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LANDSCAPE-RELATED ASPECTS OF THE SITING OF WIND FARMS IN POLAND: A CASE STUDY OF THE GREAT MASURIAN LAKE DISTRICT

1. INTRODUCTION

There has been a vivid discourse in Poland over the recent years around landscape-specific consequences of developing the wind power industry. Controversies surround the construction of wind turbines in valuable landscapes, for instance in the Great Masurian Lakes. The wind energy development projects already completed in neighbouring regions as well as developers' declared intentions to invest in some municipalities lying in the above lake district (*Elektrownia wiatrowa*…, 2012) make the problem look real.

The objective of this paper is to determine consequences borne by the landscape due to the construction of wind power facilities in areas endowed with unique scenic values and therefore possessing high tourism assets. Once the problem is diagnozed, the evolving recommendations should be incorporated into the process of spatial planning and management of the region's valuable landscape resources, found in the aggregated area of individual municipalities. The presentation of model guidelines underlying an assessment of the impact and effects of a wind energy venture on landscape values in areas zoned for the development of wind farms is an essential part of this article.

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2. THE TERRITORIAL RANGE AND ADMINISTRATIVE STRUCTURE OF THE ANALYZED REGION

Initially, our analysis comprised the whole of Poland, but the detailed examination was limited to the part of Poland called the Great Masurian Lake District (Kondracki, 2000), covering around 1,730 km^2. The area is divided into four administrative districts with the seats in the following towns: Węgorzewo, Giżycko, Pisz and Morąg. These four districts are subdivided into 16 municipalities, which in total cover 462.4 thousand ha. Because of the specific, transboundary nature of wind farms, surpassing both geographical and administrative boundaries, our study covered the area of all the municipalities lying in the four districts which contain the Great Masurian Lakes (figure 1).

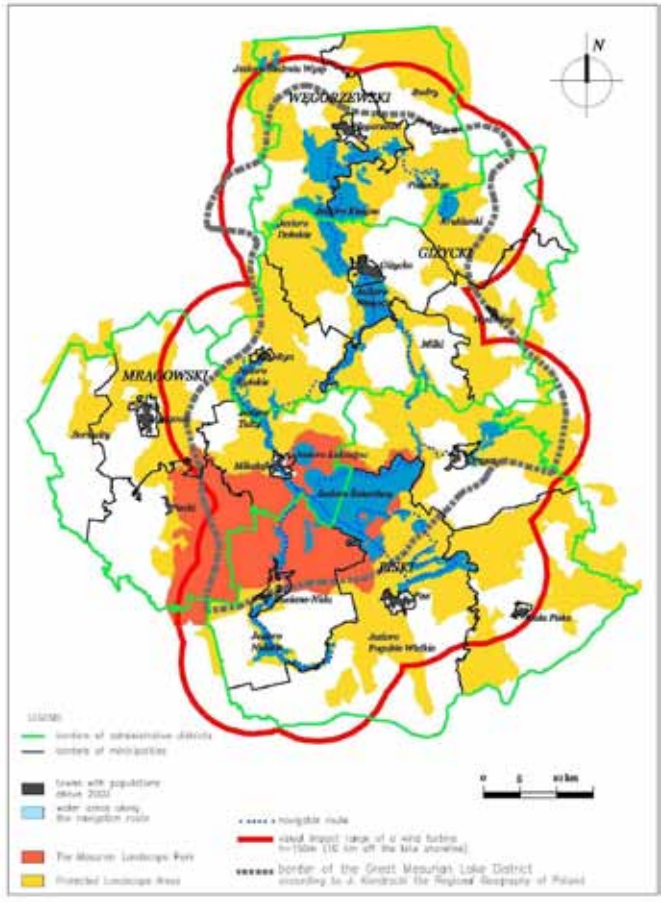

Fig. 1. Location of the Great Masurian Lake District against the background of the administrative division, including the visual impact zone of a wind turbine
Source: the co-author: W. Gadomska

The above region is characterized by the glacial land relief with a multitude of lakes. Much of the region has been submitted to different forms of nature (landscape) conservation (figure 2).

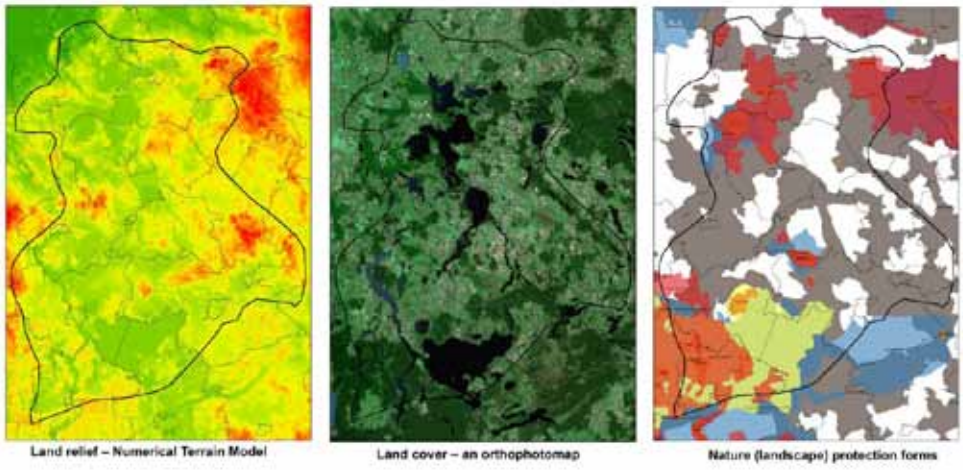

Fig. 2. Land relief – NMT (DTM, DEM), land cover (orthophotomap) and forms of nature (landscape) protection in the Great Masurian Lake District

