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Analysis of Visal Impacts

Construction of a wind farm in the area of Dębsk - Zielona in Żuromin i Kuczbork-Osada communes, Mazowieckie voivodeshio

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Assotiations and organizations

The analysis of the impact of light phenomena of the undertaking relying on the construction of the wind farm in the region of Dębsk-Zielona, the communes of Żuromin and Kuczbork-Osada, the Masovian Voivodeship

Made in accordance with Article 66 of the act of 3 October 2008 *on access to information on environment and its protection, public participation in environment protection and assessments of impact on environment* [i.e. Journal of Laws of 2013, item 1235], in particular including data:

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1. INTRODUCTION

The following study includes in its scope an issue concerning an effect of light phenomena of an undertaking relying on building a wind farm in the region of Dębsk - Zielona in the commune of Żuromin, the Masovian Voivodeship. Within the framework of the undertaking it is planned to build 57 wind turbine generators, each with a capacity of 3 MW, with a rotor diameter of about 112m and the height of about 120m. The Vestas V112 turbine, with a capacity 0f 3MW, a rotor diameter of 112m and the tower height of 119m has been adopted as a reference turbine.

In particular, in the following study the scope of an effect of the designed wind farm along with the accompanying infrastructure has been defined:

- concerning the stroboscopic effect,
- concerning the shadow flicker effect.

Based on European experience there have been discussed acceptable values defining the shadow flicker effect and critical values, considered as safe, in reference to the stroboscopic effect.

2. NON-TECHNICAL SUMMARY

The designed wind power plant along with the accompanying infrastructure will be located in an area of the commune of Żuromin, in the Masovian Voivodeship.

The functioning of wind power plants involves two light effects. The first one is the so-called stroboscopic effect (called also as a discotheque effect) relying on cyclical, intensive reflections of sun's rays against moving rotors of a power plant. Under unfavorable topographic conditions, when sun rays are reflected toward residential buildings, sudden and intensive reflections of frequency above 2,5Hz may be a source of epilepsy attacks in persons sensitive to such effects. The phenomenon is similar to that taking place while using stroboscopic lamps in entertainment establishments or to the phenomenon taking place while watching TV broadcast with the use of traditional tubes. The phenomenon is particularly visible in case of using turbines of relatively low capacities (below 500kW), where the rotation speed of blades is above 50 rotations per minute. In case of the designed WTG, its rotation speed is within the range from 12,8 rotations per minute to 15,3 rotations per minute. It makes that a frequency of potential reflections is below 1Hz. Furthermore, blades are covered with appropriate matt layers which eliminate a possibility of sun's ray reflections. It makes that the designed wind power plant will not cause a stroboscopic effect and consequently will not pose a threat in that scope.

The second often met light effect, accompanying the work of wind power plants, is the so-called shadow flicker effect. It relies on cyclical obscuring sun's rays by rotating blades, which causes that the moving shadow appears. Despite of lack of research in that scope, the effect is often defined by the residents from areas located in the neighborhood of wind power plants as oppressive and causing irritation. However, the national legislation lacks any regulations in that scope. Thus the present documentation uses German guidelines. To mark out zones of potential impact of the power plant as far as a shadow flicker effect is concerned, the dedicated WindPro 2.8 with the SHADOW module has been used. The acceptable values, proposed in German guidelines, have been referred to the results of calculations in computational points localized on elevations of the nearest residential buildings situated in the neighborhood of the designed power plant. It has been stated after analyzing the calculations that the designed power plant will not be oppressive in that scope. The calculations have been made in 2 variants:

1. **For the worst-case scenario that may theoretically appear**, that is, in case when the sun shines directly in the whole period from rise to set with the cloudless sky, the blades surface is set vertically against sun's rays and the power plant works with nominal power, thus with maximum possible throughout the whole year (the so-called astronomically potential maximum shading time),
2. **For the real scenario**, that is, in case when shading time is calculated taking into account statistical atmospheric conditions found in a given region. Lon-term meteorological data from state meteorological services (the so-called meteorologically probable length of shading time) are the basis of those calculations.

The calculations for the first theoretical scenario indicate that in part of computational points, marked by buildings in the neighborhood of the wind farm, the time of shadow flicker effect may exceed. It is related to low-density housing characteristic of that region.

However, the calculations made for the second real scenario do not indicate that acceptable values, according to German guidelines, that is 30 minutes per day and 30 hours per year have been exceeded.

3. LIST OF USED FORMAL-LEGAL MATERIALS, ARCHIVAL DOCUMENTATION AND REFERNCES

3.1. Formal-legal materials

[1] The Convention of 25 June 1998 on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (The Aarhus Convention) ratified by the act of 21 June 2001 on the ratification of The Convention of 25 June 1998 on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters [Journal of Laws, no. 89, item 970]

[2] Council Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment

[3] Council Directive 97/11*/EC of* 3 March 1997 amending Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment

3.2. Archival documentation and program-spatial concepts

[4] The construction of one wind power plant of a 4,5 capacity, of the maximum height up to 190 m along with accompanying infrastructure and an electric medium-voltage connector and a telecommunications connector; lot no. 16/4 within the area of the town of Redecz Kalny, commune Lubraniec. Information Chart of the Undertaking.

[5] The acoustic characteristic of Vestas turbines, materials available within the WindPro packet

[6] The acoustic characteristic of Gamesa turbines, materials available within the WindPro packet

[7] The guidelines on forecasting the effects of wind farms on the environment, GDOŚ, Warszawa, 2011.

3.3. References

[8] Praca zbiorowa, *Poradnik przeprowadzania ocen oddziaływania na środowisko,* Ekokonsult, Gdańsk, 1998

[9] Tomasz Żylicz, *Ekonomia środowiska i zasobów naturalnych,* Polskie Wydawnictwo Ekonomiczne, Warszawa, 2004

[10] Zbigniew Lubośny, *Elektrownie wiatrowe w systemie elektroenergetycznym*, Wydawnictwo Naukowo-Techniczne, Warszawa, 2006

[11] Witold M. Lewandowski, *Proekologiczne odnawialne źródła energii,* Wydawnictwo Naukowo-Techniczne, Warszawa, 2007

[12] Tomasz Boczar, *Energetyka wiatrowa – aktualne możliwości wykorzystania,* Wydawnictwo Pomiary Automatyka Kontrola, Warszawa, 2007

[13] Hinweise zur Ermittlung Und Beurteilung der optischen Immissionen von Windenergieanlagen (WEA-Schattenwurf-Hinweise), 13.03.2002

4. DESCRIPTION OF THE PLANNED UNDERTAKING AND ANALYZED VARIANTS

The designed undertaking relies on constructing a wind farm in the region of Dębsk – Zielona, Żuromin Commune, the Masovian Voivodeship. Within the framework of the undertaking 57 WTGs, each with a capacity of 3 MW, are planned to be constructed.

The basic parameters of the designed WTG are as follows:

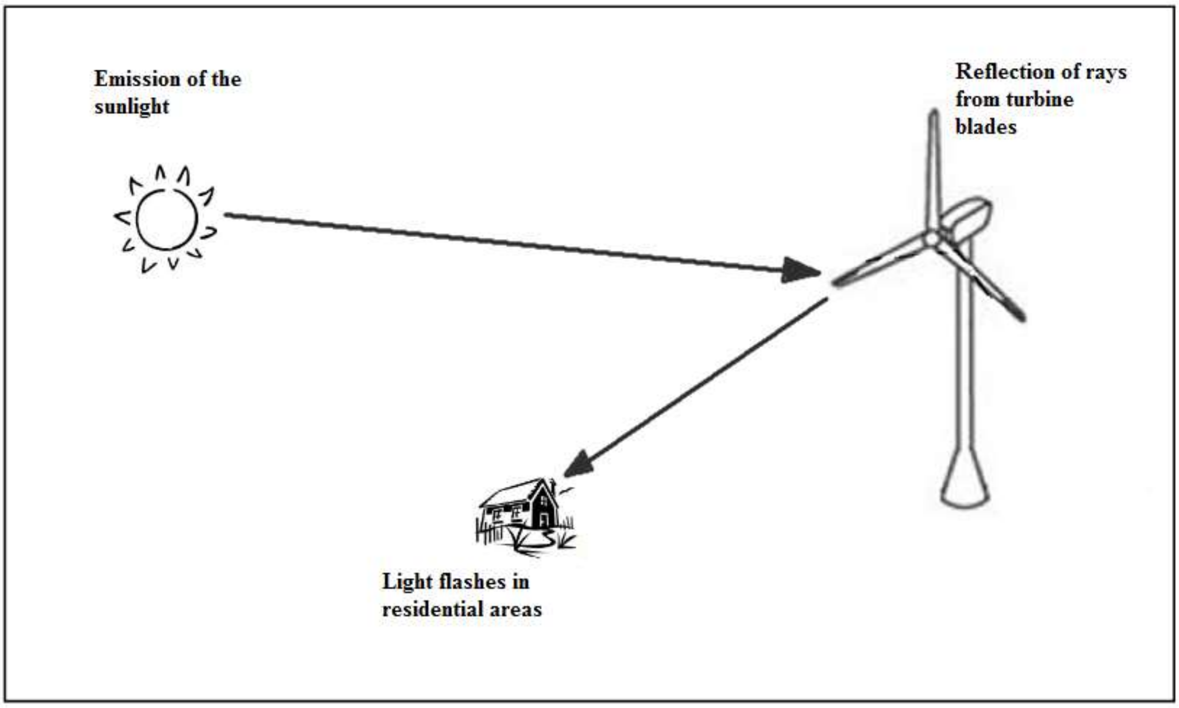
- the height of the tower (placing the nacelle) about 120m above the ground.
- The tower height with the rotor up to176 m above the ground.
- The rotor diameter about 112 m,
- The foundation surface will constitute a circle with a maximum diameter up to 30 m.

