Brynrhyd Solar Farm

SOLAR PV GLINT AND GLARE STUDY

APPLICATION SUBMISSION

JUNE 2021

PAGERPOWER
Urban & Renewables

Solar Photovoltaic Glint and Glare Study

Brynrhyd

June 2021

PLANNING SOLUTIONS FOR:

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

www.pagerpower.com

ADMINISTRATION PAGE

Job Reference:	10398A
Date:	April 2021
Author:	Kai Frolic
Telephone:	01787 319 001
Email:	kai@pagerpower.com

First Reviewer:	Waqar Qureshi
Second Reviewer	Michael Sutton
Date:	April 2021
Telephone:	01787 319001
Email:	waqar@pagerpower.com; michael@pagerpower.com

Issue	Date	Detail of Changes
1	21 May 2021	Initial issue
2	28 May 2021	Second issue – following comments from the landscape team regarding screening
3	9 June 2021	Third issue – administrative revisions

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 the Brynrhyd solar photovoltaic (PV) development in Wales, UK. The assessment pertains to the possible impact upon surrounding road users and dwellings in accordance with industry best practice.

Pager Power

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.

Guidance and Studies

Pager Power's approach to assessing glint and glare is based on its published guidance document[1], now in its third edition. This was published following a literature review, stakeholder consultation and engagement with solar developers. Broadly, the process is to undertake geometric reflection calculations and, where a solar reflection is predicted, consider the screening (existing and/or proposed) between the receptor and the reflecting solar panels. The scenario in which a solar reflection can occur for all receptors is then identified and discussed, and a comparison is made against the available solar panel reflection studies to determine the overall impact.

The reflections produced are of intensity similar to or less than those produced from still water and significantly less than reflections from glass and steel[2].

Conclusions

Potential effects are possible for four dwellings. Proposed and existing screening will mitigate the majority of potential reflections towards dwelling receptors (comments from the landscape team on the screening are presented in Section 7.2). The remaining level of effect is likely to be acceptable based on the restricted reflecting areas that remain visible and the fact that effects would coincide with direct sunlight.

Significant impacts on road users are not predicted due to the level of screening and the fact that any remaining effects would occur from outside the directly of travel.

Specific analysis of road user receptors is presented in Section 7.1. Specific analysis of dwelling receptors is presented in Section 7.2.

It is likely that there will be no unacceptable adverse impacts due to reflected light, in accordance with the requirement of Future Wales Policy 18.

---

[1] Solar Photovoltaic Development – Glint and Glare Guidance Issue 3.1, April 2021 (can be downloaded here).

[2] SunPower, 2009, SunPower Solar Module Glare and Reflectance (appendix to Solargen Energy, 2010).

Impacts on Public Rights of Way that run throughout the site are not significant because effects would be similar to those from common outdoor features of the environment and because there is no associated safety hazard.

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

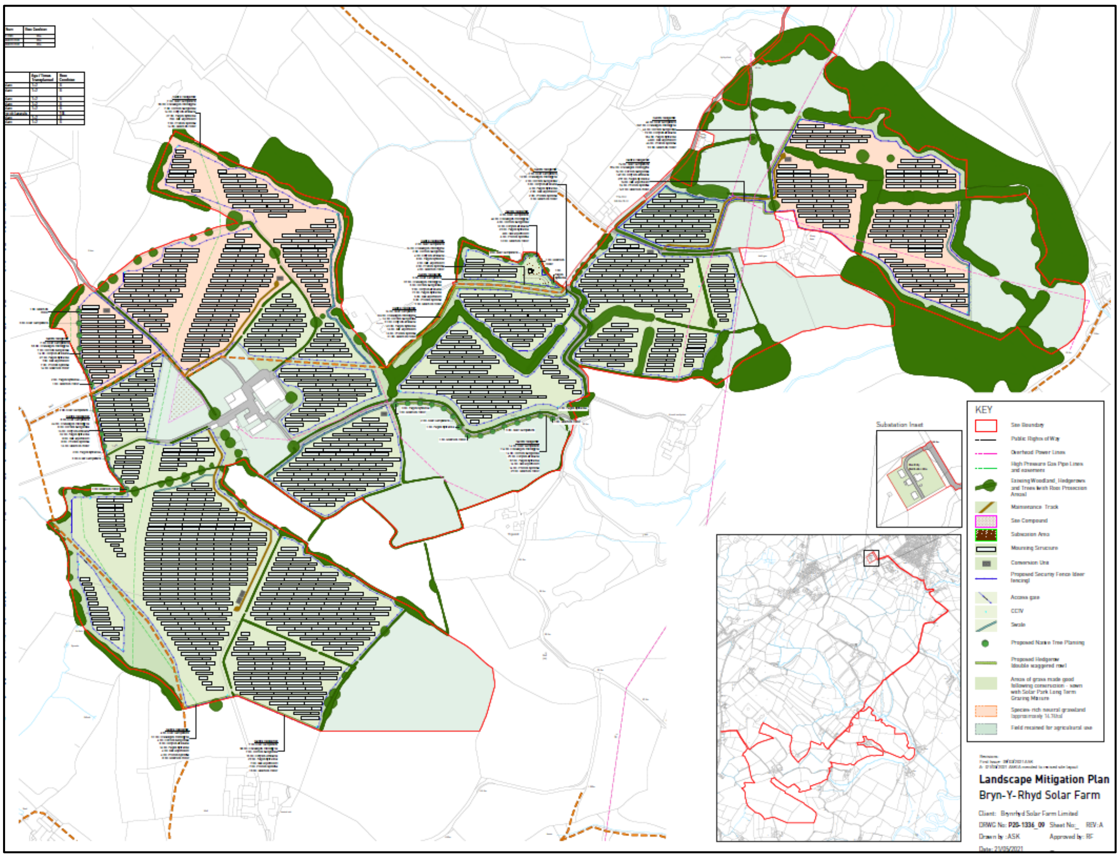


Figure 1 *Proposed screening plan*

[3] Provided to Pager Power by Pegasus, cropped.

LIST OF CONTENTS

PAGERPOWER
Urban & Renewables

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 50 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

This glint and glare assessment has been prepared by Pager Power on behalf of Brynrhyd Solar Farm Limited [the applicant and developer] and forms part of a suite of documents supporting a planning application for Development of National Significance for the construction, operation, management and subsequent decommissioning of a solar farm at Brynrhyd Farm, Llanedi, Carmarthenshire, SA18 3PL.

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.
- Mitigation strategies (high-level).
- 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[4]:

- 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.

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

1.4 Relevant Policies

Future Wales Policies 17 and 18 are relevant in the context of potential glint and glare effects. These require that "*all proposals should demonstrate that they will not have an unacceptable adverse impact on the environment*" (Policy 17) and that "*There are no unacceptable adverse impacts by way of shadow flicker, noise, reflected light, air quality or electromagnetic disturbance*" (Policy 18).

2 SOLAR DEVELOPMENT LOCATION AND DETAILS

2.1 Proposed Development

Figure 2 below[5] shows the site location plan. The blue rectangular areas denote the solar panel locations.

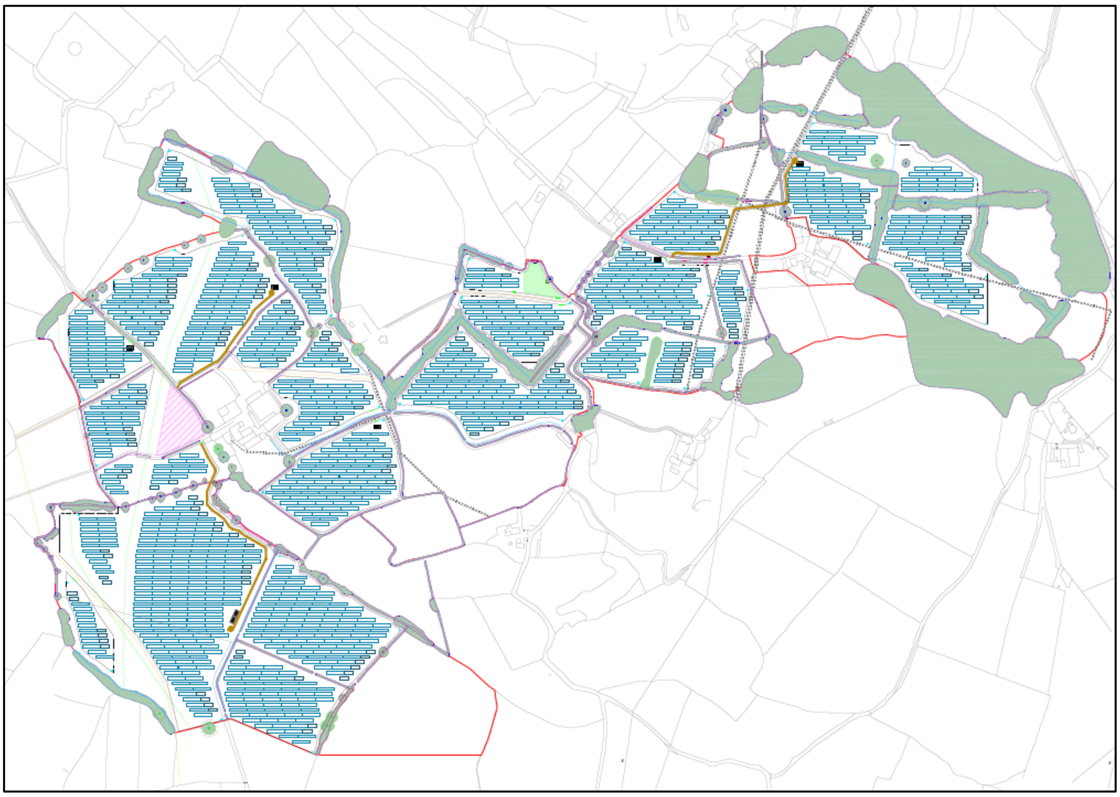


Figure 2 *Proposed development layout*

[5] Provided to Pager Power by the developer's team, original prepared by Island Green Power, cropped.

2.2 Photovoltaic Panel Mounting Arrangements and Orientation

The proposed solar development will have fixed solar panels, the assessed centre height is 2.0m above ground level (agl). The azimuth angle of the panels is 180 degrees (south-facing) and the vertical tilt angle will be 15 degrees.

Figure 3 below shows a profile view of the panels[6].

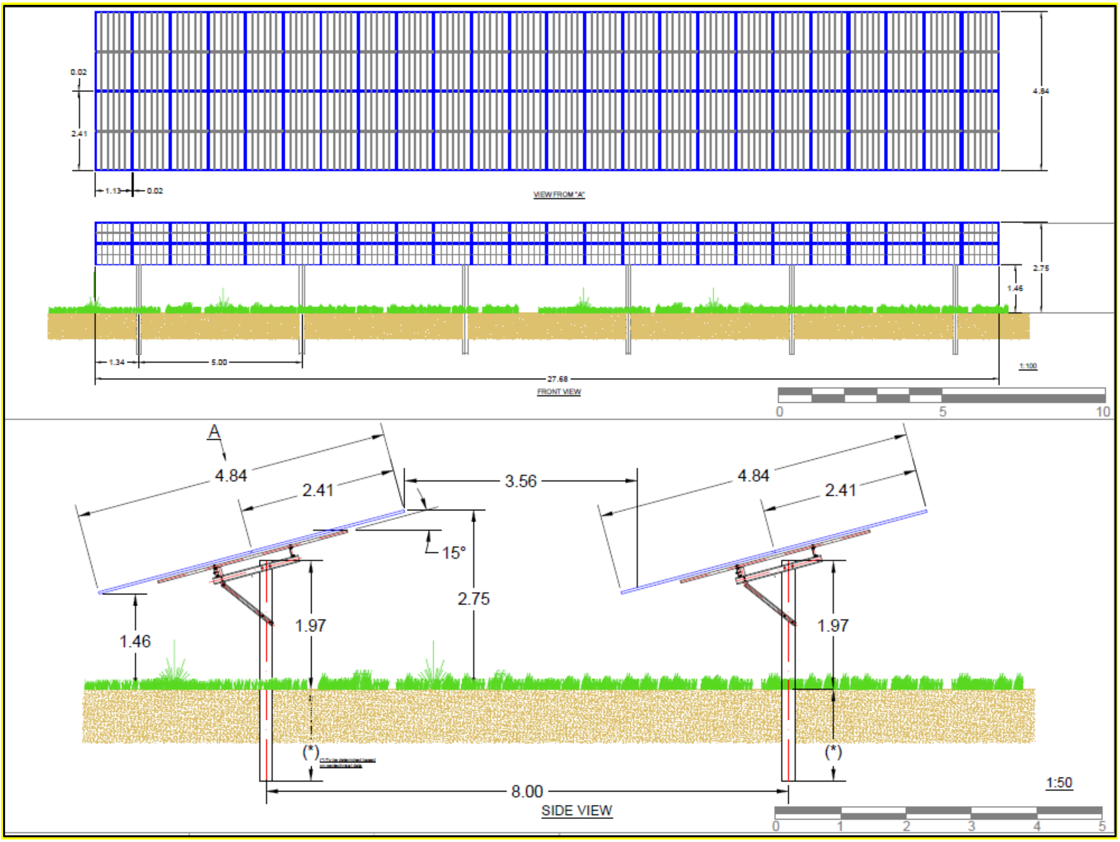


Figure 3 *Panel profile*

---

[6] Provided to Pager Power by the developer's team, original prepared by Island Green Power, cropped.