Source: the co-author: M. Antolak, based on http://www.nasa.gov/ and http://www.geoportal.gov.pl (1.03.2013)

3. METHODS

This paper discusses the growth of the wind power industry in Poland. Additionally, it specifies the scale of the said development in the Province of Warmia and Masuria, as manifested by the number of administrative decisions such as building permits issued for construction of wind turbines and farms in the last eight years, including their power capacity. The policy adopted by individual municipalities with respect to potential wind energy projects and its implementation into planning documents are also discussed. In the later sections of the article, the authors analyzed how the landscape's scenic values can be affected by wind farms located along the shores of the lakes which constitute the main navigation route in the whole district. The extent to which they could interfere with the high-quality landscape was determined. The juxtaposition of the tendency for developing wind farms in the analyzed region and the scale of potential negative consequences to the local landscape highlights the gravity of the problem and the need to anticipate its effects. Finally, the authors recommend basic guidelines for performing analyzes of the impact and effects of building wind farms on the landscape values.

4. THE WIND POWER INDUSTRY IN POLAND

According to the data supplied by the Energy Power Regulation Office, there are 488 wind power facilities in Poland, with the total capacity of 1,480 MW (data of September 23, 2011). In 2009, the wind power industry gained a leading position in Poland with respect to power generation capacity. The increase in the energy power produced by Polish wind farms equalled 382 MW in 2011 (7th position in Europe), that is 52.3% (*Raport*, 2011). A report published by the Polish Wind Power Association (*Raport*, 2011) predicts that the power capacity installed by the year 2020 will reach 13 GW generated by wind farms and 600 MW produced by small wind power facilities. Such a substantial growth of the wind power industry in Poland is encouraged by the EU Directive 2009/28/EC of April 23, 2009 on promotion of energy from renewable resources. It will be impossible to comply with the provisions of the European Union's energy and climate package without an evident growth of the wind energy industry. On the other hand, development of wind power installations provokes numerous social and ecological conflicts. Possible locations of wind energy generation facilities in Poland are limited by the scattered rural land development and dense network of nature protected areas (Stryjecki and Mielniczuk, 2011). In Poland, the wind power industry is characterized by the implementation of highly varied models of turbines, which tend to be demonstrably higher so as to ensure superior profitability. Notable is also the community opposition, frequently encouraged by numerous non-government organisations of ecologists. The distribution of wind power installations in Poland is uneven. Most of such constructions can be found in the north, on or close to the shores of the Baltic Sea. Although each province in Poland has adopted a different policy governing the consenting procedures for wind energy installations, the provisions in planning documentation all across Poland are limited to laconic statements, which leave much freedom to developers. It is only strictly forbidden to construct wind power installations in national parks and nature reserves. Planning documents, however, foresee a possible prohibition to build wind turbines in landscape parks, protected landscape areas and in the Natura 2000 sites. Other contraindications include airfields, most valuable landscape macro-interiors, scenic roads with a defined exposure direction, water landscape platforms and selected, visually attractive components of the material culture (*Plan*, 2009; Kubicz *et al*., 2003).

5. WIND POWER INDUSTRY – ITS SCALE IN THE PROVINCE OF WARMIA AND MASURIA

The investment activity by the wind power sector in the Province of Warmia and Masuria results from the intensive development of the alternative energy industry observed countrywide. Out of the 378 wind farms built in Poland as of 2010, eleven lie in the Province of Warmia and Masuria, and their aggregated energy capacity contributes approximately 4.5% to the Polish total wind power capacity. It is important to notice how fast wind energy installations have been developed over the recent years. Year after year, the sector has grown by tens of percent and the growth continues (*Raport*, 2010a). The claim that developers are interested in wind power and that this sector in Warmia and Masuria keeps growing is confirmed by the number of building permits issued by the authorities of particular districts in the whole province in the last few years (table 1).

Table 1. Growth of the wind power industry in districts of the Province of Warmia and Masuria

District	Year	No of decisions	The planning basis of issued decisions	No of wind farm	No of wind turbines	Total power capacity
Bartoszycki	2008	1	decision on location of a public purpose investment	0	1	80 kW
	2010	2	decision on location of a public purpose investment	2	40	80 MW
					29	58 MW
Braniewski	2011	1	text and map extracts from local spatial development plan	1	10	20 MW
Działdowski	2010	2	text and map extracts from local spatial development plan	0	2	2MW
	2011	1	text and map extracts from local spatial development plan	0	1	2 MW
	2012	1	decision on location of a public purpose investment	–	19	38 MW
Elbląski	no decisions involving development of wind power industry					
Ełcki	2009	1	text and map extracts from local spatial development plan	0	1	10 kW
	2011	1	decision on land development conditions	1	4	9.2 kW

Table 1 (cont.)

District	Year	No of decisions	The planning basis of issued decisions	No of wind farm	No of wind turbines	Total power capacity
Giżycki	2010	1	text and map extracts from local spatial development plan	1	3	4,500 kW
Gołdapski	2007	4	decision on land development conditions	0	1	600 kW
			decision on land development conditions	0	1	600 kW
			decision on land development conditions	1	2	1.2 MW
			decision on land development conditions	0	1	500 kW
	2008	1	decision on location of a public purpose investment	1	23	69
	2009		decision on land development conditions	1	2	3 MW
Iławski	2005	1	text and map extracts from local spatial development plan	1	27	40.5 MW
	2006	1	text and map extracts from local spatial development plan	0	1	2 MW
	2008	1	text and map extracts from local spatial development plan	1	20	40 MW
	2009	3	decision on location of a public purpose investment	1	2	1.6 MW
			decision on location of a public purpose investment	0	1	2MW
			decision on location of a public purpose investment	1	2	1.2 MW
	2011		text and map extracts from local spatial development plan	1	3	6 MW
Kętrzyński	2010	3	text and map extracts from local spatial development plan	1	24	48 MW
			text and map extracts from local spatial development plan	1	9	18 MW
			text and map extracts from local spatial development plan	1	2	4 MW

