Shadow Impact Study
for the proposed wind farm at Oleksandrivka
(Zaporizhia)
Ukraine

Author
Andrzej Łuczak
Ewelina Dembińska

2017

Contents

1. Introduction

The client (EuroCape Ukraine, Kyiv) intend to build a wind farm in the northern outskirts of Oleksandrivka, Ukraine. The wind farm will consist up to 167 WTGs (wind turbine generators): 16 type V-112 by Vestas Company (nominal capacity – 3.45 MW, rotor diameter – 112 m, tower height – 119 m),123 wind turbine generators type V-126 by Vestas and 28 wind turbine generators type General Electric Wind Energy GE 3.6 (nominal capacity – 3.63 MW, rotor diameter – 137 m, tower height – 110 m).

The intended wind farm is within an agriculturally used area with some hedges. Nearby there lie single provincial towns and places like Devninskoe, Nechkine, Dunaivka, Viktorivka, Girsivka, Mordvinivka, Dobrovka, Nadeshdine, Novopokrovka and Volna.
Beside positive environmental effects of electricity produced by WTGs, e.g. with respect to air pollution control, wind farms can have negative impacts on human well-being because of shadow flickering. On sunny days shadow flickering is caused by the moving rotors of operating wind turbines. These shadow flickers are harmless in terms of health and safety but under certain circumstances can be annoying. Shadow flicker intensity is defined as the difference or variation in brightness at a given location in the presence and absence of a shadow. Please note that shadow flicker is different from a related strobe-like phenomenon that is caused by intermittent chopping of the sunlight behind the rotating blades. By a shadow flicker study it can be investigated if the noise emission of a planned wind farm will be harmful for nearby dwellings. In Ukraine by now no recommendation, guide line or law exists to evaluate possible shadow flickering caused by an operation wind farm. However, as the client wishes to investigate possible impacts to dwellings the study evaluates possible shadow flicker of the intended wind-farm according to the threshold values of 30 min/day or 30h/year (partly internationally adopted [1])

2. Shadow flicker measurement

On sunny days the periodical disruption of the sun ray by the rotating blades of an operating wind turbine causes an effect called shadow flicker. Especially in rooms which are lit by day light, shadow flicker can lead to a pulsating light level with a frequency of three times the rotor speed (see figure 1). Modern wind turbines (600 – 3000 kW) are typically three-bladed machines that rotate at rates of 26 – 16 revolutions per minute (RPM). Thus, if for example sunlight passes through the rotor of a three-bladed wind turbine rotating at 20 RPM then the light will flicker at a rate of 3x20=60 shadows per minute, i.e. 1 per second or 1 Hertz (Hz). Such low frequencies are harmless in terms of health and safety but under certain circumstances can be annoying. Another effect, the so-called “disco effect”, where flashes of light are caused by periodic reflection of the sun’s rays on the rotor blades can be minimized by optimizing the rotor blade surface smoothness as well as by minimizing the reflection properties of the paint used on the blades and is not investigated here. Shadow flicker, however, cannot be avoided.

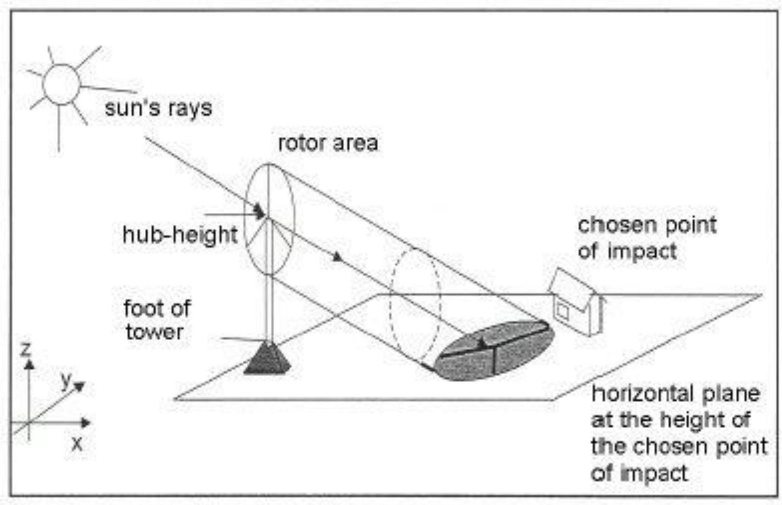


Fig. 1. Shadow impact of wind turbine

Shadow flicker is usually quantified by the number of hours per year during which a location would be exposed to flickering from nearby wind turbines. While this is primarily a simple matter of geometry other factors must be considered even at times when the sun is lined up geometrically with the turbine and the receptor. For instance it is not possible for shadow flicker to occur at any time when the sun is not visible, such as on cloudy or foggy days or if a wind turbine is not rotating. Objects located between a wind turbine and the viewer, such as trees, hills, and buildings will also reduce or eliminate the duration and/or intensity of shadow flicker.

At distances greater than approximately 1.5 kilometer light is sufficiently dispersed by particles in the air that the blades no longer produce distinct shadows. Consequently the rotor of a wind turbine will not cause shadow flicker and beyond this distance it is not necessary to consider shadow flicker.

