PAGERPOWER

Urban & Renewables

Solar Photovoltaic Glint and Glare Study

Infinis Solar Developments Ltd

Aldeby Solar Park

30 March 2021

PLANNING SOLUTIONS FOR:

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

www.pagerpower.com

ADMINISTRATION PAGE

Job Reference:	9889A
Date:	September, 2020
Author:	Michael Sutton
Telephone:	01787 319001
Email:	michael@pagerpower.com

First Reviewer:	Aaron Williams
Second Reviewer	Kai Frolic
Date:	September, 2020
Telephone:	01787 319001
Email:	aaron@pagerpower.com; kai@pagerpower.com

Issue	Date	Detail of Changes
1	04 September 2020	Initial issue
2	15 September 2020	Second issue – Administrative revisions
3	18 September 2020	Third issue – Administrative revisions
4	08 December 2020	Fourth issue – Administrative revisions
5	30 March 2021	Fifth issue – Inclusion of landscape strategy

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:*+44 (0)1787 319001* E:*info@pagerpower.com* W: *www.pagerpower.com*

EXECUTIVE SUMMARY

Report Purpose

Pager Power has been retained to assess the possible effects of glint and glare from a solar photovoltaic (PV) development located southeast of Aldeby, Norfolk, in the UK. The assessment pertains to the possible impact upon surrounding road users and dwellings.

Guidance

Pager Power has undertaken over 600 glint and glare assessments in the UK, Europe and internationally. The company's own glint and glare guidance is based on industry experience and extensive consultation with industry stakeholders including airports and aviation regulators.

Conclusions and Recommendations

No significant impacts upon the surrounding road users have been identified.

The developer has proposed screening in the form of native hedgerow planting for two dwellings where a moderate impact has been predicted.

Modelling Results

- No significant impacts upon surrounding road users are predicted as all roads surrounding the proposed development are considered local roads where traffic volumes and/or speeds are likely to be relatively low. This means any predicted solar reflections would be considered 'low' impact in the worst case.
- Solar reflections are geometrically possible towards four out of the eight assessed dwelling receptors, however solar reflections will not be experienced in practice at dwellings 1 and 8 due to screening in the form of existing vegetation, which will obstruct views of the reflecting panels.
- For two dwellings located close to the proposed development, the modelling has indicated that an observer will experience solar reflections for less than 60 minutes per day but for more than 3 months per year. The impact upon these dwellings is moderate in accordance with the guidance presented in Appendix D, and the developer has therefore proposed screening to significantly obstruct views of the reflecting panel area[1].

[1] The height of this screening should ensure that the reflecting panel area is sufficiently obscured from view.

LIST OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 49 countries within Europe, Africa, America, Asia and Australasia.

The company comprises a team of experts to provide technical expertise and guidance on a range of planning issues for large and small developments.

Pager Power was established in 1997. Initially the company focus was on modelling the impact of wind turbines on radar systems. Over the years, the company has expanded into numerous fields including:

- Renewable energy projects.
- Building developments.
- Aviation and telecommunication systems.

Pager Power prides itself on providing comprehensive, understandable and accurate assessments of complex issues in line with national and international standards. This is underpinned by its custom software, longstanding relationships with stakeholders and active role in conferences and research efforts around the world.

Pager Power's assessments withstand legal scrutiny and the company can provide support for a project at any stage.

1 INTRODUCTION

1.1 Overview

Pager Power has been retained to assess the possible effects of glint and glare from a solar photovoltaic (PV) development located southeast of Aldeby, Norfolk, in the UK. The assessment pertains to the possible impact upon surrounding road users and dwellings.

This report contains the following:

- Solar development details.
- Explanation of glint and glare.
- Overview of relevant guidance.
- Overview of relevant studies.
- Overview of Sun movement.
- Assessment methodology.
- Identification of receptors.
- Glint and glare assessment for identified receptors.
- Results discussion.

1.2 Pager Power's Experience

Pager Power has undertaken over 600 Glint and Glare assessments in the UK and internationally. The studies have included assessment of civil and military aerodromes, railway infrastructure and other ground-based receptors including roads and dwellings.

1.3 Glint and Glare Definition

The definition of glint and glare can vary however, the definition used by Pager Power is as follows[2]:

- Glint – a momentary flash of bright light typically received by moving receptors or from moving reflectors.
- Glare – a continuous source of bright light typically received by static receptors or from large reflective surfaces.

The term 'solar reflection' is used in this report to refer to both reflection types i.e. glint and glare.

---

[2]These definitions are aligned with those of the Federal Aviation Administration (FAA) in the United States of America.

2 SOLAR DEVELOPMENT LOCATION AND DETAILS

2.1 Proposed Development Site Plan

The proposed development site plan is shown in Figure 1[3] below.

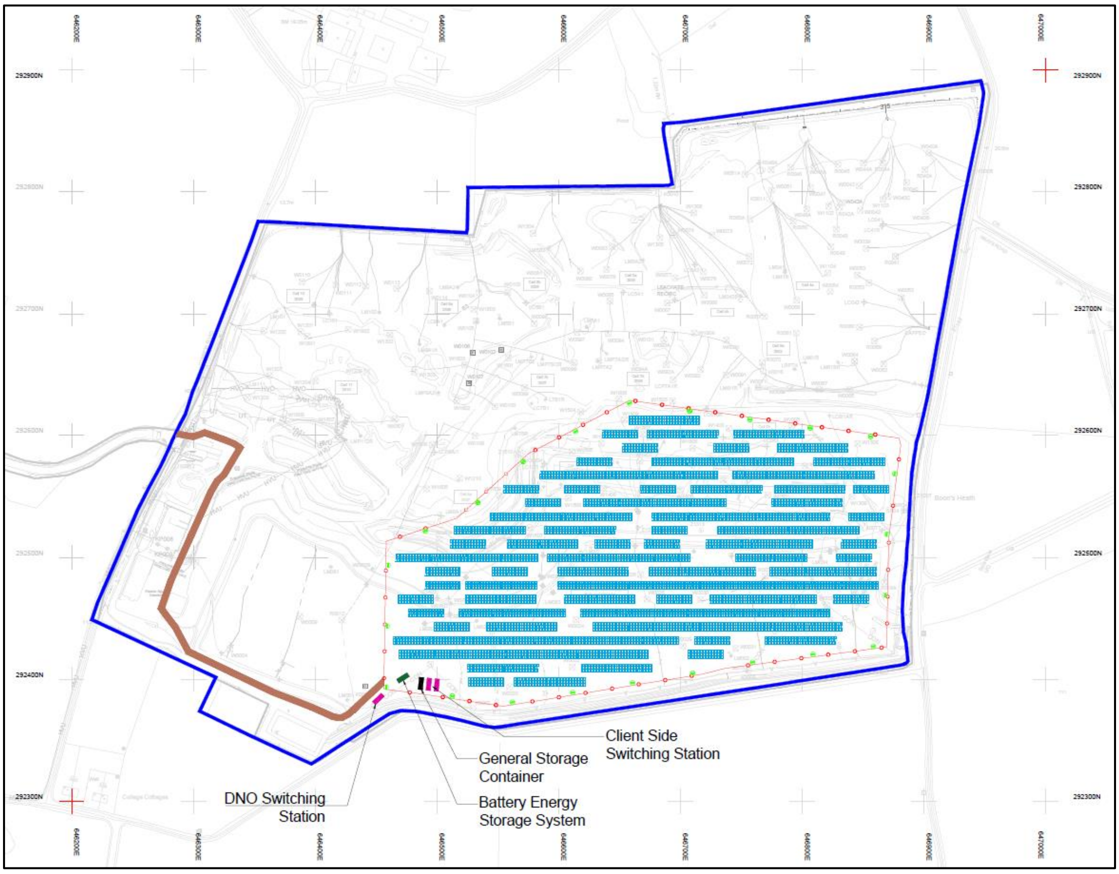


Figure 1 *Proposed development site plan*

[3] Source: 20200729-ALP-REV02-Aldeby Solar Farm Preliminary Layout Drawing.pdf (cropped).

2.2 Proposed Development Site Plan – Aerial Image

The site plan overlaid onto aerial imagery is shown in Figure 2[4] below. The solar panels are shown as the red area and blue horizontal blocks in the south easterly section of the site.

The panel bounding coordinates have been extrapolated from the site drawings and are presented in Appendix G.