District	Year	No of decisions	The planning basis of issued decisions	No of wind farm	No of wind turbines	Total power capacity
Lidzbarski	no decisions involving development of wind power industry					
Mrągowski	no decisions involving development of wind power industry					
Nidzki	2011	2	decision on location of a public purpose investment	0	1	2 MW
			decision on location of a public purpose investment	1	5	10 MW
Nowomiejski	2009	1	decision on location of a public purpose investment	0	1	0.6 MW
Olecki	2010	1	decision on land development conditions	1	2	1,000 kW?
	2012	1	decision on land development conditions	1	2	3,6MW
Olsztyński	no decisions involving development of wind power industry					
Ostródzki	no decisions involving development of wind power industry					
Piski	no decisions involving development of wind power industry					
Szczycieński	no decisions involving development of wind power industry					
Węgorzewski	no decisions involving development of wind power industry					

Source: the co-author, based on data provided by the district authorities: W. Gadomska.

While commenting on the current progress in the development of the wind power infrastructure, it is possible to predict its scale in the following ten to twenty years. A future tendency for siting new projects can be foreseen based, for example on the Energy Policy of the European Union, which promotes renewable energy resources (Jock and Henrichs, 2010; *Dyrektywa*, 2009). Prospects of the wind power sector in Poland are in accord with the EU policy in that the expected share of energy from renewable resources will have reached 15% by 2020. The predicted energy capacity generated by wind power installations will be more than five-fold higher in 2010 (*Perspektywy*, 2011). At this point, worth noticing is certain spatial asymmetry in the cited forecasts, namely while the predicted 15% increase in renewable energy is attributed to whole Poland, the actual generation of this power will accumulate in only a few, economically most viable areas, whose landscapes will considerably change as a result. The wind turbines and farms which already operate in Warmia and Masuria, are thought to be something of a novelty in the landscape, acceptable as some form of landscape enrichment, but they ought to be seen as a symptom of the future change in the local scenery, prone to rapid multiplication and essentially modifying substantial parts of the region (Gray, 2008).

Several reports have been drawn up regarding the siting of wind farms in Warmia and Masuria, including *Guidelines for the Localization of Wind Farms*

in Poland's Green Lungs (Demianowicz, 2011) or *The Nature-specific and Spatial Aspects of Localization of Wind Power Facilities in the Province of Warmia and Masuria* (Olech and Juchnowska, 2006). The Spatial Management Plan for the Province of Warmia and Masuria, which is currently being elaborated, is expected to zone some areas for this type of development. The Marshal of the Province has addressed an official letter to the authorities of all the municipalities in the Province, requesting them to withhold issuing decisions about the sitting of wind farms until the new Plan is passed (*Pismo*, 2012). This notwithstanding, the procedures in particular municipalities are continued. The current localisation of wind turbines in the province often neglects local landscape assets and cause degradation of the cultural landscape. Examples are the wind farms Łodygowo and Łęgowo, both in the municipality of Kisielice, which are now a co-dominant landscape feature, competing with the historic church in Kisielice, and feature strongly in a panoramic vista opening up on the approach to the town (figure 3).

6. LOCAL CONDITIONS CATALYZING INVESTMENT INTO WIND POWER

From the point of view of wind power developers, the analyzed region looks attractive – it reveals such a combination of natural and anthropogenic conditions that favour wind energy generation.

– winds and terrain roughness: on a mesoscale wind map of Poland (Lorenc, 2001) nearly 72% of the Great Masurian Lake District lies in the 2nd (favourable) wind power sphere, 25% is classified into the 3rd (quite favourable) sphere and only 3% presents unfavourable wind conditions. There is also synergy with the local land relief: nearly 12% of the land surface is covered by water bodies, characterized by the best, zero class of roughness, while over 40% belongs to farmland, which is assigned the first class of terrain roughness (Tytko, 2011). These two factors have a direct influence on the wind power generation efficiency (Dillon Consulting Limited, 2009);

– demographic factors and local settlement network: the Great Masurian Lake District lies in a province with the lowest average population density in Poland (www.stat.gov.pl/…). The extensive settlement network over the analyzed region gathers nearly 75% of the whole population in 9 towns, while the average population density in rural areas is much below the province's average (*Województwo*, 2010). This specific character of the region seems to favour the development of the wind power industry, as it reduces the risk of resistance by local communities and narrows down the fields of possible functional conflicts between wind farms and populated land;

