

Shadow Flicker Impact Assessment - Addendum

RSK Environment Limited

Hollandmey Renewable Energy Development

October 2021



PLANNING SOLUTIONS FOR:

- Solar
- Defence
- Airports
- Telecoms
- Buildings
- Radar
- Railways
- Wind
- Mitigation

www.pagerpower.com

ADMINISTRATION PAGE

Job Reference:	10008D and 10008H
Date:	December 2020 and August 2021
Author:	Danny Scrivener
Telephone:	01787 319 001
Email:	danny@pagerpower.com

Reviewer:	Kai Frolic and Michael Sutton
Date:	December 2020 and August 2021
Telephone:	01787 319 001
Email:	kai@pagerpower.com

Issue	Date	Detail of Changes
1	December 2020	Initial issue (10008D)
2	August 2021	Assessment of updated T8 location (10008H)
3	October 2021	Minor amendments
4	October 2021	Technical addendum considering an 11 rotor diameter assessment area

Confidential: The contents of this document may not be disclosed to others without permission.

Copyright © 2021 Pager Power Limited

Stour Valley Business Centre, Brundon Lane, Sudbury, CO10 7GB

T:01787 319001 E:info@pagerpower.com W:www.pagerpower.com

TECHNICAL ADDENDUM

Report Purpose

Pager Power has been commissioned to assess the shadow flicker effects out to 11 rotor diameters from the proposed wind turbines at the request of the local planning authority. The initial technical report (10008H - Shadow Flicker Impact AssessmentV2) considered an assessment area of 10 rotor diameters, as is recommended within the industry guidance. This addendum presents the results of the analysis considering 11 rotor diameters for the proposed Hollandmey Wind Farm located in northern Scotland, UK.

Assessment Methodology

Dwelling receptors have been identified¹ in the area surrounding the proposed wind development up to 11-rotor diameters (1,452m) from the nearest wind turbine.

The assessment has considered a 'view height' of 1.5 metres above ground level with each window having dimensions of 1m by 1m which directly faces the nearest wind turbine. The model considers terrain, the relative geometry of the turbine to the receptor, the dimensions of the wind turbines and the path of the Sun across the sky throughout a single year. The minimum Sun elevation at which shadow flicker effects could be deemed to materialise is 2 degrees above the horizon. The wind turbine dimensions and locations, guidance and receptor details are presented within the full technical report which accompanies this addendum.

Note that the time results are given as a decimal, where 0.5 hours = 30 minutes.

Discussion – 10 Rotor Diameter Assessment Area Versus 11 Rotor Diameter

It is common to use 10 rotor diameters as a maximum limit within which significant shadow flicker effects can occur. The validity of this limit is discussed at length within the relevant literature². The guidance on this particular criterion varies in different documents and countries, with some stating that effects can only occur within this distance and others stating that this is a general rule or that the risk beyond this distance is low.

Pager Power generally considers receptors within 10 rotor diameters. This makes the 10 rotor diameter zone for each turbine measure out to 1,320m from the turbine. This is considered an appropriate zone for potentially significant effects based on the available guidance and because other features of the modelling are highly conservative³ as set out in Table 2 of the full technical report. In the full technical report, an additional 50m micro-siting allowance was also considered.

¹ Provided by the developer.

² See Table 2 for references.

³ For example the assumption that all properties have a single window facing the development and ignoring potential cloud cover or low wind speeds that could reduce the effects.

The local planning authority has however requested that the shadow flicker analysis be undertaken out to 11 rotor diameters (1,452m from the individual wind turbines). This addendum therefore considers this assessment area.

Assessed Receptors

Figure 1⁴ below shows the dwellings considered⁵ for shadow flicker analysis and turbine locations, specifically:

- The turbine positions (circular icons);
- The 10-rotor diameter zone (1,320m radius) relative to the turbines (red line) – for reference;
- The 11-rotor diameter zone (1,452m radius) relative to the turbines (yellow lined area);
- IDs for the dwellings within the 11-rotor diameter zone (dwellings 21, 26 and 27).

