Wind Farm in Open Landscape

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Abstract

Wind farms are the result of the needs related to the production of renewable energy. They are composed of many wind turbines, which are characterized by a considerable size. It is associated with power plant efficiency and profitability of the investment. For this reason, wind farms are located in open areas, often on the hills, near seas and lakes, away from building. The height of tower of power plant, spread of the rotor blades and a large number of power plants, measurably affect on the landscape. It constitutes a clear dominant in the landscape, rebuilding the existing understanding of the term "dominant" in the open landscape. Wind farms predominate in landscape, are visible from many miles before the farm. In addition wind farms affect the reading and understanding of a wide panorama viewing behind farm. Often it is a protected area, which has not only special environmental value, but also the landscape value. The article describes the interaction of location, size and visual impact of a wind farm, in the aspect of landscape “background”, which is protected by environmental areas (national parks, landscape parks).

Key words: *landscape architecture, environmental protection, renewable energy, wind farm.*

Introduction

Energy from wind is now one of the most attractive sources of renewable energy. Wind turbines are increasingly greater efficiency and systematically growing interest in building wind farms. The first wind farms were built since 80’s of the twentieth century, now leaders in the production of energy from wind are the U.S., China, Australia, Spain, Germany, Denmark (Pasqualetti 2002, AusWEA i ACNT 2004, Flaga 2008,Yuanchang, Zhi i Sha 2011). At the turn of the XX and XXI century started the construction of large wind farms in Poland (PWE 2011, Malczyk, 2013). They are located at three zones: northern, central and southern [Kondracki 2000] (Fig. 1). Most farms are in the northern part, where prevail the best wind conditions. In addition, the terrain is mostly flat with a height of from 0m to about 100m above sea level. In the central area height of wind turbines fluctuates from about 150m to about 250 meters above sea level. However, the southern areas are mountainous and very attractive to the location of wind farms, because in these areas and at higher altitudes, there are strong and intense winds. The height of power plant location and its considerable size (total height above 160m), affect particularly on good eco-energy efficiency investments. At the same time, it represents clear and unbeatable landscape dominant. This applies to the area even to 20 km from the power plant (location on the flat terrain) and more than 30 km (location on hilly terrain) (University of Newcastle 2002, Stryjecki and Mielniczuk 2011, Malczyk 2013). The area with particularly strong visual and aesthetic impact on the landscape is approximately 5–7 km from the wind turbines (Sullivan et al., 2011; Malczyk 2013a; Malczyk, 2013b). It occurs on the axis: the village – a wind farm, or road – wind farm, or observation point – wind farm. In contrast, equally important is the observation on axis: the point of observation – wind farm – horizon (landscape – background).

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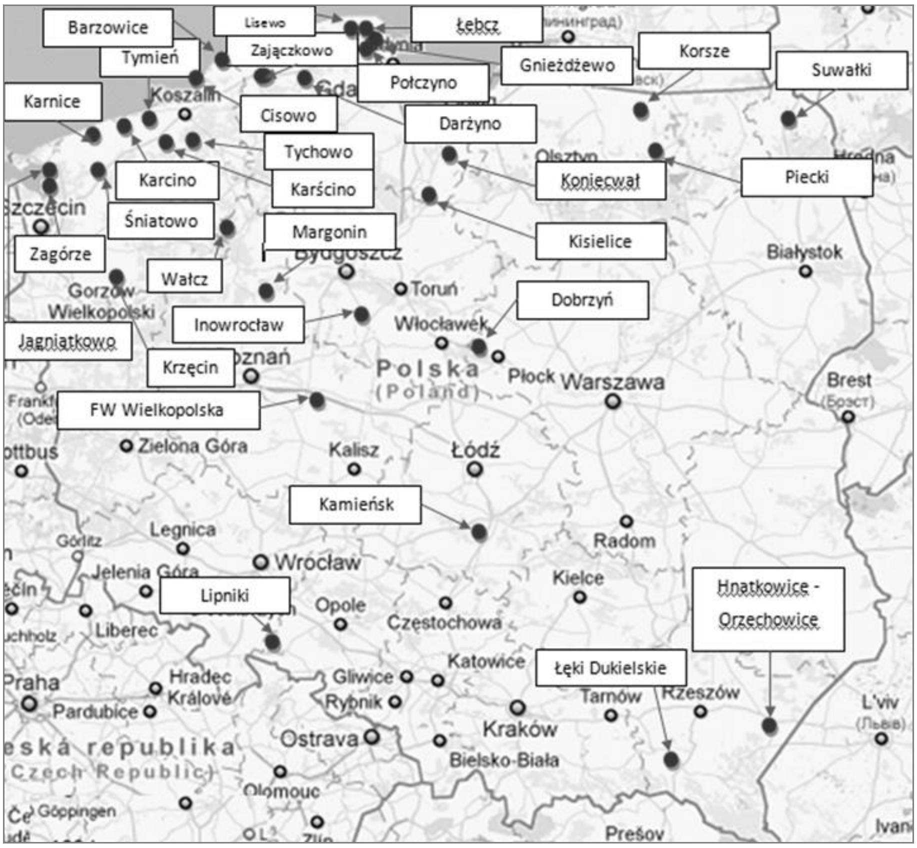