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.

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.

The above parameters and industry experience indicate that a 1km buffer from the proposed panel area is appropriate for glint and glare effects on ground-based receptors.

Potential receptors within the 1km buffer are identified based on mapping and aerial photography of the region. The initial judgement is made based on high-level consideration of aerial photography and mapping i.e. receptors are excluded if it is clear from the outset that no visibility would be possible. A more detailed assessment is made if the modelling reveals a reflection would be geometrically possible.

Terrain elevation heights have been interpolated based on Ordnance Survey of Great Britain (OSGB) 50m Panorama data. Receptor details can be found in Appendix G.

Figure 4 below[7] shows an approximate[8] 1 km buffer as a green polygon. This zone is based on a combined 1 km around relevant vertices of the extrapolated panel areas, it is therefore an irregular shape. The panel footprint areas themselves are shown by the blue polygons.

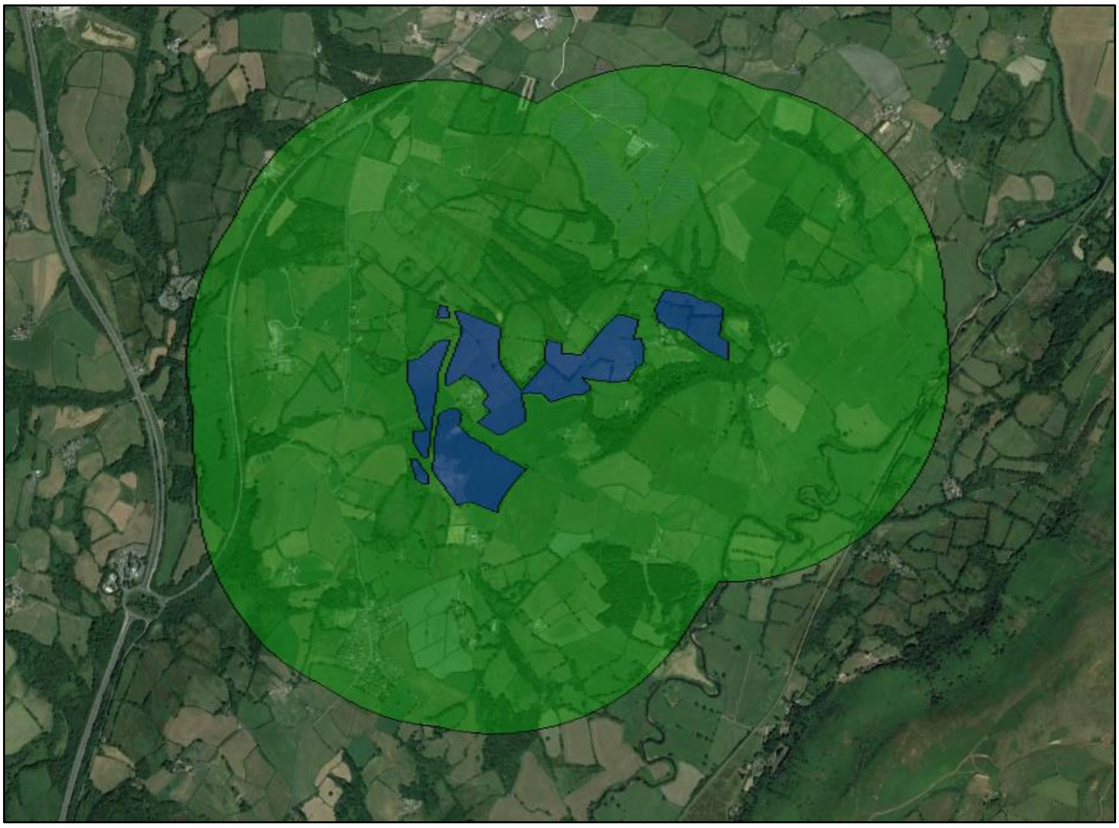


Figure 4 *Ground-based receptor buffer (1 km)*

4.2 Road Receptors

Road types can generally be categorised as:

- Major National – Typically a road with a minimum of two carriageways with a maximum speed limit of up to 70mph. These roads typically have fast moving vehicles with busy traffic.
- National – Typically a road with a one or more carriageways with a maximum speed limit of up to 60mph or 70mph. These roads typically have fast moving vehicles with moderate to busy traffic density.
- Regional – Typically a single carriageway with a maximum speed limit of up to 60mph. The speed of vehicles will vary with a typical traffic density of low to moderate; and
- Local – Typically roads and lanes with the lowest traffic densities. Speed limits vary.

---

[7] Copyright © 2021 Google.

[8] The buffer has been generated to encapsulate receptors within the 1 km range by considering the vertices that define an all-encompassing perimeter, it does not follow the exact contours of the outer panel edge.

Assessment is not recommended for local roads, where traffic volumes and/or speeds are likely to be relatively low, as any solar reflections from the proposed development that are experienced by a road user would be considered low impact in the worst case.

The assessed road receptors surrounding the panel area are shown in the aerial image in Figure 5 below[9]. The pink icons show the assessed road locations – which are all on the B4297 (Ebenezer Road). A height of 1.5 metres above ground level has been modelled, this is a typical eye level for a road user. Road user location that are further north than any of the panels have been excluded from assessment because reflections towards ground-based receptors further north than the panels are not likely at this latitude[10].

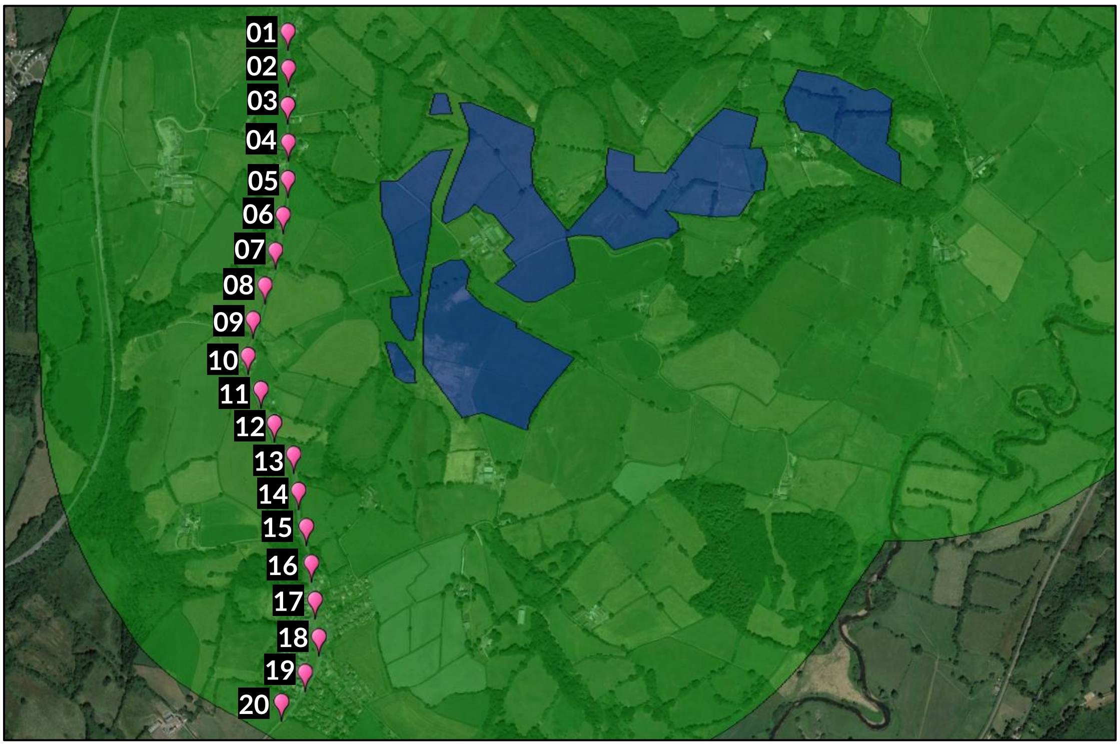


Figure 5 *Main roads surrounding panel area*

Other roads within the 1 km buffer have not been modelled because they meet one or more of the following criteria:

- They are local roads where traffic volumes/speeds are generally low (including most of the access routes around the individual panel areas).
- They are north of the panels where effects are not geometrically possible.
- They are significantly screened such that effects would not be noticeable (including the A483).

---

[9] Copyright © 2021 Google.

[10] For south-facing fixed panels like the ones proposed in this case.

4.3 Dwelling Receptors

The analysis has considered dwellings that:

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

Dwellings that are further north than any of the panels have been excluded from assessment because reflections towards ground-based receptors further north than the panels are not likely at this latitude[11].

The assessed dwelling receptors are shown in Figure 6 below[12]. A total of 55 dwelling locations have been assessed.

Figure 6 *Assessed dwelling receptors*

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, since this is typically the most occupied floor of a dwelling throughout the day. Visibility from all storeys is considered for receptors where effects are

[11] For south-facing fixed panels like the ones proposed in this case.
[12] Copyright © 2021 Google.

possible based on the technical modelling. Where it is unclear whether a property is a dwelling or a commercial building, it has been assessed as a dwelling to remain conservative.

In some cases, a single receptor point may be used to represent a small number of separate addresses. In such cases, the results for the receptor will be representative of the adjacent observer locations, such that the overall level of effect in each area is captured reliably.

Close-up images to illustrate the dwelling receptors are presented[13] in figures 7-13 below and on the following pages.

Figure 7 *Dwellings 01-07*

[13] Copyright © 2021 Google.

Figure 8 *Dwellings 08-14*

Figure 9 *Dwellings 15-21*

Figure 10 *Dwellings 22-38*

Figure 11 *Dwellings 39-41, 48-49, 51-53 and 55*

Figure 12 *Dwellings 42-47*

Figure 13 *Dwellings 50 and 54*

4.4 Public Rights of Way

Public rights of way that run through the site. Reflections towards observers on these public rights of way could therefore be experienced under certain conditions (typically when the Sun is low in the sky beyond the panels. Impacts are not significant in practice because:

- Effects would typically coincide with direct sunlight.
- The reflection intensity is similar for solar panels and still water – which is frequently a feature of the outdoor environment surrounding public rights of way. Overall, the reflections are likely to be comparable to those from common outdoor sources.
- There is no safety hazard associated with reflections towards an observer on a footpath.

The overall impact is low and no mitigation requirement has been identified.

5 ASSESSED REFLECTORS

5.1 Reflector Area

A number of representative panel locations are selected within the proposed area. The bounding coordinates for the proposed solar development have been extrapolated from the application plans. Ground heights have been based on OSGB terrain data.

The coordinate data can be found in Appendix G. The assessed panel areas are shown in Section 2 of this report.

The assessment resolution within each panel area was 20 metres, which results in over 1,100 panel locations on which each calculation for each receptor is based. This resolution is sufficiently high to maximise the accuracy of the results. Increasing the resolution further would not make the results more meaningful.

6 GLINT AND GLARE ASSESSMENT – TECHNICAL RESULTS

6.1 Evaluation of Effects

The tables in the following subsections present the results of the technical analysis. The final column summarises the predicted impact considering the level of identified screening based on a desk-based review of the available imagery.

The significance of the predicted effects has been evaluated in accordance with Pager Power's published guidance document[14].

The flowcharts setting out the impact characterisation and presented in Appendix D[15]. The list of assumptions and limitations are presented in Appendix F. The modelling output for key receptors can be found in Appendix H.

When evaluating visibility in the context of glint and glare, it is only the ***reflecting*** panel area that must be considered. For example, if the western half of the development is visible, but reflections would only be possible from the eastern half, it can be concluded that the reflecting area is not visible and no impacts are predicted. This is why there can be instances where visibility of the development is predicted, but glint and glare issues are screened.

Receptors are included within the assessment based on the potential visibility of the development as a whole, among other factors. Once the modelling output has been generated, the assessment can be refined to evaluate the visibility of the reflecting area specifically.

---

[14] Solar Photovoltaic Development – Glint and Glare Guidance Issue 3.1, April 2021.

[15] There is no standard methodology for evaluating effects on ground-based receptors beyond a kilometre (such as the Priory and the Castle) or for cycle paths. These receptors have been considered based on first principles and the general methodology for ground-based receptors, keeping in mind the relative safety/amenity implications for differing receptor types.

6.2 Roads

Road Receptor(s)	Approximate predicted reflection times (GMT)		Comment
	am	pm	
1	None.	None.	No solar reflections predicted. No impact predicted.
2	Between 06:10 and 06:40 for parts of March and September.	None.	Visibility of the reflecting area is not predicted from this location. No impact predicted in practice.
3	Between 06:00 and 06:40 for parts of March-April and August-September.	None.	Visibility of the reflecting area is not predicted from this location. No impact predicted in practice.
4-5	Between 05:30 and 06:30 for parts of March-September.	None.	Visibility of the reflecting area is not predicted from this location. No impact predicted in practice.
6	Between 05:00 and 06:30 for parts of March-September.	None.	Reflections would originate significantly outside a driver's primary field of view when facing the direction of travel. Furthermore, the reflecting panel area is likely to be partially or entirely screened by rising terrain between the receptor point and the development. The worst-case impact is low, which is acceptable without further mitigation.
7	Between 05:00 and 06:30 for parts of March-September.	None.	Visibility of the reflecting area is not predicted from this location. No impact predicted in practice.
8	Between 05:00 and 06:30 for parts of March-September.	None.	Reflections would originate significantly outside a driver's primary field of view when facing the direction of travel. Furthermore, the reflecting panel area is likely to be partially or entirely screened by rising terrain between the receptor point and the development. The worst-case impact is low, which is acceptable without further mitigation.
9	Between 05:00 and 06:30 for parts of March-September.	None.	Visibility of the reflecting area is not predicted from this location. No impact predicted in practice.