While there is no Ukraine standard regulating, in Germany the tolerable impact of shadow flicker was set to 30 minutes per day or 30 hours per year [1]. These threshold values are adopted by other countries such as Poland, Great Britain or Ireland.

3. Applied method to evaluate shadow flicker

Whether or not shadow flicker from a wind turbine affects a location can be mainly described as a simple geometrical problem. If the sun, the rotor and the location of interest are in one line then the location of interest will be possible imposed to shadow flicker. The duration of this impact measured in hours per day or year is calculated with WindPRO by EMD, module SHADOW, including the following factors:

- Location of the sun in the sky
- Times and duration of turbine operation
- Direction of the wind (determines the direction the rotor will face)
- Likelihood of sunshine
- Orography and land use of the area
- Objects, such as trees and buildings reducing or eliminating the duration and/or intensity of shadow flicker.
- Size and position of the location of interest, e.g. a window or patio (named shadow recipient)
- Hub height and rotor diameter of the turbine.

The model simulates the solar course of one year in 1-minutes steps. For each step the shadow flicker impact is calculated for each shadow recipient separately. The conditions assumed for this calculation are that: the sky is cloudless; there is enough wind for the rotor to rotate; the wind direction is the same as the sun's azimuth so that the maximum possible shadowing is caused by the rotor and the turbine is always in service. Refraction or bending of the sun's rays is not taken into account. Thus shadow flicker is calculated simply using astronomical data leading to the most conservative results with a maximal impact. This "worst case" calculation will result in an impact value which is obviously to height as the assumptions listed above would never occur throughout the whole year. If meteorological data such as the amount of sunshine hours per year and the distribution of wind direction is available the probable shadow impact per year (or real-world value) can be calculated. However, for economical reasons at this stage of the project only the "worst case" approach was modeled. If necessary "real-world value" could be calculated for critical areas.

4. Location and WTG data

The customer plans to build a wind farm approximately north of the village Oleksandrivka. Nearby there lie single provincial towns and places like Devninskoe (DE), Nechkine (NE), Dunaivka (DU), Viktorivka (V), Girsivka (G), Mordvinivka (M), Dobrovka (DO), Nadeshdine (NA), Novopokrovka (NO) and Volna (VO).

The wind farm area is surrounded by an agriculturally used area, criss-crossed by hedges (see the photos 1- 4).

Photo 1. Typical outskirt of Oleksandrivka I

Photo 2. Typical outskirt of Oleksandrivka II

Photo 3: Agricultural land, criss-crossed by hedges

Photo 4: A typical hedge

Based on a desk based analysis of the topographic maps UA-L36-059, UA-L36-060, UA-L36-048 and UA-L36-047 (scale 1:100.000) and generally accessible aerial picture information, verified through customer information a total of 52 dwellings identified as sensible areas, possible affected by noise emissions from the wind farm. These are the nearest houses in the peripheral zones of the villages Devninskoe, Nechkine, Dunaivka, Viktorivka, Girsivka, Mordvinivka, Dobrovka, Nadeshdine, Novopokrovka, Volna and Oleksandrivka. The position of the shadow recipients are shown in Appendix 1. The coordinates as well as the distances between the noise recipients and the WTG (in meters) are given in the appendix (see WindPro main result and detailed results). The characteristics of the turbine type are shown in Tab. 1.

Tab. 1. Working data WEA

	Vestas V112	**Vestas V126**	**General Electric GE3.6**
Number of turbines	16	123	28
Producer	Vestas	Vestas	General Electric
WEA type	Vestas V112-3.3	Vestas V126-3.3	GE 3.6
Rotor diameter \m	112	126	137
Hub height \m	119	117	110
Capacity MW	3.45 MW	3.45MW	3.63MW
Rotor speed m/s	10	10	10

5. Results

The calculated shadow flicker at each of the 52 dwellings are shown in table 2. An overview about the location of each shadow recipient and also the shadow flicker contours and the detailed results of the WindPRO analysis are presented in the appendix. In lack of Ukraine regulations these results are based on German threshold recommendations which are partly international adopted.

Calculations are carried out using the worst case (WC) method. The WC method assumes the sun is shining all the time, the turbines are running permanently and the rotor swept area of the turbines is perpendicular to the examined dwellings. The threshold value is 30 hours/year and 30 min/day of shadow impact at each dwelling. At the dwelling Vol_04 and Vol_01 these demands are exceeded slightly. The causing turbines are 138a and 93a. These turbines might be equipped with the Vestas Shadow Detection System (VSDS, 0018-5554 V03) to control the turbine operation. It stops the turbine if the yearly/daily shadow contingent is reached.

