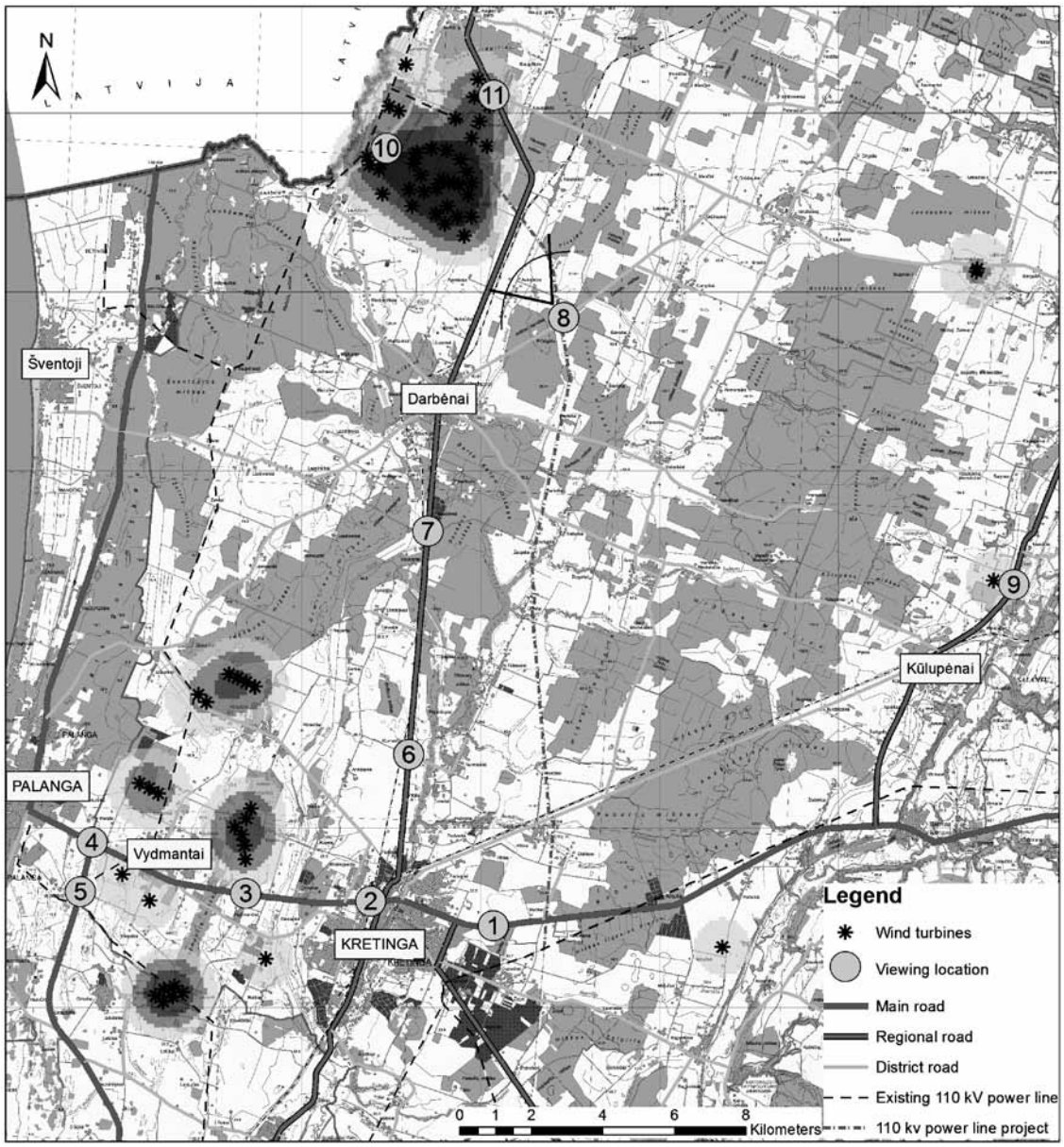

Fig. 2. Locations of wind turbines, their farms (WT farms) and viewing points and the levels of wind turbines concentration (author of the map: J. Abromas, 2013)

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 (Frantál, Kunc 2011; Saindur *et al.* 2011).