Road Receptor(s)	Approximate predicted reflection times (GMT)		Comment
	am	pm	
10	Between 05:00 and 06:20 for parts of March-September.	None.	Reflections would originate significantly outside a driver's primary field of view when facing the direction of travel. Furthermore, the reflecting panel area is likely to be partially or entirely screened by rising terrain between the receptor point and the development. The worst-case impact is low, which is acceptable without further mitigation.
11	Between 05:30 and 06:20 for parts of April-September.	None.	Reflections would originate significantly outside a driver's primary field of view when facing the direction of travel. Furthermore, the reflecting panel area is likely to be partially or entirely screened by rising terrain between the receptor point and the development. The worst-case impact is low, which is acceptable without further mitigation.
12	Between 05:20 and 06:00 for parts of April-September.	None.	Reflections would originate significantly outside a driver's primary field of view when facing the direction of travel. Furthermore, the reflecting panel area is likely to be partially or entirely screened by rising terrain between the receptor point and the development. The worst-case impact is low, which is acceptable without further mitigation.
13	Between 05:20 and 06:00 for parts of April-August.	None.	Visibility of the reflecting area is not predicted from this location. No impact predicted in practice.
14	Between 05:20 and 06:00 for parts of May-August.	None.	Visibility of the reflecting area is not predicted from this location. No impact predicted in practice.
15-20	None.	None.	No solar reflections predicted. No impact predicted.

Table 1 *Results – road receptors*

6.3 Dwellings

Dwelling(s)	Approximate predicted reflection times (GMT)		Comment
	am	pm	
01	Between 06:00 and 06:40 for parts of March and September for up to approximately 10 minutes per day.	None.	The model output shows potential effects that would last for less than three months per year and less than 60 minutes per day. The worst-case impact is low, which is acceptable without further mitigation.
02-03	Between 06:10 and 06:40 for parts of March to April and August to September for up to approximately 20 minutes per day.	None.	The model output shows potential effects that would last for less than three months per year and less than 60 minutes per day. The worst-case impact is low, which is acceptable without further mitigation.
04	Between 06:10 and 06:40 for parts of March to May and July to September for up to approximately 20 minutes per day.	None.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. The worst-case impact is moderate, which requires further consideration (see Section 7.2).
05-06	Between 05:30 and 06:30 for parts of March to May and July to September for up to approximately 20 minutes per day.	None.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. The worst-case impact is moderate, which requires further consideration (see Section 7.2).

Dwelling(s)	Approximate predicted reflection times (GMT)		Comment
	am	pm	
07	Between 05:30 and 06:30 for parts of March to September for up to approximately 20 minutes per day.	None.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. The worst-case impact is moderate, which requires further consideration (see Section 7.2).
08	Between 05:30 and 06:30 for parts of March to April and August to September for up to approximately 20 minutes per day.	None.	The model output shows potential effects that would last for less than three months per year and less than 60 minutes per day. The worst-case impact is low, which is acceptable without further mitigation.
09	Between 05:30 and 06:30 for parts of March to May and August to September for up to approximately 20 minutes per day.	None.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. The worst-case impact is moderate, which requires further consideration (see Section 7.2).
10-15	Between 05:20 and 06:30 for parts of March to September for up to approximately 30 minutes per day.	None.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. The worst-case impact is moderate, which requires further consideration (see Section 7.2).

Dwelling(s)	Approximate predicted reflection times (GMT)		Comment
	am	pm	
16-17	Between 05:30 and 06:10 for parts of April to September for up to approximately 30 minutes per day.	None.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. The worst-case impact is moderate, which requires further consideration (see Section 7.2).
18-19	Between 05:30 and 06:00 for parts of April to September for up to approximately 20 minutes per day.	None.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. The worst-case impact is moderate, which requires further consideration (see Section 7.2).
20	Between 05:20 and 06:00 for parts of April to August for up to approximately 15 minutes per day.	None.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. The worst-case impact is moderate, which requires further consideration (see Section 7.2).
21	Between 05:20 and 05:40 for parts of May to June and July for up to approximately 10 minutes per day.	None.	The model output shows potential effects that would last for less than three months per year and less than 60 minutes per day. The worst-case impact is low, which is acceptable without further mitigation.
22-38	None.	None.	No solar reflections predicted. No impact predicted.

Dwelling(s)	Approximate predicted reflection times (GMT)		Comment
	am	pm	
39	Between 05:30 and 06:30 for parts of March to September for up to approximately 20 minutes per day.	Between 18:30 and 19:20 for parts of April to September for parts of April to September.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. The worst-case impact is moderate, which requires further consideration (see Section 7.2).
40	Between 05:30 and 06:30 for parts of March to September for up to approximately 20 minutes per day.	Between 18:30 and 19:20 for parts of March to September for parts of April to September.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. The worst-case impact is moderate, which requires further consideration (see Section 7.2).
41	None.	Between 18:20 and 19:30 for parts of March to September for up to approximately 20 minutes per day.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. The worst-case impact is moderate, which requires further consideration (see Section 7.2).
42-46	None.	None.	No solar reflections predicted. No impact predicted.
47	None.	Between 18:40 and 19:40 for parts of April to August for up to approximately 40 minutes per day.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. The worst-case impact is moderate, which requires further consideration (see Section 7.2).

Dwelling(s)	Approximate predicted reflection times (GMT)		Comment
	am	pm	
48	Between 06:20 and 07:00 for parts of March to May and August to September for up to approximately 10 minutes per day.	None.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. The worst-case impact is moderate, which requires further consideration (see Section 7.2).
49	Between 06:00 and 07:00 for parts of March to September for up to approximately 20 minutes per day.	Between 18:30 and 19:20 for parts of April-September for up to approximately 10 minutes per day.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. The worst-case impact is moderate, which requires further consideration (see Section 7.2).
50	None.	Between 18:40 and 19:40 for parts of April to August for up to approximately 10 minutes per day.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. The worst-case impact is moderate, which requires further consideration (see Section 7.2).
51	Between 06:00 and 06:30 for parts of May and July for up to approximately 10 minutes per day.	Between 18:30 and 19:20 for parts of April to September for up to approximately 20 minutes per day.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. The worst-case impact is moderate, which requires further consideration (see Section 7.2).
52	None.	Between 18:30 and 19:30 for parts of April to September for up to approximately 20 minutes per day.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. The worst-case impact is moderate, which requires further consideration (see Section 7.2).

Dwelling(s)	Approximate predicted reflection times (GMT)		Comment
	am	pm	
53	Between 06:00 and 06:30 for parts of May and July for up to approximately 10 minutes per day.	Between 18:30 and 19:20 for parts of April to September for up to approximately 20 minutes per day.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. The worst-case impact is moderate, which requires further consideration (see Section 7.2).
54	None.	Between 19:00 and 19:40 for parts of May to August for up to approximately 20 minutes per day.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. The worst-case impact is moderate, which requires further consideration (see Section 7.2).
55	Between 06:00 and 07:00 for parts of March to May and August to September for up to approximately 15 minutes per day.	None.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. The worst-case impact is moderate, which requires further consideration (see Section 7.2).

Table 2 *Results – dwelling receptors*

7 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

7.1 Road Results

The process for quantifying impact significance is defined in the report appendices. For major national, national and regional roads are:

- Whether a reflection is predicted in practice.
- The location of the reflecting panels relative to a road user's direction of travel. Where reflections originate from significantly outside of a road user's field of view, the impact significance is low, and mitigation is not required. Where reflections originate from inside of a road user's field of view but there are mitigating circumstances, the impact significance is moderate and expert assessment of the mitigating factors is required to determine the mitigation requirement (if any). Of particular relevance is whether the solar reflection originates from directly in front of a road user, the separation distance between the reflecting panels and the receptor location, and the extent to which effects coincide with direct sunlight. Where reflections originate from directly in front of a road user and there are no further mitigating circumstances, the impact significance is high, and mitigation is required.

Reflections towards the B4297 (Ebenezer Road) are not significant because they would occur from a bearing that is outside a driver's primary field of focus when facing the direction of travel.

Furthermore, the reflecting area is likely to be partially or entirely screened by intervening terrain at locations where reflections would be geometrically possible.

Impacts on road users are low at worst and mitigation measures are not required.

7.2 Dwelling 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.
    - 60 minutes per day.

Where effects occur for less than 3 months per year and less than 60 minutes per day, the worst-case impact significance is low and mitigation is not required.

Where effects last for more than 3 months per year and less than 60 minutes per day[16], the worst-case impact significance is moderate and expert assessment of any mitigating factors is required to determine the mitigation requirement (if any). Of particular relevance is the level of

[16] Or if effects last for less than 3 months per year but more than 60 minutes per day, which is a scenario that is almost never seen in practice but could occur in theory.

likely screening, the separation distance between the reflecting panels and the receptor location[17] and the extent to which effects coincide with direct sunlight.

Where effects last for more than 3 months per year and more than 60 minutes per day, the worst-case impact is high, and mitigation is required. In the case of Brynrhyd, there are no instances of high impact, even under worst-case conditions.

A conservative review of the available imagery has been undertaken within the desk-based assessment, whereby it is assumed views of the panels are possible if it cannot be reliably determined that existing screening will remove effects.

Moderate impacts have been predicted for dwellings 4-7, 9-20, 39, 40-41, 47-49, and 50-55. In all cases, this is due to worst-case effects potentially lasting for more than 3 months per year and less than 60 minutes on any one day. The maximum duration on any one day would be approximately 40 minutes, which is below the threshold of 60 minutes that would lead to a high impact.

The dwellings that could experience moderate impacts are shown in Figure 14 below[18].

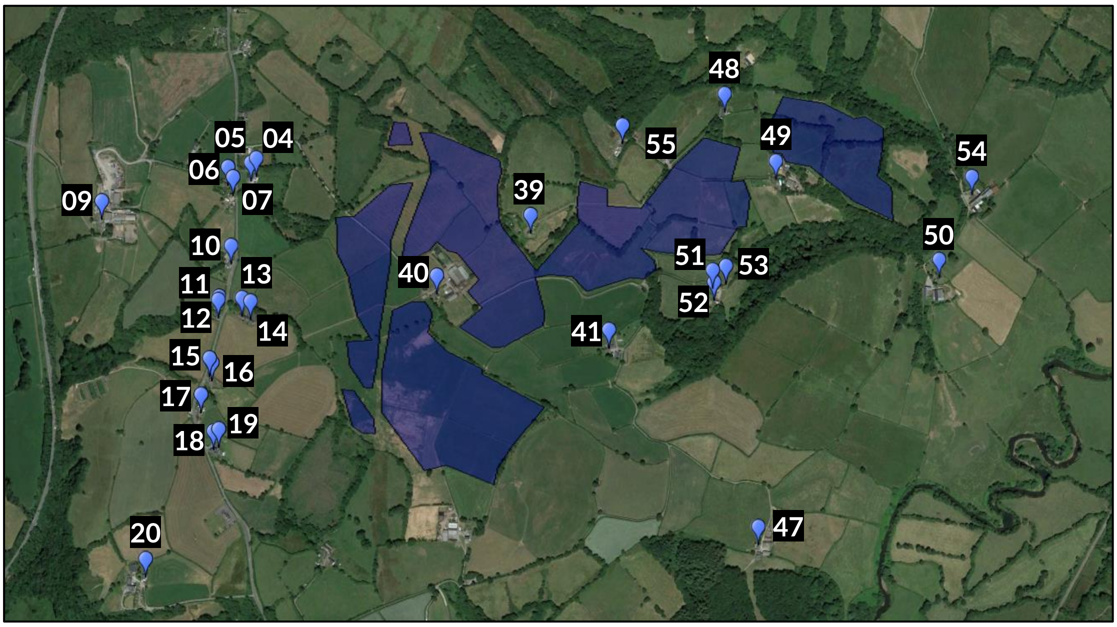


Figure 14 *Dwellings that could experience moderate impacts*

Individual modelling output charts are shown for each of these dwellings in Appendix H. Each moderately impacted dwelling has been considered in turn to evaluate whether a mitigation requirement would be appropriate.

---

[17] Which is often greater than the nearest panel boundary, because not all areas of the site cause specular reflections towards particular receptor locations.

[18] Copyright © 2021 Google.

The primary considerations in the determination of a mitigation requirement for moderate impacts[19] are:

- Visibility of the reflecting area – if the reflecting area is obscured from view, effects will not be noticeable in practice. If the reflecting area is partially obscured from view, effects will be diminished relative to the worst-case results shown in the modelling output.
- Separation distance – increased separation distance between the reflecting areas and the observer decreases the level of impact. This is because the proportion of an observer's field of view that is taken up by the reflecting area diminishes, and the reflecting area will appear generally less intrusive.
- Sun position relative to the reflecting area – where reflections and direct sunlight are experienced simultaneously from a similar position, the significance of the effect decreases. This is because direct sunlight is significantly more intense and intrusive than reflections from a solar panel.