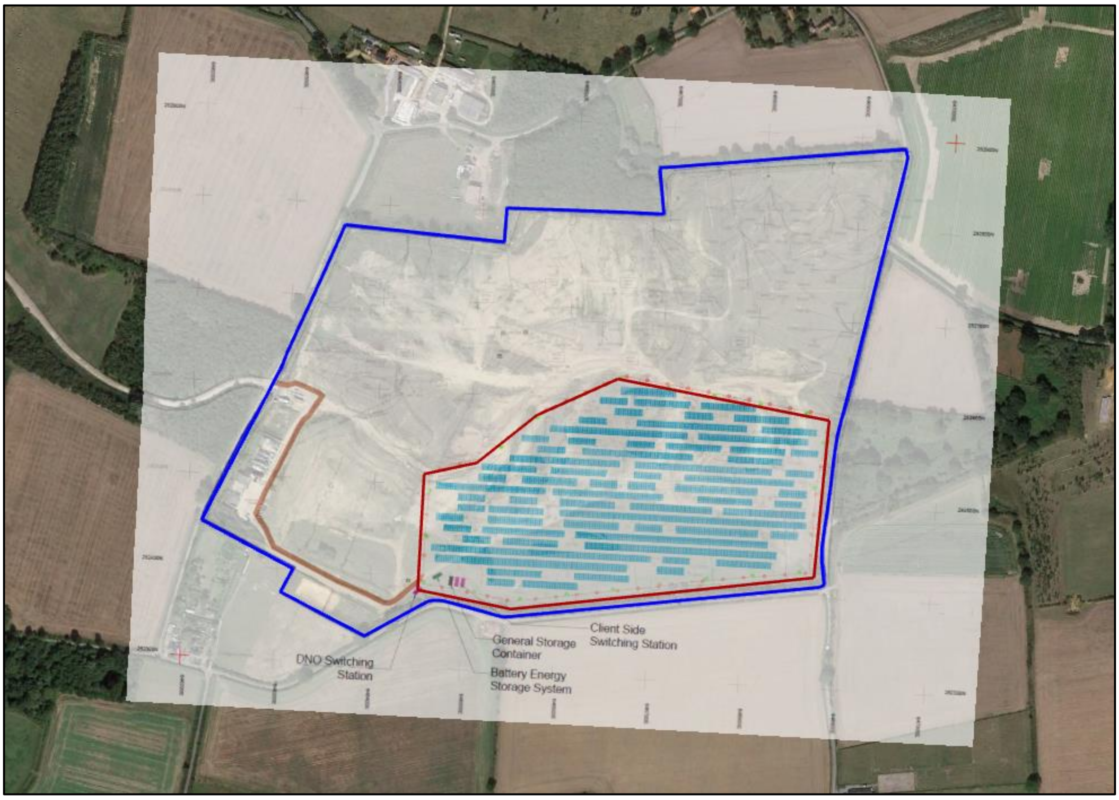


Figure 2 *Proposed development site plan – aerial image*

2.3 Solar Panel Information

The solar panel characteristics are presented in Table 1 below.

Panel Information	
Azimuth angle (°)	180
Elevation angle (°)	17
Assessed centre height (m)	1.9 agl

Table 1 *Panel information*

---

[4] Copyright © 2021 Google.

3 GLINT AND GLARE ASSESSMENT METHODOLOGY

3.1 Guidance and Studies

Appendices A and B present a review of relevant guidance and independent studies with regard to glint and glare issues from solar panels. The overall conclusions from the available studies are as follows:

- Specular reflections of the Sun from solar panels are possible.
- The measured intensity of a reflection from solar panels can vary from 2% to 30% depending on the angle of incidence.
- Published guidance shows that the intensity of solar reflections from solar panels are equal to or less than those from water. It also shows that reflections from solar panels are significantly less intense than many other reflective surfaces, which are common in an outdoor environment.

3.2 Background

Details of the Sun's movements and solar reflections are presented in Appendix C.

3.3 Pager Power's Methodology

The glint and glare assessment methodology has been derived from the information provided to Pager Power through consultation with stakeholders and by reviewing the available guidance and studies. The methodology for a glint and glare assessments is as follows:

- Identify receptors in the area surrounding the solar development.
- Consider direct solar reflections from the solar development towards the identified receptors by undertaking geometric calculations.
- Consider the visibility of the panels from the receptor's location. If the panels are not visible from the receptor then no reflection can occur.
- Based on the results of the geometric calculations, determine whether a reflection can occur, and if so, at what time it will occur.
- Consider both the solar reflection from the solar development and the location of the direct sunlight with respect to the receptor's position.
- Consider the solar reflection with respect to the published studies and guidance.
- Determine whether a significant detrimental impact is expected in line with the process presented in Appendix D.

Within the Pager Power model, the solar development area is defined, as well as the relevant receptor locations. The result is a chart that states whether a reflection can occur, the duration and the panels that can produce the solar reflection towards the receptor.

3.4 Assessment Methodology and Limitations

Further technical details regarding the methodology of the geometric calculations and limitations are presented in Appendix E and Appendix F.

4 GROUND-BASED RECEPTORS

4.1 Ground-Based Receptors – Overview

There is no formal guidance with regard to the maximum distance at which glint and glare should be assessed. From a technical perspective, there is no maximum distance for potential reflections. The significance of a reflection however decreases with distance because the proportion of an observer's field of vision that is taken up by the reflecting area diminishes as the separation distance increases. Terrain and shielding by vegetation are also more likely to obstruct an observer's view at longer distances.

A 1km buffer is considered appropriate for glint and glare effects on ground-based receptors. Receptors within this distance are identified based on mapping and aerial photography of the region.

Reflections towards ground-based receptors to the north of the panels are unlikely at this latitude for fixed panels facing south and have therefore not been considered. A more detailed assessment is made if the modelling reveals a reflection would be geometrically possible.

Terrain elevation heights have been interpolated based on OSGB36 data.

4.2 Road Receptors

Road types can generally be categorised as:

- Major National;
- National;
- Regional; and
- Local.

All roads surrounding the solar farm are considered local roads where traffic volumes and/or speeds are likely to be relatively low and have therefore not been considered for the assessment. Any solar reflections from the proposed development that are experienced by a road user would be considered 'low' impact in the worst case.

4.3 Dwelling Receptors

The analysis has considered dwellings that:

- Are within, or close to one kilometre of the proposed development; and
- Have a potential view of the panels.

The eight assessed dwelling receptor locations are shown in Figure 3[5] on the following page. A height of 1.8 metres above ground level has been taken as typical eye level for an observer on the ground floor of the dwelling. The co-ordinate data is presented in Appendix G.

---

[5] Copyright © 2021 Google.

