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 **RE Future**

Mumblin Wind Farm

Application for Planning Permit
Appendix G – Shadow Flicker Assessment
October 2025

Version History

Version	Author	Reviewer	Date	Description
1	SS	PL	28/04/21	Revision 1
2	VM	SS	23/01/22	Updated draft
3	VM	SS	31/01/22	Updated draft
4	VM	SS	15/07/22	Updated draft
5	VM	SS	19/08/24	Final

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Table of Contents

Table of Contents	ii
1 Introduction	1
2 Planning Policy Context.....	1
3 Shadow Flicker Modelling	2
4 Potential Impact on Road Users.....	3
5 Conclusion.....	4
Appendix: WindPro Shadow Flicker Report.....	6

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1 Introduction

Under the provisions of the Corangamite Planning Scheme, proponents of wind farms are required to consider the effect of the proposal on the surrounding area in terms of shadow flicker. Shadow flicker occurs when the movement of wind turbine blades creates a rotating shadow that appears as an intermittent, or flickering, shadow when experienced from a single vantage point in the vicinity of a wind turbine. Shadow flicker does not pose any risk of causing health effects; however, it does have the potential to adversely impact the amenity of nearby dwellings by subjecting residents to sharp contrasts of shade and light in short succession.

2 Planning Policy Context

Clause 52.32 of the Corangamite Planning Scheme sets out the application requirements for planning permit applications for wind energy facilities. Among other matters for consideration, Clause 52.32 stipulates that permit applications must address the potential impact of the wind farm in terms of shadow flicker.

Clause 52.32 does not specifically address the criteria against which wind farm shadow flicker is to be assessed, however it does list the *Planning Guidelines for the Development of Wind Energy Facilities 2023* (Planning Guidelines) as a document which must be considered by the responsible authority in assessing a wind farm planning permit application. The Planning Guidelines list a single criterion for the assessment of shadow flicker caused by wind farms, namely:

The shadow flicker experienced immediately surrounding the area of a dwelling (garden fenced area) must not exceed 30 hours per year as a result of the operation of the wind energy facility.

Neither Clause 52.32 nor the Planning Guidelines address the theory of shadow flicker or its assessment in detail. However, the Draft National Wind Farm Development Guidelines 2010 (National Guidelines) contain an in-depth discussion of shadow flicker theory and address a number of aspects of shadow flicker modelling and assessment. While the National Guidelines are not referenced in either Clause 52.32 or the Planning Guidelines, they nevertheless describe the phenomenon of shadow flicker and guide best practice modelling and impact assessment.

The National Guidelines distinguish two kinds of receptors of shadow flicker, namely participating landowners and neighbouring landowners. Participating landowners are those landowners who have entered into an agreement with the wind farm to host wind turbines and/or associated infrastructure, and who therefore have an interest in its successful development. Neighbouring landowners are the owners of land in the vicinity of the wind farm which may experience impacts from the wind energy facility.

The National Guidelines also list a number of best practice modelling assumptions which are addressed in the following section.

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3 Shadow Flicker Modelling

In order to determine the amount of shadow flicker that will be experienced by dwellings surrounding the wind farm, shadow flicker modelling was conducted using industry standard software, namely WindPro. Modelling was conducted on the basis of worst-case assumptions listed in the National Guidelines. These assumptions are listed in the Table 1 below.

Table 1: Modelling Assumptions

Modelling Parameter	Description
Zone of influence of shadows	265 x maximum chord length
Receptor height	1.5 m
Minimum angle of the sun	3 degrees
Acceptance criteria	Modelled – maximum of 30 hours per year
Cloud cover correction	Modelled – yes

The resulting shadow flicker map is presented in Figure 1. The levels of shadow flicker predicted at dwellings located within 2 km of a turbine are summarised in Table 2.