Tab. 2. Shadow flicker modeling results

Shadow receptor	**place**	**Result Shadow hours / year**	**Result Max shadow hours per day**
A	Devninskoe Village	00:00	00:00
B	Devninskoe Village	00:00	00:00
C	Devninskoe Village	00:00	00:00
D	Devninskoe Village	00:00	00:00
E	Dobrovka Village	00:00	00:00
F	Dobrovka Village	03:50	00:16
G	Dobrovka Village	05:39	00:18
H	Dobrovka Village	00:00	00:00
I	Dunaivka Village	00:00	00:00
J	Dunaivka Village	00:00	00:00
K	Dunaivka Village	03:32	00:10
L	Dunaivka Village	32:52	00:29
M	Dunaivka Village	20:15	00:23
N	Dunaivka Village	02:35	00:09
O	Girsivka Village	00:00	00:00
P	Girsivka Village	02:45	00:09
Q	Girsivka Village	11:20	00:22
R	Girsivka Village	06:34	00:18
S	Girsivka Village	00:57	00:07
T	Mordvinivka Village	00:00	00:00
U	Mordvinivka Village	00:00	00:00
V	Mordvinivka Village	00:00	00:00
W	Mordvinivka Village	00:00	00:00
X	Mordvinivka Village	00:00	00:00
Y	Nadeshdine Village	00:00	00:00
Z	Nadeshdine Village	00:00	00:00
AA	Nadeshdine Village	00:00	00:00
AB	Nadeshdine Village	00:00	00:00
AC	Nadeshdine Village	00:00	00:00
AD	Nadeshdine Village	00:00	00:00
AE	Nechkine Village	00:00	00:00
AF	Nechkine Village	00:00	00:00
AG	Nechkine Village	00:00	00:00
AH	Nechkine Village	00:00	00:00
AI	Novopokrovka Village	00:00	00:00
AJ	Novopokrovka Village	00:00	00:00
AK	Novopokrovka Village	00:00	00:00
AL	Oleksandrivka Village	00:56	00:06
AM	Oleksandrivka Village	00:00	00:00
AN	Oleksandrivka Village	00:00	00:00
AO	Oleksandrivka Village	00:00	00:00
AP	Oleksandrivka Village	00:00	00:00
AQ	Oleksandrivka Village	00:00	00:00
AR	Oleksandrivka Village	00:00	00:00
AS	Viktorivka Village	00:00	00:00
AT	Viktorivka Village	00:00	00:00
AU	Viktorivka Village	00:00	00:00
AV	Viktorivka Village	00:00	00:00
AW	**Volna Village**	**36:25**	**00:34**
AX	Volna Village	00:00	00:00
AY	Volna Village	00:00	00:00
AZ	**Volna Village**	**74:19**	**00:39**

6. Summary

The Client intend to build a wind farm in the northern outskirts of Oleksandrivka, Ukraine. The wind farm will consist of up to 167 WTGs (wind turbine generators): 16 type V-112 by Vestas Company (nominal capacity – 3.45 MW, rotor diameter – 112 m, tower height – 119 m), and 151 123 wind turbine generators type V-126 by Vestas and 28 wind turbine generators type General Electric Wind Energy GE 3.6 (nominal capacity – 3.63 MW, rotor diameter – 137 m, tower height – 110 m).

The intended wind farm is within an agriculturally used area, criss-crossed by hedges. Nearby there lie the single provincial towns Devninskoe, Nechkine, Dunaivka, Viktorivka, Girsivka, Mordvinivka, Dobrovka, Nadeshdine, Novopokrovka, Volna and Oleksandrivka.

Based on a desk based analysis of the topographic maps UA-L36-059, UA-L36-060, UA-L36-048 and UA-L36-047 (scale 1:100 000) and generally accessible aerial picture information, verified through customer information a total of 52 dwellings identified as possible affected by shadow flicker from the wind farm. These are the nearest houses in the peripheral zones of the above-named neighboring villages.

The potential shadow impact of the 52 dwellings was calculated with the WindPRO software, module SHADOW. Please note that in this case the "worst case" (this means the maximal impact by 167 WTG) was calculated. In Ukraine by now no recommendation, guide line or law exists to evaluate possible shadow flickering caused by an operation wind farm. However, as the client wishes to investigate possible impacts to dwellings, the study evaluates possible shadow flicker of the intended wind-farm according to the threshold values of 30 min/day or 30h/year.

The worst case calculation under the basic conditions shows that in two of the 52 potentially affected dwellings the critical values are exceeded. The causing turbines are 138a and 93a. These turbines might be equipped with the Vestas Shadow Detection System to control the turbine operation. On account of our experience it can be assumed, that the calculation of the real-world values will reduce the shadow flicker impact to approximately one-third of the maximum value given in **Error! Reference source not found.**.

7. References

[1] Shadow Casting from Wind Turbines, www.windpower.org/en/tour/env/shadow/index.htm

[2] Bundesimmissionsschutzgesetz vom 4.Oktober 2004. Gesetz zum Schutz vor schädlichen Umweltwirkungen durch Luftunreinheiten, Geräusche, Erschütterung und ähnlichen Vorgängen. Letzte Änderung durch Art. 1 vom 23.Oktober 2007 (BGBL. S. 2470)

[3] WEA-Schattenwurf-Leitlinie. Leitlinie des Ministeriums für Landwirtschaft, Umweltschutz und Raumordnung des Landes Brandenburg zur Ermittlung und Beurteilung der optischen Immissionen von Windenergieanlagen vom 24. März 2003 (ABL. Nr. 18 vom 7.05.2003)

Appendix 1. Shadow flicker modeling results

Project:
Zaporizha_UKR_R00_20170203

Licensed user:
GE Infrastructure, Energy
Wind Application Engineering
. .