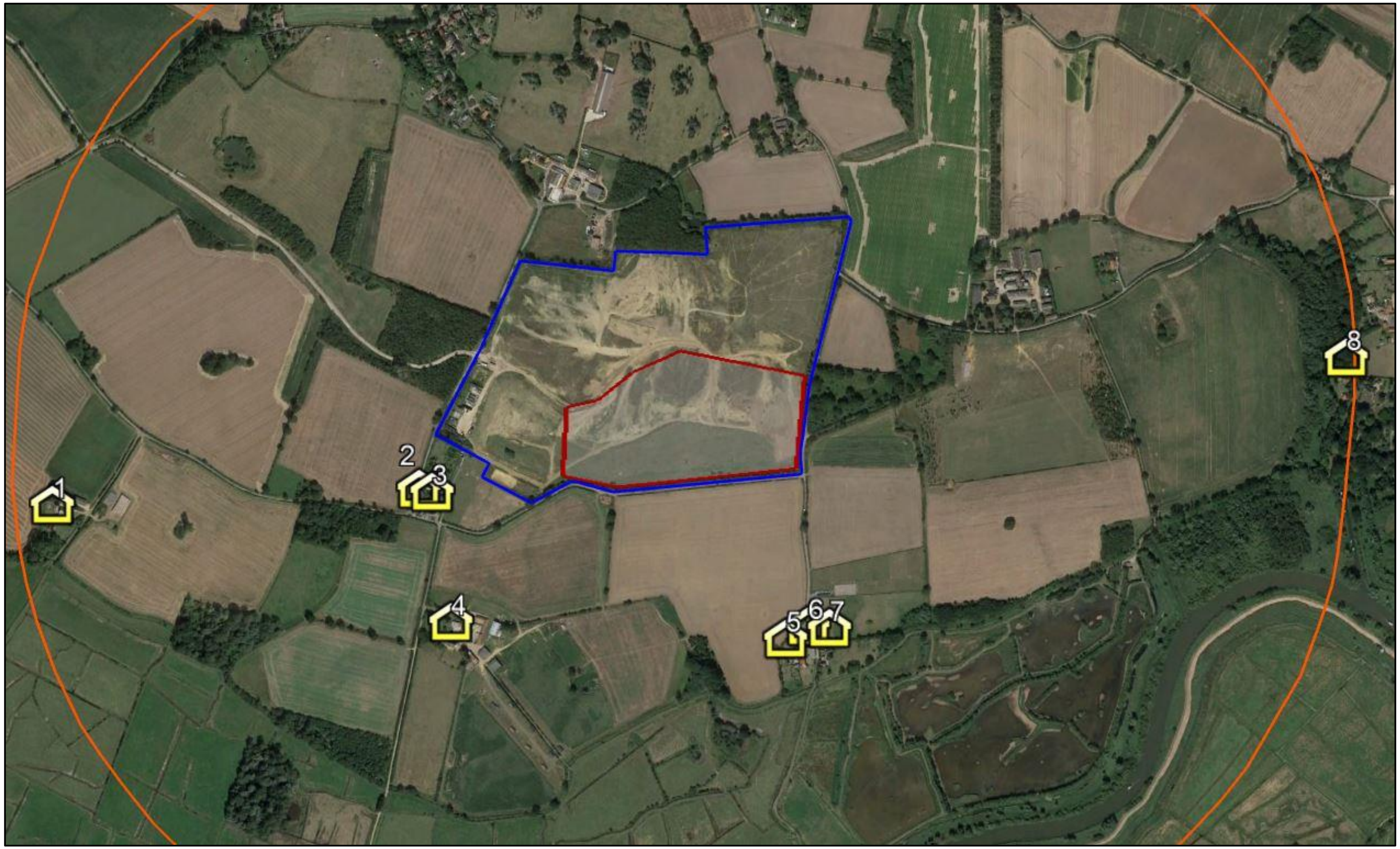


Figure 3 *Assessed dwelling receptors*

5 ASSESSED REFLECTOR AREA

5.1 Reflector Area

A number of representative panel locations are selected within the proposed reflector area with the number of modelled reflector points being determined by the size of the reflector area and the assessment resolution. The bounding co-ordinates for the proposed solar development have been extrapolated from the site plans. All ground heights have been based on OSGB36 terrain data.

A resolution of 5m has been chosen for this assessment. This means that a geometric calculation is undertaken for each identified receptor every 5m from within the defined area. This resolution is sufficiently high to maximise the accuracy of the results – increasing the resolution further would not significantly change the modelling output. If a reflection is experienced from an assessed panel location, then it is likely that a reflection will be viewable from similarly located panels within the proposed solar development.

The assessed reflector area is shown in Figure 4 below.

Figure 4 *Assessed reflector area*

6 GLINT AND GLARE ASSESSMENT – TECHNICAL RESULTS

6.1 Overview

The table in the following subsection summarise the results of the assessment. The predicted glare times are based solely on bare-earth terrain i.e. without consideration of screening from buildings and hedgerows. The final column summarises the predicted impact considering the level of predicted screening based on a desk-based review of the available imagery. The significance of any predicted impact is discussed in the subsequent report sections.

The modelling output showing the precise predicted times and the reflecting panel area is shown in Appendix H.

6.2 Geometric Calculation Results Overview – Dwelling Receptors

Receptor	Pager Power Results Reflection Possible Towards Receptor?		Comments
	am	pm	
1	Yes – Between 05:20 and 06:00 from late March to late April. Between 05:30 and 05:50 from mid-August to mid-September.	No.	Predicted solar reflections will not be experienced in practice due to significant screening in the form of existing vegetation. No impact predicted.
2 – 3	Yes – Between 05:05 and 05:55 from early April to early September.	No.	Solar reflections are predicted to be experienced at these dwellings. Discussed in Section 7.2.
4 – 7	No.	No.	No solar reflections geometrically possible. No impact possible.
8	No.	Yes – At sunset in late March and mid-September	Predicted solar reflections will not be experienced in practice due to significant screening in the form of existing vegetation. No impact predicted.

Table 2 *Geometric analysis results – dwelling receptors*

7 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

7.1 Dwelling Receptor Results

The process for quantifying impact significance is defined in the report appendices. For dwelling receptors, the key considerations are:

- Whether a significant reflection is predicted in practice.
- The duration of the predicted effects, relative to thresholds of:
    - 3 months per year; and
    - 60 minutes per day.

The results of the modelling indicate that solar reflections are geometrically possible towards four out of the eight assessed dwelling receptors. A review of the available imagery however shows solar reflections will not be experienced in practice at dwellings 1 and 8 due to screening in the form of existing vegetation, which will obstruct views of the reflecting panels. No impacts are therefore predicted.

Figure 5[6] below and Figure 6[5] on the following page show the areas of existing vegetation screening relative to these dwellings.

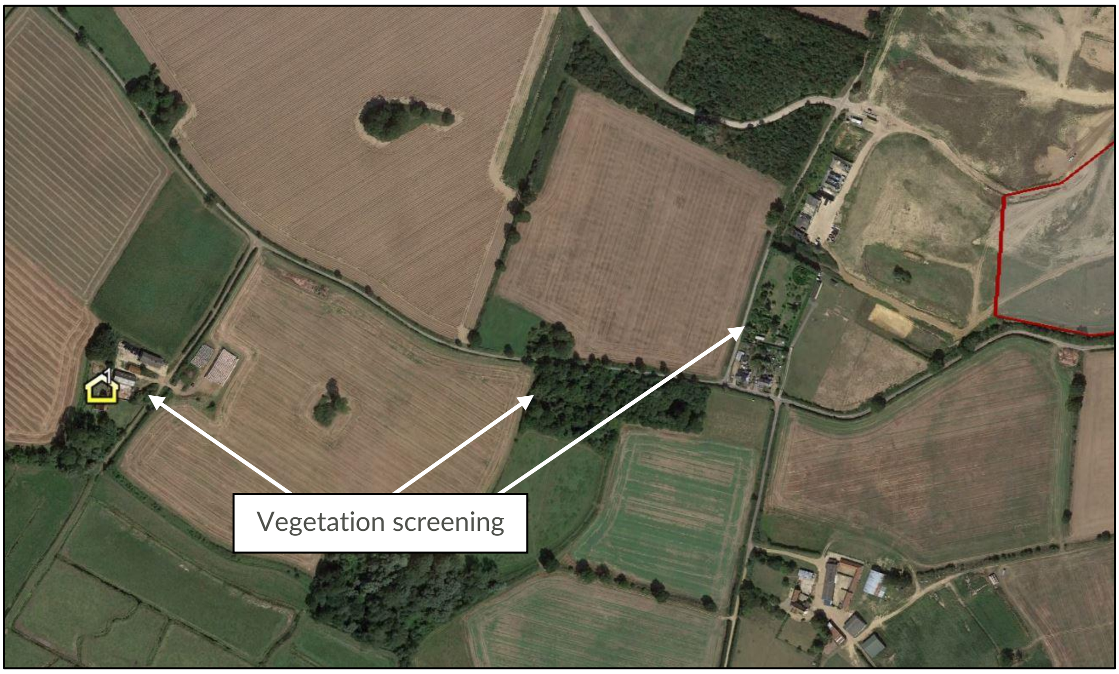


Figure 5 *Significant screening – dwelling 1*

[6] Copyright © 2021 Google.

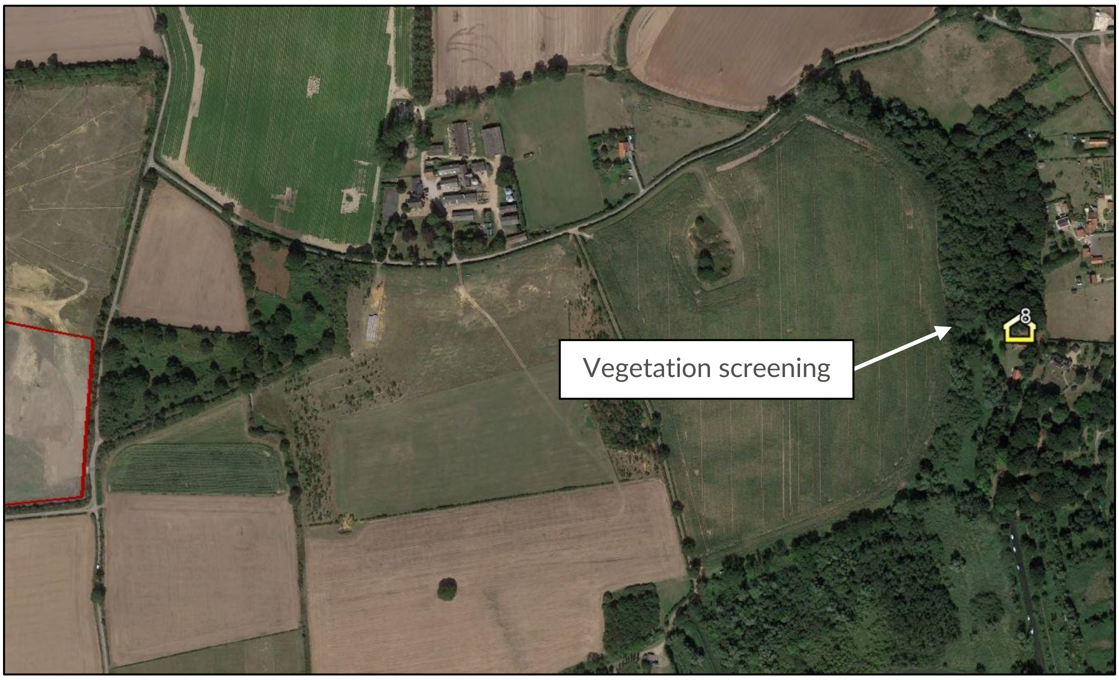


Figure 6 *Significant screening – dwelling 8*

For dwellings 2 and 3, the modelling has indicated that an observer will experience solar reflections for less than 60 minutes per day but for more than 3 months per year. It is however expected that the dwellings will not have views of the entire panel area, which will reduce the duration of the effects.