A screening plan has been prepared for the scheme. This is shown in Figure 15 below[20].

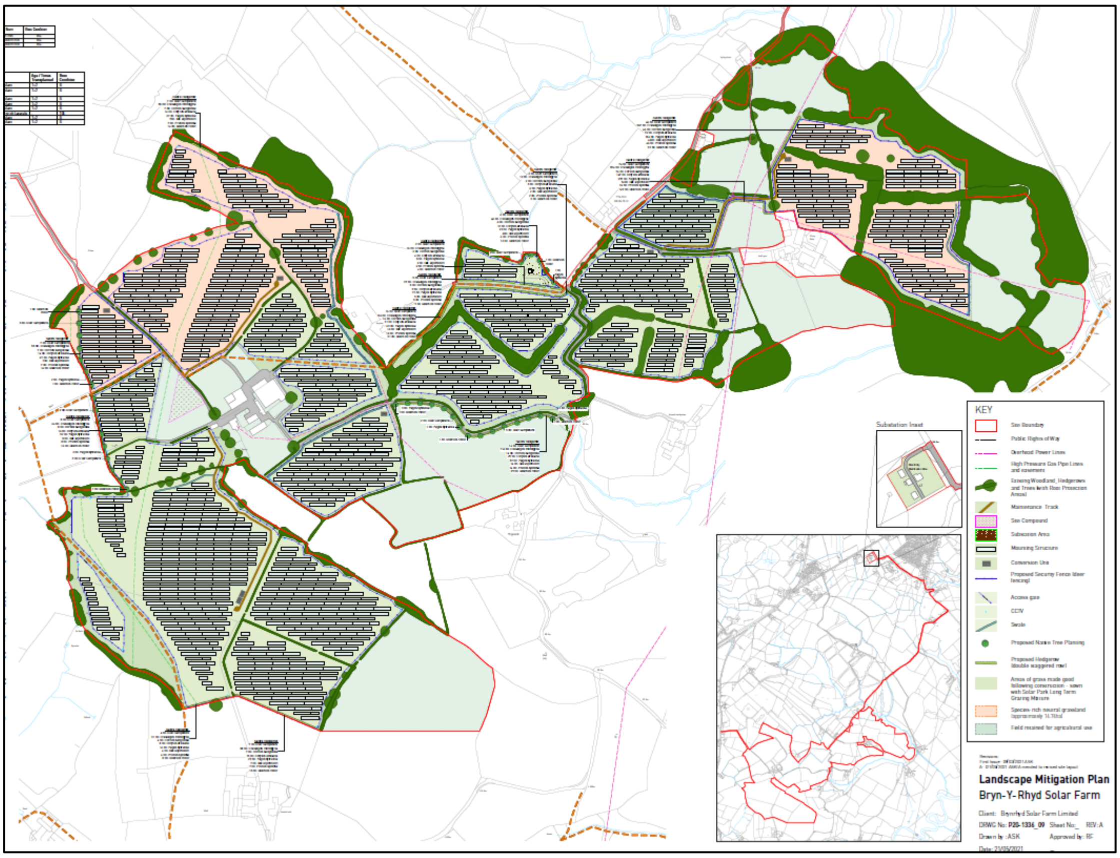


Figure 15 *Landscape plan*

---

[19] Mitigation is not a requirement for low impact and an automatic requirement for high impacts.
[20] Provided to Pager Power by Pegasus, cropped.

The landscape team has reviewed the key reflecting areas with reference to predicted visibility of the reflecting areas[21] for the dwellings that would be potentially the most affected. Their findings are presented in Table 3 below. These have been incorporated within the mitigation conclusions for these dwellings, set out in Table 5.

Dwelling Receptor(s)	Pegasus landscape team comments on predicted visibility
39	The western reflecting area will be approximately 50% screened. The eastern reflecting area will be approximately 30% screened.
40	The western reflecting will be entirely screened. The eastern reflecting area will be approximately 70% screened.
41	The reflecting area (located to the west) will be entirely screened.
48	The reflecting area (located to the east) will be approximately 60% screened.
49	The western reflecting will be entirely screened. The eastern reflecting area will be approximately 70% screened.
51-53	The reflecting area (located to the west) will be entirely screened.

Table 3 *Evaluation of screening from landscape team*

Tables 4 and 5 on the following pages present the evaluation of mitigation requirements for moderately affected dwellings.

For ease of reference, Table 4 presents the dwellings for which no mitigation requirement has been identified, while Table 5 presents the dwellings for which mitigation is recommended.

[21] Comments provided to Pager Power on 27 May 2021.

Dwelling Receptor(s)	Consideration			Mitigation requirement conclusion
	Visibility	Separation distance	Sun position	
4-5	It is likely that the reflecting areas will be partially or entirely screened by intervening hedgerows. This cannot be conclusively determined based on the available imagery alone, particularly due to the elevated terrain at the dwelling locations.	The nearest reflecting area is more than 300 metres from the dwellings. The furthest reflecting area is more than 1.6 km from the dwellings.	Effects would occur from the east approximately 90 minutes or less after sunrise. Reflections would coincide with direct sunlight.	Mitigation is not a requirement.
6-7	It is likely that the reflecting areas will be entirely screened by intervening hedgerows. Any remaining visibility is likely to be partial and from upper floors only.	The nearest reflecting area is more than 400 metres from the dwellings. The furthest reflecting area is more than 1.6 km from the dwellings.	Effects would occur from the east approximately 90 minutes or less after sunrise. Reflections would coincide with direct sunlight.	Mitigation is not a requirement due to existing factors that diminish the significance of likely effects.
9	Visibility of the reflecting areas is not predicted based on screening from elevated terrain, buildings and hedgerows.	N/A – visible reflections not predicted.	N/A – visible reflections not predicted.	Mitigation is not a requirement because impacts are not predicted in practice.

Dwelling Receptor(s)	Consideration			Mitigation requirement conclusion
	Visibility	Separation distance	Sun position	
10-19	It is likely that the reflecting areas will be partially or entirely screened by intervening hedgerows. The potential for partial visibility, particularly from upper floors, cannot be ruled out.	The nearest reflecting area is more than 250 metres from the dwellings. The furthest reflecting area is more than 1.7 km from the dwellings.	Effects would occur from the east approximately 90 minutes or less after sunrise. Reflections would coincide with direct sunlight.	Mitigation is not a requirement due to existing factors that diminish the significance of likely effects.
20	Visibility of the reflecting areas is not predicted based on screening from elevated terrain, buildings and hedgerows.	N/A – visible reflections not predicted.	N/A – visible reflections not predicted.	Mitigation is not a requirement because impacts are not predicted in practice.
47	Visibility of the reflecting areas is not predicted based on screening from elevated terrain between the dwelling and the reflecting panels.	N/A – visible reflections not predicted.	N/A – visible reflections not predicted.	Mitigation is not a requirement because impacts are not predicted in practice.
50 and 54-55	Visibility of the reflecting areas is not predicted based on screening from significant vegetation between the dwellings and the reflecting panels (identified based on aerial imagery).	N/A – visible reflections not predicted.	N/A – visible reflections not predicted.	Mitigation is not a requirement because impacts are not predicted in practice.

Table 4 *Investigation of mitigation requirements (no requirement concluded)*

Dwelling Receptor(s)	Consideration			Mitigation requirement conclusion
	Visibility	Separation distance	Sun position	
39	It is likely that this dwelling benefits from some screening due to existing hedgerows, the level of remaining visibility cannot be reliably concluded based on available imagery.	The nearest reflecting area is approximately 85 metres from the dwelling. The furthest reflecting area is more than 900 metres from the dwelling.	Effects would occur from the east approximately two hours or less after sunrise, and from the west approximately two hours or less before sunset. Reflections would coincide with direct sunlight.	Based on the predicted visibility provided by the landscape team, some effects will remain for this dwelling during the AM and PM. Overall, the reduction in visibility of the reflecting areas and the fact that effects would coincide with direct sunlight reduces the remaining level of effect. The remaining level of effect is likely to be acceptable, particularly if the nearest panels within the reflecting area are obscured from view.

Dwelling Receptor(s)	Consideration			Mitigation requirement conclusion
	Visibility	Separation distance	Sun position	
40	It is likely that some reflecting areas will be visible to this dwelling.	The nearest reflecting area is approximately 100 metres from the dwelling. The furthest reflecting area is more than 1.2 km from the dwelling.	Effects would occur from the east approximately two hours or less after sunrise, and from the west approximately two hours or less before sunset. Reflections would coincide with direct sunlight.	Based on the predicted visibility provided by the landscape team, some effects will remain for this dwelling during the AM. Overall, the reduction in visibility of the reflecting areas and the fact that effects would coincide with direct sunlight reduces the remaining level of effect, which is judged to be acceptable.
41	It is possible that this dwelling benefits from some screening due to existing hedgerows, the level of remaining visibility cannot be reliably concluded based on available imagery.	The nearest reflecting area is approximately 170 metres from the dwelling. The furthest reflecting area is more than 750 metres from the dwelling.	Effects would occur from the west approximately two hours or less before sunset. Reflections would coincide with direct sunlight.	The landscape team has confirmed that the reflecting area is screened from view. No remaining effects are predicted.

Dwelling Receptor(s)	Consideration			Mitigation requirement conclusion
	Visibility	Separation distance	Sun position	
48	It is possible that the reflecting area will be visible from this dwelling due to the elevated terrain at the dwelling location, the level of visibility cannot be reliably concluded based on available imagery.	The nearest reflecting area is approximately 130 metres from the dwelling. The furthest reflecting area is more than 400 metres from the dwelling.	Effects would occur from the east approximately two hours or less after sunrise. Reflections would coincide with direct sunlight.	Based on the predicted visibility provided by the landscape team, some effects will remain for this dwelling during the AM. Overall, the reduction in visibility of the reflecting areas and the fact that effects would coincide with direct sunlight reduces the remaining level of effect, which is judged to be acceptable.
49	It is likely that this dwelling benefits from some screening due to existing hedgerows and vegetation, particularly to east. The level of visibility cannot be reliably concluded based on available imagery.	The nearest reflecting area is approximately 50 metres from the dwelling, although this section of the site may not be visible. The furthest reflecting area is approximately 300 metres from the dwelling.	Effects would occur from the east approximately two and a half hours or less after sunrise, and from the west approximately two hours or less before sunset. Reflections would coincide with direct sunlight.	Based on the predicted visibility provided by the landscape team, some effects will remain for this dwelling during the AM. Overall, the reduction in visibility of the reflecting areas and the fact that effects would coincide with direct sunlight reduces the remaining level of effect, which is judged to be acceptable.

Dwelling Receptor(s)	Consideration			Mitigation requirement conclusion
	Visibility	Separation distance	Sun position	
51-53	It is likely that these dwellings benefits from some screening due to existing hedgerows and vegetation, the level of remaining visibility cannot be reliably concluded based on available imagery.	The nearest reflecting area is approximately 150 metres from the dwellings. The furthest reflecting area is more than 950 metres from the dwellings.	Effects would occur from the west approximately 90 minutes or less before sunset. Effects from the east are not predicted to be visible due to the separation distance and existing screening. Reflections would coincide with direct sunlight.	The landscape team has confirmed that the reflecting area is screened from view. No remaining effects are predicted.

Table 5 *Investigation of mitigation requirements (requirement concluded)*

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[22] (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.'

---

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

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. 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[23] which was produced due to the absence of existing guidance and a specific standardised assessment methodology.

[23] Solar Photovoltaic Development – Glint and Glare Guidance, Edition 3.1, April 2021. Pager Power.

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

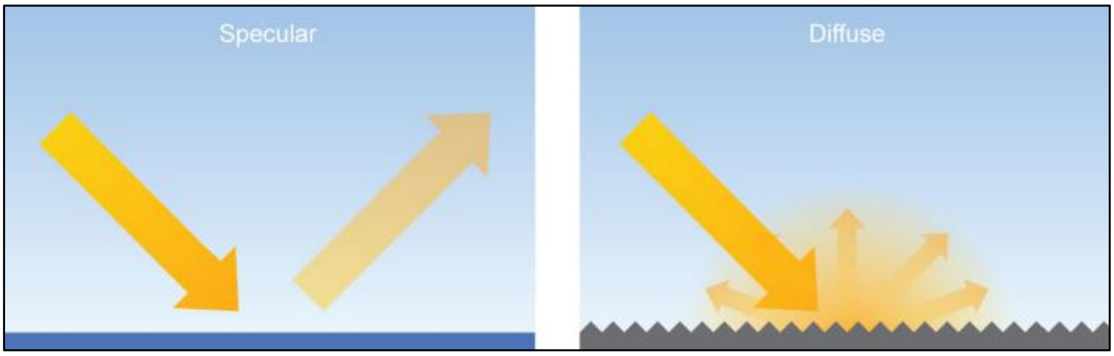
Overview

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

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, taken from the FAA guidance[24], 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

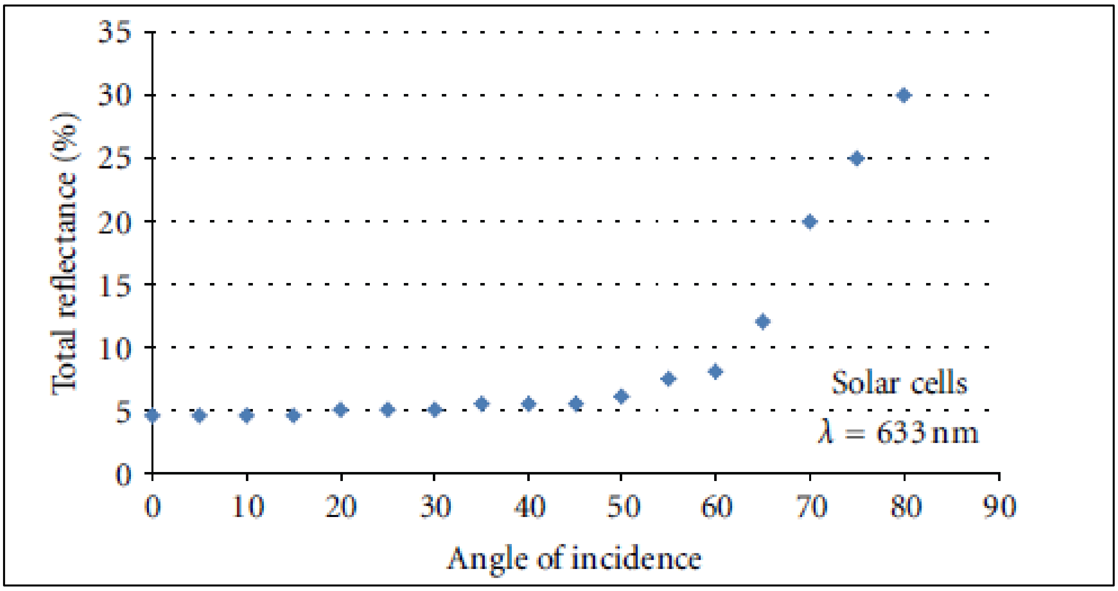
[24]Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.