Table 2: Modelled Shadow Flicker Levels at Dwellings within 2 km (Hours/Year)

Dwelling Number	Dwelling Type	Modelled Flicker	Cloud Correction Factor	Final Flicker Levels
26	Neighbouring	0:00	0.441	0:00
27	Neighbouring	0:00	0.441	0:00
35	Neighbouring	0:00	0.441	0:00
37	Neighbouring	0:00	0.441	0:00
38	Neighbouring	0:00	0.441	0:00
39	Participating	0:00	0.441	0:00
56	Neighbouring	0:00	0.441	0:00
57	Neighbouring	0:00	0.441	0:00
58	Neighbouring	0:00	0.441	0:00
59	Neighbouring	0:00	0.441	0:00
60	Neighbouring	0:00	0.441	0:00
61	Participating	0:00	0.441	0:00
62	Neighbouring	0:00	0.441	0:00
63	Neighbouring	0:00	0.441	0:00
64	Neighbouring	0:00	0.441	0:00
65	Neighbouring	0:00	0.441	0:00
73	Neighbouring	0:00	0.441	0:00
74	Neighbouring	0:00	0.441	0:00
75	Neighbouring	0:00	0.441	0:00
76	Neighbouring	0:00	0.441	0:00
77	Neighbouring	0:00	0.441	0:00
79	Participating	0:00	0.441	0:00

80	Participating	28:55	0.441	12:46
81	Participating	0:00	0.441	0:00
82	Participating	0:00	0.441	0:00
83	Participating	0:00	0.441	0:00
96	Participating	0:00	0.441	0:00
98	Participating	0:00	0.441	0:00
99	Participating	0:00	0.441	0:00
100	Participating	0:00	0.441	0:00
101	Neighbouring	0:00	0.441	0:00
102	Neighbouring	0:00	0.441	0:00
103	Neighbouring	0:00	0.441	0:00
104	Neighbouring	0:00	0.441	0:00
105	Neighbouring	0:00	0.441	0:00
107	Neighbouring	0:00	0.441	0:00
176	Neighbouring	0:00	0.441	0:00
177	Participating	0:00	0.441	0:00
178	Participating	0:00	0.441	0:00
225	Neighbouring	0:00	0.441	0:00
226	Neighbouring	0:00	0.441	0:00

Modelled flicker values represent a worst case scenario where it is assumed the sun always shines, there are no intervening obstacles, wind turbines are always facing perpendicular to the line of sight between the point of observation and the turbine, and shadow receptors face all directions. It is important to note that actual shadow flicker will be lower than the levels predicted above.

One simple method for determining a closer estimate of actual shadow flicker is to subtract the proportion of cloudy days from the annual prediction of shadow flicker using weather data from the nearest Bureau of Meteorology weather station. In the case of the present wind farm this weather station is located at Warrnambool Airport, approximately 40 km from the wind farm site. According to this data Mumblin experiences on average 204.1 cloudy days per year, which equates to a reduction in annual shadow flicker of 55.9%. Cloud cover corrected predictions for shadow flicker are included in the table above.

Shadow flicker modelling was based on the worst case candidate turbine model. In the event that the ultimate choice of turbine differs from the Vestas V172 HH166 all modelling will be redone on the basis of the final model selected and the wind farm will comply with all conditions of development approval.

4 Potential Impact on Road Users

While it is not directly addressed by either Clause 52.32 or the Planning Guidelines, the potential impact of wind farm shadow flicker on major roads has recently emerged as a potential planning consideration for proposed wind farms. However, the proposed wind farm is not located in the vicinity of any major roads.

Shadow flicker is a common feature of the road users experience, especially on rural roads which are bordered by mature vegetation, and in metropolitan areas where roads pass large buildings and overpasses. There are two established road safety standards which address this kind of shadow flicker and which can be used as a guide for the assessment of the potential impact of wind farm shadow flicker on road users. In particular, road related shadow flicker is addressed by Australian Standard AS 1158:5:2007 (Lighting for roads and public spaces – Part 5: Tunnels and underpasses) (Section 3.3.8) and Commission Internationale de L'Eclairage Standard CIE 88:2004 (Guide for Lighting of Roads Tunnels and Underpasses 2nd ed.) (Section 6.14). According to these standards shadow flicker will be noticeable to road users and potentially cause annoyance when it occurs between 2.5 – 15 Hz, and that shadow flicker between 4 – 11 Hz should be avoided for periods of twenty seconds or longer.