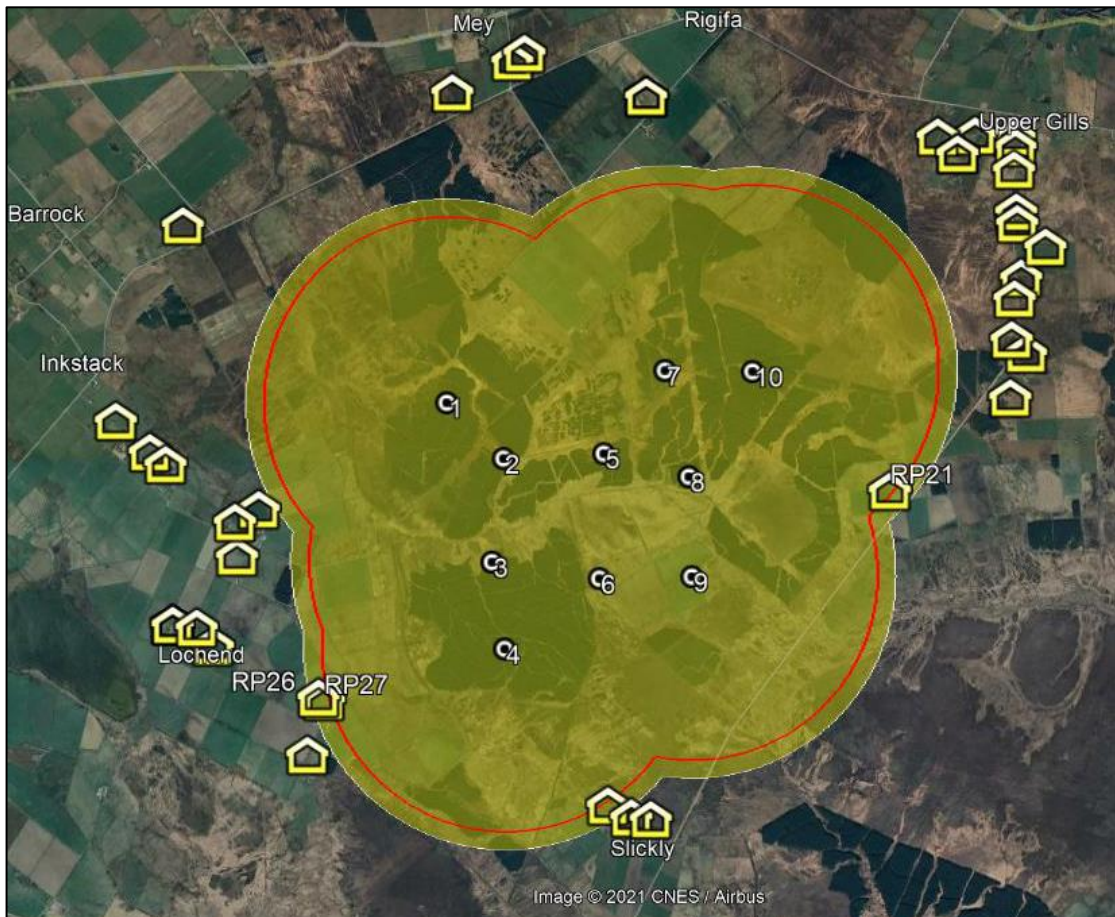


Figure 1 Identified dwelling receptors considered for the assessment

⁴ Source: Aerial image copyright © 2021 Google.

⁵ Provided by the developer.

Acceptable Limits

There is no formal limit on the amount of shadow flicker that is considered acceptable within the UK.

Other European countries do have limits, and these vary from one country to another⁶. A typical limit, which has been utilised in Northern Ireland, Republic of Ireland, Germany and Belgium, is 30 hours per year with a maximum of 30 minutes per day. Since there is no formal guidance on this subject in the UK, the discussion of the results relative to these limits is for reference purposes only.