The Vestas V112 turbine, with a capacity of 3MW, a rotor diameter of 112m and the tower height of 119m has been adopted as a reference turbine.

Within the frameworks of the undertaking 57 WTGs with the total capacity of 171MW are planned to be constructed. They are localized in the region of Zielona, Przyspa, Kuczbork Wieś, Kolonia Kuczbork, Sadowo, Kosewo, Kliczewo Małe, Kliczewo Duże, Olszewko, Wólka Kliczewska, Olszewo, Franciszkowo, Dębsk, Chamsk i Kolonia Chamsk.

5. ANALYSIS OF THE STROBOSCOPIC EFFECT

The stroboscopic effect has been presented in **DRAWING 1.**



Drawing 1. The stroboscopic effect

The stroboscopic effect, also known as „the discotheque effect", relies on the cyclical light reflection on the rotor blades. This phenomenon is dependent on the degree of the sheen of the surface of blades and the light reflectivity of the paint that was used to finish a blade. During the work of the power plant, rays of the light which fall on the blades of the rotor may be reflected, which under unfavorable topographical conditions may cause strong, cyclical flashes of light, directed toward buildings.

The research made by the British Epilepsy Association in 2009 found that the stroboscopic effect caused by wind turbines can be a nuisance to individuals if its frequency is higher than 2,5Hz. Such flashes, in susceptible individuals or those suffering from epilepsy can cause attacks. Such frequencies occur in case of turbines with relatively low power (under 500kW), where the rotational speed of the blades is more than 50 revolutions per minute (RPM).

In case of the designed wind turbine, the rotational speed of the blades of the rotor varies from 12, 8 RPM to 15, 3 RPM. Because of this speed, the frequency of the potential flashes ranges from 0.6Hz to 0.8Hz, therefore below the critical value. In addition, in order to eliminate this phenomenon, the special coatings are used on the blades, made of matt paints that do not cause any lights reflections. It is therefore recommended to use turbines with blades that are covered with translucent paints, e.g. RAL 7035-HR of matt levels of sheen.

Regardless of the applied coatings, the stroboscopic effect may also occur in case of the icing of the blades. Then, a layer of ice located on the blades can be a very good reflective surface. In this case, safeguards that are commonly used in such wind turbines are sufficient. In the case of icing, the laminar flow of the wind stream changes to a turbulent, resulting in the increased torsional-flexural vibrations. Diagnostic control systems used in wind turbines cause the automatic shutdown of the plant. Although this system was created in order to prevent damage to the turbine, also work well as protection against the stroboscopic effect occurring in periods of low air temperatures.

6. ANALYSIS OF THE SHADOW FLICKER EFFECT APPEARANCE

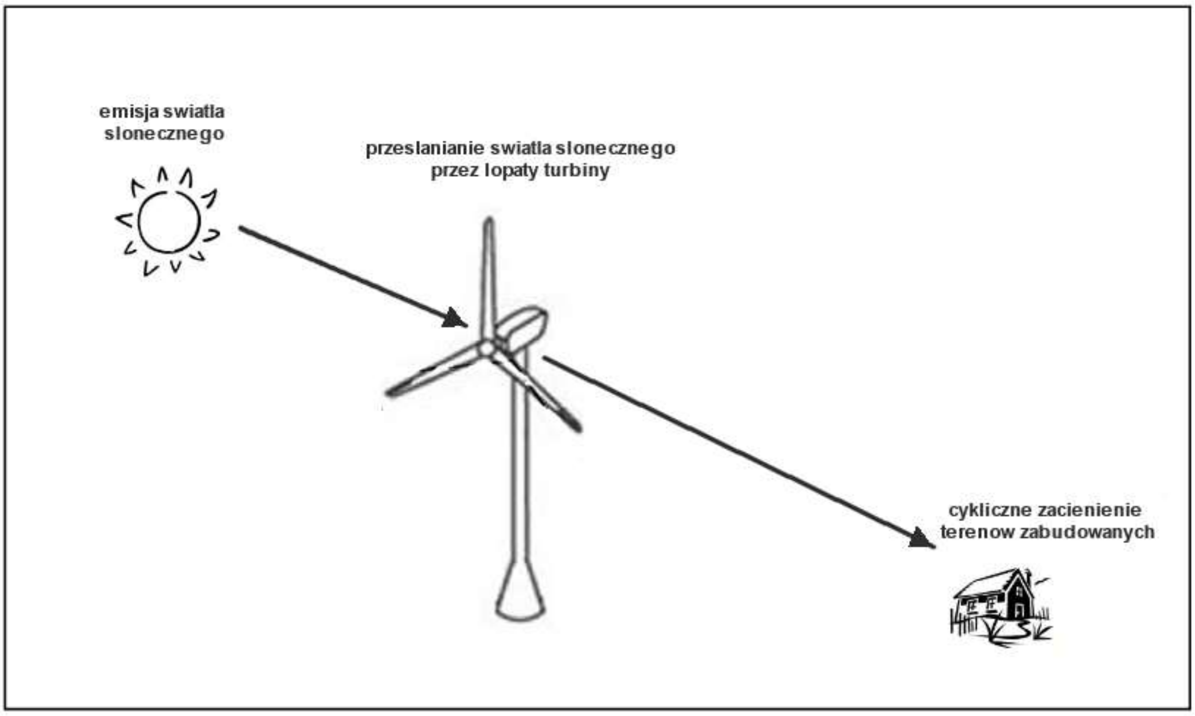
6.1. The shadow flicker effect

The shadow flicker effect relies on a cyclical shading of the sunlight by the moving turbine blades. The sun rays falling on the turbine are shaded, which causes that a dynamic shadow appears. The intensity of the effect, and in the process its perception by people, depends on several factors:

- the height of and diameter of the rotor
- distances of the observer from the wind farm - the further the residential areas are from the investment, the smaller is the effect of shadow flicker. It is assumed that the shadow flicker is not perceptible from a distance equal to 10 times the diameter of the rotor (in average from 400 - 800 meters),
- the season of the year,

- cloudiness - the greater the extent of cloudiness, the smaller the intensity of shadow flicker
- presence of trees between the wind turbine and the *observer* - trees and buildings existing between the WTG and the observation point significantly reduce the shadow flicker effect
- window exposition in buildings, which are in the shadow flicker zone
- light in the room - if a given room has an additional artificial lighting or light comes through a window, which is not in the zone of shadow flicker, the intensity of this effect may be significantly limited.

The shadow flicker effect is presented in **DRAWING 2.**



Drawing 2. The shadow flicker effect

The shadow flicker effect is related to the following terms defined in the German guidelines Hinweise zur Ermittlung Und Beurteilung der optischen Immissionen von Windenergieanlagen (WEA-Schattenwurf-Hinweise):

- temporary shading – a repeating obscuring of a perpendicular sun's ray through the WTG's blades. Shading is dependent on the weather conditions, the wind direction, the sun location and the work time of the power plant. The human eye perceives a difference in brightness if it is greater than 2,5%,

- shading area – area in which there is a temporary shading,

- astronomic potential maximum shading time (potentially the worst day_ - time during which the sun shines directly from rise to set by the cloudless sky, the surface of blades is set vertically to the sun's rays and the power plant works with a nominal output,
- factual shading time – really measured on the spot and the aggregated time of the impact of the shadow flicker effect. If the intensity of perpendicular insolation on the normal surface set perpendicularly to the direction of its falling is more than 120W/$m^{2,}$ the sunlight should be considered as tantamount with the shadow flicker effect,
- meteorologically probable length of shading time – time in which shading is calculated taking into account statistical atmospheric conditions. They are based on long-term meteorological data from state meteorological services.

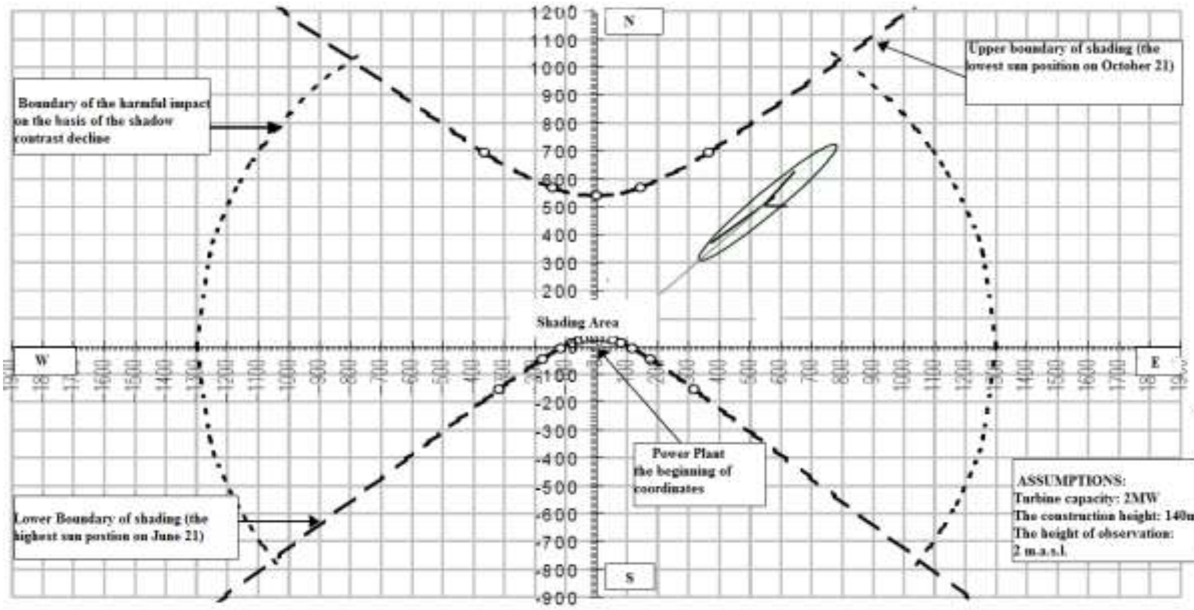
Observation points of shading caused by the work of wind turbines should be located within:

- rooms requiring protection that are used as:
- residential rooms, including corridors:
  - sleeping rooms, including sleeping halls in nigh shelters and rooms with beds in hospital and sanatoria
  - classrooms in schools and higher schools, training rooms and similar rooms for work.