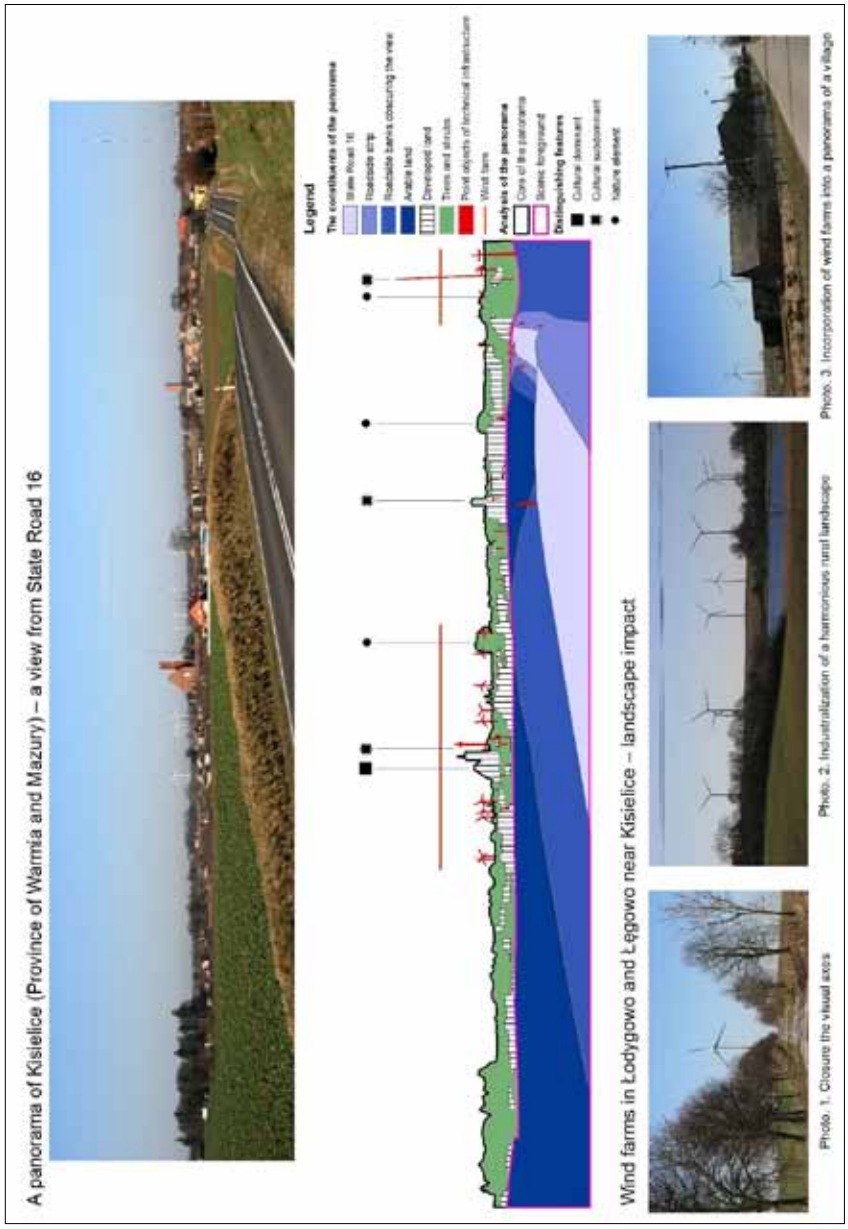

Fig. 3. An adverse effect of wind energy development on landscape assets, a case of wind farms Łodygowo and Łęgowo near Kisielice, the Province of Warmia and Masuria

Source: the co-author: M. Antolak

– economic conditions: the average real estate market price on farmland in Warmia and Masuria is among the lowest quotes in Poland. For developers, this is an advantage, which translates into lower costs of land purchase for construction of a wind farm and ancillary facilities (*Raport*, 2010a). Another essential consideration is the generally weak economic condition of the municipalities in the analyzed geographical region. Most municipalities in the Great Masurian Lake District have a lower average revenue *per capita* than the whole province (województwo warmińsko-mazurskie). An argument in favour of wind energy could be the prospect of an improved budget of a given municipality owing to a completed development project or declarations made by developers to participate financially in various economic ventures pursued by local governments (*Raport*, 2010a).

7. THE ATTITUDE OF MUNICIPALITIES IN THE GREAT MASURIAN LAKE DISTRICT TOWARDS THE DEVELOPMENT OF WIND POWER IN THE PROVINCE OF WARMIA AND MASURIA

A survey conducted among the municipalities lying in the region of the Great Masurian Lakes (a questionnaire form was mailed to 16 municipalities in the analyzed region) has revealed the lack of a consistent approach. Out of the sixteen respondents, seven declared being 'interested in the development of the wind power industry in their territory', four municipalities concluded they were 'not interested in the development of the wind power industry in their territory', and the remaining five communities admitted that they 'have not arrived at a decision in this matter'. The subsequent sections of the survey showed that six out of the sixteen municipalities had taken steps to prepare local spatial management plans under wind power investments or had already approved such plans. Noteworthy is the fact that declarations to accept the siting of a wind energy installation are encouraged by an actual interest expressed by a specific developer, and that such documents are officially passed by the local authorities usually after an investor has submitted an offer of a specific venture.

8. IMPLICATIONS FOR THE LANDSCAPE OF THE GREAT MASURIAN LAKES

When looking at a wind turbine as a form abstracted from the landscape, some distinguishing aesthetic and design features are attributable. The characteristic silhouette, the slender tower, the mutual proportions of the major construction

components (the tower, hub, rotor blades), the elaborate engineering detail and the colour make it a well-designed spatial form assessed in the categories of industrial design (Fiell and Fiell, 2006). A specific wind turbine constructed in a specific landscape situation enters in strong interactions with the surrounding space, profoundly affecting the landscape (Good, 2006). The principal components in the relationship between a wind farm and its environs are the height of a wind turbine, anthropogenic genesis and industrial connotation.

The landscape typical of the Great Masurian Lakes creates a cohesive unity, in which a unique synthesis of nature (lakes, forests) and man-shaped elements (human settlements, the hydrological system and farmland) is respected (Gadomska, 2012). An advent of an element which is new, alien and dominant in size may lead to the farfetched depreciation of this landscape (Klepinger, 2007). The Great Masurian Lakeland is about 1,730 km² in area (Kondracki, 2000). Relative to this surface size, the area visually affected by a single 150-metre high wind turbine which can extend over 18% of the area of the whole lake district (*Europejska Konwencja Krajobrazowa*, 2011). When several single wind turbines are raised across the region, the problem will reach a perceptible scale, meaning that a strong and culturally foreign dominant element will feature in the perception of the scenery. Any further escalation of the development of wind farms and the region may become dominated by their vast skylines.