The frequency of shadow flicker caused by a wind farm is directly proportional to the rotational velocity of the wind turbine rotor. The maximum rotational velocity of the Vestas V172 is 12.1 RPM, which equates to 36.3 shadow events per minute, or a shadow flicker frequency of 0.605 Hz. Accordingly, the shadow flicker caused by the proposed wind farm will be well below the threshold set by AS 1158:5:2007 and CIE 88:2004 for annoyance, and as such will have no impact on road safety adjacent to the wind farm site.

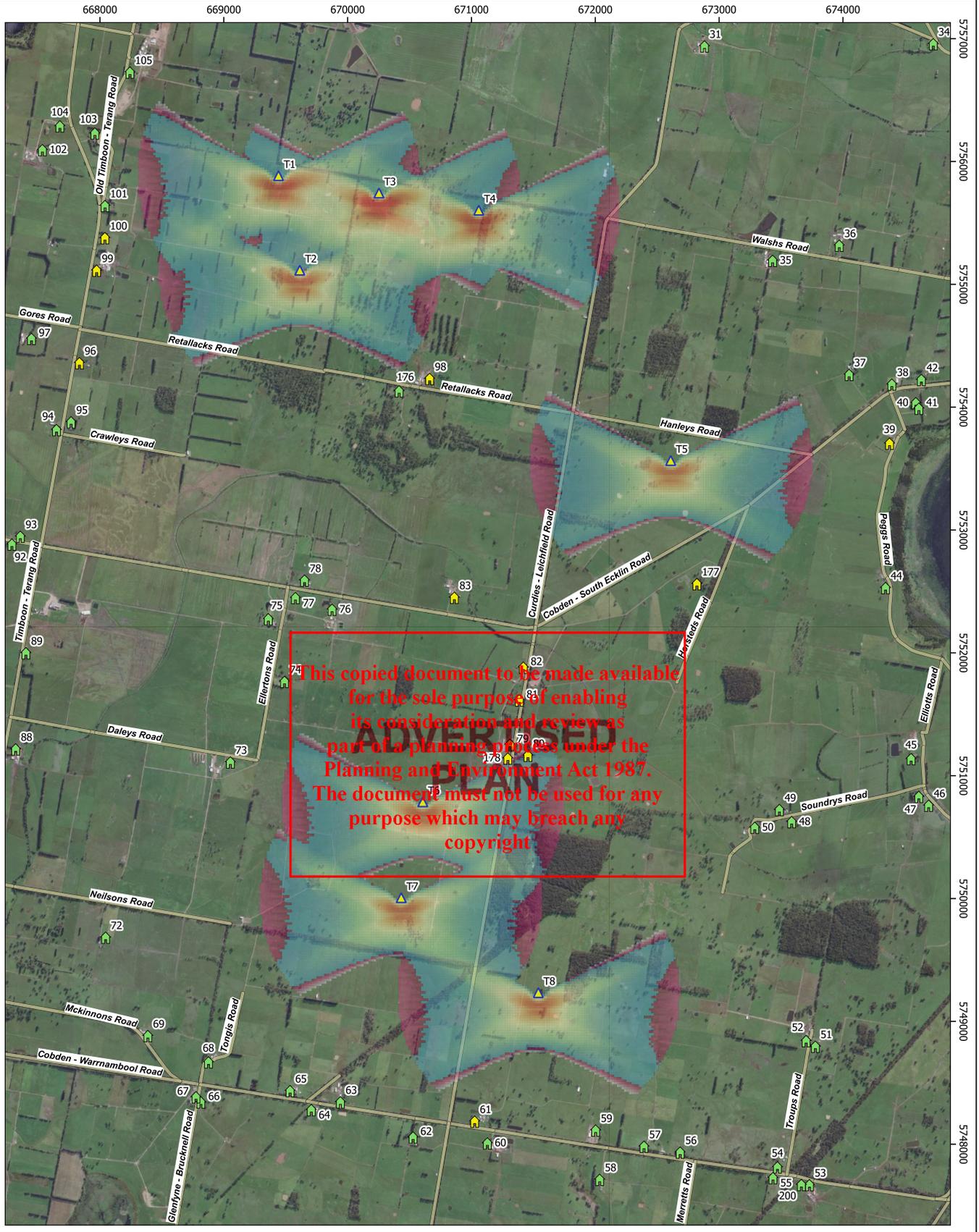
While it is possible that the shadow flicker of two or more wind turbines could be superimposed in one location (in the event that the wind turbines formed a line between the sun and the point of observation) and thereby increase the frequency of shadow flicker to 1.21 Hz or even 1.815 Hz, this resulting frequency remains below the annoyance level defined by AS 1158:5:2007 and CIE 88:2004.