Solar reflections are also only predicted when the sun is low in the sky beyond the reflecting panels. This is significant because it means an observer looking towards a reflecting panel would also be looking towards the sun, which is a far more intense source of light than a reflection.

The impact upon these dwellings is moderate in accordance with the guidance presented in Appendix D.

The developer has therefore proposed screening in the form of native hedgerows to significantly obstruct views of the reflecting panel area[7]. The specific location of the proposed screening is presented in Figure 7[8] on the following page.

[7] The height of this screening should ensure that the reflecting panel area is sufficiently obscured from view.
[8] 3757_DR_LAN-101B (edited).

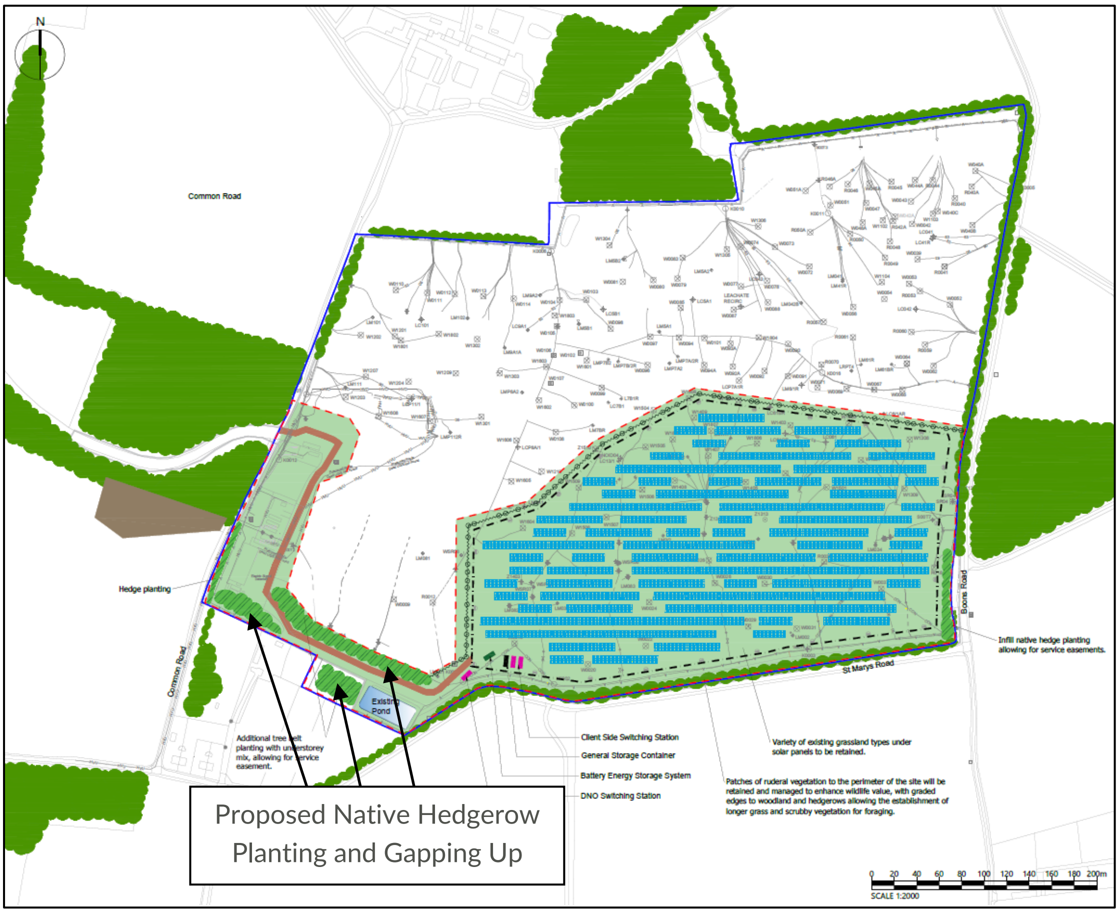


Figure 7 *Landscape strategy*

8 OVERALL CONCLUSIONS

8.1 Modelling Results

- No significant impacts upon surrounding road users are predicted as all roads surrounding the proposed development are considered local roads where traffic volumes and/or speeds are likely to be relatively low. This means any predicted solar reflections would be considered 'low' impact in the worst case.
- Solar reflections are geometrically possible towards four out of the eight assessed dwelling receptors, however solar reflections will not be experienced in practice at dwellings 1 and 8 due to screening in the form of existing vegetation, which will obstruct views of the reflecting panels.
- For dwellings 2 and 3, the modelling has indicated that an observer will experience solar reflections for less than 60 minutes per day but for more than 3 months per year. The impact upon these dwellings is moderate in accordance with the guidance presented in Appendix D, and the developer has therefore proposed screening to significantly obstruct views of the reflecting panel area[9].

8.2 Conclusions and Recommendations

No significant impacts upon the surrounding road users have been identified.

The developer has proposed screening in the form of native hedgerow planting for dwellings 2 and 3 where a moderate impact has been predicted.

[9] The height of this screening should ensure that the reflecting panel area is sufficiently obscured from view.

APPENDIX A – OVERVIEW OF GLINT AND GLARE GUIDANCE

Overview

This section presents details regarding the relevant guidance and studies with respect to the considerations and effects of solar reflections from solar panels, known as 'Glint and Glare'. This is not a comprehensive review of the data sources, rather it is intended to give an overview of the important parameters and considerations that have informed this assessment.

UK Planning Policy

The National Planning Policy Framework under the planning practice guidance for Renewable and Low Carbon Energy[10] (specifically regarding the consideration of solar farms, paragraph 013) states:

'What are the particular planning considerations that relate to large scale ground-mounted solar photovoltaic Farms?

The deployment of large-scale solar farms can have a negative impact on the rural environment, particularly in undulating landscapes. However, the visual impact of a well-planned and well-screened solar farm can be properly addressed within the landscape if planned sensitively.

Particular factors a local planning authority will need to consider include:

…

- *the proposal's visual impact, the effect on landscape of glint and glare (see guidance on landscape assessment) and on* ***neighbouring uses and aircraft safety****;*
- *the extent to which there may be additional impacts if solar arrays follow the daily movement of the sun;*

…

The approach to assessing cumulative landscape and visual impact of large scale solar farms is likely to be the same as assessing the impact of wind turbines. However, in the case of ground-mounted solar panels it should be noted that with effective screening and appropriate land topography the area of a zone of visual influence could be zero.'

Assessment Process – Ground-Based Receptors

No process for determining and contextualising the effects of glint and glare are, however, provided for assessing the impact of solar reflections upon surrounding roads and dwellings. Therefore, the Pager Power approach is to determine whether a reflection from the proposed solar development is geometrically possible and then to compare the results against the relevant guidance/studies to determine whether the reflection is significant.

---

[10] Renewable and low carbon energy, Ministry of Housing, Communities & Local Government, date: 18 June 2015, accessed on: 17/06/2020.

The Pager Power approach has been informed by the policy presented above, current studies (presented in Appendix B) and stakeholder consultation. Further information can be found in Pager Power's Glint and Glare Guidance document[11] which was produced due to the absence of existing guidance and a specific standardised assessment methodology.

[11] Solar Photovoltaic Development – Glint and Glare Guidance, Second Edition 2, October 2018. Pager Power.

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

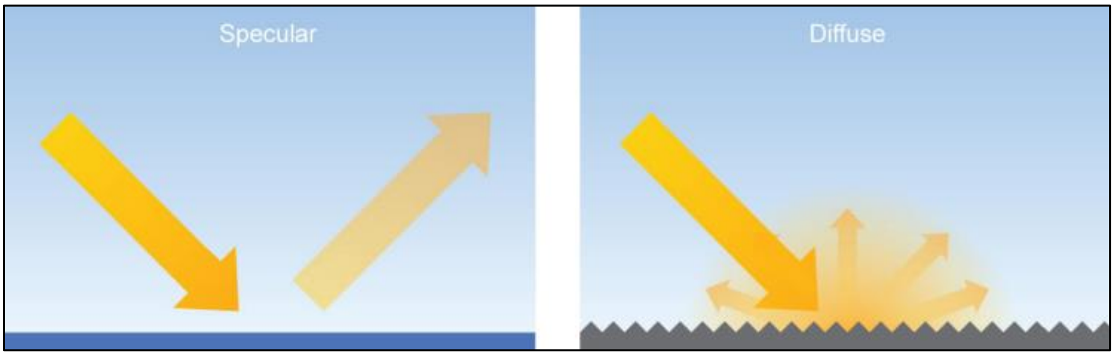
Overview

Studies have been undertaken assessing the type and intensity of solar reflections from various surfaces including solar panels. An overview of these studies is presented below.