If shadow flicker effects are predicted beyond this limit, mitigation may be required to prevent the occurrence of shadow flicker. This is typically controlled by remote automatic wind turbine shutdown so that in effect, no neighbouring property will experience the occurrence of shadow flicker beyond the limits specified above. There are two approaches to mitigation:

- Complete removal of effects;
- Reduction of any effects to the acceptable limit specified above.

Shadow flicker effects can only occur under specific conditions so, in reality, turbine shutdown may not be required to eliminate effects i.e. shadow flicker cannot occur if the weather at the time of predicted effects is not clear and sunny or if the rotor is not facing a dwelling.

Shadow Flicker Results

Table 1 below summarises the key findings for the receptors.

Number of receptors predicted to experience no shadow flicker at all.	Number of receptors predicted to experience less than 30 minutes per day and less than 30 hours per year	Number of receptors predicted to experience more than 30 minutes per day and/or more than 30 hours per year	Maximum hours per day predicted at any receptor	Maximum hours per year predicted at any receptor
None	Three Receptors 21, 26 and 27	None	0.41 Receptor 26	12 Receptor 27

Table 1 Results summary – effects at receptors

⁶ Parsons Brinckerhoff (2011): *Update of UK Shadow Flicker Evidence Base*.

Table 2 below quantifies the shadow flicker effects by receptor.

Receptor	Days per year of shadow flicker	Maximum hours per day	Mean hours per day	Total hours per year
21	14	0.14	0.11	1.5
26	36	0.40	0.31	11.3
27	37	0.41	0.32	12.0

Table 2 Results - shadow flicker per receptor

Table 3 below quantifies the shadow flicker effects by turbine.

Turbine	Days per year of shadow flicker	Maximum hours per day	Mean hours per day	Total hours per year
4	41	0.48	0.37	15.1
10	14	0.14	0.11	1.5

Table 3 Results - shadow flicker per turbine

Shadow flicker results summary

Shadow flicker effects are only possible if there is an unobstructed path from the turbines to the window(s). If there is no view of the turbines from a receptor, there will be no noticeable effects because the turbine shadow will not pass over the window.

Receptors 21, 26 and 27 would all receive shadow flicker effects for less than the reference limit of 30 minutes per day and 30 hours per year and would not require mitigation.

The assessment has assumed that the receptors all have a 1m by 1m window facing the nearest wind turbine and out to 11 rotor diameters. This is a worst-case assumption of as the disc described by the turbine blades is parallel to the house.

Shadow Flicker Date Time Graph

Figure 2 on the following page illustrates the combined shadow flicker times on all receptors from all turbines (red hatched areas). The red lines illustrate the sunrise and sunset times. It can be seen that effects generally occur when the Sun is low in the sky⁷, which is to be expected since this equates to the longest shadows.

Further detailed breakdowns are presented in Appendices B and C where effects are predicted, including:

- Summary of effects for each individual receptor;
- Graphs for individual turbines;
- Contour map.

⁷ This includes during the winter months where the Sun's maximum elevation is around 12 degrees.