Another distinguishing feature of the region is the high percentage of land covered by lakes (Kondracki, 2000). On the one hand, this is the characteristic that makes the region so attractive. On the other hand, it now functions as a catalyst of adverse landscape modifications, imminent should wind farms be constructed. The water table of a lake forms a convenient viewing foreground, ensuring a broad spectrum of long-distance observations of a wind turbine's tower and rotor (Böhm, 2006). Moreover, the sequence of macro-interiors created by the system of the Great Masurian Lakes multiplies scenery viewpoints, axes and planes that can potentially expose single wind turbines or silhouettes of wind farms as landscape dominant components.

A wind turbine standing on the leeward side of the Masurian lakes that constitute a navigable route (an optimal location owing to the prevailing north-westerly winds) will remain permanently visible in the viewing spectrum of an observer moving along the watercourse axis. At the assumed height of a turbine equal 150 m and its location about 500 m off the shoreline, the vertical angle of observation for particular lakes ranges between 10° from the narrow ribbon lake called Tałty down to 1° in the case of Śniardwy Lake, a moraine thaw water body (figure 3). Given the freedom of an observer sailing over the whole system of the lakes, the visibility range of wind turbines should be analyzed in parallel to the perspective of a person standing on the lake shore. The lake shoreline is an extremely attractive part of the landscape, where much of the tourist activities concentrates (sail-

ing marinas, camping sites, holiday homes, hotels etc.). The observational sphere delineated around the Great Masurian Lakes, according to the visibility distance of a 150-metre high wind turbine of 10 km (figure 3), will exceed 390,000 ha, which corresponds to 85% of the analyzed area. A more precise determination of the borders marking the visual impact of a wind turbine on the landscape will require a more detailed analytical method, for example one composed of the determination of a series of cross-sectional views perpendicular to the lake shoreline, including the hypsometry of the terrain as an aspect. The above sphere almost completely encompasses the geographical region known as the Great Masurian Lake District (figure 3), in which 75% of the total area has been given a status of protected land, mostly as protected landscape areas (Gadomska, 2011).

9. LEGAL FOUNDATIONS OF LANDSCAPE PROTECTION AND CURRENT STATE OF SPATIAL PLANNING IN THE ANALYZED AREA IN THE CONTEXT OF POTENTIAL WIND POWER DEVELOPMENT

According to the Act on Nature Protection of April 16, 2004, building civil engineering constructions and technical facilities, including wind power installations, is strictly prohibited in national parks and nature reserves. The Great Masurian Lake District does not contain any protected natural environments granted the status of a national park, while nature reserves cover a total area of 12.5 thousand ha, which equals 2.7% of the whole region (Gadomska, 2011). Other valuable examples of landscapes, with the legal status of a landscape park or protected landscape areas, do not exclude possible development projects in wind power generation. The Act on Nature Protection (*Ustawa*, 2004) states that a consent to such a venture depends among others on the results of an environmental impact assessment. With large areas of the Great Masurian Lake District being covered by some legal form of nature protection, including the Masurian Landscape Park with 53 thousand ha (*ca* 11% of the whole district) and protected landscape areas with a total of 285 thousand ha (*ca* 60% of the whole analyzed region), the cited provision of the Act on Nature Protection raises concerns that it may be impossible to elaborate a coherent, uniform policy to protect the unique local landscape against depreciation caused by enforced wind power development projects. It is worth underlining that an environmental impact assessment of a planned development treats landscape-related issues as just one of the aspects taken into consideration (*Ustawa*, 2008), but no way guarantees that professional landscape architects will be engaged in drawing up such a report.

Apart from the generally applicable law, legal regulations binding locally are particularly suited to give protection to landscapes. Any permission or prohibition to raise wind farms and turbines should be precisely stated in local spatial man-