2. Location and visual parameters of wind turbines in the region's territory

At the beginning of 2013 there were 5 wind farms and the sixth farm (with 10 minor wind turbines) was under construction in Kretinga region. Seven single wind turbines were built. Three of them are located in the vicinity of Pryšmančiai and Vydmantai villages, one in each village of Mišučiai and Nasrėnai and two, earlier maintained in other countries, were built near Leliūnai village (Table 1). The total number is 58 units.

The first farm in Kretinga region (in Lithuania, too) was built in 2006, in the area between Palanga and Kretinga towns, next to the village of Vydmantai (in Kiauleikiai, Kveciai and Rūdaičiai villages). The farm consists of 15 turbines located in three groups (Fig. 2). They are of a single type – Enercon E-70 (2 MW capacity). The hub height is 86 m, the rotor diameter is 71 m, and the blade-tip height of the turbine is 121.5 m.

In this part (south-west) of the region, in Liepynė village, another wind farm of six turbines of different installed capacity was constructed.

Other three farms (the fourth is under construction) are situated in the north-west part of the region between

Table 1. Wind turbines located in Kretinga region and their technical – visual parameters

No.	Regimentation	Wind turbine location name	Wind turbine type	Number of wind turbines	Power (kW)	Total power (kW)	Installation year	Dimensions of wind turbines		
								Hub height	Rotor diameter	Blade-tip height
1	Wind farms	Kiauleikiai, Kveciai, Rūdaičiai	Enercon E-70	15	2000	30000	2006	86	71	121.5
2		Benaičiai	Vestas V100	6	2750	16500	2007	80	100	130
3		Sūdėnai	Enercon E-82	7	2000	14000	2009	86	82	127
4		Liepynė	Enercon E-82	4	2000	9130	2009	86	82	127
			Enercon E-53	1	800			73	52.9	99.5
			Enercon E-33	1	330			50	33.4	66.7
5		Benaičiai	Enercon E-82	17	2000	34000	2010	109	82	150
6		Benaičiai	Vestas V27	7	225	2475	Construction	30.8	29	45
			Enercon E-40	3	250			65	40.3	85.2
7	Single wind turbines	Vydmantai	Enercon E-40	1	630	630	2004	78	44	99.5
8		Pryšmančiai	Enercon E -44	1	800	800	2006	55	44	77
9		Bajoraliai	Bonus-95	2	95	190	2007	24,5	18	33.5
10		Vydmantai	Enercon E-82	1	2000	2000	2011	109	82	150
11		Mišučiai	Enercon E-33	1	250	250	2011	50	33.4	66.7
12		Nasrėnai	Enercon E-40	1	250	250	2012	65	40.3	85.2

Darbėnai and the Senoji Įpiltis villages. First, in this territory, nearer to the road Darbėnai–Lenkimai (No. 218), the farm of six wind turbines was built in 2007 (all the turbines are of a single model Vestas V 100). Later, in 2009 the farm of seven turbines (Enercon E-82) was built on both sides of the road Laukžemė – the Senoji Įpiltis (No. 2310). The third farm of seventeen turbines Enercon

E-82 in this territory was built in 2010. Currently, the fourth farm of ten wind turbines is being built. The turbines of the farm are visually strongly different from those built earlier. They are wind turbines of two models Vestas V27 and Enercon E-44, the total blade-tip height of which amounts to 45 m and 85.2 m respectively (Table 1).

The construction of wind turbines in the south-west and north-west part of Kretinga region is promoted by the existence of the power transmission line of 110 kW capacity and by the fact that the major wind farms of the north-west can be connected to the grid of that voltage.

Currently, the overhead power transmission line is completely loaded because of the connected wind farms. Therefore, a special plan of the construction of 110 kW power transmission line Kretinga–Benaičiai is being prepared. On implementation of the project, a new wind farm can be built in the north-west part of Kretinga region (in the vicinity of the presently located wind farms). Then, a total number of wind turbines may reach around 80–90 units. Since the national road Kretinga–Skuodas (No. 218) is near that territory, the wind turbines are visible and significant as the roadscape elements.