- surfaces adjoining buildings outside (for example, terraces and balconies),

- unbuilt areas at the height of 2m above ground level in which it is permitted to build buildings with rooms which are subject to protection against the impact of the shading effect, based on the provisions of the local spatial planning.

The area that is subject to the impact of the shading effect is variable during the year. This is due to the different height of the sun above the horizon during the whole year. **The maximum range of the impact is therefore during the fall and spring**. Potential shading area of a big wind power plant (> 2 MW) is shown in **DRAWING 3**.



Drawing 3. Potential shading area of a big wind power plant

The remaining the shadow flicker effect directly affects the ability to concentrate and ability to perform works. Under the most unfavorable conditions, this phenomenon can lead to irritability

6.2. Acceptable values

National legislation and EU legislation do not contain any standards or guidelines, concerning the analysis of the impact of wind farms as far as the shadow flicker effect is concerned. There is no legal basis governing both acceptable values and methodology as a basis for this type of analyses. In this case it seems justifiable to use the experience of other European countries where the issue of shadow flicker has been recognized and found its reflection either in specific methodology of forecasting this effect or in the guidelines on acceptable values. For the purpose of this documentation the German experience has been used. It is the country which has many years of experience in the field of wind energy, including practical experience connected with operation of many wind farms. Furthermore, Germany's geographical position makes the general meteorological conditions similar to those occurring in Poland.

In accordance with the document called “Hinweise zur Ermittlung Und Beurteilung der optischen Immissionen von Windenergieanlagen (WEA-Schattenwurf-Hinweise)”, which is the basis for analyzing the shadow flicker in Germany, the indicator of the duration of shading should not exceed 30 hours per calendar year. The indicator of the duration of shading during the day should be maximum 30 minutes. The same values are used in many other European countries, although they are not regulated by law (e.g. Great Britain, France, and Holland).

6.3. Occurrence of the shadow flicker effect in case of the designed undertaking

In order to determine the scope and intensity of the impact of the designed wind power plant in relation to the shadow flicker effect, the German guidelines have been used, which are defined in the document "Hinweise zur Ermittlung Und Beurteilung der optischen Immissionen von Windenergieanlagen (WEA-Schattenwurf-Hinweise)".

The methodology of works connected with building a calculation model comprised the following assumptions:

- minimum height of the sun above the horizon: 3 º,
- the shadow flicker effect will occur when the rotor will shade at least 20% of the falling light,
- calculations of the impact of the shadow flicker effect were made at a height of 1.5 m above ground level,
- calculations of the impact of the shadow flicker effect were made for each day of the year separately, assume that each year has 365 days,
- calculation step was defined every 1 minute.

6.3.1. Meteorological data concerning insolation

One of the most essential elements of the calculation model is to define meteorological data concerning insolation. In the subject case there have been adopted average values from many years to central Poland confirmed by the analysis of maps of insolation for the whole territory of Poland made available by the Institute of Meteorology and Water Management (the material made available on www.imgw.pl). The tabulated statistical probability of insolation has been presented in the table below.

TABLE 1. Average daily insolation throughout the year

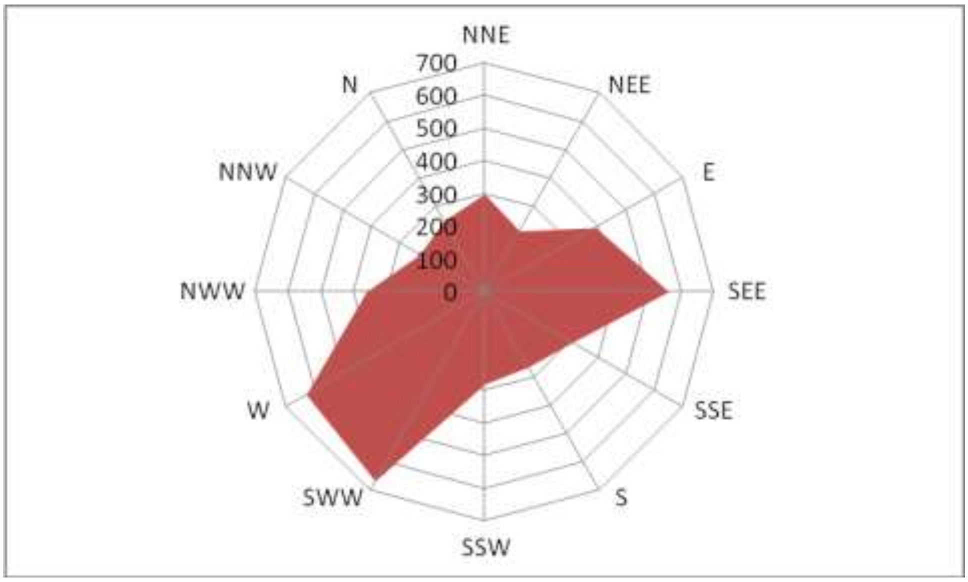
month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
hourly insolation during the day [h/day]	1,37	2,16	3,44	5,13	7,49	7,51	7,60	7,23	4,58	3,17	1,42	0,93

6.3.2 Meteorological data concerning states of the atmosphere

The second element of the calculation model is to define the frequency of the occurrence of particular winds. This value directly affects both, the work time of the wind turbines and the location of the rotor blades against the falling sun's rays. In that subject case the meteorological data coming from the research for the city of Toruń conducted for many years have been used. The distance between the designed wind power plant and the city of Toruń is about 80 km, which in case of meteorological phenomena (especially those coming from many years standing statistical research) is a small distance allowing successfully to apply the data. The tabulated meteorological data have been presented in the table below.

TABLE 2. Balance of atmosphere states

	Total	NNE	NEE	E	SEE	SSE	S	SSW	SWW	W	NWW	NNW	N
Total	%	7,05	5,46	7,96	10,85	7,01	7,41	7,69	14,46	12,89	8,12	5,42	5,67
1 m/s	26,86	2,10	1,71	1,90	2,22	1,88	2,31	2,45	3,63	3,11	2,28	1,52	1,74
2 m/s	22,16	1,54	1,32	1,59	2,20	1,58	2,05	2,01	3,21	2,58	1,71	1,30	1,08
3 m/s	18,45	1,33	0,94	1,43	1,97	1,4	1,43	1,44	2,64	2,38	1,49	0,99	1
4 m/s	12,65	0,85	0,7	1,06	1,52	0,95	0,8	0,88	1,92	1,62	1,01	0,66	0,69
5 m/s	9,11	0,66	0,37	0,82	1,22	0,64	0,47	0,42	1,34	1,36	0,75	0,47	0,57
6 m/s	4,52	0,28	0,21	0,49	0,63	0,26	0,19	0,24	0,72	0,69	0,36	0,17	0,27
7 m/s	3,12	0,17	0,13	0,33	0,51	0,16	0,1	0,17	0,5	0,52	0,23	0,14	0,17
8 m/s	1,64	0,07	0,07	0,16	0,29	0,08	0,03	0,05	0,26	0,26	0,17	0,11	0,09
9 m/s	0,69	0,02	0,01	0,09	0,12	0,02	0,01	0,01	0,14	0,15	0,04	0,04	0,03
10 m/s	0,53	0,02	0,01	0,06	0,11	0,02	0,01	0,01	0,08	0,12	0,04	0,02	0,02
>10 m/s	0,26	0,01	0	0,03	0,05	0,01	0	0,01	0,03	0,08	0,03	0	0,01



Drawing 4. The wind rose for the city of Toruń

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Because of the fact that the starting wind speed for wind turbines with a capacity of 3MW is 2.5m/s, duration of winds with lower speed was treated as a period of atmospheric silence occurrence.

6.3.3 Calculation points location

The calculation of the impact of the shadow flicker effect were conducted for 97 calculation points involving resident houses located in the zone of the potential impacts of the proposed wind power plant, in the nearest areas, i.e., Zielona, Przyspa, Kuczbork Wieś, Kolonia Kuczbork, Sadowo, Kosewo, Kliczewo Małe, Kliczewo Duże, Olszewko, Wólka Kliczewska, Olszewo, Franciszkowo, Dębsk, Chamsk and Kolonia Chamsk. The location of calculation points was selected in such a way so that each of the points should represent the area of housing homogenous as to distances from the wind turbines and their localization toward the world directions.