There are no specific studies for determining the effect of reflections from solar panels with respect to dwellings. The guidelines presented are related to aviation safety. The results are applicable for the purpose of this analysis.

Reflection Type from Solar Panels

Based on the surface conditions reflections from light can be specular and diffuse. A specular reflection has a reflection characteristic similar to that of a mirror; a diffuse will reflect the incoming light and scatter it in many directions. The figure below[12], taken from the FAA guidance, illustrates the difference between the two types of reflections. Because solar panels are flat and have a smooth surface most of the light reflected is specular, which means that incident light from a specific direction is reradiated in a specific direction.



Specular and diffuse reflections

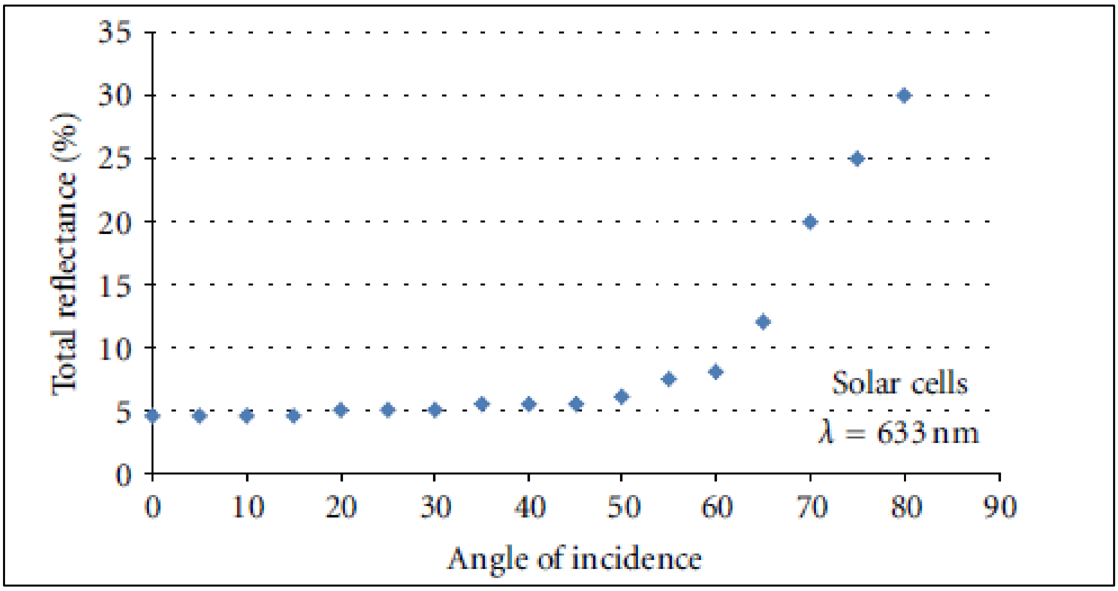
[12] http://www.faa.gov/airports/environmental/policy_guidance/media/airport_solar_guide_print.pdf

Solar Reflection Studies

An overview of content from identified solar panel reflectivity studies is presented in the subsections below.

Evan Riley and Scott Olson, "A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems"

Evan Riley and Scott Olson published in 2011 their study titled: *A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems*[13]". They researched the potential glare that a pilot could experience from a 25 degree fixed tilt PV system located outside of Las Vegas, Nevada. The theoretical glare was estimated using published ocular safety metrics which quantify the potential for a postflash glare after-image. This was then compared to the postflash glare after-image caused by smooth water. The study demonstrated that the reflectance of the solar cell varied with angle of incidence, with maximum values occurring at angles close to 90 degrees. The reflectance values varied from approximately 5% to 30%. This is shown on the figure below.



Total reflectance % when compared to angle of incidence

The conclusions of the research study were:

- The potential for hazardous glare from flat-plate PV systems is similar to that of smooth water;
- Portland white cement concrete (which is a common concrete for runways), snow, and structural glass all have a reflectivity greater than water and flat plate PV modules.

FAA Guidance- "Technical Guidance for Evaluating Selected Solar Technologies on Airports"[14]

---

[13] Evan Riley and Scott Olson, "A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems," ISRN Renewable Energy, vol. 2011, Article ID 651857, 6 pages, 2011. doi:10.5402/2011/651857

[14] FAA, November (2010): *Technical Guidance for Evaluating Selected Solar Technologies on Airports.*

The 2010 FAA Guidance included a diagram which illustrates the relative reflectance of solar panels compared to other surfaces. The figure shows the relative reflectance of solar panels compared to other surfaces. Surfaces in this figure produce reflections which are specular and diffuse. A specular reflection (those made by most solar panels) has a reflection characteristic similar to that of a mirror. A diffuse reflection will reflect the incoming light and scatter it in many directions. A table of reflectivity values, sourced from the figure[15] within the FAA guidance, is presented below.

Surface	Approximate Percentage of Light Reflected[16]
Snow	80
White Concrete	77
Bare Aluminium	74
Vegetation	50
Bare Soil	30
Wood Shingle	17
Water	5
Solar Panels	5
Black Asphalt	2

Relative reflectivity of various surfaces

Note that the data above does not appear to consider the reflection type (specular or diffuse).

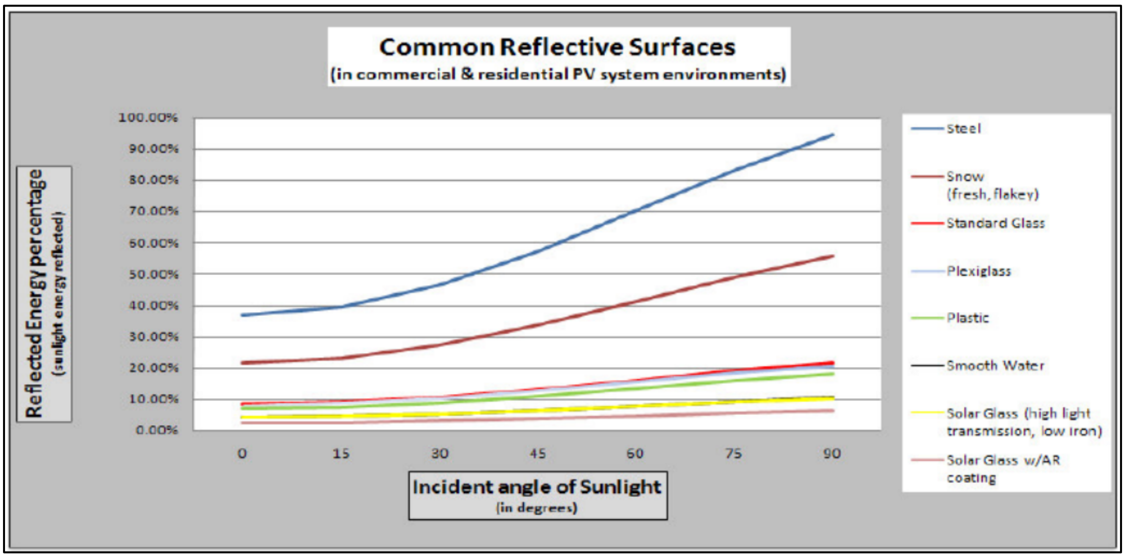
An important comparison in this table is the reflectivity compared to water which will produce a reflection of very similar intensity when compared to that from a solar panel. The study by Riley and Olsen study (2011) also concludes that still water has a very similar reflectivity to solar panels.

[15] http://www.faa.gov/airports/environmental/policy_guidance/media/airport_solar_guide_print.pdf
[16] Extrapolated data, baseline of 1,000 W/m^2 for incoming sunlight.

SunPower Technical Notification (2009)

SunPower published a technical notification[17] to '*increase awareness concerning the possible glare and reflectance impact of PV Systems on their surrounding environment'*.

The figure presented below shows the relative reflectivity of solar panels compared to other natural and manmade materials including smooth water, standard glass and steel.



Common reflective surfaces

The results, similarly to those from Riley and Olsen study (2011) and the FAA (2010), show that solar panels produce a reflection that is less intense than those of '*standard glass and other common reflective surfaces*'.