Fig. 1. *The typical location of selected wind farms in Poland. Own study*

This is crucial in noticing and defining the influence of wind farms on the values, which characterize the natural landscape panoramas. In most cases, these panoramas have natural and environmental forms. Repeatedly those areas are considered as particularly valuable and are covered by the various forms of environmental protection, such as: national park, landscape park, protected landscape area, etc. Created by nature and protected by man, they are not only natural national heritage, but also are part of the identity of the environmental and landscape space. Forms of nature protection are not only closed enclaves, whose main value is inside the area, but also scenic panoramas which are possible to capture (observations) from long distance (about 10–30 km) (Malczyk 2013). Wind farms, especially on mountainous areas, are standing on viewing axis: the observer – a form of nature conservation (landscape – background), which prevents freely observation of scenic natural panoramas. The aim of the study was to assess the impact of wind turbines on the landscape, particularly with regard to the background of landscape, which is composed of various forms of nature conservation (e.g. national park, landscape park).

Materials and methods

Research methods. Several research methods based on methodology of assessment of environmental and landscape values were used in the paper. These include: a) the Bajerowski matrix of values method that analyses the maps for the grid designation with defined values for the location of: farms, areas and geographical points (Bajerowski et al. 2007, Litwin, Bacior i Piech 2009), b) the Wejchert curve of sensations method, defining emotional experience, which observation result determined space at a given time (Senetra 2010), c) the method of Visual Impact Assessment (VIA), in terms of visual farms perception at different distances from the nature protection forms and analysis of photographic materials (Buchan 2002), d) the Viewpoints, definition of place of the profitable and representing specific conditions in a particular place

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(Horner & Maclennan, Envision 2006), e) the method of Visual Impact Evaluation Matrix (VIEM), in terms of buildings and wind farms location, the visibility of the wind farms from buildings areas, spatial layout of each wind turbines and their visibility from different angles (Hurtado, Fernandez, Parrondo i Blanco 2004).

At the first stage of the work there were made choice and location analysis of three wind farms, typical to southern area of Poland. Farms were created in mountainous areas at a distance of 40–50 km from the Poland and the Czech Republic border. At the next stage there were marked zones of wind farm locations, in terms of the visible nature conservation forms indicated on the visual interactions in the test area. At the last stage there was made analysis of the actual absorption of the landscape, associated with the location of wind farms. It was taken into account possible observation points of farm on the axis: the observation point – wind farm – horizon (landscape – background). At the same time, there is appointed the absorption field, described by wind turbines and their specific location in the aspect of visible background (horizon) nature conservation forms.

Characteristics of the research area. Research area includes two large wind farms located in the south-western part of Poland. These include Wind Farms: Modlikowice and Łukaszów, located on the border of Macroregions: Silesian-Lusatian Lowlands, Foothills of Western Sudetes and Mountanis of Western Sudetes, which include: Chojnowska Plain, Foothills and Mountains of Kaczawskie (Kondracki 2002) (Fig. 2). The height terrain under wind farms is between approx.190 to 210 m above sea level.