The visual effect of wind turbines is strongly dependent not only on the hub height/blade-tip height of the wind turbine, but also on the rotor diameter. For example, in Kretinga region, near Vydmantai village there stands the power plant Enercon E-82, its hub height being 86 m and the rotor diameter 82 m. The first demonstration wind turbine Enercon E-40 was built in the same territory with the hub height of 78 m and the rotor of 44 m in diameter (Jaskelevičius, Užpelkienė 2008). In studying the visual impact of the turbines, a great difference between large proportions and the rotor's space can be seen. Enercon E-40 wind turbine with a rotor of half the diameter becomes visually "lighter" and less dominating in the landscape (Fig. 4).

3. Factors of visual impact on the landscape and their assessment

In assessing the impact of wind turbines on the landscape it is essential to find how the observed landscape is seen, i.e. from a static or a dynamic position of the observer. In this respect the roadscape observed from a dynamic position is important.

The factors considered in determining the degree of contrast:

– 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.

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 (due to a large scope of study, the assessment results in the paper are presented from six observation places only)

No., road and observation place	Visually influenced villages	Distance to the wind turbines (km)	Nature of visual impact	Visual significance (VS) and contrast degree (CD)
1. Šiauliai–Kretinga (No. E27). Entering the town Kretinga	Kretinga	7.5	Wind turbines are seen on the right side of the road incorporated in a cultural landscape. The towers are partially masked by the forest in the background and individual residential houses. The blades are fully visible. Degree of visual impact is similar to the one of 110 kW electricity lines pillars placed at a distance of 1.5 km away from the observer. On the road ahead, the chimney of the town's boiler house and the water supply tower are obviously dominating. Visual impact is positive, wind turbines are becoming general elements of the landscape.	Falls into the level of subdominants (VS) Weak (due to the observation distance) (CD)
2. Road Kretinga–Palanga (No. E272). From the railway viaduct	Kretinga	4	On the right side, 2/3rds of the lower part of the tower are fully masked by trees. Wind turbines visually 'compete' with the existing verticals, i.e. boiler house chimneys, water supply tower. Different vertical elements are visible in the landscape; extra verticals of the turbines make a negative influence on the environment.	Falls into the level of visual accents (VS) Medium (due to the observation distance) (CD)
	Kretinga	6	On the left side, another farm of six turbines (Liepynė) is visible. The blade movement is clearly visible, and the towers are masked by tracery crowns of deciduous trees. Since the turbines are of different model, visual significance is also different. A single wind turbine in Pryšmančiai becomes the landscape accent due to a smaller distance. Visual impact is positive.	Turbines are perceived as landscape subdominants (VS) Weak/medium (due to observation distance and relative size) (CD)
3. Road Kretinga–Palanga (No. E272). Close to Pryšmančiai village		1–2	The hill in an observation area on the right side is visually heightened due to six turbines on it. Green colored lower part of the tower is visible. Other six turbines in a distance (5 km away) due to relief and woodland become background elements. Turbines obviously dominate due to a big scale and small observation distance thus changing the picture of the environment. Visual impact is negative.	The wind turbines is dominant in the landscape (VS) Strong (due to observation distance and relative size) (CD)
	Pryšmančiai	3.5	On the left side of the road, above the vegetation of Pryšmančiai village and buildings, wind turbines' rotors are visible. Blade movement is visible. In an open space on a hill, a single Pryšmančiai wind turbine is visible (at a distance of 1.9 km from the observer). Since there are no other vertical elements, the turbine is generally dominating in the landscape and visually does not make a negative effect.	Falls into the level of visual accents (VS) Medium (due to observation distance) (CD)
		3.5	On the axis of the road perspective, a single Vydmantai wind turbine is visible, which, due to a smaller blade length, does not produce a negative visual effect. On the contrary, it is a positive dynamic landmark of the roadscape.	Generally dominates in the landscape (VS) Medium (CD)
7. Kretinga–Darbėnai (No. 218). On entering Darbėnai village	Darbėnai	7	When driving, the Darbėnai church tower as a vertical object (landmark) on the road perspective axis and the rotors of major wind turbines' (blade-tip height 150 m) in the region' north-west part are visible. These dominants visually compete blocking the sacral dominant. The impact of turbines on the landscape is negative.	Noticeable/dominate generally in the landscape (VS) Medium (due to relative size and spatial relations) (CD)