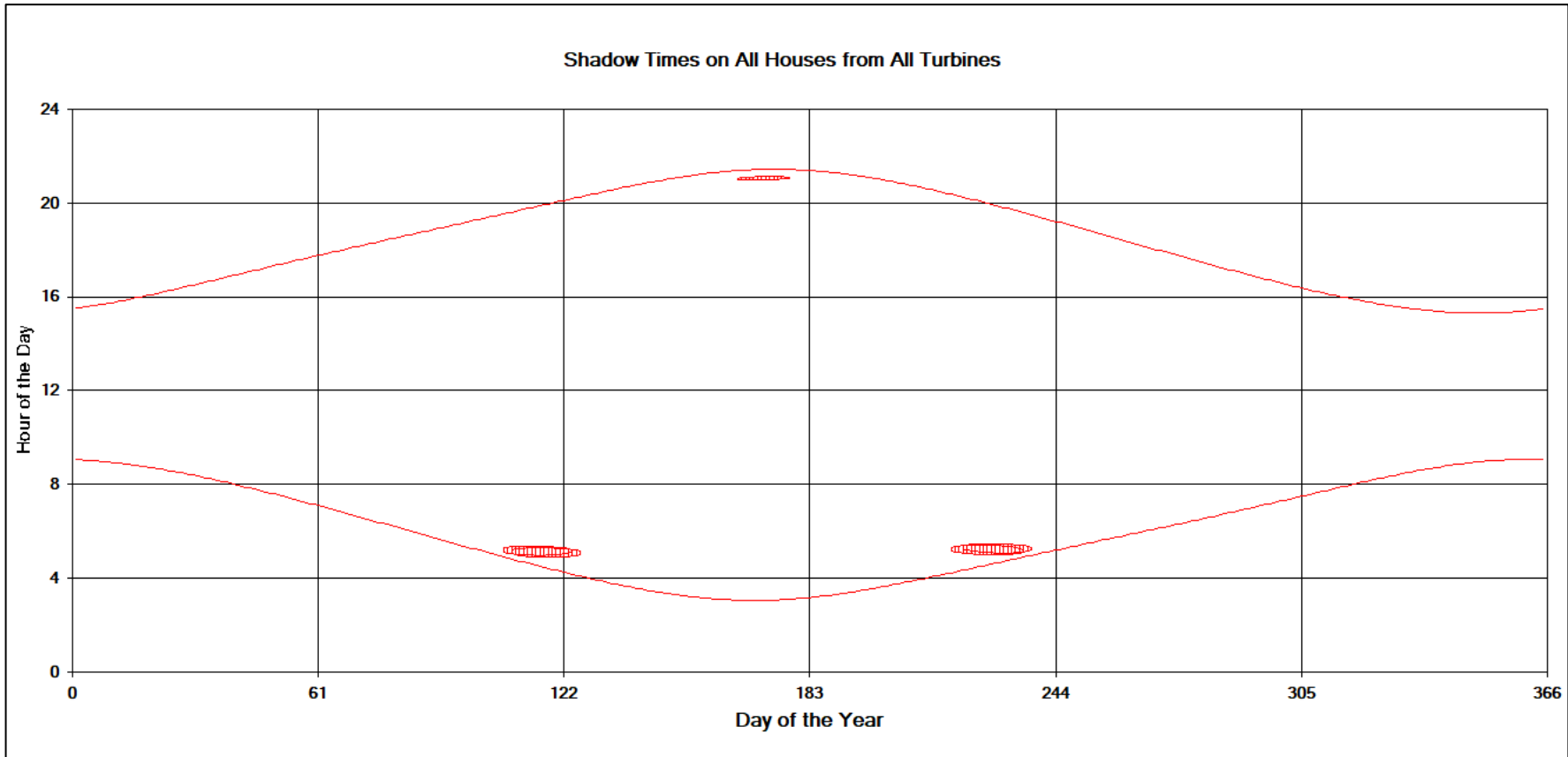


Figure 2 Shadow flicker times - all receptors and all turbines

Mitigation Measures

No mitigation measures are required considering the predicted shadow flicker.

Cumulative Shadow flicker Assessment

The potential for cumulative shadow flicker impacts has been determined by considering the results of the shadow flicker analysis and identifying existing wind developments in the wider area.

There are operational wind farms in the vicinity of the proposed wind development - Lochend, consisting of four wind turbines, and Slickly, consisting of 11 wind turbines. There are no significant cumulative shadow flicker effects predicted in conjunction with the proposed wind development because all identified dwellings are beyond 11 rotor diameters from these operational wind farms.

No significant cumulative shadow flicker impacts are predicted with respect to the proposed wind development and any existing wind developments surrounding it.

Addendum Conclusions

The overall conclusions are presented below:

- The analysis presents worst-case shadow flicker analysis out to 11 rotor diameters for the receptors provided to Pager Power by the developer;
- Three receptors (dwellings 21, 26 and 27) would experience shadow flicker effects for less than the reference limit of 30 minutes per day and 30 hours per year and would not require mitigation;
- All remaining assessed dwellings are outside of the 11 rotor diameter zone and do not require assessment or mitigation.