Marek Cherubin / marek.cherubin1@ge.com
Calculated:
5/4/2017 11:11 AM/3.1.617

SHADOW - Main Result

Calculation: Real Case - 3 Phases

Assumptions for shadow calculations

Maximum distance for influence
Calculate only when more than 20 % of sun is covered by the blade
Please look in WTG table

Minimum sun height over horizon for influence	3 °
Day step for calculation	1 days
Time step for calculation	1 minutes

Sunshine probability S (Average daily sunshine hours) [ODESSA]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2.30	2.76	3.91	5.93	8.43	9.46	9.87	9.48	7.82	5.25	2.51	1.81

Operational hours are calculated from WTGs in calculation and wind distribution:
NDSD_Cleaned_MCP_Filled_4Y_LTC

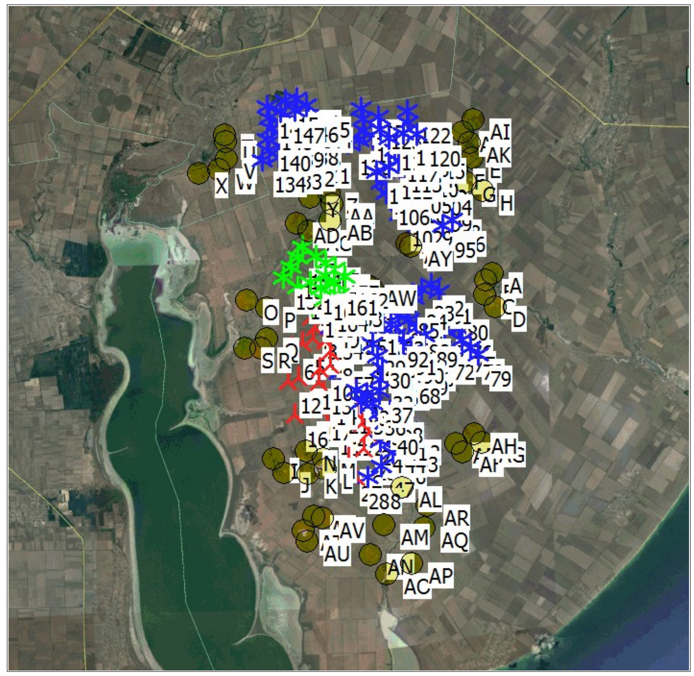
Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
738	712	901	1,123	837	464	558	585	620	720	644	616	8,517

Idle start wind speed: Cut in wind speed from power curve

A ZVI (Zones of Visual Influence) calculation is performed before flicker calculation so non visible WTG do not contribute to calculated flicker values. A WTG will be visible if it is visible from any part of the receiver window. The ZVI calculation is based on the following assumptions:
Height contours used: Height Contours: CONTOURLINE_ONLINEDATA_0.wpo (1)
Obstacles used in calculation
Eye height: 1.5 m
Grid resolution: 10.0 m

All coordinates are in
UTM (north)-WGS84 Zone: 36



Scale 1:400,000
New WTG
Shadow receptor
Existing WTG

WTGs

	Easting	Northing	Z	Row data/Description	WTG type Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	Shadow data Calculation distance	RPM
			[m]					[kW]	[m]	[m]	[m]	[RPM]
1	685,853	5,169,675	10.0	9	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
2	686,063	5,168,446	10.0	16	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
3	686,291	5,167,888	11.8	24	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
4	686,169	5,167,295	10.0	25	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
5	685,608	5,167,062	10.0	26	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
6	685,043	5,166,832	10.0	27	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
7	686,863	5,167,168	15.0	28	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
8	687,087	5,166,600	15.0	29	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
9	687,072	5,165,907	10.0	33	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
10	686,514	5,165,686	10.0	34	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
11	685,398	5,165,236	5.0	35	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
12	684,842	5,165,011	5.0	36	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
13	686,496	5,164,995	10.0	37	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
14	686,734	5,164,395	9.3	39	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
15	685,784	5,163,489	5.0	48	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
16	685,210	5,163,255	5.0	49	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
17	686,476	5,163,573	5.0	50	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
18	686,928	5,162,828	5.0	51	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
19	687,531	5,162,779	10.0	52	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
20	687,836	5,163,296	10.0	53	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
21	687,399	5,163,964	8.4	54	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
22	688,505	5,163,305	11.3	56	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
23	688,805	5,162,783	15.0	63	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
24	689,147	5,162,284	15.0	64	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
25	688,871	5,161,473	10.0	74	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
26	688,084	5,160,947	10.0	75	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
27	688,079	5,160,345	10.0	76	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
28	688,494	5,159,926	10.0	77	Yes	General Electric Wind Energy	3.6-137-3,630	3,630	137.0	110.0	2,500	0.0
29	689,325	5,167,029	15.0	21	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
30	689,600	5,166,348	15.0	43	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
31	689,839	5,165,736	15.0	45	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1

To be continued on next page...