Continued Table 2

No., road and observation place	Visually influenced villages	Distance to the wind turbines (km)	Nature of visual impact	Visual significance (VS) and contrast degree (CD)
8. Darbėnai–Grūšlaukė (No. 2311)		4.5	From the observation place, woodlands and agrarian territories as well as all four (including that under construction) wind farms are visible. The 330 kW power transmission line with supports is also influential as an anthropogenic element. The observation place is essential in that all four wind turbines are within the human field of view at a time. Even though almost all wind turbines located in the north-west part of Kretinga region are visible from that observation place, they do not make a negative effect (Fig. 3).	Falls into the level of visual accents (VS) Medium (due to observation distance and relative size) (CD)
9. Salantai–Kūlupėnai (No. 226). Near Nasrėnai village	Nasrėnai	0.6	Since the hub height and the blade-tip height (65/85.2 m) of the wind turbine are significantly smaller than those discussed above, the turbine only generally dominates in the landscape when observing it from the road at a small distance. Small tree groups near the roadside and overhead power transmission lines are visible. The wind turbine built on a hill visually heightens it and accentuates the relief. Visual impact is positive.	The wind turbine is generally dominant in the landscape (VS) Strong (due to observation distance) (CD)

– 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; Carmen Torres Sibillea *et al.* 2009; Rodrigues *et al.* 2010).

The visual effect on the landscape is also highly dependent on the urbanized territories, woodlands or single trees near the road (Tsoutsos *et al.* 2009; Molina-Ruiz *et al.* 2011). Since according to the spatial perspective, the relationship of the visual size (h) of the object (wind turbine) and the real size of the object (H) is a linear dependence on the square of the distance to it (d), i.e. $h/H = kd^2$, therefore, the visual size decreases in a non-linear dependence on the distance, which causes some visual effect, when the nearby small objects can cover the major objects occurring in the observation direction (e.g. 2×2 m objects at a distance of 2 m away from the observer can blot out 50 square meters) (Kavaliauskas 2006).

Wind turbines in the roadscape visual space are seen when driving along the main highways, national and regional roads Šiauliai–Palanga (No. E272), Klaipėda–Palanga (No. E272), Klaipėda–Kretinga (No. 168), Kretinga–Skuodas (No. 218), Salantai–Darbėnai (No. 2311), Darbėnai–Palanga (No. 2304/2309), Salantai–Kūlupėnai (No. 226), Laukžemė–Senoji Įpiltis (No. 2310). The roads mentioned are also important as part of tourist routes.

The assessment carried out from eleven observation places showed that the visual influence of wind turbines is most significant from the road Šiauliai–Palanga (No. E272). When observing the turbines from different observation places, visual significance covers the levels of dominats-accents/subdominats. The main observation

places, from which the observed turbines make a negative effect on the visual picture, are No. 3 (on the right side of the road) and No. 7. The number of wind turbines seen from the observation places No. 11 and No. 8 at the same time is the biggest not only in Kretinga region, but also all over Lithuania (34 wind turbines are visible). Since in the area between Darbėnai and the Senoji Ipiltis (northwest part of the region) four wind farms have been constructed at different times, the accumulating effect on the landscape is clearly seen.

4. Assessment of visual effect on Kretinga and Grobina townscape, and regional villages

Kretinga townscape is visually influenced by wind turbines when driving along the roads Šiauliai–Palanga (No. E272) and Klaipėda–Kretinga (No. 168). Kretinga's west part is visually influenced by a single wind turbine located in Pryšmančiai and the wind farm of 15 turbines in the villages of Kiauleikiai, Kveciai and Rūdaičiai. Since those turbines are 4–5 km away from Kretinga, they fall into the area of psychological effect. Also, that territory is characteristic of surplus visual pollution of vertical elements due to the existing water towers and boiler house chimneys.