In accordance with the industry standard shadow flicker methodology, there will be no significant shadow flicker effects at any of the identified dwellings, either in isolation or cumulatively, requiring mitigation.

APPENDIX A – RECEPTOR INFORMATION

The table below shows the receptor information incorporated into the modelling (British National Grid).

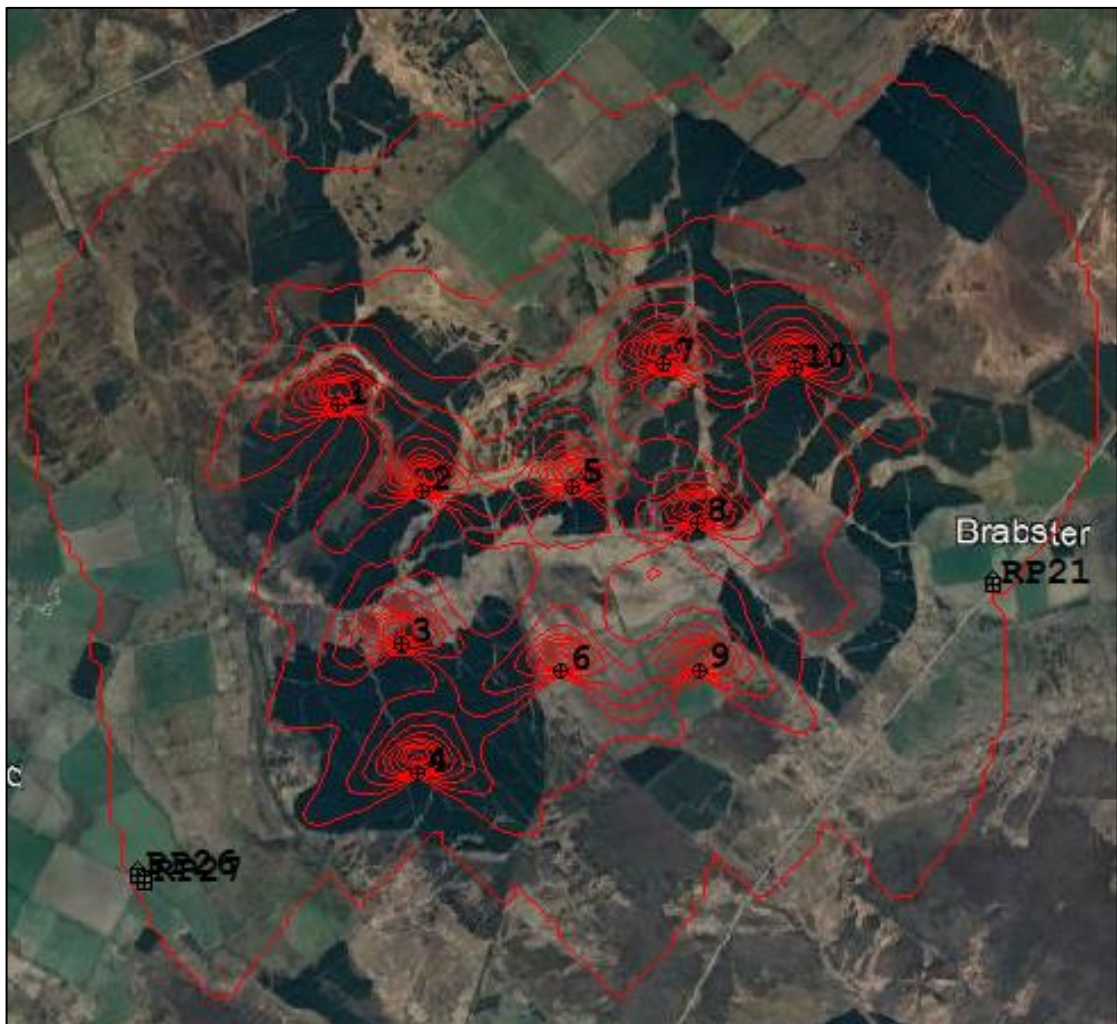
Receptor	Easting	Northing	Nearest Turbine	Distance to Nearest Turbine (m)	Bearing of Window to the Nearest Turbine (°)
21	331542	969143	10	1413	316.5
26	327429	967739	4	1442	68.7
27	327466	967716	4	1416	67.2