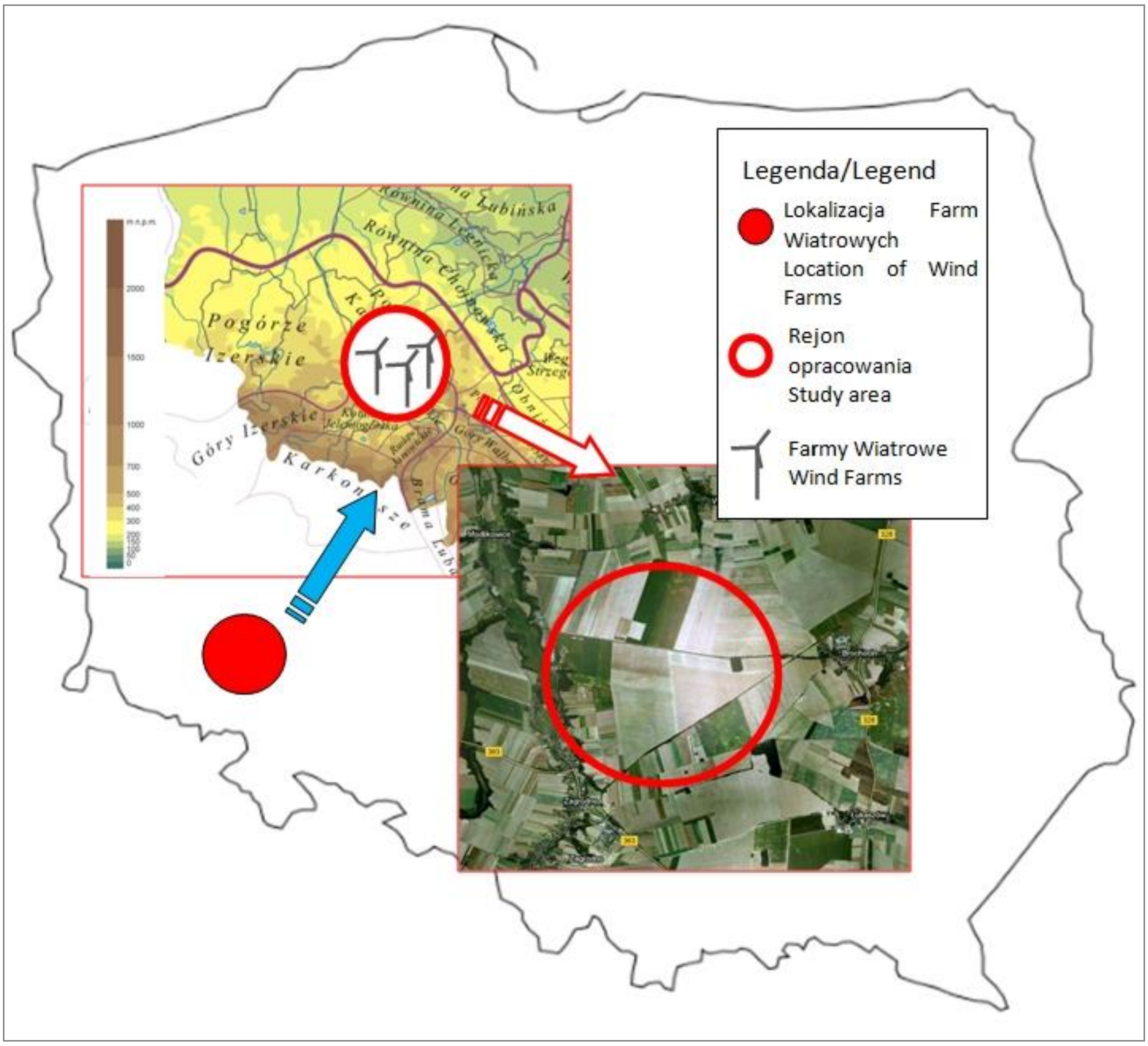

Fig. 2. *Location of the study area. Own study*

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Results and discussion

Wind Farms: Łukaszów and Modlikowice are in the province of Lower Silesia, District Złotoryja, Commune Zagrodno. The area designated for farms, extends from the village Modlikowice (north-west), Brochocin (north-east) and New Countryside Złotoryjska (south). Farms encompassed by study, were built in 2011 and consist of 12 wind turbines with a total capacity of 24 MW (Wind Farm Modlikowice) and 17 wind turbines with a total capacity of 34 MW (Wind Farm Łukaszów). The total power of this group of wind turbines is 58 MW. The area in which wind farms are surveyed is particularly attractive for such investments. It is associated with a large open area belonging to Chojnowska Plain, extending from Legnica Plain (north side) to Kaczawskie Foothills (south side) and the Izerskie Foothills (west side) to the Wałbrzyskie Foothills (east side). A particular advantage of this location is a large open area with low roughness class. This allows maintaining a large force of wind, which prevails in that region (western direction) (Zathey et al., 2010). Ultimately, this area will be filled with more wind farms.