The calculations, in accordance with the guidelines of the document Hinweise zur Ermittlung Und Beurteilung der optischen Immissionen von Windenergieanlagen (WEA-Schattenwurf-Hinweise) have been conducted each time at the height of 1,5m above ground level.

6.3.4 The results of calculation of shading in the calculation points

The calculations of shading have been conducted in 97 calculation points localized by resident buildings, existing in an area of the potential impact of the designed wind power plant. In accordance with the guidelines presented in Chapter 6.2 of this document, the results of those calculations have been referred to one day and to one year. In both cases there have been analyzed theoretical values (the worst-case scenario) and statistical values based on many years standing meteorological observation (the real scenario). The results of the calculations have been presented in tables below.

TABLE 3. Shading time for the period of one day – impact of the designed wind farm

	Calculation point localization	Theoretical astronomic length of the time of shading	Impact in real conditions (meteorological probable length of the time of shading)		
			Acceptable level of shading	Meteorological probable length of the time of shading	Exceeding the acceptable level
1	Zielona 01	0:18 h/day	**0:30 h/day**	**0:02 h/day**	---
2	Zielona 02	0:17 h/day	**0:30 h/day**	**0:02 h/day**	---
3	Zielona 03	0:11 h/day	**0:30 h/day**	**0:01 h/day**	---
4	Zielona 04	0:05 h/day	**0:30 h/day**	**0:00 h/day**	---
5	Przyspa 01	1:06 h/day	**0:30 h/day**	**0:07 h/day**	---
6	Przyspa 02	0:41 h/day	**0:30 h/day**	**0:04 h/day**	---
7	Kuczbork Wieś 01	0:44 h/day	**0:30 h/day**	**0:04 h/day**	---
8	Kuczbork Wieś 02	0:33 h/day	**0:30 h/day**	**0:03 h/day**	---
9	Kuczbork Wieś 03	0:45 h/day	**0:30 h/day**	**0:05 h/day**	---
10	Kuczbork Wieś 04	0:32 h/day	**0:30 h/day**	**0:03 h/day**	---
11	Kuczbork Wieś 05	0:32 h/day	**0:30 h/day**	**0:03 h/day**	---
12	Kuczbork Wieś 06	1:20 h/day	**0:30 h/day**	**0:08 h/day**	---
13	Kolonia Kuczbork 01	0:23 h/day	**0:30 h/day**	**0:02 h/day**	---
14	Sadowo 01	0:31 h/day	**0:30 h/day**	**0:03 h/day**	---
15	Sadowo 02	0:55 h/day	**0:30 h/day**	**0:06 h/day**	---
16	Sadowo 03	0:26 h/day	**0:30 h/day**	**0:03 h/day**	---
17	Sadowo 04	0:29 h/day	**0:30 h/day**	**0:03 h/day**	---
18	Sadowo 05	0:20 h/day	**0:30 h/day**	**0:02 h/day**	---

19	Kosewo 01	0:35 h/day	**0:30 h/day**	**0:04 h/day**	---
20	Kosewo 02	0:43 h/day	**0:30 h/day**	**0:04 h/day**	---
21	Kosewo 03	0:37 h/day	**0:30 h/day**	**0:04 h/day**	---
22	Kosewo 04	0:23 h/day	**0:30 h/day**	**0:02 h/day**	---
23	Kliczewo Małe 01	0:00 h/day	**0:30 h/day**	**0:00 h/day**	---
24	Kliczewo Małe 02	0:00 h/day	**0:30 h/day**	**0:00 h/day**	---
25	Kliczewo Małe 03	0:00 h/day	**0:30 h/day**	**0:00 h/day**	---
26	Kliczewo Małe 04	0:00 h/day	**0:30 h/day**	**0:00 h/day**	---
27	Kliczewo Małe 05	0:00 h/day	**0:30 h/day**	**0:00 h/day**	---
28	Kliczewo Małe 06	0:27 h/day	**0:30 h/day**	**0:03 h/day**	---
29	Olszewko 01	0:38 h/day	**0:30 h/day**	**0:04 h/day**	---
30	Olszewko 02	0:20 h/day	**0:30 h/day**	**0:02 h/day**	---
31	Olszewko 03	0:22 h/day	**0:30 h/day**	**0:02 h/day**	---
32	Olszewko 04	0:22 h/day	**0:30 h/day**	**0:02 h/day**	---
33	Olszewko 05	0:23 h/day	**0:30 h/day**	**0:02 h/day**	---
34	Olszewko 06	0:23 h/day	**0:30 h/day**	**0:02 h/day**	---
35	Olszewko 07	0:19 h/day	**0:30 h/day**	**0:02 h/day**	---
36	Olszewko 08	0:16 h/day	**0:30 h/day**	**0:02 h/day**	---
37	Kliczewo Duże 01	2:05 h/day	**0:30 h/day**	**0:13 h/day**	---
38	Kliczewo Duże 02	1:09 h/day	**0:30 h/day**	**0:07 h/day**	---
39	Kliczewo Duże 03	1:06 h/day	**0:30 h/day**	**0:07 h/day**	---
40	Kliczewo Duże 04	1:04 h/day	**0:30 h/day**	**0:06 h/day**	---
41	Kliczewo Duże 05	1:00 h/day	**0:30 h/day**	**0:06 h/day**	---
42	Kliczewo Duże 06	0:50 h/day	**0:30 h/day**	**0:05 h/day**	---
43	Kliczewo Duże 07	0:47 h/day	**0:30 h/day**	**0:05 h/day**	---
44	Wólka Kliczewska 01	0:34 h/day	**0:30 h/day**	**0:03 h/day**	---
45	Wólka Kliczewska 02	0:42 h/day	**0:30 h/day**	**0:04 h/day**	---
46	Wólka Kliczewska 03	0:48 h/day	**0:30 h/day**	**0:05 h/day**	---
47	Wólka Kliczewska 04	0:49 h/day	**0:30 h/day**	**0:05 h/day**	---
48	Wólka Kliczewska 05	0:21 h/day	**0:30 h/day**	**0:02 h/day**	---
49	Olszewo 01	1:54 h/day	**0:30 h/day**	**0:12 h/day**	---
50	Olszewo 02	1:08 h/day	**0:30 h/day**	**0:07 h/day**	---
51	Olszewo 03	1:13 h/day	**0:30 h/day**	**0:08 h/day**	---
52	Olszewo 04	1:29 h/day	**0:30 h/day**	**0:09 h/day**	---
53	Olszewo 05	1:30 h/day	**0:30 h/day**	**0:09 h/day**	---
54	Olszewo 06	0:57 h/day	**0:30 h/day**	**0:6 h/day**	---
55	Olszewo 07	1:05 h/day	**0:30 h/day**	**0:07 h/day**	---

56	Franciszkowo 01	0:24 h/day	**0:30 h/day**	**0:02 h/day**	---
57	Franciszkowo 02	0:26 h/day	**0:30 h/day**	**0:03 h/day**	---
58	Franciszkowo 03	0:28 h/day	**0:30 h/day**	**0:03 h/day**	---
59	Franciszkowo 04	0:29 h/day	**0:30 h/day**	**0:03 h/day**	---
60	Franciszkowo 05	0:36 h/day	**0:30 h/day**	**0:04 h/day**	---
61	Franciszkowo 06	0:38 h/day	**0:30 h/day**	**0:04 h/day**	---
62	Dębsk 01	0:35 h/day	**0:30 h/day**	**0:04 h/day**	---
63	Dębsk 02	0:38 h/day	**0:30 h/day**	**0:04 h/day**	---
64	Dębsk 03	0:28 h/day	**0:30 h/day**	**0:03 h/day**	---
65	Dębsk 04	0:29 h/day	**0:30 h/day**	**0:03 h/day**	---
66	Dębsk 05	1:07 h/day	**0:30 h/day**	**0:07 h/day**	---
67	Dębsk 06	1:14 h/day	**0:30 h/day**	**0:07 h/day**	---
68	Dębsk 07	0:44 h/day	**0:30 h/day**	**0:04 h/day**	---
69	Dębsk 08	0:42 h/day	**0:30 h/day**	**0:04 h/day**	---
70	Dębsk 09	0:30 h/day	**0:30 h/day**	**0:03 h/day**	---
71	Dębsk 10	0:39 h/day	**0:30 h/day**	**0:04 h/day**	---
72	Dębsk 11	0:44 h/day	**0:30 h/day**	**0:04 h/day**	---
73	Dębsk 12	0:27 h/day	**0:30 h/day**	**0:03 h/day**	---
74	Dębsk 13	0:26 h/day	**0:30 h/day**	**0:03 h/day**	---
75	Dębsk 14	0:25 h/day	**0:30 h/day**	**0:03 h/day**	---
76	Dębsk 15	0:08 h/day	**0:30 h/day**	**0:01 h/day**	---
77	Chamsk 01	0:33 h/day	**0:30 h/day**	**0:03 h/day**	---
78	Chamsk 02	0:28 h/day	**0:30 h/day**	**0:03 h/day**	---
79	Chamsk 03	0:30 h/day	**0:30 h/day**	**0:03 h/day**	---
80	Chamsk 04	0:44 h/day	**0:30 h/day**	**0:04 h/day**	---
81	Chamsk 05	0:36 h/day	**0:30 h/day**	**0:04 h/day**	---
82	Chamsk 06	0:30 h/day	**0:30 h/day**	**0:03 h/day**	---
83	Chamsk 07	0:29 h/day	**0:30 h/day**	**0:03 h/day**	---
84	Chamsk 08	0:45 h/day	**0:30 h/day**	**0:05 h/day**	---
85	Chamsk 09	1:09 h/day	**0:30 h/day**	**0:07 h/day**	---
86	Chamsk 10	0:37 h/day	**0:30 h/day**	**0:04 h/day**	---
87	Chamsk 11	0:35 h/day	**0:30 h/day**	**0:04 h/day**	---
88	Chamsk 12	0:33 h/day	**0:30 h/day**	**0:03 h/day**	---
89	Chamsk 13	0:27 h/day	**0:30 h/day**	**0:03 h/day**	---
90	Kolonia Chamsk 01	0:49 h/day	**0:30 h/day**	**0:05 h/day**	---
91	Kolonia Chamsk 02	0:31 h/day	**0:30 h/day**	**0:03 h/day**	---
92	Kolonia Chamsk 03	0:35 h/day	**0:30 h/day**	**0:04 h/day**	---