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*[25]". 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.

[25] 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

FAA Guidance – "Technical Guidance for Evaluating Selected Solar Technologies on Airports"[26]

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 within the FAA guidance, is presented below.

Surface	Approximate Percentage of Light Reflected[27]
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).

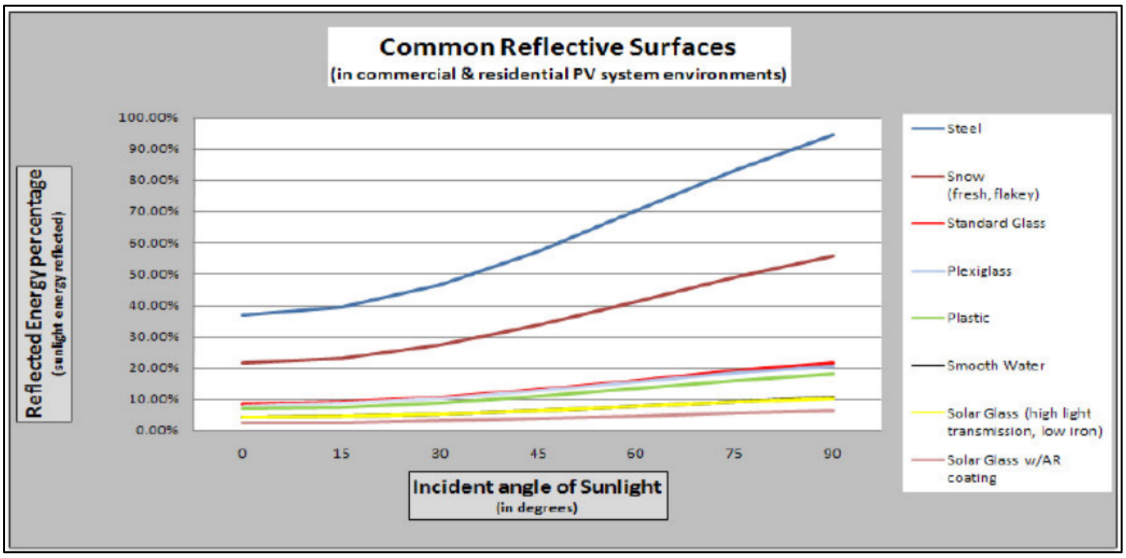
An important comparison in this table is the reflectivity compared to water which will produce a reflection of very similar intensity when compared to that from a solar panel. The study by Riley and Olsen study (2011) also concludes that still water has a very similar reflectivity to solar panels.

[26] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.
[27] Extrapolated data, baseline of 1,000 W/m^2 for incoming sunlight.

SunPower Technical Notification (2009)

SunPower published a technical notification[28] 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.

[28] 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).

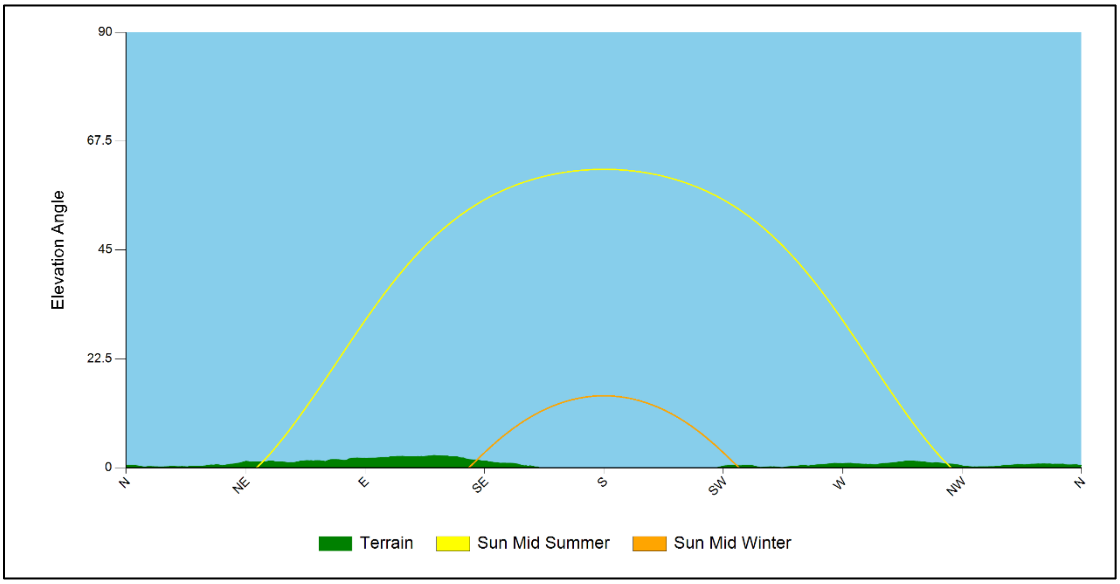
The Sun's position can be accurately calculated for a specific location. The following data being used for the calculation:

- 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 terrain sun curve at the development location is shown below.



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

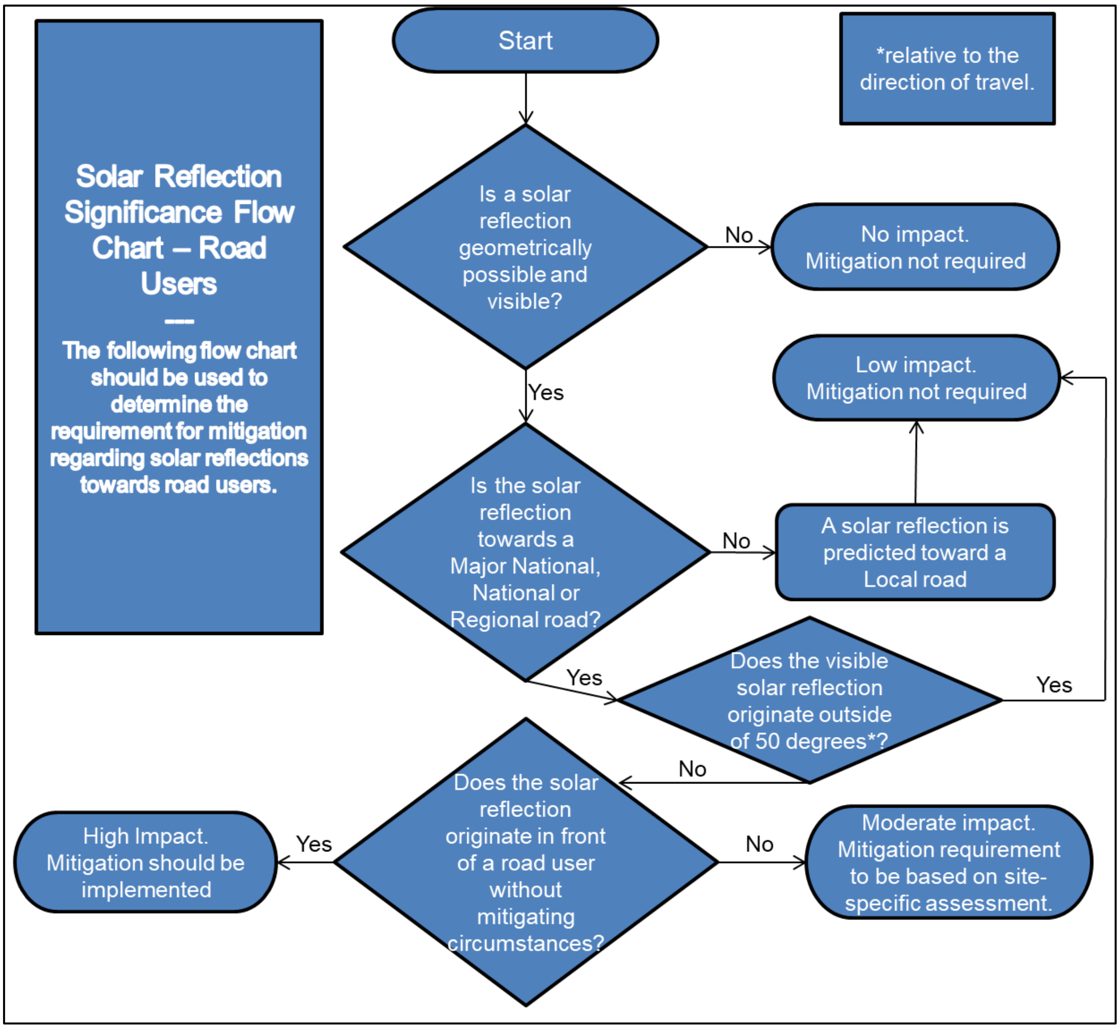
The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

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

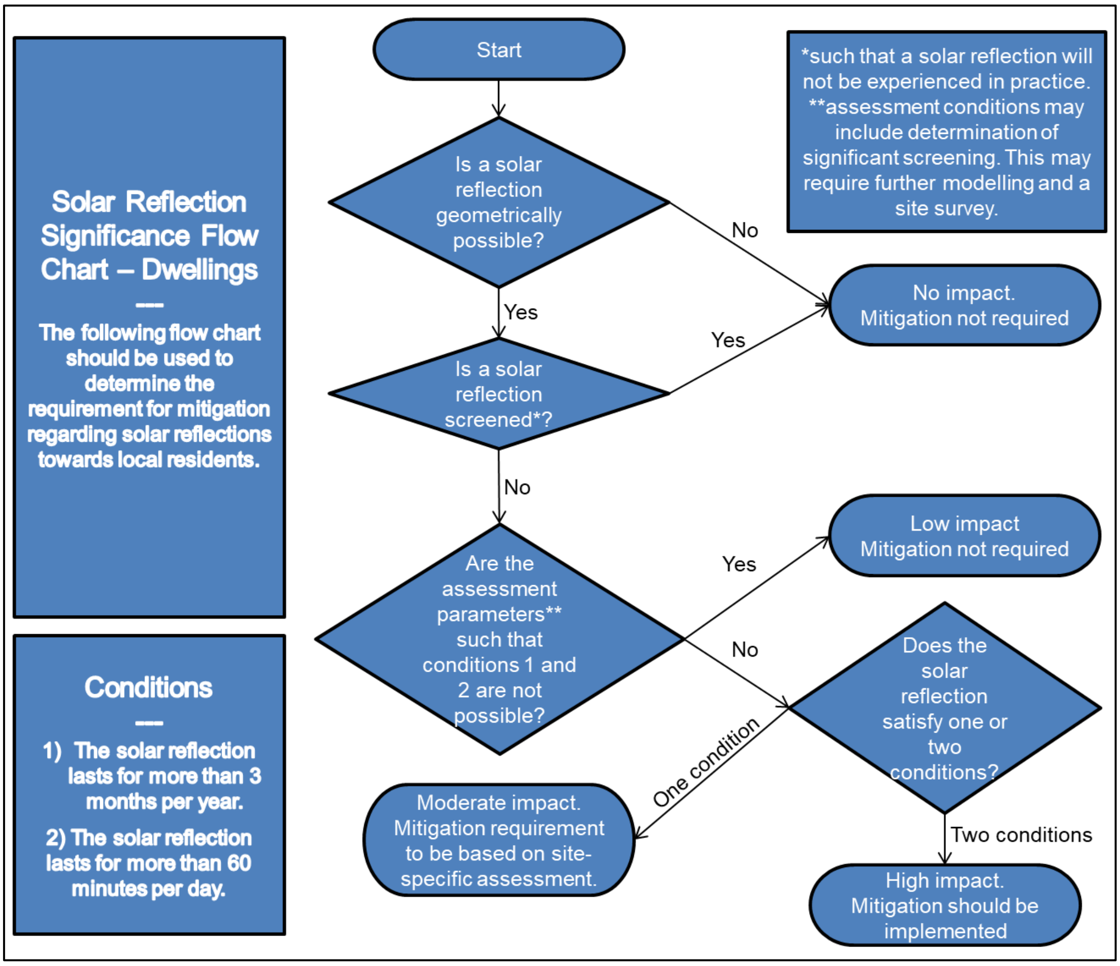
The flow chart presented below has been followed when determining the mitigation requirement for road receptors.