Placing wind farms in open areas is a normal and scientifically proven procedure of effectiveness of individual wind turbines, which are reflected into a large efficiency and gaining of renewable energy. On the other hand, the lack of high greenery terrains, buildings and other significant natural barriers, makes wind farms very well visible from a considerable distance (reaching up to 30 km) (Sullivan et al., 2011). Farms consist of wind turbines with tower high at 105 meters and a rotor diameter at 90m. Scientific studies often assess the impact of wind farms in relation to the distance from wind farm. It determines the greatest impact of viewing zones, which include areas with a radius of 3, 5, 7, 10, 15 and 20 km (University of Newcastle 2002; Stryjecki i Mielniczuk 2011; Sullivan et al., 2011; Malczyk 2013). The assessment is on the axis: observer – wind farm. The reports, which assessing the impact of wind farms on the landscape, often assess this issue (ROONŚ 2007, ROONŚ 2011).

In contrast, there should be also assessed the relationship on the axis: observer – wind farm – horizon (panorama viewing – background) (Malczyk, 2013). This is particularly important, when the background has various of environmental protection forms, such as national parks, landscape parks, protected landscape areas. They are sources of nature and landscape of high values within the area (e.g. inside area of national park), but also beyond their borders. Especially, when they are on highlands, foothills and mountains areas and are recognizable element of the panorama view, which defines the identity of the place (Marx 1964; Tuan 1974; Pippos 2005; Malczyk 2013). This makes them highly visible from a distance of even 40 km.

This is in case of analysed wind farms (Fig. 3). At a distance of 13 – 20 km from the farm there are two landscape parks (Bóbr Valley Landscape Park, south-west side and Chełmy Landscape Park, south side). Next protected areas are in the south side, at a distance of 35 km (Rudawski Landscape Park) and 45 km (south-eastern side) Księżański Landscape Park.

On the border line, 45 km from wind farm in the south-west, there is the Karkonosze National Park. Landscapes parks are clearly visible due to their location, because extend to the foothills and mountains.

The paper selected three main directions of observation, which define the line of vision of different distances in relation to the farm (Fig. 4). The west-south direction No. I (length of about 13 km from the observation point). The south-west direction No. II (length of about 15-20 km from the observation point), and the south direction No. III (length of about 20-30 km).

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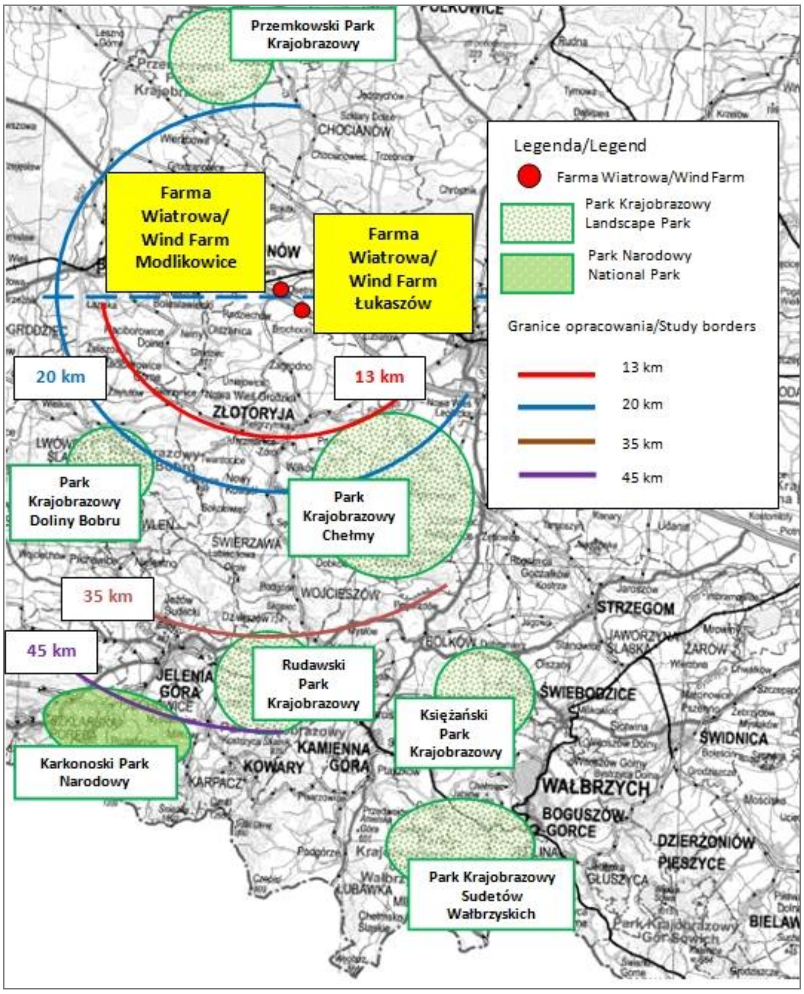