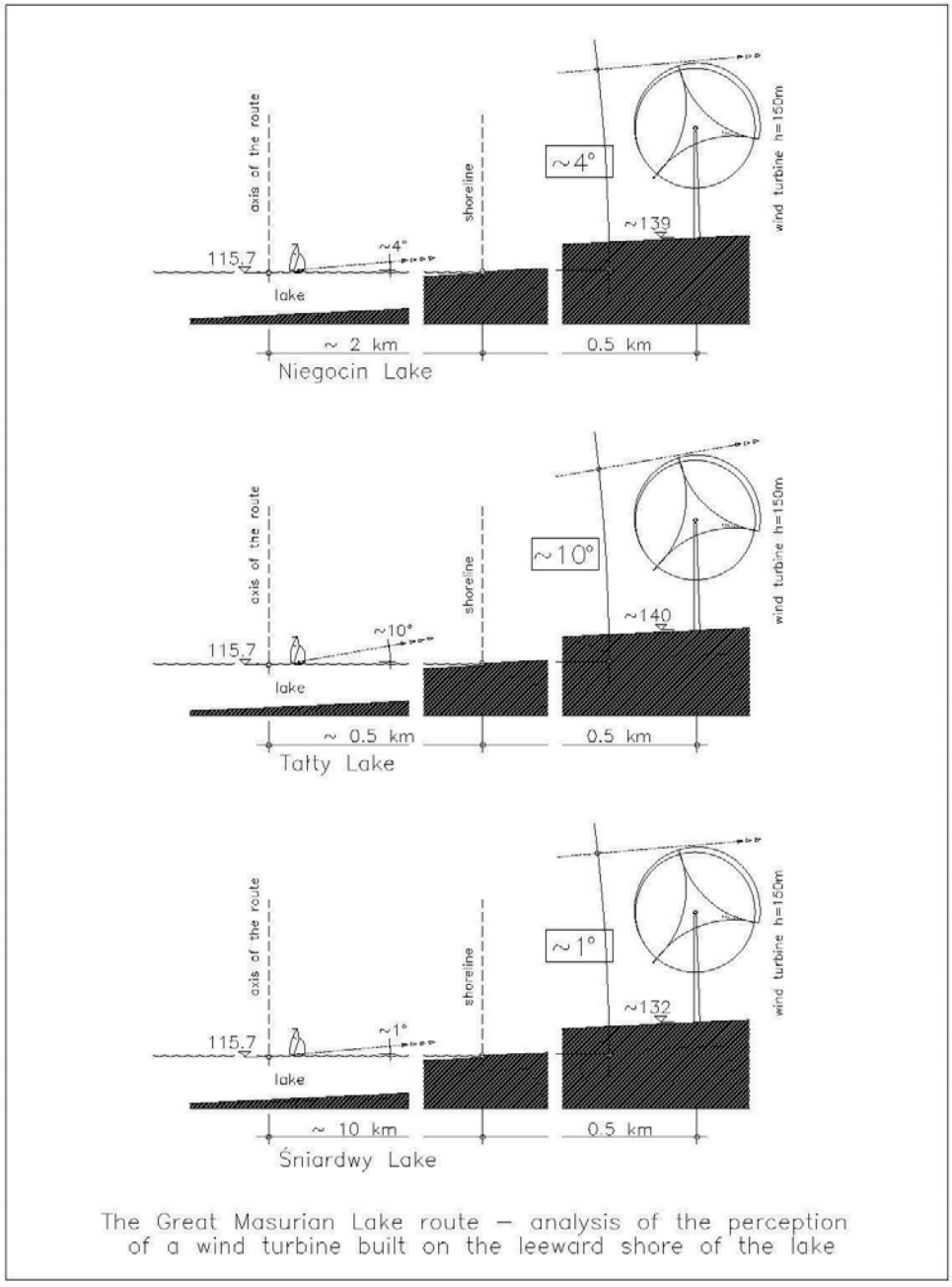

Fig. 4. The route of the Great Masurian Lakes – an analysis of the perception of a wind turbine standing on the leeward shore of a lake

Source: the co-author: W. Gadomska

agement plans, which are the foundation of the spatial management in a given community (*Ustawa*, 2003). Unfortunately, such plans cover a mere 3.55% of the whole region. Thus, the conservation, protection and management of valuable landscapes in the Great Masurian Lake District raise many concerns, not only because of a potential development of wind farms. Each municipality is obliged to work out a *Study on the Conditions*…, but the quality of these documents varies, which aggravates the situation. Although the *Study on the Conditions*…. is not an act of local law, its provisions defining the directions pursued in the spatial management within a given municipality are binding both at the stage of creating local spatial management plans and when issuing decisions on building conditions (*Wyrok*, 2009). It is very unfortunate that among the 16 examined municipalities, only six included in their *Studies* conditions directly related to the siting of wind farms in their territory (data from the survey). In the remaining cases, the question of wind power has not been mentioned. This can lead to a situation when lack of disagreement can be proven between a planned development project and the provisions of the relevant *Study*, which in turn gives grounds for commencing a procedure of passing a local spatial management plan or initiating an administrative process, which may result in issuing a consent for a development, which is otherwise perceived as questionable.

10. ANTICIPATION OF CONSEQUENCES FOR LANDSCAPE

The modest coverage of the analyzed region with local spatial management plans, in the context of wind power installations, creates a dual threat to the landscape. First, it is worrying that development projects are undertaken based on a *Decision of Building Conditions and Land Management*, passed in the absence of local spatial management plans, often burdened with consequences of a clerical 'independent decision-making' process (Böhm, 2006), or justly perceived in many aspects as a 'lower quality' planning instrument (Kolipiński, 2011). Another reason for concern is the selective, fragmentary creation of spatial management plans, tailored to specific investment plans (Böhm, 2006) and disregarding a broader spatial context. A plan thus prepared might be compliant with the formal requirements, but can easily transform into a tool for legalisation of a developer's expectations rather than a superior instrument for the imposition of spatial order in a whole municipality. Particularly worrying are the cases when decisions on building conditions or to create local spatial management plans are made in the context of planned wind power development projects, but the question of wind energy installations is completely neglected in the binding *Study on the Conditions*… (a situation demonstrated by the results of our survey).

The question discussed herein at the lowest level of the administrative division (a municipality) will cause problems felt on a macroscale, such as the whole region. Landscape-specific consequences of wrong location of wind farms and turbines will cross borders. For the successful landscape protection in the Great Masurian Lake District, all the municipalities involved must undertake consistent and coherent action. Least they can do is to establish an organisational framework and operational platform for such cooperation. The scale of the problem evidently surpasses the administrative borders of an individual municipality.

In view of the above, it is worth making a reference to the provisions of the Spatial Management Plan for the Province of Warmia and Masuria, which is higher in the hierarchy than documents regulating the spatial management policy of single municipalities. In the Plan drawn in 2002, the question of wind power is given marginal attention, for example chapter IV, which pertains to the policy of spatial management in the province, contains the following statement: 'localization of wind farms is acceptable in areas where they will not collide with landscape protection and nature protection' (*Plan*, 2002). Unfortunately, this statement is not developed any further in the document titled *The Problem Areas which Require Solutions and an Adequate Spatial Policy towards the Management of the Sailing Route of the Great Masurian Lakes.*

A framework algorithmic approach needs to be adopted to facilitate the anticipation of negative landscape-specific consequences evoked by the construction of wind farms and turbines in the province's areas endowed with priceless landscape resources. The first step ought to be the inclusion of the above issue in strategic documents, especially in the spatial management plan for the whole province. It is essential to indicate problem areas in the context of wind power development, also because of its predicted adverse impact on the landscape (*Ustawa*, 2004). The second step should be taken by individual municipalities, which need to update provisions of their *Studies on the Conditions*…, and find out how they correlate with the provincial plan as far as possible localisation of wind farms is concerned; this step does not exclude a possibility of indicating which sites are available for building wind farms. For particularly suitable sites, where negative landscape impact issues are few or absent, the municipalities could work out local spatial management plans including provisions designed to accommodate possible development projects. Having access to such plans would ensure that decisions about the number and height wind turbines as well as their exact siting are made on a sound foundation, respecting a broader landscape context of a given site (*Europejska Konwencja Krajobrazowa*, 2011). An offer thus prepared by a given municipality and addressed to developers, could be incorporated into the measures for the preservation of the municipality's sustainable development, in which the superior nature and landscape values are duly respected.