With respect to aviation and solar reflections observed from the air, SunPower has developed several large installations near airports or on Air Force bases. It is stated that these developments have all passed FAA or Air Force standards with all developments considered "No Hazard to Air Navigation". The note suggests that developers discuss any possible concerns with stakeholders near proposed solar farms.

[17] Source: Technical Support, 2009. SunPower Technical Notification – Solar Module Glare and Reflectance.

APPENDIX C – OVERVIEW OF SUN MOVEMENTS AND RELATIVE REFLECTIONS

The Sun's position in the sky can be accurately described by its azimuth and elevation. Azimuth is a direction relative to true north (horizontal angle i.e. from left to right) and elevation describes the Sun's angle relative to the horizon (vertical angle i.e. up and down).

The Sun's position can be accurately calculated for a specific location. The following data being used for the calculation:

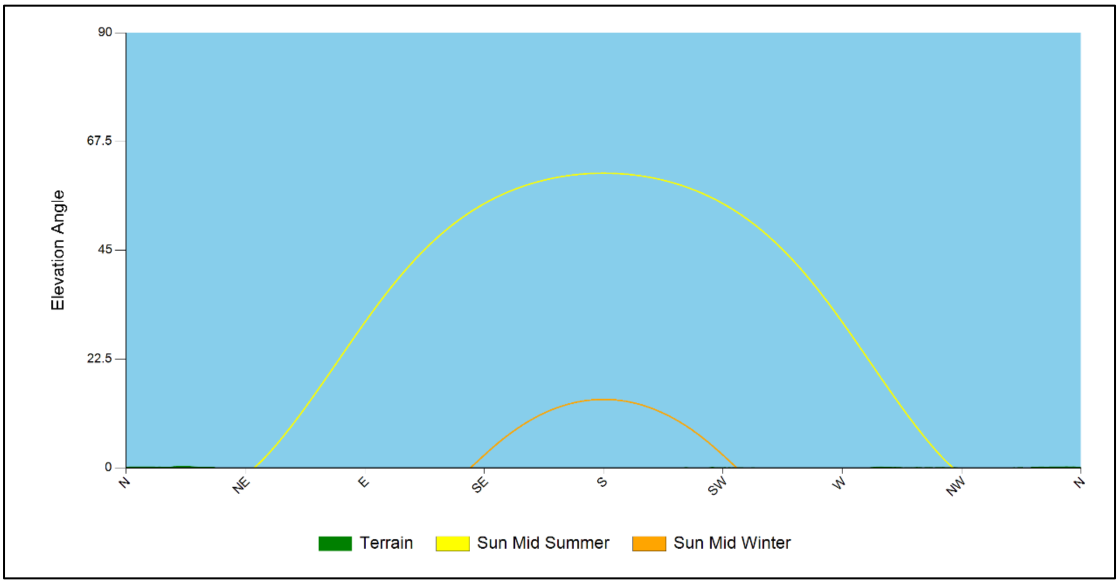
- Time.
- Date.
- Latitude.
- Longitude.

The following is true at the location of the solar development:

- The Sun is at its highest around midday and is to the south at this time.
- The Sun rises highest on 21 June (longest day).
- On 21 December, the maximum elevation reached by the Sun is at its lowest (shortest day).

The combination of the Sun's azimuth angle and vertical elevation will affect the direction and angle of the reflection from a reflector. The figure below shows terrain at the horizon as well as the sunrise and sunset curves throughout the year.

Terrain Sun Curve - From Lon: 1.63011, Lat: 52.474692



Terrain elevation at the horizon

APPENDIX D – GLINT AND GLARE IMPACT SIGNIFICANCE

Overview

The significance of glint and glare will vary for different receptors. The following section presents a general overview of the significance criteria with respect to experiencing a solar reflection.

Impact Significance Definition

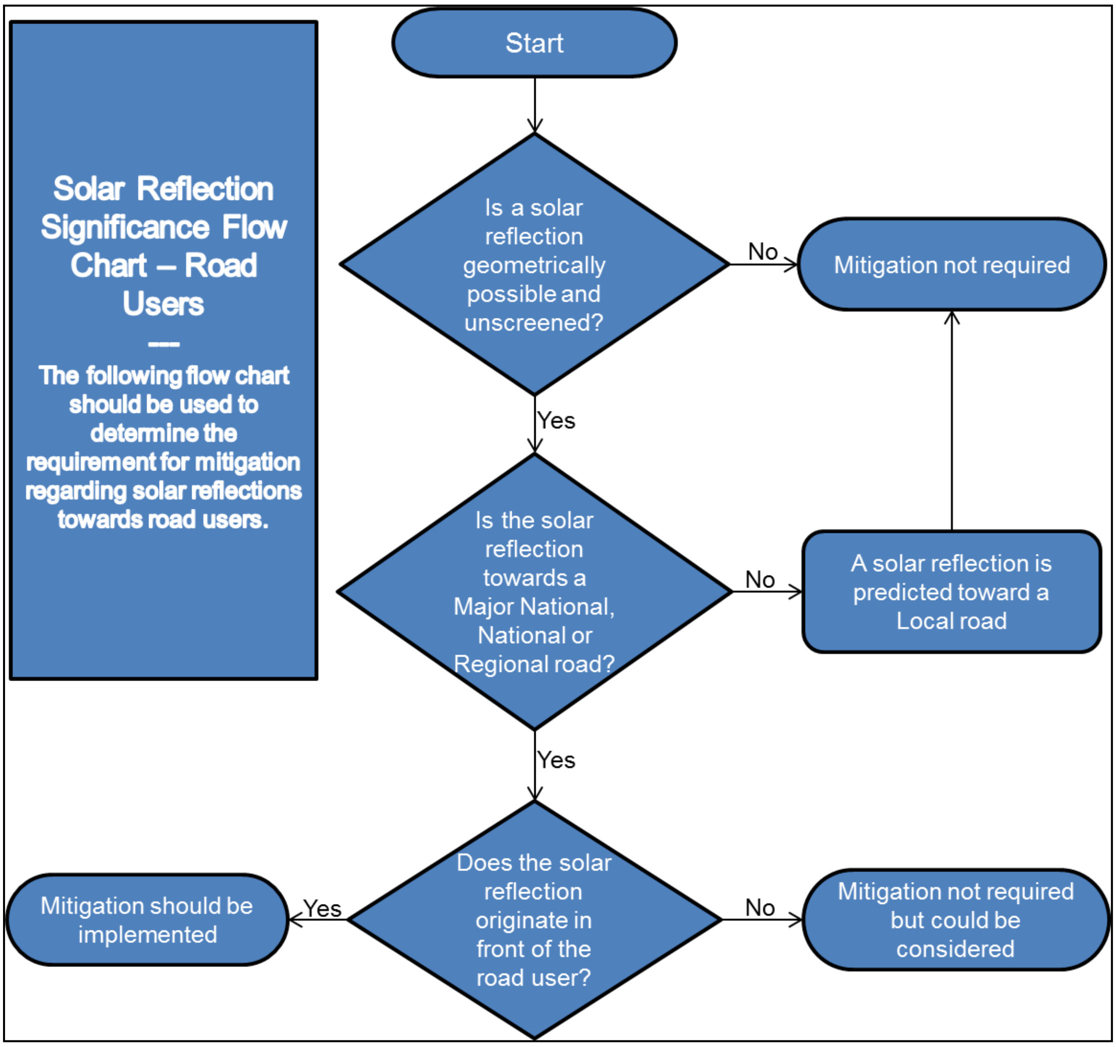
The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

Impact Significance	Definition	Mitigation Requirement
No Impact	A solar reflection is not geometrically possible or will not be visible from the assessed receptor.	No mitigation required.
Low	A solar reflection is geometrically possible however any impact is considered to be small such that mitigation is not required e.g. intervening screening will limit the view of the reflecting solar panels.	No mitigation required.
Moderate	A solar reflection is geometrically possible and visible however it occurs under conditions that do not represent a worst-case.	Whilst the impact may be acceptable, consultation and/or further analysis should be undertaken to determine the requirement for mitigation.
Major	A solar reflection is geometrically possible and visible under conditions that will produce a significant impact. Mitigation and consultation is recommended.	Mitigation will be required if the proposed solar development is to proceed.