Fig. 3. *Relationships between location of wind farms and conservation areas. Own study*

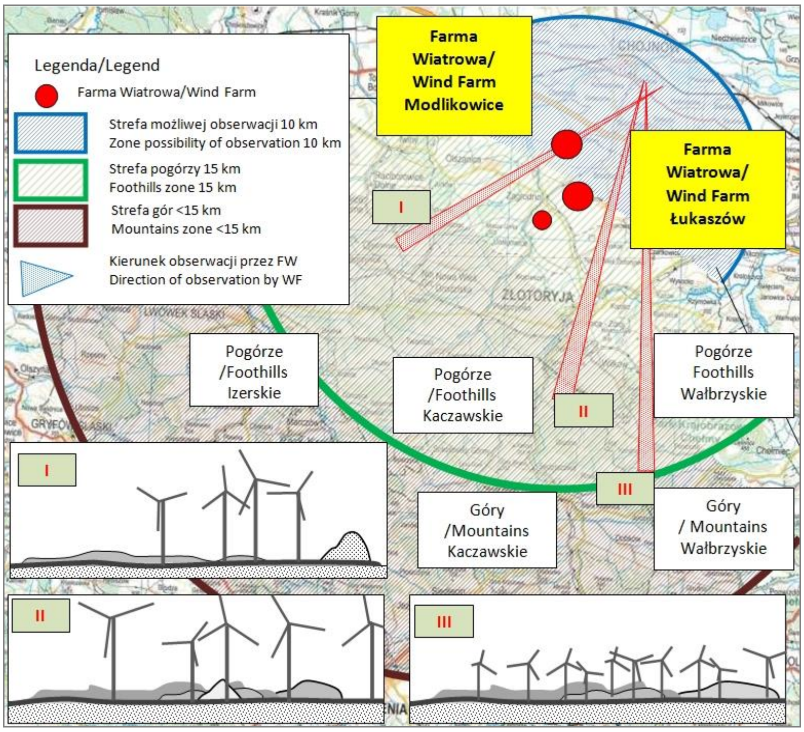

Fig. 4. *Observation point and silhouettes in selected directions (I, II, III). Own study*

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The analyses indicate a high correlation between: distance, wind turbines layout at the area of wind farm, as well as the height of location of nature protection forms and landscape, which are a natural background for wind farms (Fig. 5). The proportions of height of wind turbines and the ridge line of foothills and mountains (background) make farms becoming significant dominant features in landscape. Dominants "divide" the scenic panorama and measurably interfere with the perception of the whole landscape background. It changes existing views, which determined the identity of the place. The further there is visible background – the more farms dominate. In contrast, the higher hill in the background of landscape, the smaller negative interaction between farms – background.

Another aspect is the movement of wind turbines rotor, which intensifies visual activity of the wind farm. Accumulation of the rotation of all individual wind turbines leads to the occurrence of the absorption of landscape field (Peeters et al. 2001). It's virtual determinant, but visible, real visual impact fields of wind farms (Fig. 5). This phenomenon is particularly visible, when assessing the impact of wind farms in areas with mountainous background (figs. 6 and 7) (LUC 2010, Malczyk, 2013). Wind turbines are usually in motion with variable dynamics. This concerns the movement of the rotor blades, own rotor rotation and changes the tower colour (as a result of changes in intensity of solar radiation on sunny or cloudy days) (Gripe 2002, Malczyk 2013).