Kretinga region has two towns (Kretinga and Salantai), and two villages have the status of township (Kartena and Darbėnai). Due to a big distance and relief, the visual impact of wind turbines on Darbėnai and Kartena is nonexistent, thus, not subject to consideration.

Darbėnai township in Kretinga region is visually affected by wind turbines located in Benaičiai village. The character of the visual impact on the village is somewhat ambiguous:

1. The north part of Darbėnai township is within the area of the effect of the wind turbines. The distance from the villages to the turbines is rather big (5 km). Since between Darbėnai village

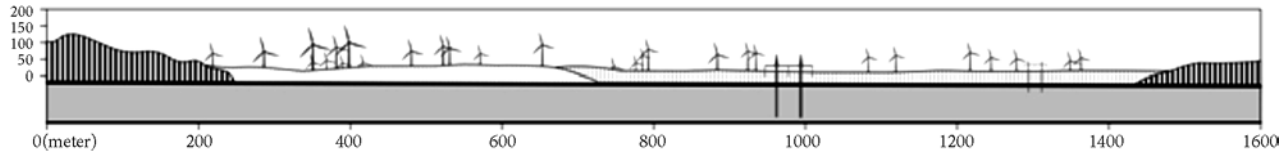

Fig. 3. Visibility of wind turbines from observation place No. 8

Fig. 4. Photos made from observation points No.: 1, 3, 4, 7 (photos by J. Abromas, 2013)

and the territory of wind farms there lay isolated woodlands and scattered homesteads, differing overhead power transmission lines and poles, the turbines viewed from some observation points can be sufficiently clearly visible as landscape elements, and from others – as landscape subdominants. The visual effect on the village is not negative.

2. On the perspective axis of the road Kretinga–Darbėnai (No. 218) the towers of Kretinga and Darbėnai churches are visible. In the middle of the distance all the towers are seen at the same time. In the autumn of 2010, when building a wind farm in Benaičiai, new vertical dominants – wind turbines – appeared in the road effect area (towards Darbėnai). This is how the sacral dominant is dwarfed. The effect on the landscape is negative.

The accumulating effect of the turbines is possible when the wind farm is planned to be located in the neighborhood of the existing farms (Ladenburg *et al.* 2013; Ladenburg, Dahlgaard 2012). This is relevant for the north-west part of the region due to the growing number and density of wind turbines (Fig. 2).

In assessing the visual effect of wind turbines on the roadscape it was found that more often than not the woodlands and individual big trees make a significant effect on the visibility of turbines (Domingo-Santos *et al.* 2011; Katsaprakakis 2012; Cowell 2010). Minor elements of the landscape (hills, roadside bushes, etc.) near the observer also have some influence on the visibility of turbines. The turbines visible on the road perspective axis are especially important not only because they are within the field of view for a longer period of time, but because they tend to turn into a vertical landmark. In some cases, e.g. field of view for a longer period of time, but because they tend to turn into a Landmark (Vouligny *et al.* 2009). In some cases, e.g. on the road Kretinga–Darbėnai (No. 218) the tower of Darbėnai church and two wind turbines are visible. The building site for the wind farm could have been chosen more accurately, thus saving an important vertical landmark (i.e. church tower).

The location of wind turbines in the context of town visual environment most frequently is associated not only with the visual aesthetic quality, but also with the degradation of the quality of the cultural and historical environment. This applies to both the visual psychological discomfort against the skyline, or the silhouette with the Church's spire, and the overall visual and informational perception of the cultural landscape.

Approximately 70 km to the north from the wind turbines zone of Darbėnai, the wind farm in Grobina (Latvia) is located with 33 turbines (the total capacity of 19.8 MW). It is located near the transit road route of Liepāja in a relief area. In the distant view (approximately 10 km), the silhouette of a balanced industrial landscape is visible, which is added to the agricultural landscape in the forefront and forest areas in the background. As the distance decreases (up to 100 m), high concrete hub 77 m in height dominate, so creating discomfort because of the scale and proportion. Additionally the industrial landscape is complemented by a dense network of overhead electric power transmission lines. This informative space (approximately two kilometers in length) gives an impression to the driver that the urban green energy generation zone is approached.