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.



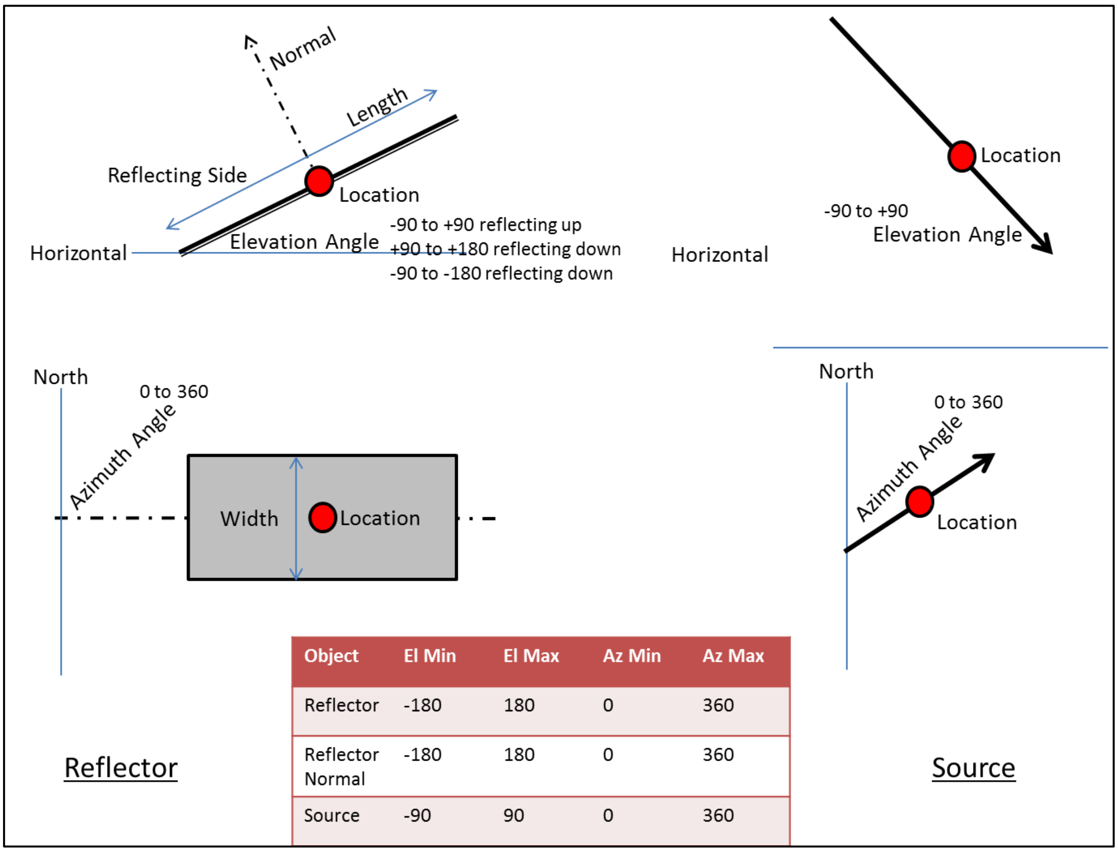
Dwelling receptor mitigation requirement flow chart

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

The model considers 100% sunlight during daylight hours which is highly conservative.

The model does not account for terrain between the reflecting solar panels and the assessed receptor where a solar reflection is geometrically possible.

The model considers terrain between the reflecting solar panels and the visible horizon (where the sun may be obstructed from view of the panels)[29].

It is assumed that the panel elevation angle assessed represents the elevation angle for all of the panels within each solar panel area defined.

It is assumed that the panel azimuth angle assessed represents the azimuth angle for all of the panels within each solar panel area defined.

Only a reflection from the face of the panel has been considered. The frame or the reverse or frame of the solar panel has not been considered.

The model assumes that a receptor can view the face of every panel (point, defined in the following paragraph) within the development area whilst in reality this, in the majority of cases, will not occur. Therefore any predicted solar reflection from the face of a solar panel that is not visible to a receptor will not occur in practice.

A finite number of points within each solar panel area defined is chosen based on an assessment resolution so that a comprehensive understanding of the entire development can be formed. This determines whether a solar reflection could ever occur at a chosen receptor. The model does not consider the specific panel rows or the entire face of the solar panel within the development outline, rather a single point is defined every 'x' metres (based on the assessment resolution) with the geometric characteristics of the panel. A panel area is however defined to encapsulate all possible panel locations. See the figure below which illustrates this process.

---

[29] UK only.

APPENDIX G – RECEPTOR AND REFLECTOR AREA DETAILS

Terrain Height

All ground heights are interpolated based on OSGB data.

Road User Data

The table below presents the coordinate data for assessed road receptors.

Road	Longitude (°)	Latitude (°)	Road	Longitude (°)	Latitude (°)
01	-4.050601	51.758638	11	-4.051666	51.749852
02	-4.050577	51.757738	12	-4.051103	51.749025
03	-4.050630	51.756840	13	-4.050339	51.748260
04	-4.050631	51.755941	14	-4.050138	51.747376
05	-4.050666	51.755044	15	-4.049806	51.746499
06	-4.050872	51.754156	16	-4.049595	51.745613
07	-4.051184	51.753282	17	-4.049437	51.744721
08	-4.051583	51.752422	18	-4.049258	51.743829
09	-4.052057	51.751575	19	-4.049757	51.742985
10	-4.052208	51.750684	20	-4.050657	51.742281

Road receptor data

Dwelling Data

The table below presents the coordinate data for assessed dwelling receptors.

Dwelling	Longitude (°)	Latitude (°)	Dwelling	Longitude (°)	Latitude (°)
01	-4.050343	51.757778	29	-4.047399	51.745560
02	-4.050434	51.756920	30	-4.047315	51.745194
03	-4.052060	51.756665	31	-4.047162	51.744907
04	-4.049900	51.756366	32	-4.048205	51.743578
05	-4.050103	51.756266	33	-4.048032	51.743389
06	-4.050956	51.756165	34	-4.047867	51.743255
07	-4.050776	51.755937	35	-4.047668	51.743146
08	-4.055739	51.755564	36	-4.047460	51.742977
09	-4.055774	51.755411	37	-4.047293	51.742834
10	-4.050909	51.754374	38	-4.046526	51.741903
11	-4.051386	51.753207	39	-4.039755	51.755087
12	-4.051415	51.753132	40	-4.043228	51.753684
13	-4.050531	51.753174	41	-4.036832	51.752438
14	-4.050206	51.753096	42	-4.042073	51.748066
15	-4.051734	51.751782	43	-4.043811	51.745482
16	-4.051645	51.751680	44	-4.043646	51.745378
17	-4.052034	51.750944	45	-4.042909	51.743939
18	-4.051542	51.750102	46	-4.038812	51.744560
19	-4.051341	51.750149	47	-4.031195	51.747844
20	-4.054160	51.747140	48	-4.032495	51.757921
21	-4.047073	51.747553	49	-4.030565	51.756364
22	-4.049406	51.745622	50	-4.024200	51.754129
23	-4.049172	51.745219	51	-4.032955	51.753822
24	-4.048599	51.745278	52	-4.032901	51.753548
25	-4.048306	51.745351	53	-4.032456	51.753922

Dwelling	Longitude (°)	Latitude (°)	Dwelling	Longitude (°)	Latitude (°)
26	-4.048129	51.745750	54	-4.022966	51.756087
27	-4.048050	51.745395	55	-4.036327	51.757157
28	-4.047730	51.745429			

Dwelling data

Modelled Reflector Data

The tables below present the coordinate data for modelled reflector area used in the assessment.

Vertex number	Longitude (°)	Latitude (°)	Vertex number	Longitude (°)	Latitude (°)
01	-4.043851	51.757396	27	-4.035634	51.754754
02	-4.043494	51.756806	28	-4.034963	51.754657
03	-4.043459	51.756461	29	-4.033594	51.754574
04	-4.044384	51.754944	30	-4.032666	51.754617
05	-4.044512	51.754472	31	-4.032002	51.755241
06	-4.044348	51.754393	32	-4.031689	51.755252
07	-4.043452	51.754695	33	-4.031546	51.755932
08	-4.043224	51.754886	34	-4.031779	51.756327
09	-4.042800	51.754668	35	-4.032255	51.756292
10	-4.042478	51.754631	36	-4.031912	51.757089
11	-4.041669	51.754016	37	-4.033275	51.757314
12	-4.042089	51.753739	38	-4.034383	51.756655
13	-4.041544	51.753360	39	-4.035614	51.755668
14	-4.042379	51.752928	40	-4.036890	51.755713
15	-4.041176	51.752455	41	-4.036887	51.756112
16	-4.040728	51.752469	42	-4.037917	51.756291
17	-4.039265	51.752964	43	-4.038035	51.755690
18	-4.039210	51.753222	44	-4.037962	51.755336
19	-4.039580	51.754071	45	-4.039535	51.754232
20	-4.039062	51.754133	46	-4.040798	51.755220
21	-4.038201	51.754098	47	-4.040926	51.755433
22	-4.037657	51.753752	48	-4.040999	51.756137
23	-4.036046	51.754067	49	-4.040824	51.756500
24	-4.035537	51.754040	50	-4.040910	51.756782

Vertex number	Longitude (°)	Latitude (°)	Vertex number	Longitude (°)	Latitude (°)
25	-4.035079	51.754255	51	-4.043319	51.757383
26	-4.035133	51.754455			

Modelled reflector area 1

Vertex number	Longitude (°)	Latitude (°)	Vertex number	Longitude (°)	Latitude (°)
01	-4.044345	51.757612	03	-4.045044	51.757103
02	-4.044813	51.757632	04	-4.044130	51.757113

Modelled reflector area 2

Vertex number	Longitude (°)	Latitude (°)	Vertex number	Longitude (°)	Latitude (°)
01	-4.044116	51.756244	09	-4.046576	51.752585
02	-4.044943	51.756190	10	-4.046467	51.752044
03	-4.046281	51.755457	11	-4.045926	51.751536
04	-4.046944	51.755442	12	-4.045614	51.751515
05	-4.046920	51.754619	13	-4.045442	51.752114
06	-4.046501	51.754075	14	-4.045334	51.752876
07	-4.046180	51.753183	15	-4.044927	51.754400
08	-4.045661	51.752626	16	-4.044929	51.754888

Modelled reflector area 3

Vertex number	Longitude (°)	Latitude (°)	Vertex number	Longitude (°)	Latitude (°)
01	-4.046315	51.751463	04	-4.045928	51.750483
02	-4.046759	51.751486	05	-4.045514	51.750469
03	-4.046347	51.750630	06	-4.045546	51.750793

Modelled reflector area 4

Vertex number	Longitude (°)	Latitude (°)	Vertex number	Longitude (°)	Latitude (°)
01	-4.043670	51.753506	09	-4.040920	51.749690
02	-4.044192	51.753489	10	-4.040331	51.750249
03	-4.044859	51.753304	11	-4.039197	51.751081
04	-4.045243	51.751960	12	-4.041534	51.751847
05	-4.045251	51.750954	13	-4.041527	51.751959
06	-4.043665	51.749624	14	-4.042848	51.752365
07	-4.042864	51.749752	15	-4.043556	51.752793
08	-4.041043	51.749324	16	-4.043386	51.753248

Modelled reflector area 5

Vertex number	Longitude (°)	Latitude (°)	Vertex number	Longitude (°)	Latitude (°)
01	-4.030258	51.758321	10	-4.026052	51.755466
02	-4.030871	51.757546	11	-4.026114	51.756234
03	-4.030751	51.757182	12	-4.026662	51.756474
04	-4.030626	51.756976	13	-4.026493	51.757075
05	-4.030343	51.756984	14	-4.026403	51.757606
06	-4.030176	51.756778	15	-4.027140	51.757887
07	-4.029229	51.756693	16	-4.027533	51.757826
08	-4.028617	51.756376	17	-4.028702	51.758185
09	-4.027542	51.755881			