SHADOW - Main Result

Calculation: Real Case - 3 Phases

...continued from previous page

	Easting	Northing	Z	Row data/Description	WTG type Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	Shadow data Calculation distance	RPM
			[m]					[kW]	[m]	[m]	[m]	[RPM]
32	689,767	5,165,117	15.0	46	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
33	688,474	5,164,585	10.2	47	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
34	688,707	5,163,878	11.2	57	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
35	689,054	5,164,379	15.0	58	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
36	689,361	5,163,862	15.0	59	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
37	689,725	5,164,486	15.0	60	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
38	690,286	5,163,420	15.0	61	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
39	689,690	5,163,328	15.0	62	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
40	690,028	5,162,829	15.0	65	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
41	690,534	5,162,505	15.0	66	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
42	691,181	5,162,532	15.0	67	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
43	691,092	5,161,913	15.0	68	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
44	690,424	5,161,874	12.7	69	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
45	689,771	5,161,880	10.4	70	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
46	690,411	5,161,241	10.0	71	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
47	689,783	5,160,518	10.0	72	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
48	689,109	5,159,931	10.0	78	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
49	686,868	5,168,466	15.0	17	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
50	688,280	5,168,139	15.0	18	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
51	688,879	5,168,153	15.0	19	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
52	689,102	5,167,589	15.0	20	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
53	687,720	5,167,915	15.0	22	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
54	687,110	5,167,863	15.0	23	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
55	688,847	5,166,636	12.8	30	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
56	688,232	5,166,383	10.0	31	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
57	687,646	5,166,142	14.9	32	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
58	687,543	5,165,471	11.3	38	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
59	687,784	5,164,881	15.0	40	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
60	688,075	5,163,997	10.0	55	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
61	688,776	5,169,344	15.0	138a	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
62	689,168	5,168,683	15.0	73a	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
63	688,288	5,170,133	17.4	93a	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
64	689,502	5,168,079	15.0	41	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
65	689,978	5,166,904	15.0	42	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
66	690,218	5,166,228	15.0	44	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
67	690,569	5,165,429	16.9	79	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
68	691,179	5,165,517	20.0	80	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
69	691,585	5,165,978	20.0	81	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
70	691,979	5,166,439	20.0	82	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
71	692,372	5,166,894	20.0	83	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
72	693,016	5,166,795	20.0	84	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
73	692,788	5,167,373	20.0	85	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
74	693,189	5,167,839	22.6	86	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
75	693,618	5,168,325	25.0	87	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
76	693,954	5,167,808	23.3	88	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
77	694,105	5,167,234	20.0	89	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
78	694,551	5,166,829	20.0	90	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
79	694,997	5,166,427	20.0	91	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
80	693,757	5,168,908	25.0	92	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
81	692,909	5,169,759	23.0	94	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
82	692,484	5,170,194	21.1	95	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
83	691,954	5,169,911	20.0	96	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
84	691,550	5,169,444	20.0	97	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
85	691,139	5,168,972	20.0	98	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
86	690,708	5,168,481	19.6	99	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
87	691,273	5,168,297	19.8	100	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
88	691,690	5,167,870	20.0	101	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
89	692,114	5,167,442	20.0	102	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
90	691,395	5,166,619	20.0	103	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
91	690,979	5,167,045	17.4	104	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
92	690,560	5,167,472	15.6	105	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
93	690,308	5,168,027	15.0	106	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
94	689,911	5,167,571	15.0	107	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
95	693,069	5,173,279	25.0	108	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1

To be continued on next page...

Licensed user:
GE Infrastructure, Energy
Wind Application Engineering
. .