Impact significance definition

Assessment Process for Road Receptors

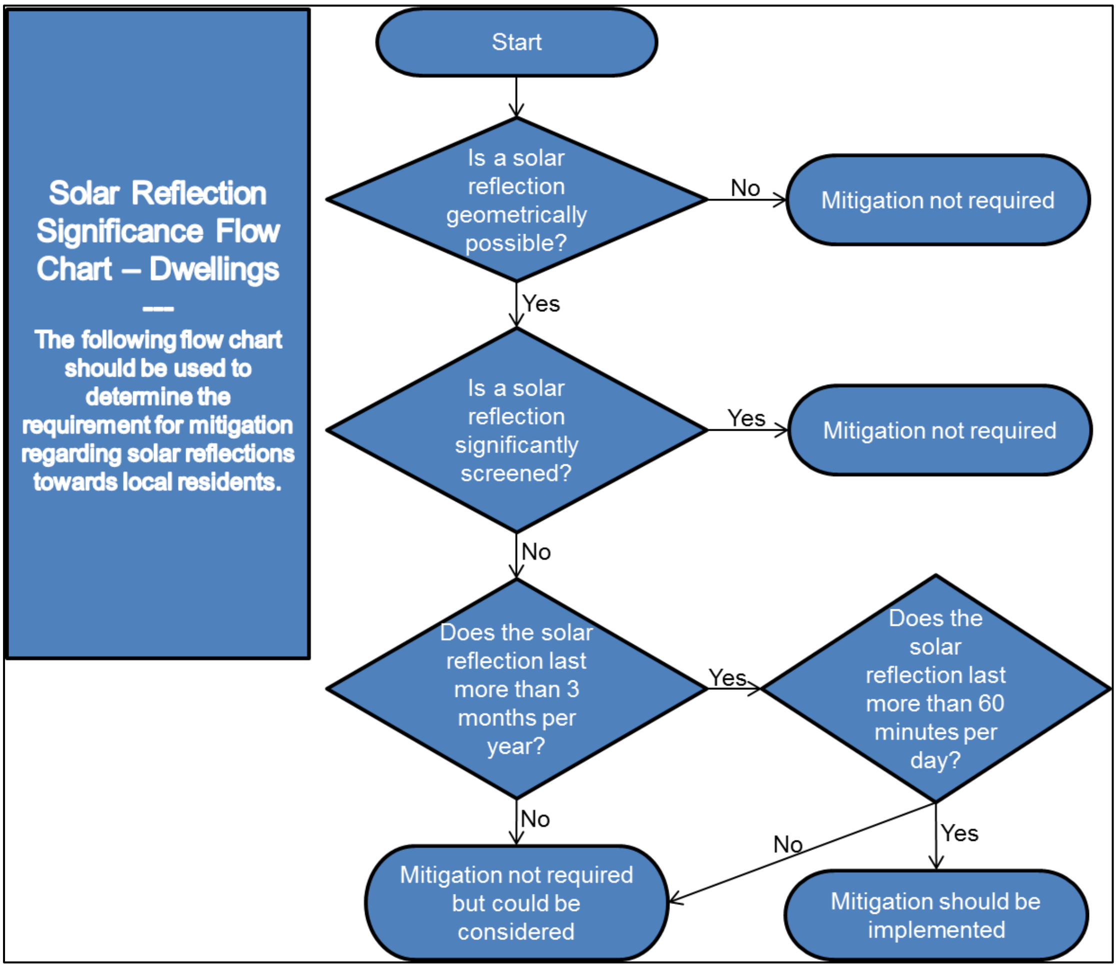
The flow chart presented below has been followed when determining the mitigation requirement for road receptors.



Road receptor mitigation requirement flow chart

Assessment Process for Dwelling Receptors

The flow chart presented below has been followed when determining the mitigation requirement for dwelling receptors.



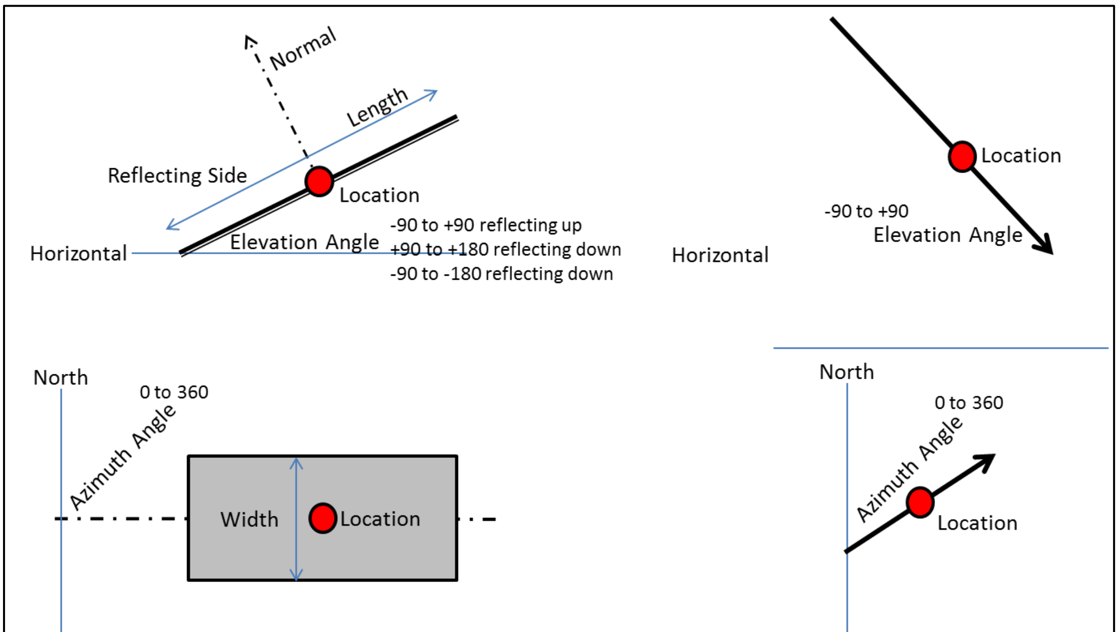
Dwelling receptor mitigation requirement flow chart

APPENDIX E – PAGER POWER'S REFLECTION CALCULATIONS METHODOLOGY

The calculations are three dimensional and complex, accounting for:

- The Earth's orbit around the Sun;
- The Earth's rotation;
- The Earth's orientation;
- The reflector's location;
- The reflector's 3D Orientation.

Reflections from a flat reflector are calculated by considering the normal which is an imaginary line that is perpendicular to the reflective surface and originates from it. The diagram below may be used to aid understanding of the reflection calculation process.



Object	El Min	El Max	Az Min	Az Max
Reflector	-180	180	0	360
Reflector Normal	-180	180	0	360
Source	-90	90	0	360

The following process is used to determine the 3D Azimuth and Elevation of a reflection:

- Use the Latitude and Longitude of reflector as the reference for calculation purposes;
- Calculate the Azimuth and Elevation of the normal to the reflector;
- Calculate the 3D angle between the source and the normal;

- If this angle is less than 90 degrees a reflection will occur. If it is greater than 90 degrees no reflection will occur because the source is behind the reflector;
- Calculate the Azimuth and Elevation of the reflection in accordance with the following:
    - The angle between source and normal is equal to angle between normal and reflection;
    - Source, Normal and Reflection are in the same plane.

APPENDIX F – ASSESSMENT LIMITATIONS AND ASSUMPTIONS

Pager Power's Model

- It is assumed that the panel elevation angle provided by the developer represents the elevation angle for all of the panels within the solar development unless otherwise stated.
- It is assumed that the panel azimuth angle provided by the developer represents the azimuth angle for all of the panels within the solar development unless otherwise stated.
- Only a reflection from the face of the panel has been considered. The frame or the reverse of the solar panel has not been considered.
- The model assumes that a receptor can view the face of every panel within the proposed development area whilst in reality this, in the majority of cases, will not occur. Therefore any predicted reflection from the face of a solar panel that is not visible to a receptor will not occur.
- A finite number of points within the proposed development are chosen based on an assessment resolution so we can build a comprehensive understanding of the entire development. This will determine whether a reflection could ever occur at a chosen receptor. The calculations do not incorporate all of the possible panel locations within the development outline.
- A single reflection point on the panel has been chosen for the geometric calculations. This will suitably determine whether a reflection can be experienced at a location and the general time of year and duration of this reflection. Increased accuracy could be achieved by increasing the number of heights assessed however this would only marginally change the results and is not considered significant.
- Whilst line of sight to the development from receptors has been considered, only available street view imagery and satellite mapping has been used. In some cases this imagery may not be up to date and may not give the full perspective of the installation from the location of the assessed receptor.
- Any screening in the form of trees, buildings etc. that may obstruct the Sun from view of the solar panels is not considered unless stated.