11. ANALYSIS OF THE IMPACT AND EFFECTS ON LANDSCAPE ASSESTS OF AREAS SET OUT FOR DEVELOPMENT OF WIND FARMS – GUIDELINES

An analysis of the impact and effects on landscape values of the areas planned to be developed under wind farms should be made as a supplement to the assessment on the environmental impact. When no such report is required, the mentioned analysis should be prepared as a separate document. The analysis should be made on each occasion, regardless of the land protection status of a given area. Below the mandatory scope of such an analysis is presented.

11.1. The Spatial and Temporal Scope

The space covered by the analysis should depend on such factors as land relief and cover, and needs to comprise an area over at least 10 km distant from planned turbines (at the height of a turbine equal 150 m). It is necessary to expand the analyzed area if, for example, the designed turbines are higher, there are historic buildings near the planned wind farm or there are long-distance viewing ranges. Ideally, the landscape analysis should be performed during the full vegetative growth of plants and when plants are leafless.

11.2. Characteristics of the Analyzed Area

The analysis must contain a section which shows the location of the analyzed area relative to the administrative division, physico-geographical division and existing forms of nature (landscape) protection. The presentation of the landscape's constituents and elements relies on the theory of landscape (urban) interior. The landscape macro-interiors distinguished within the analyzed area ought to be divided into the walls, floor, ceiling and free elements. Moreover, basic landscape components should be characterized such as land relief, vegetation cover and surface water bodies. Depending on the local conditions, the list might be lengthened. An adequately built, three-dimensional model is seen as an essential element of the said analysis. It can be created according to the existing NMT (figure 5). A 3-D model is extremely useful for illustrating viewing relations which occur within the analyzed area. The model should additionally include any viewing obstacles. Plant assemblages most often create such barriers, not just compact patches of woodland but also high crops (e.g. maize) on fields in the nearest vicinity of a viewing axis, or rudimentary vegetation growing along roads. The seasonal changeability of such plant systems is a significant question.

Another important component of the proposed analysis is the presentation of the current forms of nature (landscape) protection. The following need to be

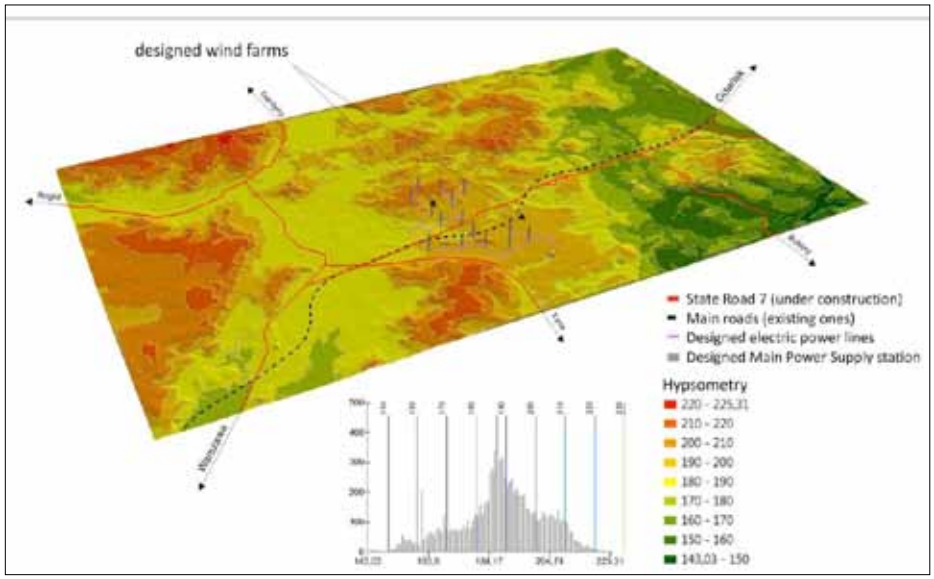

Fig. 5. An example – the siting of a planned complex of wind power turbines near the village of Frąknowo against the land relief (NMT)

Source: the co-author: M. Antolak

marked and briefly described: national parks, nature reserves, landscape parks, protected landscape areas, the Natura 2000 sites, monuments of nature, nature documentation sites, ecological utility areas and assemblages of natural and landscape resources. It is not obligatory to list protected plant, animal and fungal species. However, a presentation of nature (landscape) protection forms planned to be imposed within the analyzed area is an essential component of the analysis.

11.3. Analytical Stage

The stage when analyzes are actually performed is the key component of the document and must consist of the following sections:

- analysis of the landscape in the examined area;
- exposure of planned wind farms and turbines in the landscape;
- impact on the landscape and its consequences.

An optional part of the report could include an analysis of possible social conflicts due to the planned development.