92	Kolonia Chamsk 04	0:41 h/day	**0:30 h/day**	**0:04 h/day**	---
94	Kolonia Chamsk 05	0:45 h/day	**0:30 h/day**	**0:05 h/day**	---
95	Kolonia Chamsk 06	0:25 h/day	**0:30 h/day**	**0:03 h/day**	---
95	Kolonia Chamsk 07	0:19 h/day	**0:30 h/day**	**0:02 h/day**	---
97	Kolonia Chamsk 08	0:22 h/day	**0:30 h/day**	**0:02 h/day**	---

TABLE 4. Shading time for the whole year – impact of the designed wind farm

	Calculation point localization	Theoretical astronomic length of shading time	Impact in real conditions (meteorological probable length of shading time)		
			Acceptable shading level	Meteorological probable length of shading time duration	Exceeding the acceptable level
1	Zielona 01	9:28 h/year	**30:00 h/year**	**0:57 h/ year**	---
2	Zielona 02	7:09 h/ year	**30:00 h/year**	**0:48 h/ year**	---
3	Zielona 03	2:23 h/ year	**30:00 h/year**	**0:04 h/ year**	---
4	Zielona 04	0:34 h/ year	**30:00 h/year**	**0:01 h/ year**	---
5	Przyspa 01	66:48 h/ year	**30:00 h/year**	**2:55 h/ year**	---
6	Przyspa 02	43:47 h/ year	**30:00 h/year**	**2:13 h/ year**	---
7	Kuczbork Wieś 01	35:44 h/year	**30:00 h/year**	**4:06 h/ year**	---
8	Kuczbork Wieś 02	45:48 h/year	**30:00 h/year**	**5:55 h/ year**	---
9	Kuczbork Wieś 03	76:28 h/year	**30:00 h/year**	**10:23 h/ year**	---
10	Kuczbork Wieś 04	48:20 h/year	**30:00 h/year**	**6:31 h/ year**	---
11	Kuczbork Wieś 05	71:44 h/year	**30:00 h/year**	**8:56 h/ year**	---
12	Kuczbork Wieś 06	131:22 h /year	**30:00 h/year**	**8:47 h/ year**	---
13	Kolonia Kuczbork 01	20:52 h/year	**30:00 h/year**	**3:07 h/ year**	---
14	Sadowo 01	17:10 h/year	**30:00 h/year**	**1:31 h/ year**	---
15	Sadowo 02	28:54 h/year	**30:00 h/year**	**3:00 h/ year**	---
16	Sadowo 03	12:14 h/year	**30:00 h/year**	**1:48 h/ year**	---
17	Sadowo 04	15:33 h/year	**30:00 h/year**	**2:27 h/ year**	---
18	Sadowo 05	13:12 h/year	**30:00 h/year**	**2:08 h/ year**	---
19	Kosewo 01	43:19 h/year	**30:00 h/year**	**6:13 h/ year**	---
20	Kosewo 02	47:53 h/year	**30:00 h/year**	**6:44 h/ year**	---
21	Kosewo 03	22:27 h/year	**30:00 h/year**	**2:54 h/ year**	---
22	Kosewo 04	15:46 h/year	**30:00 h/year**	**2:25 h/ year**	---
23	Kliczewo Małe 01	0:00 h/year	**30:00 h/year**	**0:00 h/ year**	---
24	Kliczewo Małe 02	0:00 h/year	**30:00 h/year**	**0:00 h/ year**	---
25	Kliczewo Małe 03	0:00 h/ year	**30:00 h/year**	**0:00 h/ year**	---
26	Kliczewo Małe 04	0:00 h /year	**30:00 h/year**	**0:00 h/ year**	---
27	Kliczewo Małe 05	0:00 h/year	**30:00 h/year**	**0:00 h/ year**	---
28	Kliczewo Małe 06	23:26 h/year	**30:00 h/year**	**3:28 h/ year**	---

29	Olszewko 01	48:41 h/year	**30:00 h/year**	**7:14 h/ year**	---
30	Olszewko 02	7:21 h/year	**30:00 h/year**	**1:02 h/ year**	---
31	Olszewko 03	8:52 h year	**30:00 h/year**	**1:18 h/ year**	---
32	Olszewko 04	10:29 h/year	**30:00 h/year**	**1:40 h/ year**	---
33	Olszewko 05	16:48 h/year	**30:00 h/year**	**2:32 h/ year**	---
34	Olszewko 06	25:38 h/year	**30:00 h/year**	**3:45 h/ year**	---
35	Olszewko 07	12:41 h/year	**30:00 h/year**	**1:48 h/ year**	---
36	Olszewko 08	4:06 h/ year	**30:00 h/year**	**0:36 h/ year**	---
37	Kliczewo Duże 01	136:16 h/year	**30:00 h/year**	**5:51 h/ year**	---
38	Kliczewo Duże 02	71:33 h/year	**30:00 h/year**	**3:20 h/ year**	---
39	Kliczewo Duże 03	77:55 h/year	**30:00 h/year**	**3:49 h/ year**	---
40	Kliczewo Duże 04	75:48 h/year	**30:00 h/year**	**3:54 h/ year**	---
41	Kliczewo Duże 05	52:41 h/year	**30:00 h/year**	**3:01 h/ year**	---
42	Kliczewo Duże 06	30:52 h/year	**30:00 h/year**	**1:57 h/ year**	---
43	Kliczewo Duże 07	50:51 h/year	**30:00 h/year**	**3:12 h/ year**	---
44	Wólka Kliczewska 01	44:42 h/year	**30:00 h/year**	**4:39 h/ year**	---
45	Wólka Kliczewska 02	34:40 h/year	**30:00 h/year**	**4:05 h/ year**	---
46	Wólka Kliczewska 03	41:16 h/year	**30:00 h/year**	**5:53 h/ year**	---
47	Wólka Kliczewska 04	55:35 h/year	**30:00 h/year**	**8:10 h/ year**	---
48	Wólka Kliczewska 05	19:24 h/year	**30:00 h/year**	**2:15 h/ year**	---
49	Olszewo 01	121:41 h/year	**30:00 h/year**	**6:38 h/ year**	---
50	Olszewo 02	83:14 h/year	**30:00 h/year**	**4:36 h/ year**	---
51	Olszewo 03	113:39 h/year	**30:00 h/year**	**6:13 h/ year**	---
52	Olszewo 04	119:29 h/year	**30:00 h/year**	**6:31 h/ year**	---
53	Olszewo 05	103:40 h/year	**30:00 h/year**	**5:19 h/ year**	---
54	Olszewo 06	51:39 h/year	**30:00 h/year**	**2:38 h/ year**	---
55	Olszewo 07	61:18 h/year	**30:00 h/year**	**2:58 h/ year**	---
56	Franciszkowo 01	22:10 h/year	**30:00 h/year**	**1:29 h/ year**	---
57	Franciszkowo 02	21:36 h/year	**30:00 h/year**	**1:54 h/ year**	---
58	Franciszkowo 03	22:12 h/year	**30:00 h/year**	**2:22 h/ year**	---
59	Franciszkowo 04	22:35 h/year	**30:00 h/year**	**2:38 h/ year**	---
60	Franciszkowo 05	17:21 h/year	**30:00 h/year**	**2:12 h/ year**	---
61	Franciszkowo 06	16:07 h/year	**30:00 h/year**	**2:13 h/ year**	---
62	Dębsk 01	32:32 h/year	**30:00 h/year**	**4:57 h/ year**	---
63	Dębsk 02	28:45 h/year	**30:00 h/year**	**4:07 h/ year**	---
64	Dębsk 03	28:47 h/year	**30:00 h/year**	**3:50 h/ year**	---
65	Dębsk 04	38:55 h/year	**30:00 h/year**	**4:58 h/ year**	---