5 Conclusion

Shadow flicker modelling has been carried out in accordance with best practice industry guidelines. The resulting levels of shadow flicker predicted to occur at non-participating dwellings are all zero, while one dwelling belonging to a participating landowner is predicted to receive shadow flicker below the acceptable limit of 30 hours per year. A shadow flicker report from WindPro has been included as an appendix to this report.

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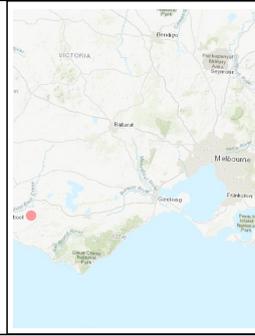
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Legend

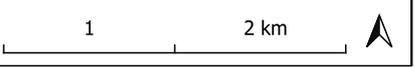
- Wind turbine
 - Dwelling
 - Host dwelling
 - ROAD
- Shadow Flicker per annum**
- Above 30 hours
 - 30 - 15 hours
 - 15 - 10 hours
 - 10 - 5 hours
 - Less than 30 hours



Mumblin Wind Farm

Predicted Shadow Flicker

Drawn	VM	Scale when printed at A3	1:30,000
Checked	SS	Date	19-08-2024
Approved	SS	Figure No:	1



Appendix: WindPro Shadow Flicker Report

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SHADOW - Main Result

Calculation: 20240819 MUM Shadow flicker Rev 6

Assumptions for shadow calculations

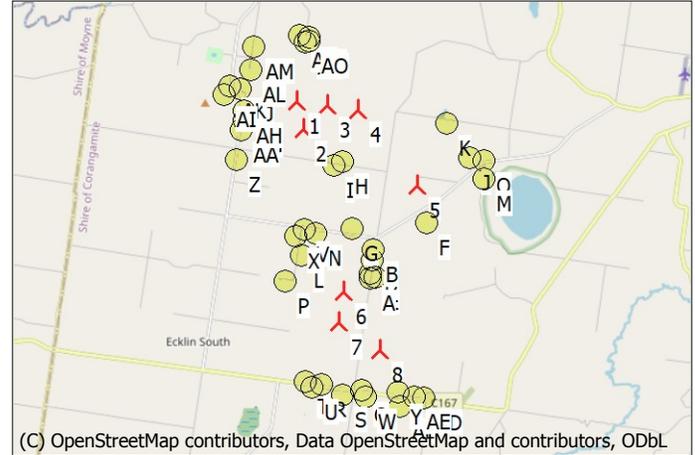
Maximum distance for influence 1,140 m
 Minimum sun height over horizon for influence 3 °
 Day step for calculation 1 days
 Time step for calculation 1 minutes

The calculated times are "worst case" given by the following assumptions:
 The sun is shining all the day, from sunrise to sunset
 The rotor plane is always perpendicular to the line from the WTG to the sun
 The WTG is always operating

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: GeoAus online contour 1 m rev 2
 Receptor grid resolution: 1.0 m

All coordinates are in
 UTM (south)-WGS84 Zone: 54



(C) OpenStreetMap contributors, Data OpenStreetMap and contributors, ODbL
 Scale 1:200,000
 New WTG
 Shadow receptor