Marek Cherubin / marek.cherubin1@ge.com

SHADOW - Main Result

Calculation: Real Case - 3 Phases

...continued from previous page

					WTG type						Shadow data	
	Easting	Northing	Z	Row data/Description	Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	Calculation distance	RPM
			[m]					[kW]	[m]	[m]	[m]	[RPM]
96	693,619	5,173,610	25.0	109	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
97	692,445	5,173,906	25.0	110	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
98	693,348	5,174,172	25.9	111	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
99	692,878	5,174,647	27.6	112	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
100	692,022	5,174,332	25.0	113	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
101	691,228	5,173,469	25.0	114	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
102	690,806	5,173,888	25.0	115	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
103	691,508	5,175,102	25.0	116	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
104	692,326	5,175,527	25.7	117	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
105	691,260	5,175,648	25.0	118	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
106	690,056	5,175,026	25.0	119	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
107	689,806	5,175,579	20.2	120	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
108	691,011	5,176,193	25.0	121	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
109	692,065	5,176,072	25.1	122	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
110	691,612	5,176,468	25.0	123	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
111	689,558	5,176,126	20.0	124	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
112	690,204	5,176,400	20.3	125	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
113	690,758	5,176,740	22.8	126	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
114	691,373	5,177,005	25.0	127	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
115	691,981	5,177,480	30.0	129	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
116	691,116	5,177,564	25.0	130	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
117	690,512	5,177,294	25.0	131	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
118	690,227	5,177,904	25.0	132	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
119	690,992	5,178,189	25.0	133	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
120	691,694	5,178,107	29.2	134	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
121	691,268	5,178,729	25.0	135	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
122	691,173	5,179,334	25.0	136	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
123	689,681	5,179,024	20.3	139	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
124	689,777	5,178,387	20.0	140	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
125	688,734	5,179,524	19.0	141	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
126	688,827	5,178,929	19.4	142	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
127	688,918	5,178,331	19.8	143	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
128	689,374	5,177,922	20.0	144	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
129	688,628	5,177,795	15.0	145	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
130	688,015	5,177,691	15.0	146	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
131	685,823	5,177,223	18.1	147	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
132	685,000	5,177,056	19.0	148	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
133	684,328	5,176,925	15.0	149	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
134	683,486	5,176,752	13.3	150	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
135	683,827	5,177,280	15.0	151	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
136	684,559	5,177,489	15.0	152	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
137	685,324	5,177,563	19.9	153	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
138	685,231	5,178,186	20.0	154	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
139	684,468	5,178,085	15.0	155	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
140	683,731	5,177,881	15.0	156	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
141	683,976	5,178,430	15.0	157	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
142	684,562	5,178,763	17.9	158	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
143	685,333	5,178,771	20.0	159	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
144	685,932	5,179,082	20.0	160	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
145	685,809	5,179,670	20.0	161	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
146	685,195	5,179,422	20.0	162	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
147	684,438	5,179,355	17.2	163	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
148	683,851	5,179,019	15.0	164	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
149	683,729	5,179,608	15.0	165	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
150	684,721	5,179,892	18.6	166	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
151	685,313	5,180,018	20.0	167	Yes	VESTAS	V126-3.6 HTq-3,600	3,600	126.0	117.0	1,720	12.1
152	684,600	5,170,530	9.9	1	Yes	VESTAS	V112-3.45-3,450	3,450	112.0	119.0	1,709	13.8
153	685,008	5,171,086	6.2	2	Yes	VESTAS	V112-3.45-3,450	3,450	112.0	119.0	1,709	13.8
154	685,342	5,171,587	10.0	3	Yes	VESTAS	V112-3.45-3,450	3,450	112.0	119.0	1,709	13.8
155	686,312	5,171,669	12.7	4	Yes	VESTAS	V112-3.45-3,450	3,450	112.0	119.0	1,709	13.8
156	686,845	5,171,309	15.0	5	Yes	VESTAS	V112-3.45-3,450	3,450	112.0	119.0	1,709	13.8
157	687,349	5,170,970	17.4	6	Yes	VESTAS	V112-3.45-3,450	3,450	112.0	119.0	1,709	13.8
158	686,833	5,170,611	13.9	7	Yes	VESTAS	V112-3.45-3,450	3,450	112.0	119.0	1,709	13.8
159	686,002	5,170,272	10.0	8	Yes	VESTAS	V112-3.45-3,450	3,450	112.0	119.0	1,709	13.8

To be continued on next page...

SHADOW - Main Result

Calculation: Real Case - 3 Phases

...continued from previous page

	Easting	Northing	Z	Row data/Description	WTG type Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	Shadow data Calculation distance	RPM
			[m]					[kW]	[m]	[m]	[m]	[RPM]
160	686,564	5,169,957	11.1	10	Yes	VESTAS	V112-3.45-3,450	3,450	112.0	119.0	1,709	13.8
161	687,299	5,170,213	15.0	11	Yes	VESTAS	V112-3.45-3,450	3,450	112.0	119.0	1,709	13.8
162	687,892	5,170,604	18.6	12	Yes	VESTAS	V112-3.45-3,450	3,450	112.0	119.0	1,709	13.8
163	687,549	5,169,589	15.0	13	Yes	VESTAS	V112-3.45-3,450	3,450	112.0	119.0	1,709	13.8
164	686,799	5,169,373	12.4	14	Yes	VESTAS	V112-3.45-3,450	3,450	112.0	119.0	1,709	13.8
165	686,104	5,169,055	10.3	15	Yes	VESTAS	V112-3.45-3,450	3,450	112.0	119.0	1,709	13.8
166	685,618	5,172,166	10.0	128a	Yes	VESTAS	V112-3.45-3,450	3,450	112.0	119.0	1,709	13.8
167	685,346	5,170,023	10.0	137a	Yes	VESTAS	V112-3.45-3,450	3,450	112.0	119.0	1,709	13.8