66	Dębsk 05	90:11 h/year	**30:00 h/year**	**12:55 h/ year**	---
67	Dębsk 06	113:26 h/year	**30:00 h/year**	**15:42 h/ year**	---
68	Dębsk 07	90:21 h/year	**30:00 h/year**	**8:36 h/ year**	---
69	Dębsk 08	55:02 h/year	**30:00 h/year**	**6:56 h/ year**	---
70	Dębsk 09	33:36 h/year	**30:00 h/year**	**4:24 h/ year**	---
71	Dębsk 10	32:52 h/year	**30:00 h/year**	**4:39 h/ year**	---
72	Dębsk 11	36:14 h/year	**30:00 h/year**	**5:30 h/ year**	---
73	Dębsk 12	26:31 h/year	**30:00 h/year**	**4:31 h/ year**	---
74	Dębsk 13	32:20 h/year	**30:00 h/year**	**5:25 h/ year**	---
75	Dębsk 14	20:07 h/year	**30:00 h/year**	**3:18 h/ year**	---
76	Dębsk 15	2:25 h/year	**30:00 h/year**	**0:23 h/ year**	---
77	Chamsk 01	66:23 h/year	**30:00 h/year**	**7:53 h/ year**	---
78	Chamsk 02	47:08 h/year	**30:00 h/year**	**4:59 h/ year**	---
79	Chamsk 03	62:48 h/year	**30:00 h/year**	**6:05 h/ year**	---
80	Chamsk 04	76:58 h/year	**30:00 h/year**	**7:03 h/ year**	---
81	Chamsk 05	68:36 h/year	**30:00 h/year**	**6:00 h/ year**	---
82	Chamsk 06	53:55 h/year	**30:00 h/year**	**5:32 h/ year**	---
83	Chamsk 07	59:04 h/year	**30:00 h/year**	**6:31 h/ year**	---
84	Chamsk 08	52:06 h/year	**30:00 h/year**	**7:24 h/ year**	---
85	Chamsk 09	118:14 h/year	**30:00 h/year**	**9:34 h/ year**	---
86	Chamsk 10	66:41 h/year	**30:00 h/year**	**7:52 h/ year**	---
87	Chamsk 11	64:07 h/year	**30:00 h/year**	**7:54 h/ year**	---
88	Chamsk 12	56:11 h/year	**30:00 h/year**	**6:54 h/ year**	---
89	Chamsk 13	32:01 h/year	**30:00 h/year**	**4:02 h/ year**	---
90	Kolonia Chamsk 01	70:26 h/year	**30:00 h/year**	**10:57 h/ year**	---
91	Kolonia Chamsk 02	46:57 h/year	**30:00 h/year**	**7:02 h/ year**	---
92	Kolonia Chamsk 03	41:37 h/year	**30:00 h/year**	**6:20 h/ year**	---
92	Kolonia Chamsk 04	67:37 h/year	**30:00 h/year**	**10:48 h/ year**	---
94	Kolonia Chamsk 05	63:36 h/year	**30:00 h/year**	**10:01 h/ year**	---
95	Kolonia Chamsk 06	27:32 h/year	**30:00 h/year**	**4:27 h/ year**	---
95	Kolonia Chamsk 07	7:31 h/year	**30:00 h/year**	**1:18 h/ year**	---
97	Kolonia Chamsk 08	20:01 h/year	**30:00 h/year**	**3:18 h/ year**	---

It results from the conducted calculations that: shading levels will not be exceeded: which are treated as safe: for the real conditions: that is, taking into account data from many years standing observations: from meteorological stations. In none of the calculation points meteorological probable length of shading time will not exceed 30 hours within the year and 30 minutes within the day.

The calculation results for the theoretical conditions (the so-called astronomic length of shading time): thus assuming: that throughout the year there will be no clouds in the sky and the turbine will be working continuously (without stoppage) with a maximum speed: indicate that: potentially the designed wind power plant may be a nuisance as far as shadow flicker is concerned. **It should be emphasized, however: that it is the possible, theoretical worst-case scenario; whose occurrence in reality is highly unlikely.**

The results of the calculations: being the direct printout from the calculation program: have been enclosed to this document in a form of a printout [APPENDIX 1] and in an electronic form (a CD).

6.4 Cummulative light impacts

In the area of the designed wind farm there currently functions a wind farm consisted of 22 GAMESA WTGs, type G90 with a capacity of 2.0MW, the rotor diameter of 90m and the tower height of 100m.

Furthermore, in the direct neighborhood of Zielona there are three smaller turbines - for the need of this documentation the same parameters as those of all the remaining have been assumed.

Photo 1. Existing WTGs in the region of Zielona

Photo 2. Existing WTGs in the region of Zielona

To define a cummulative impact of shading effects the calculations have been made in 97 calculation points, taking into account simultaneous work of all (both designed and existing) WGTs. In accordance with the guidelines presented in Chapter 6.2 of this document, the results of those calculations have been referred to one day and to one year. In both cases there have been analyzed theoretical values (the worst-case scenario) and statistical values based on many years standing meteorological observation (the real scenario). The results of the calculations have been presented in tables below.

TABLE 5. Shading time for the period of one day – cumulative impact

	Calculation point localization	Theoretical astronomic length of shading time	Impact in real conditions (meteorological probable length of shading time)		
			Acceptable shading level	Meteorological probable length of shading time duration	Exceeding the acceptable level
1	Zielona 01	0:36 h/ day	**0:30 h/ day**	**0:04 h/ day**	---
2	Zielona 02	0:23 h/ day	**0:30 h/ day**	**0:02 h/ day**	---
3	Zielona 03	0:30 h/ day	**0:30 h/ day**	**0:03 h/ day**	---
4	Zielona 04	0:28 h/day	**0:30 h/ day**	**0:03 h/ day**	---
5	Przyspa 01	1:06 h/ day	**0:30 h/ day**	**0:07 h/ day**	---
6	Przyspa 02	0:54 h/ day	**0:30 h/ day**	**0:05 h/ day**	---
7	Kuczbork Wieś 01	0:44 h/ day	**0:30 h/ day**	**0:04 h/ day**	---
8	Kuczbork Wieś 02	0:33 h/ day	**0:30 h/ day**	**0:03 h/ day**	---
9	Kuczbork Wieś 03	0:45 h/ day	**0:30 h/ day**	**0:05 h/ day**	---
10	Kuczbork Wieś 04	0:32 h/ day	**0:30 h/ day**	**0:03 h/ day**	---
11	Kuczbork Wieś 05	0:32 h/ day	**0:30 h/ day**	**0:03 h/ day**	---
12	Kuczbork Wieś 06	1:20 h/ day	**0:30 h/ day**	**0:08 h/ day**	---
13	Kolonia Kuczbork 01	0:23 h/ day	**0:30 h/ day**	**0:02 h/ day**	---

14	Sadowo 01	0:31 h/ day	**0:30 h/ day**	**0:03 h/ day**	---
15	Sadowo 02	0:55 h/ day	**0:30 h/ day**	**0:06 h/ day**	---
16	Sadowo 03	0:26 h/ day	**0:30 h/ day**	**0:03 h/ day**	---
17	Sadowo 04	0:36 h/ day	**0:30 h/ day**	**0:04 h/ day**	---
18	Sadowo 05	0:20 h/ day	**0:30 h/ day**	**0:02 h/ day**	---
19	Kosewo 01	0:35 h/ day	**0:30 h/ day**	**0:04 h/ day**	---
20	Kosewo 02	0:43 h/ day	**0:30 h/ day**	**0:04 h/ day**	---
21	Kosewo 03	0:37 h/ day	**0:30 h/ day**	**0:04 h/ day**	---
22	Kosewo 04	0:23 h/ day	**0:30 h/ day**	**0:02 h/ day**	---
23	Kliczewo Małe 01	0:00 h/ day	**0:30 h/ day**	**0:00 h/ day**	---
24	Kliczewo Małe 02	0:00 h/ day	**0:30 h/ day**	**0:00 h/ day**	---
25	Kliczewo Małe 03	0:00 h/ day	**0:30 h/ day**	**0:00 h/ day**	---
26	Kliczewo Małe 04	0:00 h/ day	**0:30 h/ day**	**0:00 h/ day**	---
27	Kliczewo Małe 05	0:00 h/ day	**0:30 h/ day**	**0:00 h/ day**	---
28	Kliczewo Małe 06	0:27 h/ day	**0:30 h/ day**	**0:03 h/ day**	---
29	Olszewko 01	0:38 h/ day	**0:30 h/ day**	**0:04 h/ day**	---
30	Olszewko 02	0:20 h/ day	**0:30 h/ day**	**0:02 h/ day**	---
31	Olszewko 03	0:22 h/ day	**0:30 h/ day**	**0:02 h/ day**	---
32	Olszewko 04	0:22 h/ day	**0:30 h/ day**	**0:02 h/ day**	---
33	Olszewko 05	0:23 h/ day	**0:30 h/ day**	**0:02 h/ day**	---
34	Olszewko 06	0:23 h/ day	**0:30 h/ day**	**0:02 h/ day**	---
35	Olszewko 07	0:19 h/ day	**0:30 h/ day**	**0:02 h/ day**	---
36	Olszewko 08	0:16 h/ day	**0:30 h/ day**	**0:02 h/ day**	---
37	Kliczewo Duże 01	2:05 h/ day	**0:30 h/ day**	**0:13 h/ day**	---
38	Kliczewo Duże 02	1:09 h/ day	**0:30 h/ day**	**0:07 h/ day**	---
39	Kliczewo Duże 03	1:06 h/ day	**0:30 h/ day**	**0:07 h/ day**	---
40	Kliczewo Duże 04	1:04 h/ day	**0:30 h/ day**	**0:06 h/ day**	---
41	Kliczewo Duże 05	1:00 h/ day	**0:30 h/ day**	**0:06 h/ day**	---
42	Kliczewo Duże 06	0:50 h/ day	**0:30 h/ day**	**0:05 h/ day**	---
43	Kliczewo Duże 07	0:47 h/ day	**0:30 h/ day**	**0:05 h/ day**	---
44	Wólka Kliczewska 01	0:34 h/ day	**0:30 h/ day**	**0:03 h/ day**	---
45	Wólka Kliczewska 02	0:42 h/ day	**0:30 h/ day**	**0:04 h/ day**	---
46	Wólka Kliczewska 03	0:48 h/ day	**0:30 h/ day**	**0:05 h/ day**	---
47	Wólka Kliczewska 04	0:49 h/ day	**0:30 h/ day**	**0:05 h/ day**	---
48	Wólka Kliczewska 05	0:21 h/ day	**0:30 h/ day**	**0:02 h/ day**	---
49	Olszewo 01	1:54 h/ day	**0:30 h/ day**	**0:12 h/ day**	---
50	Olszewo 02	1:08 h/ day	**0:30 h/ day**	**0:07 h/ day**	---