WTGs

Easting	Southing	Z [m]	Row data/Description	WTG type				Shadow data			
				Valid	Manufact.	Type generator	Power, rated [kW]	Rotor diameter [m]	Hub height [m]	Calculation distance [m]	RPM [RPM]
1 669,442	5,755,885	126.0	WTG 1	Yes	VESTAS	V172-7.2-7,200	7,200	172.0	166.0	1,140	-
2 669,614	5,755,115	126.7	WTG 2	Yes	VESTAS	V172-7.2-7,200	7,200	172.0	166.0	1,140	-
3 670,254	5,755,744	127.0	WTG 3	Yes	VESTAS	V172-7.2-7,200	7,200	172.0	166.0	1,140	-
4 671,059	5,755,604	127.0	WTG 4	Yes	VESTAS	V172-7.2-7,200	7,200	172.0	166.0	1,140	-
5 672,610	5,753,566	138.0	WTG 5	Yes	VESTAS	V172-7.2-7,200	7,200	172.0	166.0	1,140	-
6 670,607	5,750,787	127.0	WTG 6	Yes	VESTAS	V172-7.2-7,200	7,200	172.0	166.0	1,140	-
7 670,433	5,750,006	129.4	WTG 7	Yes	VESTAS	V172-7.2-7,200	7,200	172.0	166.0	1,140	-
8 671,541	5,749,233	136.0	WTG 8	Yes	VESTAS	V172-7.2-7,200	7,200	172.0	166.0	1,140	-

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Shadow receptor-Input

No.	Name	Easting	Southing	Z	Width	Height	Elevation a.g.l.	Slope of window	Direction mode	Eye height (ZVI) a.g.l.
		[m]	[m]	[m]	[m]	[m]	[m]	[°]		[m]
A	Dwelling 178	671,294	5,751,146	128.9	1.0	1.0	1.0	90.0	"Green house mode"	2.0
B	Dwelling 82	671,419	5,751,886	126.7	1.0	1.0	1.0	90.0	"Green house mode"	2.0
C	Dwelling 79	671,311	5,751,257	128.9	1.0	1.0	1.0	90.0	"Green house mode"	2.0
D	Dwelling 81	671,386	5,751,618	129.7	1.0	1.0	1.0	90.0	"Green house mode"	2.0
E	Dwelling 80	671,456	5,751,168	128.4	1.0	1.0	1.0	90.0	"Green house mode"	2.0
F	Dwelling 177	672,834	5,752,565	131.8	1.0	1.0	1.0	90.0	"Green house mode"	2.0
G	Dwelling 83	670,862	5,752,454	123.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
H	Dwelling 98	670,662	5,754,239	131.8	1.0	1.0	1.0	90.0	"Green house mode"	2.0
I	Dwelling 176	670,411	5,754,143	131.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
J	Dwelling 37	674,050	5,754,269	137.5	1.0	1.0	1.0	90.0	"Green house mode"	2.0
K	Dwelling 35	673,432	5,755,197	133.6	1.0	1.0	1.0	90.0	"Green house mode"	2.0
L	Dwelling 74	669,490	5,751,769	126.7	1.0	1.0	1.0	90.0	"Green house mode"	2.0
M	Dwelling 39	674,376	5,753,709	137.4	1.0	1.0	1.0	90.0	"Green house mode"	2.0
N	Dwelling 76	669,874	5,752,357	124.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
O	Dwelling 38	674,395	5,754,190	137.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
P	Dwelling 73	669,053	5,751,113	130.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
Q	Dwelling 61	671,026	5,748,189	129.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
R	Dwelling 63	669,941	5,748,346	126.5	1.0	1.0	1.0	90.0	"Green house mode"	2.0
S	Dwelling 62	670,528	5,748,060	130.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
T	Dwelling 65	669,535	5,748,438	130.7	1.0	1.0	1.0	90.0	"Green house mode"	2.0
U	Dwelling 64	669,706	5,748,283	126.7	1.0	1.0	1.0	90.0	"Green house mode"	2.0
V	Dwelling 77	669,578	5,752,452	125.7	1.0	1.0	1.0	90.0	"Green house mode"	2.0
W	Dwelling 60	671,129	5,748,012	127.3	1.0	1.0	1.0	90.0	"Green house mode"	2.0
X	Dwelling 75	669,361	5,752,279	127.3	1.0	1.0	1.0	90.0	"Green house mode"	2.0
Y	Dwelling 59	672,003	5,748,117	124.8	1.0	1.0	1.0	90.0	"Green house mode"	2.0
Z	Dwelling 96	667,834	5,754,365	124.9	1.0	1.0	1.0	90.0	"Green house mode"	2.0
AA	Dwelling 99	667,973	5,755,118	131.8	1.0	1.0	1.0	90.0	"Green house mode"	2.0

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To be continued on next page...