Shadow receptor-Input

No.	Easting	Northing	Z	Width	Height	Height a.g.l.	Degrees from south cw	Slope of window	Direction mode
			[m]	[m]	[m]	[m]	[°]	[°]	
A	695,734	5,170,724	10.3	1.0	1.0	1.0	0.0	90.0	"Green house mode"
B	695,411	5,170,377	13.2	1.0	1.0	1.0	0.0	90.0	"Green house mode"
C	695,317	5,169,633	17.8	1.0	1.0	1.0	0.0	90.0	"Green house mode"
D	695,908	5,168,958	20.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
E	694,650	5,176,827	20.8	1.0	1.0	1.0	0.0	90.0	"Green house mode"
F	693,876	5,176,261	30.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
G	694,296	5,175,572	25.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
H	695,249	5,175,115	15.6	1.0	1.0	1.0	0.0	90.0	"Green house mode"
I	684,080	5,160,891	0.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
J	684,610	5,160,109	5.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
K	685,900	5,160,095	5.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
L	686,835	5,160,335	5.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
M	686,714	5,160,900	5.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
N	685,807	5,161,293	5.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
O	682,666	5,169,326	0.8	1.0	1.0	1.0	0.0	90.0	"Green house mode"
P	683,700	5,168,927	8.6	1.0	1.0	1.0	0.0	90.0	"Green house mode"
Q	683,706	5,167,284	6.3	1.0	1.0	1.0	0.0	90.0	"Green house mode"
R	683,417	5,166,775	5.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
S	682,558	5,166,769	5.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
T	681,462	5,178,092	8.8	1.0	1.0	1.0	0.0	90.0	"Green house mode"
U	681,532	5,177,722	6.7	1.0	1.0	1.0	0.0	90.0	"Green house mode"
V	681,576	5,176,822	5.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
W	681,192	5,176,260	5.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
X	680,117	5,176,040	0.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
Y	686,035	5,174,759	15.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
Z	687,059	5,174,954	10.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AA	687,213	5,174,387	10.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AB	687,080	5,173,540	10.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AC	685,985	5,172,994	10.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AD	685,298	5,173,411	10.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AE	693,808	5,161,707	10.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AF	694,180	5,161,255	10.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AG	695,204	5,161,746	14.1	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AH	694,795	5,162,240	15.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AI	694,746	5,178,887	25.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AJ	694,163	5,178,250	29.1	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AK	694,509	5,177,675	28.8	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AL	690,925	5,159,361	10.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AM	689,968	5,157,380	10.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AN	689,237	5,155,791	5.9	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AO	690,115	5,154,776	0.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AP	691,458	5,155,353	6.8	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AQ	692,099	5,157,235	9.2	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AR	692,265	5,158,415	10.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AS	686,213	5,157,832	5.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AT	685,634	5,157,063	5.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AU	685,831	5,156,534	5.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AV	686,693	5,157,709	6.4	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AW	689,155	5,170,080	15.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AX	691,215	5,172,303	21.5	1.0	1.0	1.0	0.0	90.0	"Green house mode"

To be continued on next page...

SHADOW - Main Result

Calculation: Real Case - 3 Phases

...continued from previous page

No.	Easting	Northing	Z [m]	Width [m]	Height [m]	Height a.g.l. [m]	Degrees from south cw [°]	Slope of window [°]	Direction mode
AY	691,417	5,172,137	21.4	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AZ	689,341	5,169,920	16.6	1.0	1.0	1.0	0.0	90.0	"Green house mode"

Calculation Results

Shadow receptor

	Shadow, worst case			Shadow, expected values
No.	Shadow hours per year [h/year]	Shadow days per year [days/year]	Max shadow hours per day [h/day]	Shadow hours per year [h/year]
A	0:00	0	0:00	0:00
B	0:00	0	0:00	0:00
C	0:00	0	0:00	0:00
D	0:00	0	0:00	0:00
E	0:00	0	0:00	0:00
F	3:50	24	0:16	0:56
G	5:39	30	0:18	0:59
H	0:00	0	0:00	0:00
I	0:00	0	0:00	0:00
J	0:00	0	0:00	0:00
K	3:32	33	0:10	1:19
L	32:52	116	0:29	11:41
M	20:15	101	0:23	5:21
N	2:35	27	0:09	0:37
O	0:00	0	0:00	0:00
P	2:45	29	0:09	0:54
Q	11:20	61	0:22	2:51
R	6:34	36	0:18	2:08
S	0:57	12	0:07	0:17
T	0:00	0	0:00	0:00
U	0:00	0	0:00	0:00
V	0:00	0	0:00	0:00
W	0:00	0	0:00	0:00
X	0:00	0	0:00	0:00
Y	0:00	0	0:00	0:00
Z	0:00	0	0:00	0:00
AA	0:00	0	0:00	0:00
AB	0:00	0	0:00	0:00
AC	0:00	0	0:00	0:00
AD	0:00	0	0:00	0:00
AE	0:00	0	0:00	0:00
AF	0:00	0	0:00	0:00
AG	0:00	0	0:00	0:00
AH	0:00	0	0:00	0:00
AI	0:00	0	0:00	0:00
AJ	0:00	0	0:00	0:00
AK	0:00	0	0:00	0:00
AL	0:56	13	0:06	0:19
AM	0:00	0	0:00	0:00
AN	0:00	0	0:00	0:00
AO	0:00	0	0:00	0:00
AP	0:00	0	0:00	0:00
AQ	0:00	0	0:00	0:00
AR	0:00	0	0:00	0:00
AS	0:00	0	0:00	0:00
AT	0:00	0	0:00	0:00
AU	0:00	0	0:00	0:00
AV	0:00	0	0:00	0:00
AW	36:25	117	0:34	12:52
AX	0:00	0	0:00	0:00
AY	0:00	0	0:00	0:00
AZ	74:19	193	0:39	17:24