Modelled reflector area 6

APPENDIX H – DETAILLED MODELLING RESULTS

Model Output Charts

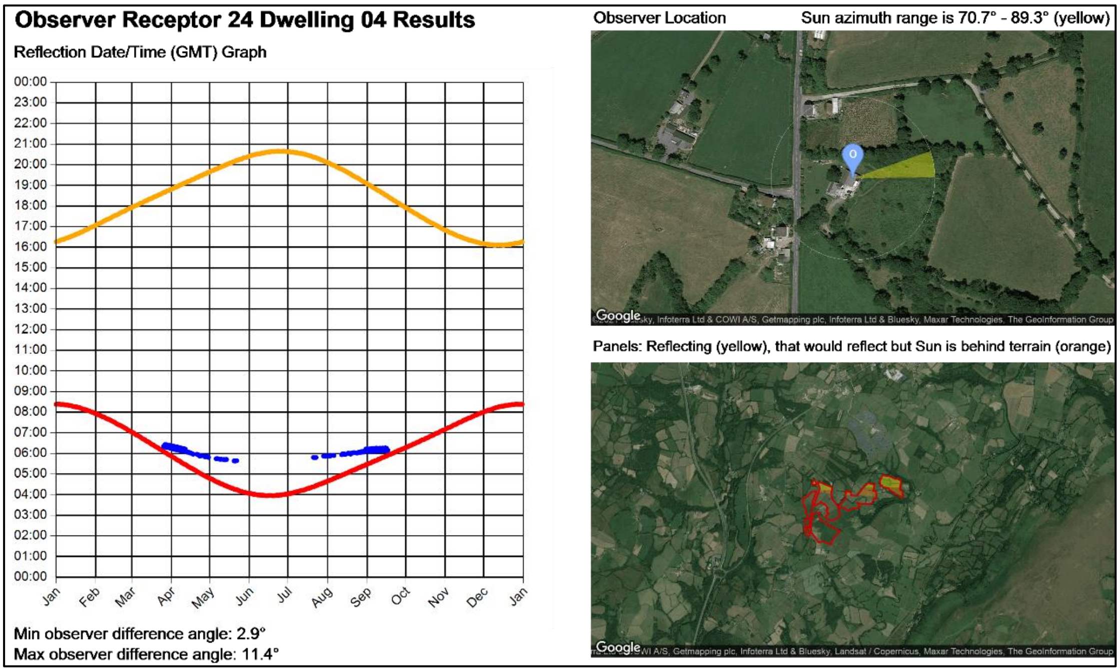
The charts for the potentially affected receptors are shown on the following pages. Each chart shows:

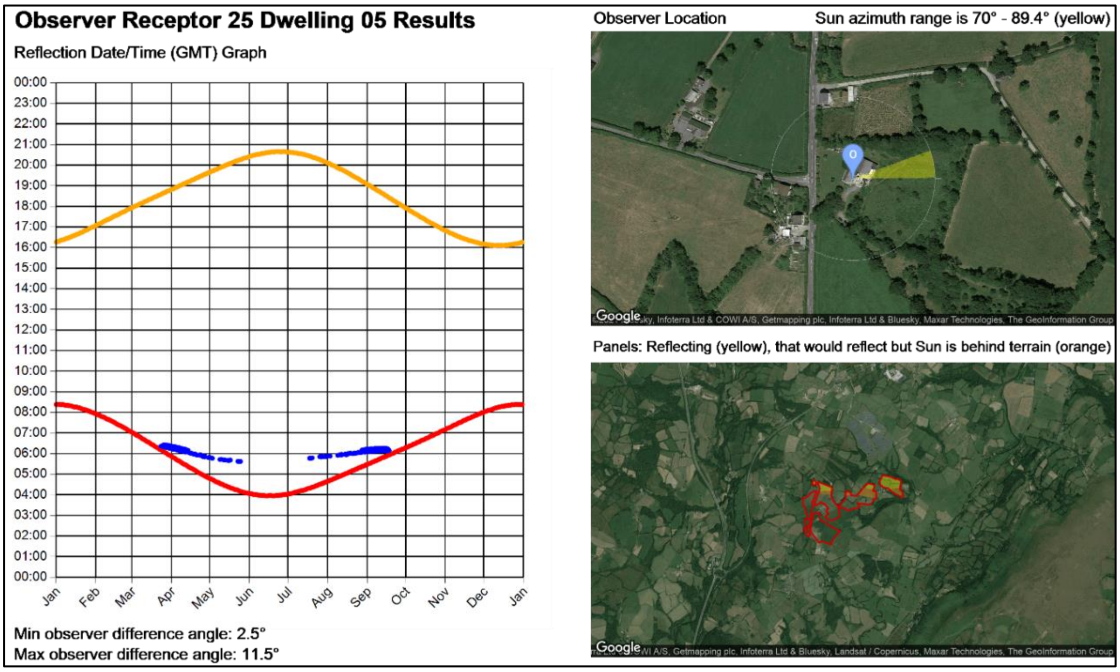
- The receptor (observer) location – top right image. This also shows the azimuth range of the Sun itself at times when reflections are possible. If sunlight is experienced from the same direction as the reflecting panels, the overall impact of the reflection is reduced as discussed within the body of the report.
- The reflecting panels – bottom right image. The reflecting area is shown in yellow. The orange areas denote panel locations that will not produce glare due to terrain screening at the horizon. 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).

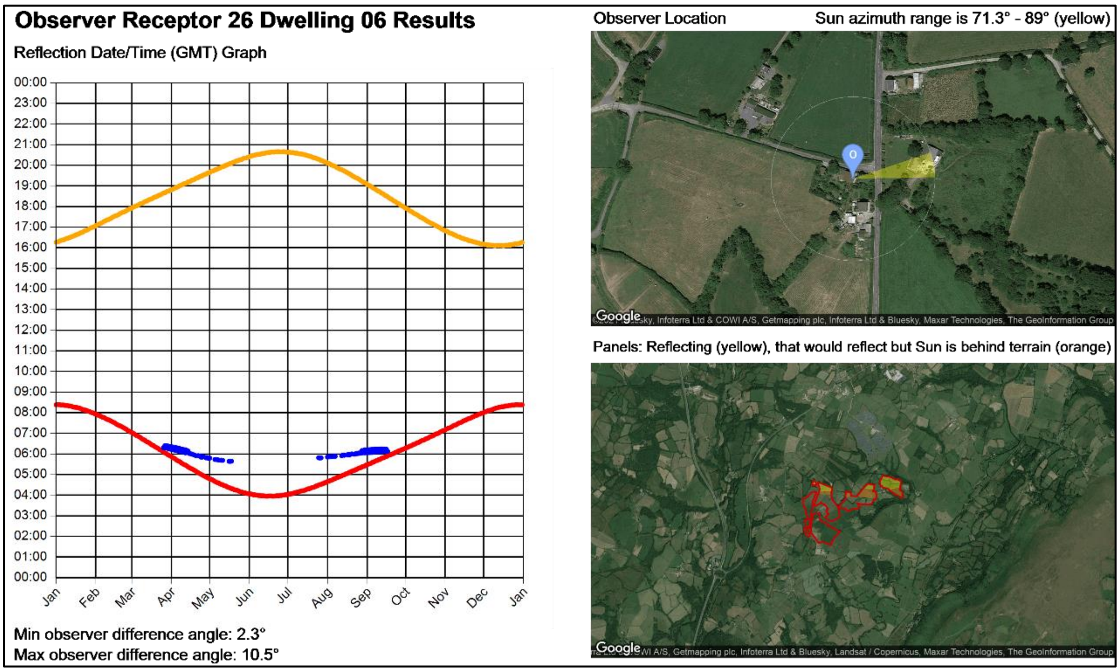
The 'Observer Receptor' reference can be ignored, this relates to the sequence in which receptors have been modelled (roads and dwellings). The dwelling reference corresponds to the references shown throughout this report.

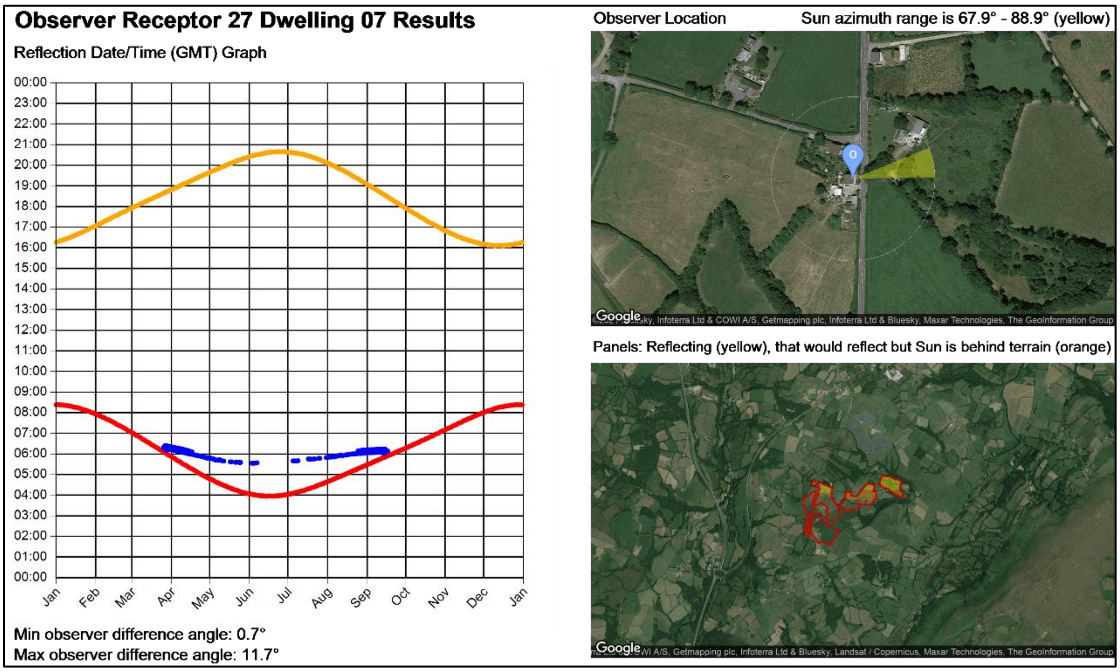
Dwelling receptors with no mitigation requirement

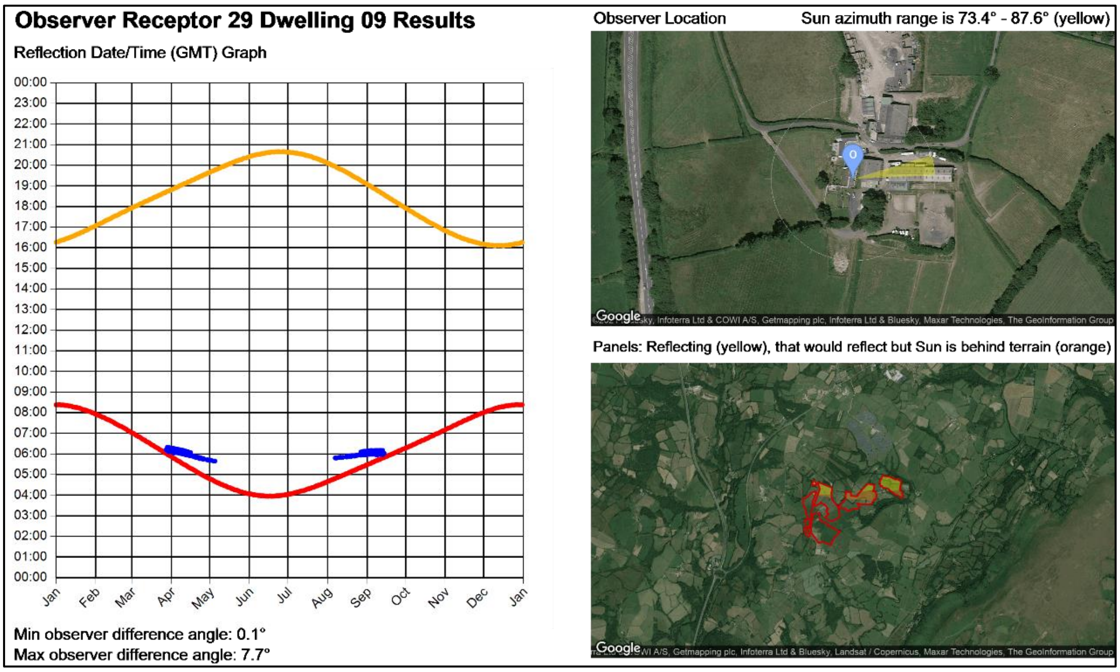
The charts below relate to the dwelling receptors where moderate impacts have been predicted but no subsequent mitigation requirement has been identified – following the assessment presented in Section 7.