APPENDIX G – RECEPTOR AND REFLECTOR AREA DETAILS

Dwelling Receptor Data

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	1.613704	52.472882	5	1.633566	52.470675
2	1.623661	52.473147	6	1.634172	52.470882
3	1.624009	52.473096	7	1.634752	52.470850
4	1.624517	52.470953	8	1.648730	52.475313

Dwelling receptor data

Panel Boundary Data

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
1	1.627667	52.474859	5	1.634071	52.475368
2	1.627561	52.473740	6	1.630745	52.475771
3	1.629030	52.473552	7	1.629457	52.475424
4	1.633842	52.473856	8	1.628507	52.474968

Panel boundary data

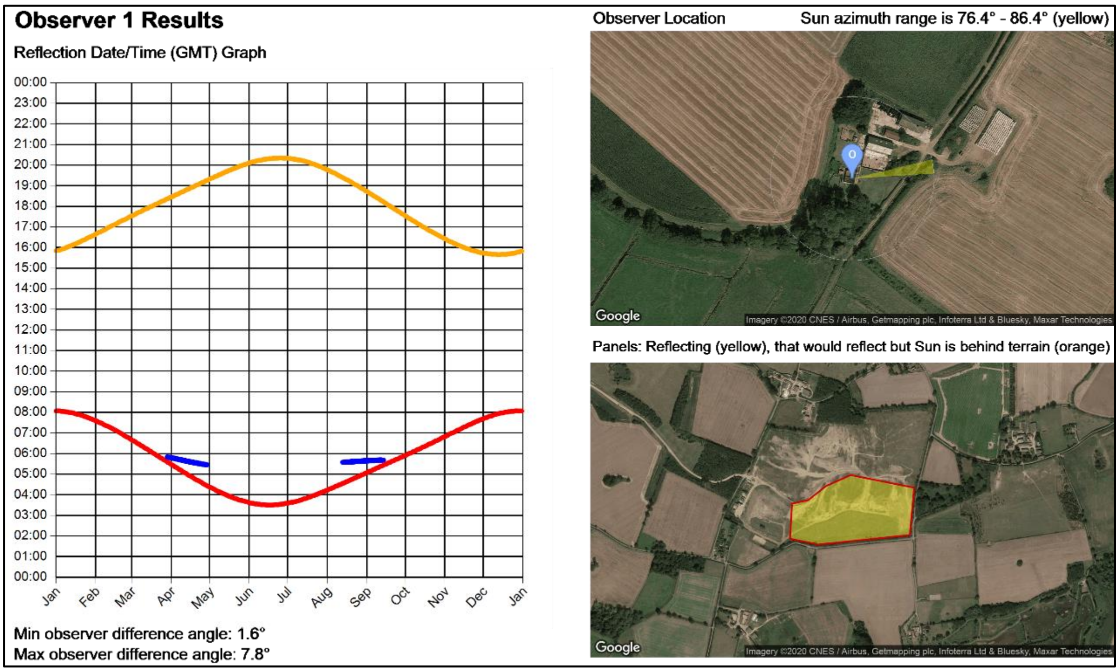
APPENDIX H – DETAILLED MODELLING RESULTS

Overview

The charts for the potentially affected receptors are shown on the following pages for completeness. Each chart shows:

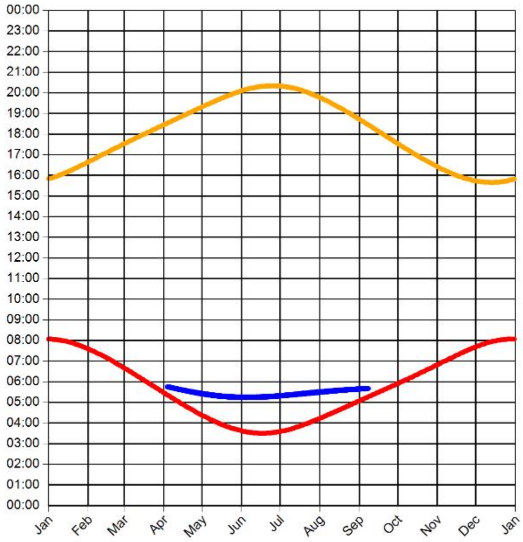
- The receptor (observer) location – top right image. This also shows the azimuth range of the Sun itself at times when reflections are possible. If sunlight is experienced from the same direction as the reflecting panels, the overall impact of the reflection is reduced as discussed within the body of the report;
- The reflecting panels – bottom right image. The reflecting area is shown in yellow. If the yellow panels are not visible from the observer location, no issues will occur in practice. Additional obstructions which may obscure the panels from view are considered separately within the analysis;
- The reflection date/time graph – left hand side of the page. The blue line indicates the dates and times at which geometric reflections are possible. This relates to reflections from the yellow areas.
- The sunrise and sunset curves throughout the year (red and yellow lines).

Dwelling Receptors



Observer 2 Results

Reflection Date/Time (GMT) Graph



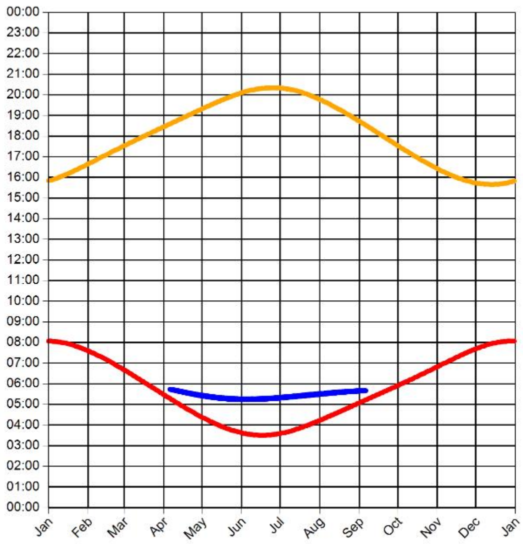
Min observer difference angle: 2.8°
Max observer difference angle: 12.7°

Observer Location — Sun azimuth range is 67.9° - 84.5° (yellow)

Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

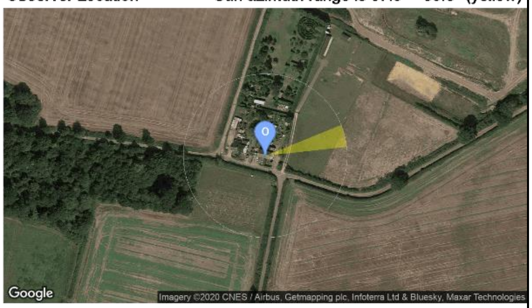
Observer 3 Results

Reflection Date/Time (GMT) Graph

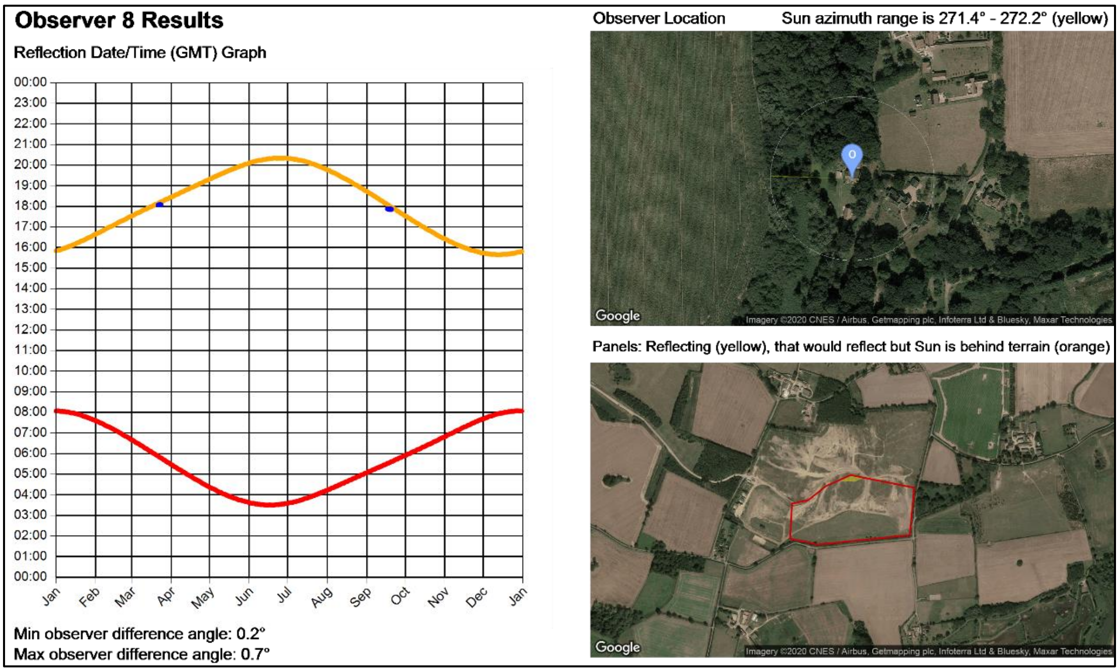


Min observer difference angle: 3.2°
Max observer difference angle: 12.9°

Observer Location — Sun azimuth range is 67.9° - 83.8° (yellow)



Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer 8 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 0.2°
Max observer difference angle: 0.7°
Observer Location
Sun azimuth range is 271.4° - 272.2° (yellow)
Google
Imagery ©2020 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2020 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Maxar Technologies

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