The landscape analysis of the examined area ought to be composed of 4 primary categories: composition links, landscape interiors, distinguishing elements and exposure. The analysis should refer to the current state. The compositional links

that need to be marked out are both compositional and functional systems (compositional axes) as well as hub points. When more complex systems need to be analyzed, they can be subdivided into categories, depending on the impact power. Besides, it is necessary to determine viewing apertures and closures at the ends of viewing axes. Main landscape interiors must be distinguished, divided into types and described with respect to their shape, extent of wall filling and readability depending on the number of free standing elements inside each interior (Bogdanowski *et al*., 1981; Jerpåsen and Larsen, 2011). The distinguishing features should be identified as dominants, subdominants and cultural as well and natural highlights. Their influence on the landscape ought to be evaluated. Positive, negative and neutral objects must be identified. The final step would be to identify cases of active and passive exposure. Active exposure comprises such important elements as viewing series, apertures, axes and scenic viewpoints. Other essential elements which affect active exposure are lines directing the eyesight (but not playing the role of compositional axes). These are mainly rows of trees and shrubs growing between fields. They are a clear division between landscape interiors, which effectively attract the eyes of space users towards a specific direction. Elements of passive exposure marked out in the analyzed area should include all objects well seen from long distances. An additional component of this part of the report should consist of a division of the whole area into landscape units.

The exposure of planned wind farms in the landscape should be analyzed only in respect of sites with the highest scenery properties and the sites from which the landscape is most often observed. The analysis needs to include important routes, apertures, axes and scenic viewpoints, as well as point (surface) systems, such as rural and urban systems and traffic routes with the highest traffic flow. The analyzed systems must be divided into groups according to the predicted visibility of the planned wind farms. An important element associated with this type of analysis is detailed documentation of the landscape, including panoramic photographs and visualisations demonstrating planned changes to the scenery (Lothian, 2007; Horner *et al*., 2005). It should be made absolutely clear whether the planned wind farms will be seen from areas covered by legal nature protection, and whether they will be responsible for a certain loss of the landscape's harmony.

The impact on the landscape and its consequences. This section of the report should describe direct, indirect, secondary, accumulated, short-, medium- and long-term as well as permanent effects and transient ones, which occur only during the construction works, exploitation and liquidation of planned wind farms. The consequences of the analyzed development project on the landscape must also be presented.

Another important part of the report contains solutions proposed in order to mitigate or prevent the negative influence on the landscape. The current state of research and knowledge on the influence of the wind power industry on the landscape is insufficient and evidently some questions are left unanswered. There are very few sug-

gestions how to minimize the adverse effect of wind farms on the landscape or mitigate the people's negative attitude to such constructions (NWCC, 2006). One of the suggested methods is to build wind turbines of the same size on a single wind farm or even on a few adjacent farms. Another solution is to use the colours of the sky (tints of grey and blue) when painting wind turbine towers and blades. The white colour is particularly well seen from long distances, especially against the backdrop of the dark sky. A lessened impact on the landscape will also be produced if a wind farm chosen to be constructed will contain fewer but more powerful turbines.

One of the most effective measures limiting the negative influence on the landscape is through the proper landscaping of roadsides. A good selection of plants and an adequate shape of road banks can successfully alleviate the negative impact and limit the visibility of wind turbines from a road. It is equally important to skilfully form rows of trees and shrubs on fields in such a way as to create lines and frames that will lead the eye towards what seems to be the most valuable element in a given environment. Whenever a need arises due to other legal regulations (e.g. noise), sound barrier walls can be built along sections of roads, and these will additionally obscure a view of wind turbines.

The European Wind Energy Association recommends the following measures to minimize the negative impact of wind farms on landscape assets:

- ensuring the visual unity of a wind farm,
- avoiding fences inside a farm,
- minimizing the number of service roads between wind farms,
- using underground electric cables,
- limiting the number of service buildings,
- avoiding construction of wind farms on steep slopes,
- regular cleaning and maintenance of wind turbine towers and other elements of a wind farm, including its environs.

The results of studies on the perception of landscapes and suggested recommendations pertaining to the design and siting of wind farms are highly divergent. Questions connected to the impact of wind farms on the landscape require urgent work and research, which will bring more detailed answers and expand our knowledge in this area.

12. CONCLUSIONS

One of the major problems caused by the siting of wind energy installations in Poland is the marginal importance given to the landscape assets while planning such constructions. The principal organ in each province in Poland which approves new sits for developing wind farms is the Regional Directorate of Environment Protec-

tion. The directorate, however, does not ensure any guidance for analyzing the impact of wind farms on the landscape, and any possible remarks concerning the siting of a wind power installation are practically limited to the protection of avifauna and chiropterofauna. The current law allows anyone to prepare the relevant documentation, even persons who lack appropriate professional education and experience.

Currently, most of the wind energy installations are situated in narrow gaps between legally protected habitats. However, the landscape impact of such facilities does not stop on the border of a protected environment. The question of the development of wind farms in Poland urgently needs perfected legal regulations and elaboration of appropriate design and siting methods. This is particularly important in regions with attractive landscapes. The Great Masurian Lake District has become a valuable trade mark in the last years and is visited by increasing numbers of tourists. The main reason is its unique landscape assets, which should not be depreciated.

The Great Masurian Lake District may be subjected to pressure on behalf of developers interested in constructing wind farms. The correlation of suitable natural and anthropogenic factors versus the insufficiently effective nature and landscape protection legal tools could threaten the region's landscape-specific values.

Successful protection of the landscape of the Great Masurian Lakes in the context of potential development of wind energy installations requires that all the municipalities which compose the region should adopt a common policy. The landscape impact of constructing wind turbines will be perceptible from a perspective far exceeding the administrative borders of individual municipalities.

Above all, any potential development of wind energy in a given region, analyzed also in the context of landscape impact, should be included in strategic documents prepared at the provincial level – it is absolutely necessary to indicate areas which deserve special protection and spheres where such development projects must be excluded in the Plan of Spatial Management of the Province.

Detailed conditions governing the siting of wind farms should originate from reports which analyze the impact and consequences for the landscape assets caused by designed wind installations, prepared individually for each of the development plans.

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