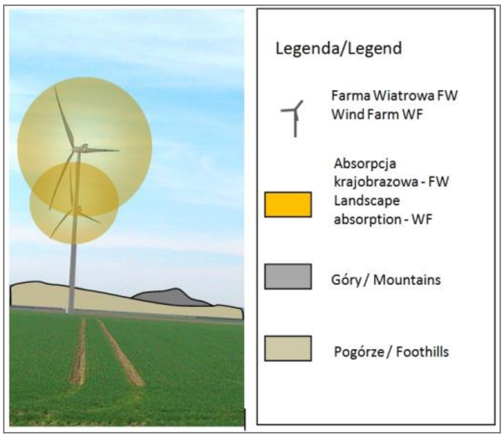

Fig. 5. *Landscape absorption in the direction No I. Own study*

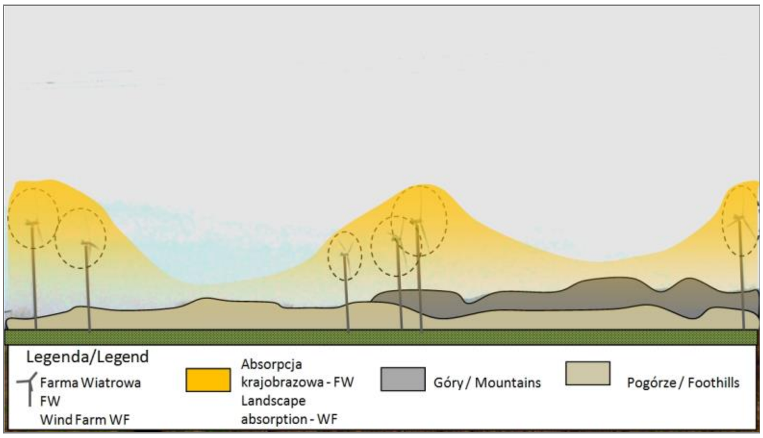

Fig. 6. *Landscape absorption in the direction No II. Own study*

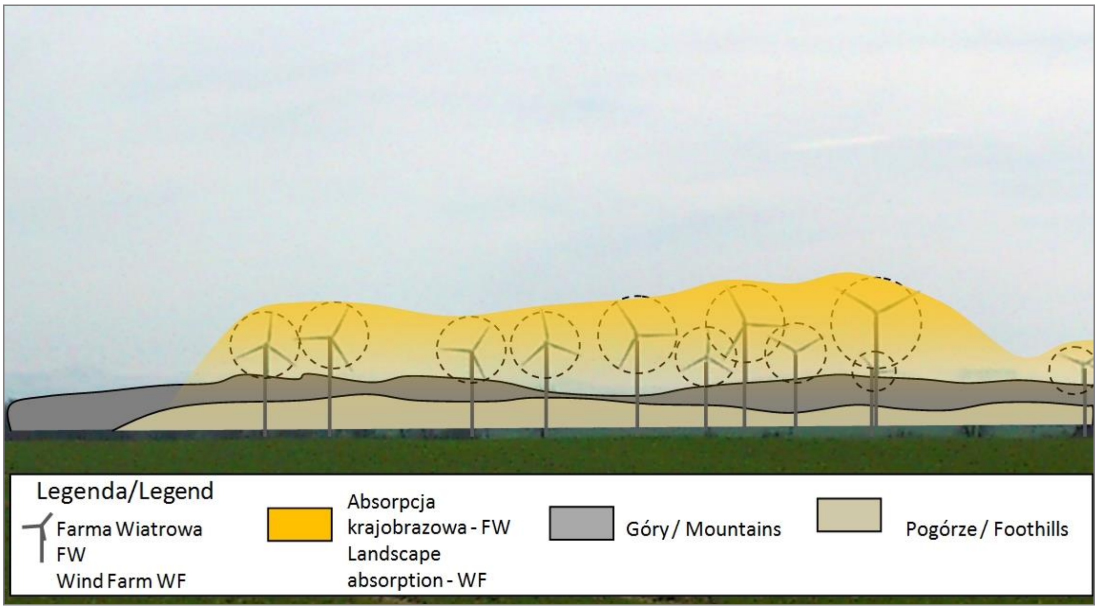

Fig. 7. *Landscape absorption in the direction No III. Own study*

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Conclusions

1. Wind farms are significant dominant features in open landscape.
2. When assessing the impact of wind farms on the landscape, there should be assessed interactions between the distance from the observer to farms and from farms to the background (landscape), especially if it is the viewing panorama with large nature and landscape values.
3. In the present case, wind farms measurably affect on assessment of impact of wind farms on the landscape (viewing panorama).
4. When locating the wind farms there should be made an expert evaluation of distance between wind farms and various forms of nature and landscape conservation, which can be observed by users and residents, especially when they concern with national parks, landscape parks, protected landscape areas, etc.
5. There should be taken special care to preserve the natural viewing panorama (landscape background), especially when it represents the identity of a place, with which residents are identified.

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