SHADOW - Main Result

Calculation: Real Case - 3 Phases

Total amount of flickering on the shadow receptors caused by each WTG

No.	Name	Worst case [h/year]	Expected [h/year]
1	9	1:45	0:39
2	16	1:00	0:15
3	24	0:00	0:00
4	25	0:58	0:17
5	26	4:25	1:21
6	27	12:31	3:20
7	28	0:00	0:00
8	29	0:00	0:00
9	33	0:00	0:00
10	34	0:00	0:00
11	35	0:00	0:00
12	36	0:00	0:00
13	37	0:00	0:00
14	39	0:00	0:00
15	48	0:00	0:00
16	49	0:00	0:00
17	50	0:00	0:00
18	51	0:00	0:00
19	52	0:00	0:00
20	53	0:00	0:00
21	54	0:00	0:00
22	56	0:00	0:00
23	63	0:00	0:00
24	64	0:00	0:00
25	74	5:09	1:59
26	75	27:19	10:11
27	76	18:50	5:23
28	77	8:35	1:55
29	21	0:00	0:00
30	43	0:00	0:00
31	45	0:00	0:00
32	46	0:00	0:00
33	47	0:00	0:00
34	57	0:00	0:00
35	58	0:00	0:00
36	59	0:00	0:00
37	60	0:00	0:00
38	61	0:00	0:00
39	62	0:00	0:00
40	65	0:00	0:00
41	66	0:00	0:00
42	67	0:00	0:00
43	68	0:00	0:00
44	69	0:00	0:00
45	70	0:00	0:00
46	71	0:00	0:00
47	72	0:00	0:00
48	78	0:00	0:00
49	17	0:00	0:00
50	18	0:00	0:00
51	19	0:00	0:00
52	20	0:00	0:00
53	22	0:00	0:00
54	23	0:00	0:00
55	30	0:00	0:00
56	31	0:00	0:00
57	32	0:00	0:00
58	38	0:00	0:00
59	40	0:00	0:00
60	55	0:00	0:00
61	138a	46:54	7:12
62	73a	0:00	0:00
63	93a	35:40	12:42
64	41	0:00	0:00
65	42	0:00	0:00
66	44	0:00	0:00

To be continued on next page...

SHADOW - Main Result

Calculation: Real Case - 3 Phases

...continued from previous page

No.	Name	Worst case [h/year]	Expected [h/year]
67	79	0:00	0:00
68	80	0:00	0:00
69	81	0:00	0:00
70	82	0:00	0:00
71	83	0:00	0:00
72	84	0:00	0:00
73	85	0:00	0:00
74	86	0:00	0:00
75	87	0:00	0:00
76	88	0:00	0:00
77	89	0:00	0:00
78	90	0:00	0:00
79	91	0:00	0:00
80	92	0:00	0:00
81	94	0:00	0:00
82	95	0:00	0:00
83	96	0:00	0:00
84	97	0:00	0:00
85	98	0:00	0:00
86	99	0:00	0:00
87	100	0:00	0:00
88	101	0:00	0:00
89	102	0:00	0:00
90	103	0:00	0:00
91	104	0:00	0:00
92	105	0:00	0:00
93	106	0:00	0:00
94	107	0:00	0:00
95	108	0:00	0:00
96	109	0:00	0:00
97	110	0:00	0:00
98	111	0:00	0:00
99	112	5:39	0:59
100	113	0:00	0:00
101	114	0:00	0:00
102	115	0:00	0:00
103	116	0:00	0:00
104	117	3:50	0:56
105	118	0:00	0:00
106	119	0:00	0:00
107	120	0:00	0:00
108	121	0:00	0:00
109	122	0:00	0:00
110	123	0:00	0:00
111	124	0:00	0:00
112	125	0:00	0:00
113	126	0:00	0:00
114	127	0:00	0:00
115	129	0:00	0:00
116	130	0:00	0:00
117	131	0:00	0:00
118	132	0:00	0:00
119	133	0:00	0:00
120	134	0:00	0:00
121	135	0:00	0:00
122	136	0:00	0:00
123	139	0:00	0:00
124	140	0:00	0:00
125	141	0:00	0:00
126	142	0:00	0:00
127	143	0:00	0:00
128	144	0:00	0:00
129	145	0:00	0:00
130	146	0:00	0:00
131	147	0:00	0:00
132	148	0:00	0:00

To be continued on next page...

SHADOW - Main Result

Calculation: Real Case - 3 Phases

...continued from previous page

No.	Name	Worst case [h/year]	Expected [h/year]
133	149	0:00	0:00
134	150	0:00	0:00
135	151	0:00	0:00
136	152	0:00	0:00
137	153	0:00	0:00
138	154	0:00	0:00
139	155	0:00	0:00
140	156	0:00	0:00
141	157	0:00	0:00
142	158	0:00	0:00
143	159	0:00	0:00
144	160	0:00	0:00
145	161	0:00	0:00
146	162	0:00	0:00
147	163	0:00	0:00
148	164	0:00	0:00
149	165	0:00	0:00
150	166	0:00	0:00
151	167	0:00	0:00
152	1	0:00	0:00
153	2	0:00	0:00
154	3	0:00	0:00
155	4	0:00	0:00
156	5	0:00	0:00
157	6	0:00	0:00
158	7	0:00	0:00
159	8	0:00	0:00
160	10	0:00	0:00
161	11	0:00	0:00
162	12	22:01	8:19
163	13	3:15	0:50
164	14	0:00	0:00
165	15	0:00	0:00
166	128a	0:00	0:00
167	137a	0:00	0:00

Total times in Receptor wise and WTG wise tables can differ, as a WTG can lead to flicker at 2 or more receptors simultaneously and/or receptors may receive flicker from 2 or more WTGs simultaneously.