51	Olszewo 03	1:13 h/ day	**0:30 h/ day**	**0:08 h/ day**	---
52	Olszewo 04	1:29 h/ day	**0:30 h/ day**	**0:09 h/ day**	---
53	Olszewo 05	1:30 h/ day	**0:30 h/ day**	**0:09 h/ day**	---
54	Olszewo 06	0:57 h/ day	**0:30 h/ day**	**0:6 h/ day**	---
55	Olszewo 07	1:05 h/ day	**0:30 h/ day**	**0:07 h/ day**	---
56	Franciszkowo 01	0:24 h/ day	**0:30 h/ day**	**0:02 h/ day**	---
57	Franciszkowo 02	0:26 h/ day	**0:30 h/ day**	**0:03 h/ day**	---
58	Franciszkowo 03	0:28 h/ day	**0:30 h/ day**	**0:03 h/ day**	---
59	Franciszkowo 04	0:29 h/ day	**0:30 h/ day**	**0:03 h/ day**	---
60	Franciszkowo 05	0:36 h/ day	**0:30 h/ day**	**0:04 h/ day**	---
61	Franciszkowo 06	0:38 h/ day	**0:30 h/ day**	**0:04 h/ day**	---
62	Dębsk 01	0:35 h/ day	**0:30 h/ day**	**0:04 h/ day**	---
63	Dębsk 02	0:38 h/ day	**0:30 h/ day**	**0:04 h/ day**	---
64	Dębsk 03	0:28 h/ day	**0:30 h/ day**	**0:03 h/ day**	---
65	Dębsk 04	0:29 h/ day	**0:30 h/ day**	**0:03 h/ day**	---
66	Dębsk 05	1:07 h/ day	**0:30 h/ day**	**0:07 h/ day**	---
67	Dębsk 06	1:14 h/ day	**0:30 h/ day**	**0:07 h/ day**	---
68	Dębsk 07	0:44 h day	**0:30 h/ day**	**0:04 h/ day**	---
69	Dębsk 08	0:42 h/ day	**0:30 h/ day**	**0:04 h/ day**	---
70	Dębsk 09	0:30 h/ day	**0:30 h/ day**	**0:03 h/ day**	---
71	Dębsk 10	0:39 h/ day	**0:30 h/ day**	**0:04 h/ day**	---
72	Dębsk 11	0:44 h/ day	**0:30 h/ day**	**0:04 h/ day**	---
73	Dębsk 12	0:27 h/ day	**0:30 h/ day**	**0:03 h/ day**	---
74	Dębsk 13	0:26 h/ day	**0:30 h/ day**	**0:03 h/ day**	---
75	Dębsk 14	0:25 h/ day	**0:30 h/ day**	**0:03 h/ day**	---
76	Dębsk 15	0:08 h/ day	**0:30 h/ day**	**0:01 h/ day**	---
77	Chamsk 01	0:33 h/ day	**0:30 h/ day**	**0:03 h/ day**	---
78	Chamsk 02	0:28 h/ day	**0:30 h/ day**	**0:03 h/ day**	---
79	Chamsk 03	0:30 h/ day	**0:30 h/ day**	**0:03 h/ day**	---
80	Chamsk 04	0:44 h/ day	**0:30 h/ day**	**0:04 h/ day**	---
81	Chamsk 05	0:36 h/ day	**0:30 h/ day**	**0:04 h/ day**	---
82	Chamsk 06	0:30 h/ day	**0:30 h/ day**	**0:03 h/ day**	---
83	Chamsk 07	0:29 h/ day	**0:30 h/ day**	**0:03 h/ day**	---
84	Chamsk 08	0:45 h/ day	**0:30 h/ day**	**0:05 h/ day**	---
85	Chamsk 09	1:09 h/ day	**0:30 h/ day**	**0:07 h/ day**	---
86	Chamsk 10	0:37 h/ day	**0:30 h/ day**	**0:04 h/ day**	---
87	Chamsk 11	0:35 h/ day	**0:30 h/ day**	**0:04 h/ day**	---

88	Chamsk 12	0:33 h/ day	**0:30 h/ day**	**0:03 h/ day**	---
89	Chamsk 13	0:27 h/ day	**0:30 h/ day**	**0:03 h/ day**	---
90	Kolonia Chamsk 01	0:49 h/ day	**0:30 h/ day**	**0:05 h/ day**	---
91	Kolonia Chamsk 02	0:31 h/ day	**0:30 h/ day**	**0:03 h/ day**	---
92	Kolonia Chamsk 03	0:35 h/ day	**0:30 h/ day**	**0:04 h/ day**	---
92	Kolonia Chamsk 04	0:41 h/ day	**0:30 h/ day**	**0:04 h/ day**	---
94	Kolonia Chamsk 05	0:45 h/ day	**0:30 h/ day**	**0:05 h/ day**	---
95	Kolonia Chamsk 06	0:25 h/ day	**0:30 h/ day**	**0:03 h/ day**	---
95	Kolonia Chamsk 07	0:19 h/ day	**0:30 h/ day**	**0:02 h/ day**	---
97	Kolonia Chamsk 08	0:22 h/ day	**0:30 h/ day**	**0:02 h/ day**	---

TABELA 6. Shading time for the whole year – cumulative impact

l.p.	Lokalizacja punktu obliczeniowego	Teoretyczna astronomiczna długość czasu zacienienia	Oddziaływanie w warunkach rzeczywistych (meteorologiczna prawdopodobna długość czasu zacienienia)		
			Akceptowalny poziom zacienienia	Meteorologiczna prawdopodobna długość czasu trwania zacienienia	Przekroczenie poziomu akceptowalnego
1	Zielona 01	63:17 h/year	**30:00 h/year**	**5:05 h/year**	---
2	Zielona 02	40:39 h/ year	**30:00 h/year**	**3:36 h/ year**	---
3	Zielona 03	26:44 h/ year	**30:00 h/year**	**2:44 h/ year**	---
4	Zielona 04	23:24 h/ year	**30:00 h/year**	**2:42 h/ year**	---
5	Przyspa 01	82:53 h/ year	**30:00 h/year**	**4:11 h/ year**	---
6	Przyspa 02	57:40 h/ year	**30:00 h/year**	**3:28 h/ year**	---
7	Kuczbork Wieś 01	35:44 h/ year	**30:00 h/year**	**4:06 h/ year**	---
8	Kuczbork Wieś 02	45:48 h/ year	**30:00 h/year**	**5:55 h/ year**	---
9	Kuczbork Wieś 03	76:28 h/ year	**30:00 h/year**	**10:23 h/ year**	---
10	Kuczbork Wieś 04	48:20 h/ year	**30:00 h/year**	**6:31 h/ year**	---
11	Kuczbork Wieś 05	71:44 h/ year	**30:00 h/year**	**8:56 h/ year**	---
12	Kuczbork Wieś 06	131:52 h/ year	**30:00 h/year**	**8:50 h/ year**	---
13	Kolonia Kuczbork 01	20:52 h/ year	**30:00 h/year**	**3:07 h/ year**	---
14	Sadowo 01	27:37 h/ year	**30:00 h/year**	**3:10 h/ year**	---
15	Sadowo 02	49:19 h/ year	**30:00 h/year**	**6:16 h/ year**	---
16	Sadowo 03	20:53 h/ year	**30:00 h/year**	**3:12 h/ year**	---
17	Sadowo 04	18:07 h/ year	**30:00 h/year**	**2:52 h/ year**	---
18	Sadowo 05	13:42 h/ year	**30:00 h/year**	**2:13 h/ year**	---
19	Kosewo 01	43:19 h/ year	**30:00 h/year**	**6:13 h/ year**	---
20	Kosewo 02	47:53 h/ year	**30:00 h/year**	**6:44 h/ year**	---
21	Kosewo 03	22:27 h/ year	**30:00 h/year**	**2:54 h/ year**	---
22	Kosewo 04	15:46 h/ year	**30:00 h/year**	**2:25 h/ year**	---