Assessed receptor details

APPENDIX B - CONTOUR MAP (FLICKER BUTTERFLY)

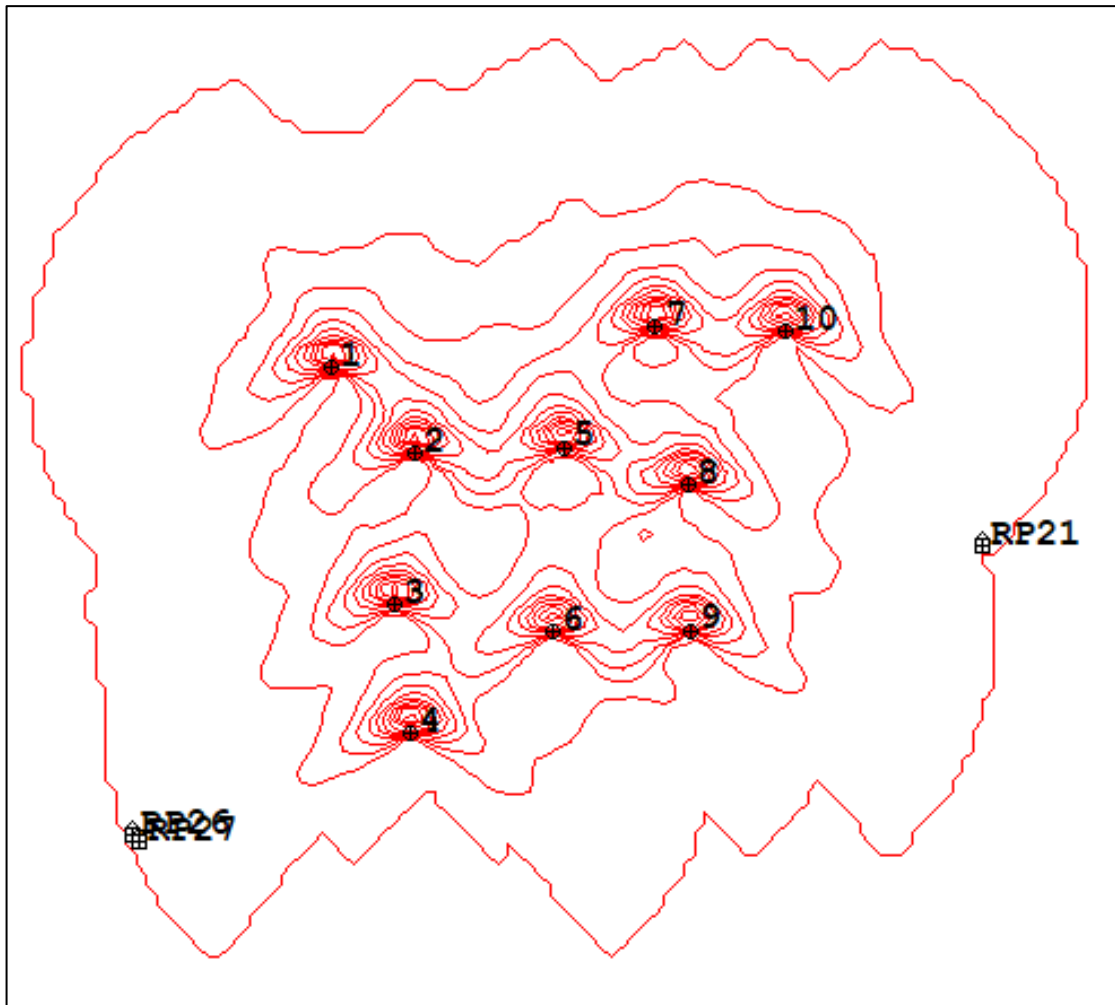
Overview

The figure⁸ below shows the shadow flicker contours associated with the proposed wind farm relative to the receptor locations. The contour spacing is 50 hours per year.