In fact it is misleading because the industrial "corridor" as the "entrance gate" leads to a unique heritage site – the town of Grobina, which was one of the most important Viking age trading centres from the 7th to 9th c. It is evident from the archaeological ensemble. It lays claim to the UNESCO World Heritage list, as it is one of the most notable Vikings' world sites in the eastern part of the Baltic Sea. In contrast, the competing in scale and imprecise location of the industrial structures lowers the quality of the town's tourism infrastructure.

Learning from mistakes, a new project has just been approved that contains a very important search of synthesis and context for the architecturally landscaped space, which affects the industry and cultural and historical landscape. In the distance of 15 km from Grobina – in the northern part of Liepāja it is intended to locate 19 wind turbines (the total capacity of 57 MW, 99 m in hub height), which is closer to the sea. The location area is hidden behind the forest from the main driveway and in the view line skyline the wind turbines will be distanced.

There has been reached a compromise in the compositional solution, since three entities with cultural significance are located in the area under the project: a monument to the Soviet Patriots, the Jewish Holocaust Memorial in Liepāja to the murdered during World War II and the Northern Forts of the Liepāja Fortress. Therefore, the issue of the protection zones is resolved. Several power plants are expected to be located in the immediate vicinity of the seacoast – in the zone of the potential coastal erosion. Undoubtedly, it is important to develop a monitoring plan for species of migratory birds and bats on the coast of the Baltic Sea.

Conclusions

1. Due to the wind farms and the single wind turbines constructed in West Lithuania, visual nature and the aesthetic-visual quality as well as semantic content of the landscape has changed. In Kretinga region alone (bordering Palanga resort) five wind farms are in operation. Therefore, the assessment of the possible impact of wind turbines, the existing ones and those to be planned, on the landscape is important. Grobina case in Latvia also substantiates the necessity of the mentioned impact assessment procedure.

2. Aesthetic potential of the landscape of the road Kretinga–Palanga (No. E272) is diminished by six wind turbines Enercon E-70, 1-2 km away from the road (observation place No. 3). The turbines obviously dominate due to a large scale and a small observation distance by blotting out natural elements of the landscape, therefore, the visual impact is negative. The wind turbine Enercon E-82 located in the neighborhood of Vydmantai villages and clearly seen from the observation place on the road No. 272, makes a negative impact on the lanscape. In other sections of the road, between the road and the turbine, there are different natural-anthropogenic elements (trees, buildings) which tend to minimize the domination of the turbine (Fig. 4, photo 2).
3. Even though the turbines are observed in several places on the perspective axis of the road, the negative effect is visible when driving along the road Kretinga–Darbėnai (No. 218), since the turbines visually compete in blotting out the sacral dominant, which leads to the loss of its domination (Fig. 4, photo 7). The first turbine constructed in the region near the Palanga viaduct (Fig. 4, photo 3) can be identified as one enhancing the aesthetic-visual potential of the landscape. That was determined by dimensions and reasonable selection of the building site. Grobina case demonstrates not only the negative impact on landscape visual-aesthetic quality but also causes the degradation of the cultural and historical environment, and changes semantic content of landscape.
4. During the assessment procedure, it was found that visual significance is characteristic not only to huge woodlands and spatial structures of the villages, but also to minor objects at small distances from the observer (roadside bushes, single buildings, trees, etc.) which also change the visual influence of wind turbines. The turbines seen on the road perspective axis are of special importance not only because they are observed for a bigger length of time, but because they often become a vertical landmark. In constructing wind turbines it is essential to take into consideration that the visual domination of the existing important vertical objects is to be preserved.
5. 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.
6. In summarizing the data obtained from different observation places, it was found that most often the landscape is positively affected when visual significance covers the level of accents-background elements. When the landscape is visually/generally dominated by wind turbines, then the aesthetic potential of the landscape is usually diminished.

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