SHADOW - Main Result

Calculation: 20240819 MUM Shadow flicker Rev 6

...continued from previous page

No.	Name	Easting	Southing	Z	Width	Height	Elevation a.g.l.	Slope of window	Direction mode	Eye height (ZVI) a.g.l.
				[m]	[m]	[m]	[m]	[°]		[m]
AB Dwelling 26	669,809	5,757,558	165.6	1.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
AC Dwelling 27	669,592	5,757,593	179.4	1.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
AD Dwelling 56	672,686	5,747,938	132.1	1.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
AE Dwelling 57	672,394	5,747,985	129.1	1.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
AF Dwelling 58	672,036	5,747,716	127.0	1.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
AG Dwelling 100	668,040	5,755,382	136.8	1.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
AH Dwelling 101	668,041	5,755,645	147.0	1.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
AI Dwelling 102	667,535	5,756,099	181.2	1.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
AJ Dwelling 103	667,959	5,756,235	164.7	1.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
AK Dwelling 104	667,676	5,756,293	173.0	1.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
AL Dwelling 105	668,242	5,756,731	192.7	1.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
AM Dwelling 107	668,337	5,757,323	192.9	1.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
AN Dwelling 225	669,736	5,757,414	158.4	1.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
AO Dwelling 226	669,819	5,757,464	158.9	1.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0

Calculation Results

Shadow receptor

Shadow, worst case

No.	Name	Shadow hours per year [h/year]	Shadow days per year [days/year]	Max shadow hours per day [h/day]
A Dwelling 178		0:00	0	0:00
B Dwelling 82		0:00	0	0:00
C Dwelling 79		0:00	0	0:00
D Dwelling 81		0:00	0	0:00
E Dwelling 80		28:55	54	0:40
F Dwelling 177		0:00	0	0:00
G Dwelling 83		0:00	0	0:00
H Dwelling 98		0:00	0	0:00
I Dwelling 176		0:00	0	0:00
J Dwelling 37		0:00	0	0:00
K Dwelling 35		0:00	0	0:00
L Dwelling 74		0:00	0	0:00
M Dwelling 39		0:00	0	0:00
N Dwelling 76		0:00	0	0:00
O Dwelling 38		0:00	0	0:00
P Dwelling 73		0:00	0	0:00
Q Dwelling 61		0:00	0	0:00
R Dwelling 63		0:00	0	0:00
S Dwelling 62		0:00	0	0:00
T Dwelling 65		0:00	0	0:00
U Dwelling 64		0:00	0	0:00
V Dwelling 77		0:00	0	0:00
W Dwelling 60		0:00	0	0:00
X Dwelling 75		0:00	0	0:00
Y Dwelling 59		0:00	0	0:00
Z Dwelling 96		0:00	0	0:00
AA Dwelling 99		0:00	0	0:00
AB Dwelling 26		0:00	0	0:00
AC Dwelling 27		0:00	0	0:00
AD Dwelling 56		0:00	0	0:00
AE Dwelling 57		0:00	0	0:00
AF Dwelling 58		0:00	0	0:00
AG Dwelling 100		0:00	0	0:00
AH Dwelling 101		0:00	0	0:00
AI Dwelling 102		0:00	0	0:00
AJ Dwelling 103		0:00	0	0:00
AK Dwelling 104		0:00	0	0:00
AL Dwelling 105		0:00	0	0:00
AM Dwelling 107		0:00	0	0:00
AN Dwelling 225		0:00	0	0:00
AO Dwelling 226		0:00	0	0:00

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19/08/2024 9:57 PM/4.0.547

SHADOW - Main Result

Calculation: 20240819 MUM Shadow flicker Rev 6

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

No.	Name	Worst case [h/year]
1	WTG 1	0:00
2	WTG 2	0:00
3	WTG 3	0:00
4	WTG 4	0:00
5	WTG 5	0:00
6	WTG 6	28:55
7	WTG 7	0:00
8	WTG 8	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.

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