Contours - with map

⁸ Source: Aerial image copyright © 2021 Google.



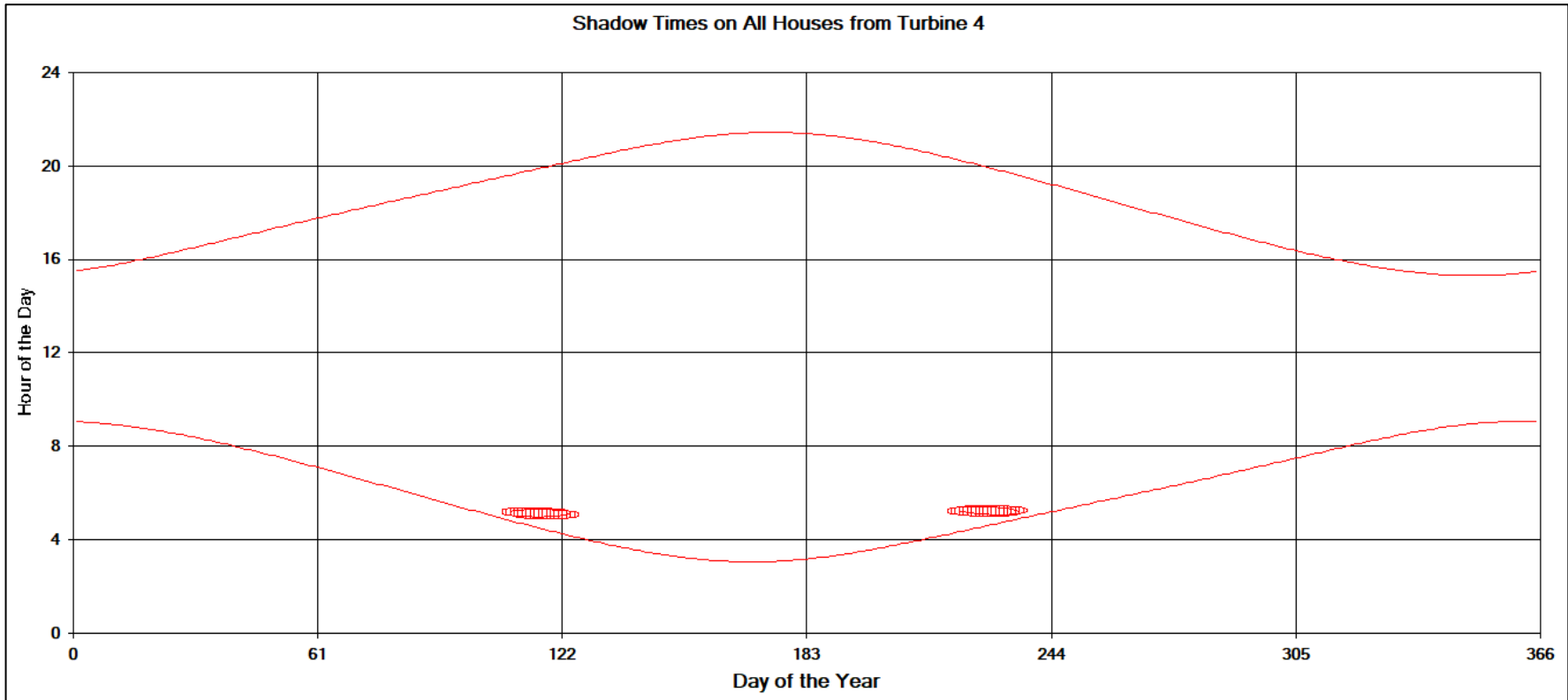
Contours - without map

APPENDIX C – SHADOW FLICKER CHARTS

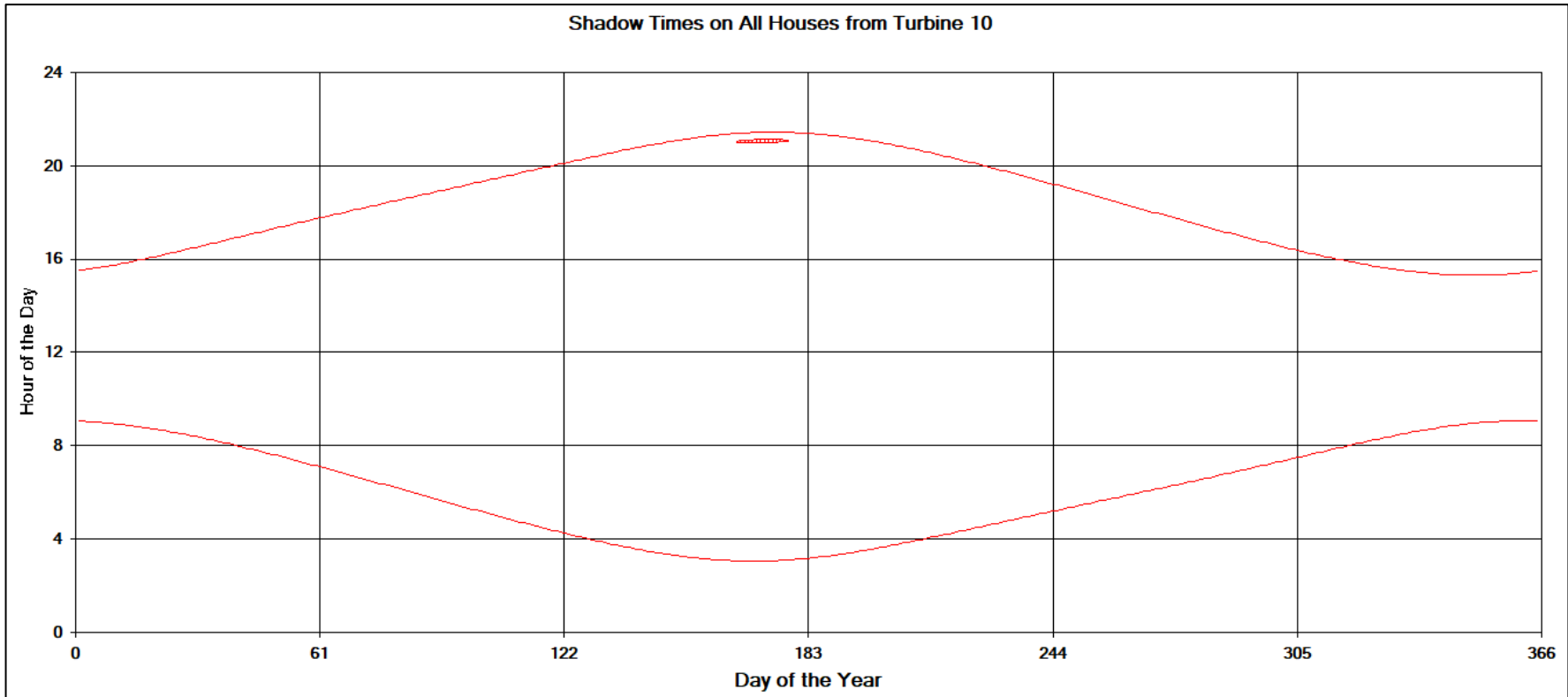
The charts on the following pages show:

- The sunrise and sunset times throughout the year (thin red lines at the top and bottom of the chart);
- The days/times at which effects could occur (red hatched area).

The results are presented per turbine, considering all receptors.



Predicted shadow flicker - turbine 4



Predicted shadow flicker - turbine 10

PAGERPOWER 
Urban & Renewables

Pager Power Limited
Stour Valley Business Centre
Sudbury
Suffolk
CO10 7GB

Tel: +44 1787 319001 **Email:** info@pagerpower.com **Web:** www.pagerpower.com