23	Kliczewo Małe 01	0:00 h/ year	**30:00 h/year**	**0:00 h/ year**	---
24	Kliczewo Małe 02	0:00 h/ year	**30:00 h/year**	**0:00 h/ year**	---
25	Kliczewo Małe 03	0:00 h/ year	**30:00 h/year**	**0:00 h/ year**	---
26	Kliczewo Małe 04	0:00 h/ year	**30:00 h/year**	**0:00 h/ year**	---
27	Kliczewo Małe 05	0:00 h/ year	**30:00 h/year**	**0:00 h/ year**	---
28	Kliczewo Małe 06	23:26 h/ year	**30:00 h/year**	**3:28 h/ year**	---
29	Olszewko 01	48:41 h/ year	**30:00 h/year**	**7:14 h/ year**	---
30	Olszewko 02	7:21 h/ year	**30:00 h/year**	**1:02 h/ year**	---
31	Olszewko 03	8:52 h/ year	**30:00 h/year**	**1:18 h/ year**	---
32	Olszewko 04	10:29 h/ year	**30:00 h/year**	**1:40 h/ year**	---
33	Olszewko 05	16:48 h/ year	**30:00 h/year**	**2:32 h/ year**	---
34	Olszewko 06	25:38 h/ year	**30:00 h/year**	**3:45 h/ year**	---
35	Olszewko 07	12:41 h/ year	**30:00 h/year**	**1:48 h/ year**	---
36	Olszewko 08	4:06 h/ year	**30:00 h/year**	**0:36 h/ year**	---
37	Kliczewo Duże 01	136:16 h/ year	**30:00 h/year**	**5:51 h/ year**	---
38	Kliczewo Duże 02	71:33 h/ year	**30:00 h/year**	**3:20 h/ year**	---
39	Kliczewo Duże 03	77:55 h/ year	**30:00 h/year**	**3:49 h/ year**	---
40	Kliczewo Duże 04	75:48 h/ year	**30:00 h/year**	**3:54 h/ year**	---
41	Kliczewo Duże 05	52:41 h/ year	**30:00 h/year**	**3:01 h/ year**	---
42	Kliczewo Duże 06	30:52 h/ year	**30:00 h/year**	**1:57 h/ year**	---
43	Kliczewo Duże 07	50:51 h/ year	**30:00 h/year**	**3:12 h/ year**	---
44	Wólka Kliczewska 01	44:42 h/ year	**30:00 h/year**	**4:39 h/ year**	---
45	Wólka Kliczewska 02	34:40 h/ year	**30:00 h/year**	**4:05 h/ year**	---
46	Wólka Kliczewska 03	41:16 h/ year	**30:00 h/year**	**5:53 h/ year**	---
47	Wólka Kliczewska 04	55:35 h/ year	**30:00 h/year**	**8:10 h/ year**	---
48	Wólka Kliczewska 05	19:24 h/ year	**30:00 h/year**	**2:15 h/ year**	---
49	Olszewo 01	121:41 h/ year	**30:00 h/year**	**6:38 h/ year**	---
50	Olszewo 02	83:14 h/ year	**30:00 h/year**	**4:36 h/ year**	---
51	Olszewo 03	113:39 h/ year	**30:00 h/year**	**6:13 h/ year**	---
52	Olszewo 04	119:29 h/ year	**30:00 h/year**	**6:31 h/ year**	---
53	Olszewo 05	103:40 h/ year	**30:00 h/year**	**5:19 h/ year**	---
54	Olszewo 06	51:39 h/ year	**30:00 h/year**	**2:38 h/ year**	---
55	Olszewo 07	61:18 h/ year	**30:00 h/year**	**2:58 h/ year**	---
56	Franciszkowo 01	22:10 h/ year	**30:00 h/year**	**1:29 h/ year**	---
57	Franciszkowo 02	21:36 h/ year	**30:00 h/year**	**1:54 h/ year**	---
58	Franciszkowo 03	22:12 h/ year	**30:00 h/year**	**2:22 h/ year**	---
59	Franciszkowo 04	22:35 h/ year	**30:00 h/year**	**2:38 h/ year**	---

60	Franciszkowo 05	17:21 h/ year	**30:00 h/year**	**2:12 h/ year**	---
61	Franciszkowo 06	16:07 h/ year	**30:00 h/year**	**2:13 h/ year**	---
62	Dębsk 01	32:32 h/ year	**30:00 h/year**	**4:57 h/ year**	---
63	Dębsk 02	28:45 h/ year	**30:00 h/year**	**4:07 h/ year**	---
64	Dębsk 03	28:47 h/ year	**30:00 h/year**	**3:50 h/ year**	---
65	Dębsk 04	38:55 h/ year	**30:00 h/year**	**4:58 h/ year**	---
66	Dębsk 05	90:11 h/ year	**30:00 h/year**	**12:55 h/ year**	---
67	Dębsk 06	113:26 h/ year	**30:00 h/year**	**15:42 h/ year**	---
68	Dębsk 07	90:21 h/ year	**30:00 h/year**	**8:36 h/ year**	---
69	Dębsk 08	55:02 h/ year	**30:00 h/year**	**6:56 h/ year**	---
70	Dębsk 09	33:36 h/ year	**30:00 h/year**	**4:24 h/ year**	---
71	Dębsk 10	32:52 h/ year	**30:00 h/year**	**4:39 h/ year**	---
72	Dębsk 11	36:14 h/ year	**30:00 h/year**	**5:30 h/ year**	---
73	Dębsk 12	26:31 h/ year	**30:00 h/year**	**4:31 h/ year**	---
74	Dębsk 13	32:20 h/ year	**30:00 h/year**	**5:25 h/ year**	---
75	Dębsk 14	20:07 h/ year	**30:00 h/year**	**3:18 h/ year**	---
76	Dębsk 15	2:25 h/ year	**30:00 h/year**	**0:23 h/ year**	---
77	Chamsk 01	66:23 h/ year	**30:00 h/year**	**7:53 h/ year**	---
78	Chamsk 02	47:08 h/ year	**30:00 h/year**	**4:59 h/ year**	---
79	Chamsk 03	62:48 h/ year	**30:00 h/year**	**6:05 h/ year**	---
80	Chamsk 04	76:58 h/ year	**30:00 h/year**	**7:03 h/ year**	---
81	Chamsk 05	68:36 h/ year	**30:00 h/year**	**6:00 h/ year**	---
82	Chamsk 06	53:55 h/ year	**30:00 h/year**	**5:32 h/ year**	---
83	Chamsk 07	59:04 h/ year	**30:00 h/year**	**6:31 h year**	---
84	Chamsk 08	52:06 h/ year	**30:00 h/year**	**7:24 h/ year**	---
85	Chamsk 09	118:14 h/ year	**30:00 h/year**	**9:34 h/ year**	---
86	Chamsk 10	66:41 h/ year	**30:00 h/year**	**7:52 h/ year**	---
87	Chamsk 11	64:07 h/ year	**30:00 h/year**	**7:54 h/ year**	---
88	Chamsk 12	56:11 h/ year	**30:00 h/year**	**6:54 h/ year**	---
89	Chamsk 13	32:01 h/ year	**30:00 h/year**	**4:02 h/ year**	---
90	Kolonia Chamsk 01	70:26 h/ year	**30:00 h/year**	**10:57 h/ year**	---
91	Kolonia Chamsk 02	46:57 h/ year	**30:00 h/year**	**7:02 h/ year**	---
92	Kolonia Chamsk 03	41:37 h/ year	**30:00 h/year**	**6:20 h/ year**	---
92	Kolonia Chamsk 04	67:37 h/ year	**30:00 h/year**	**10:48 h/ year**	---
94	Kolonia Chamsk 05	63:36 h/ year	**30:00 h/year**	**10:01 h/ year**	---
95	Kolonia Chamsk 06	27:32 h/ year	**30:00 h/year**	**4:27 h/ year**	---
95	Kolonia Chamsk 07	7:31 h/ year	**30:00 h/year**	**1:18 h/ year**	---

97	Kolonia Chamsk 08	20:01 h/ year	**30:00 h/year**	**3:18 h/ year**	---

It results from the conducted calculations that: also in case of a cumulative light impact shading levels will not be exceeded:which are treated as safe: for the real conditions: that is, taking into account data from many years standing observations: from meteorological stations. In none of the calculation points meteorological probable length of shading time will not exceed 30 hours within the year and 30 minutes within the day.

The results of the calculations: being the direct printout from the calculation program: have been enclosed to this document in a form of a printout [APPENDIX 2] and in an electronic form (a CD).

6.5 The proposed recommendations and restrictions

Polish law does not regulate in any way the issues related to the reduction of the shadow flicker effect. Hence it is impossible to impose on the investor any recommendations or restrictions related to it.

7. FORECASTING METHOD

The calculations of the impact of the shadow flicker effect have been carried out by using the computer program WindPro 2.7 with SHADOW module [License for ProSilence Krzysztof Kręciproch: Opole]. The program performs calculations of the shading effect based on the document Hinweise zur Ermittlung Und Beurteilung der optischen Immissionen von Windenergieanlagen (WEA-Schattenwurf-Hinweise). The calculation algorithm: allowing to determine the shading field distribution in the vicinity of wind power plants: encompasses in its scope four basic stages:

- completing the data related to the landform features and significant obstacles: which may limit the potential light phenomena,
- completing the data: localization of the wind turbines: wind turbine parameters: the location of residential buildings,
- defining meteorological data on insolation and states of atmosphere,
- calculating the shading effect at calculation points (receptors) and in a calculation net
- comparing the results of calculations with the values treated as safe

Calculations at the calculation points have been made for the so- called greenhouse model: i.e. assuming that: each calculation point in its whole is exposed to the impact.

8. INDICATIONS FOR ENVIRONMENTAL MONITORING

The issue of the impact of wind farms in the scope of the shading effect is not regulated by national law: therefore there is no legal basis for imposing on the Investor any obligation to monitor the impact of a wind farm in this scope.

9. SUMMARY AND CONCLUSIONS

- The designed undertaking may be a source of the impact as regards to light phenomena.
- The realization of this undertaking will not be a source of a nuisance in terms of the stroboscopic effect. In order to eliminate the impact in this scope, blades of the wind turbine will be coated with translucent paints of a matt texture.
- The realization of this undertaking should not a nuisance in terms of the shading effect. The results of the calculations for factual meteorological conditions have not shown that the designed wind power plant could cause shading of a higher level than regarded as not oppressive.