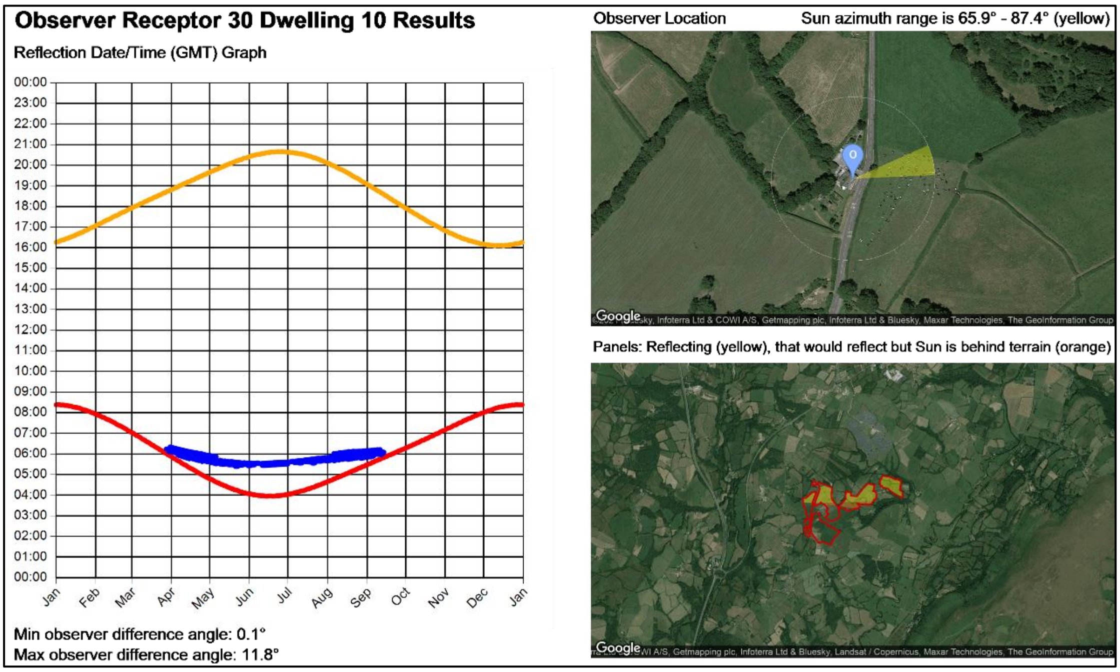


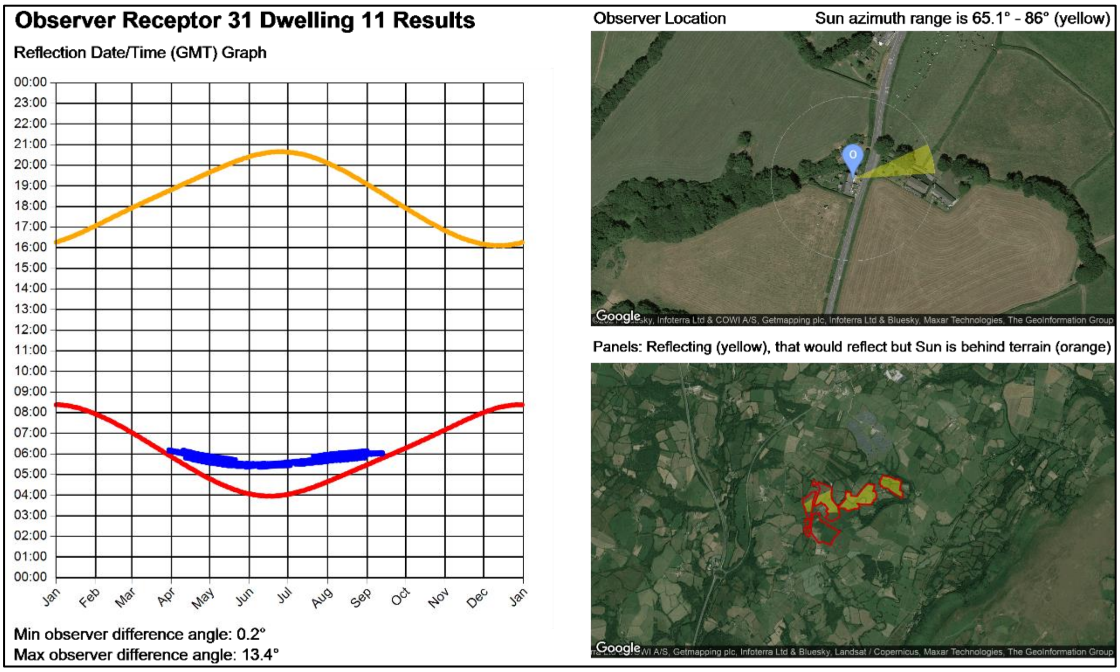


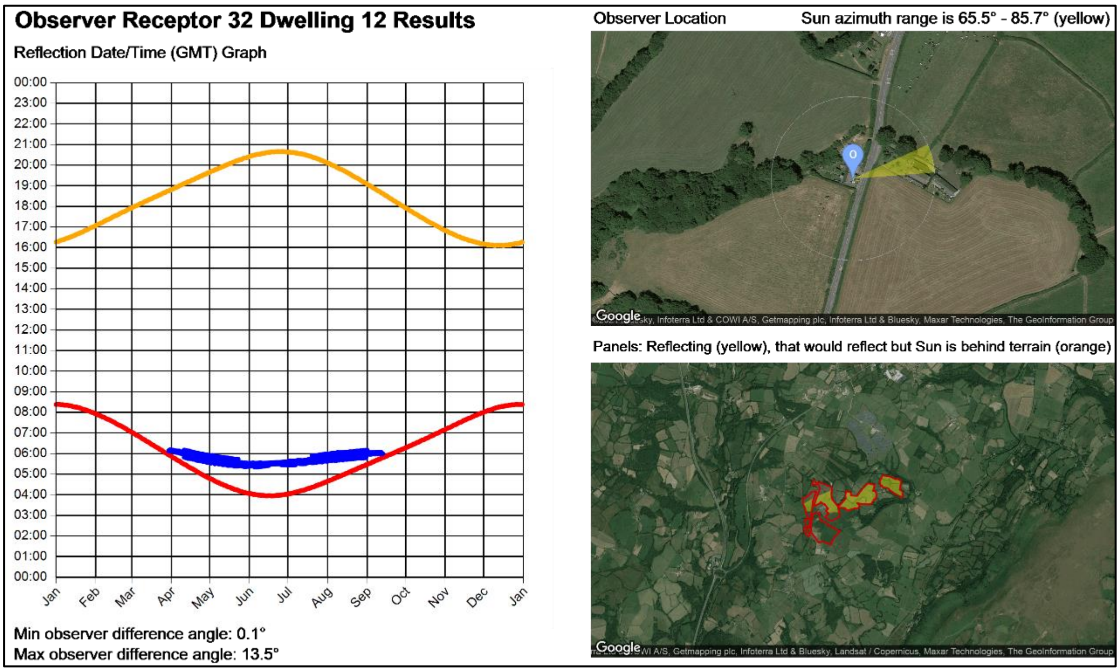

Observer Receptor 26 Dwelling 06 Results
Reflection Date/Time (GMT) Graph
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 2.3°
Max observer difference angle: 10.5°
Observer Location
Sun azimuth range is 71.3° - 89° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

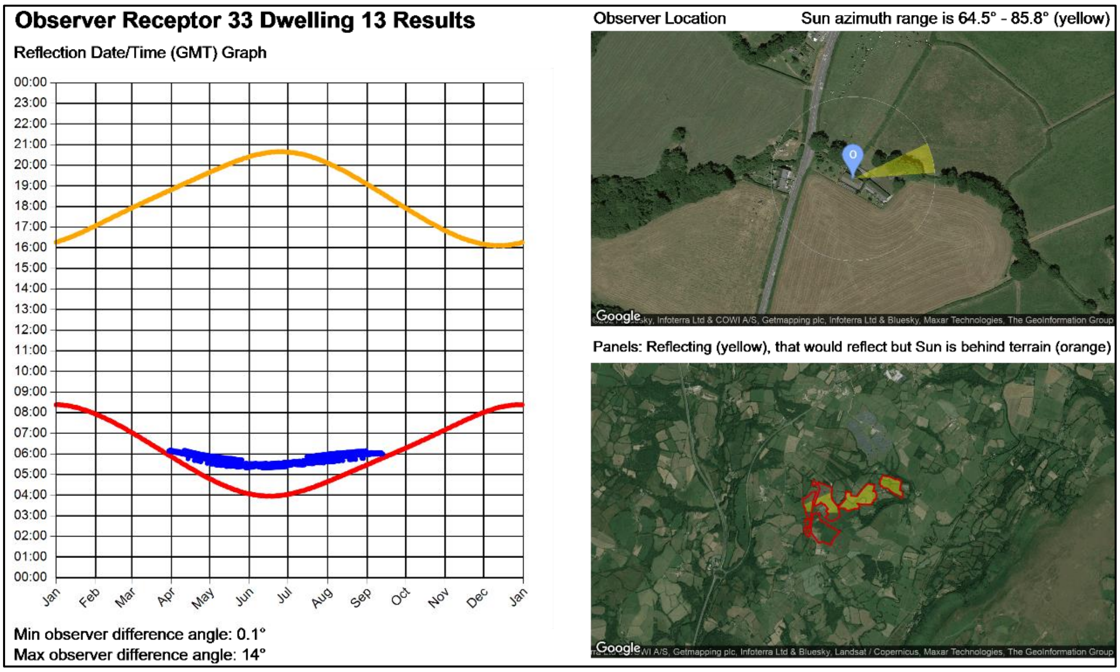

Observer Receptor 27 Dwelling 07 Results
Reflection Date/Time (GMT) Graph
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.7°
Max observer difference angle: 11.7°
Observer Location
Sun azimuth range is 67.9° - 88.9° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

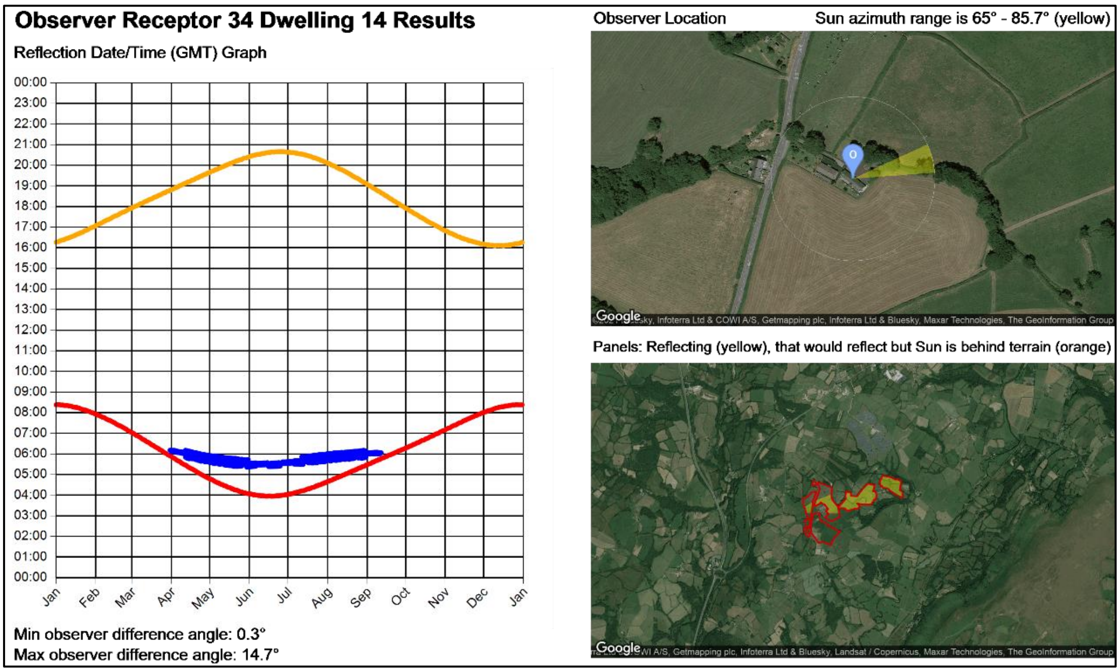

Observer Receptor 29 Dwelling 09 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.1°
Max observer difference angle: 7.7°
Observer Location
Sun azimuth range is 73.4° - 87.6° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

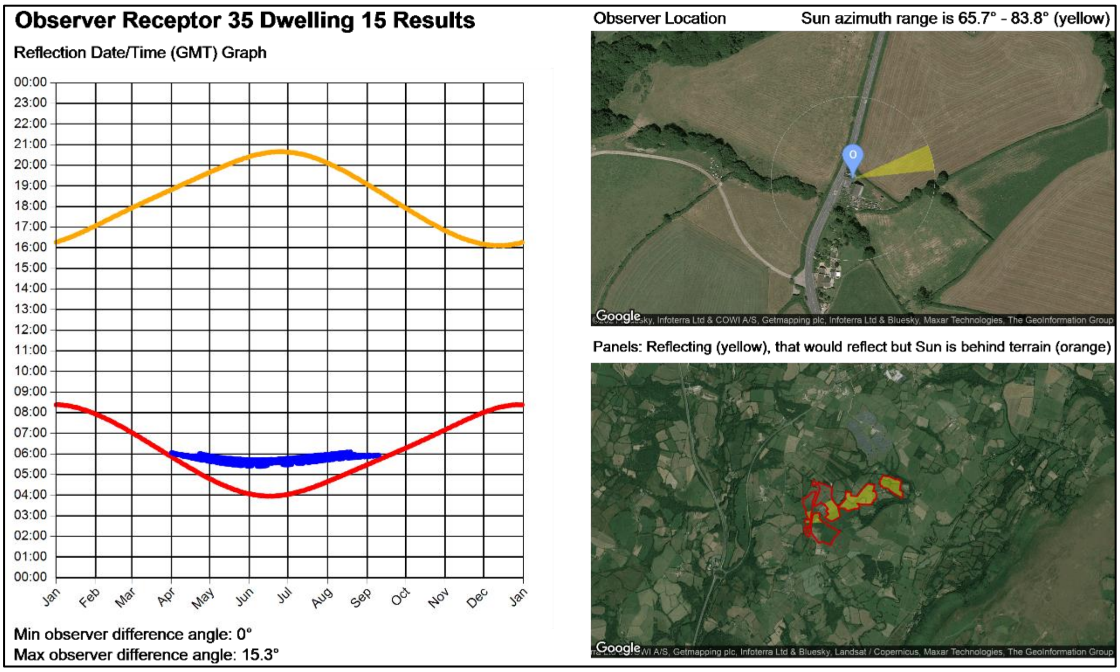

Observer Receptor 30 Dwelling 10 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.1°
Max observer difference angle: 11.8°
Observer Location
Sun azimuth range is 65.9° - 87.4° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

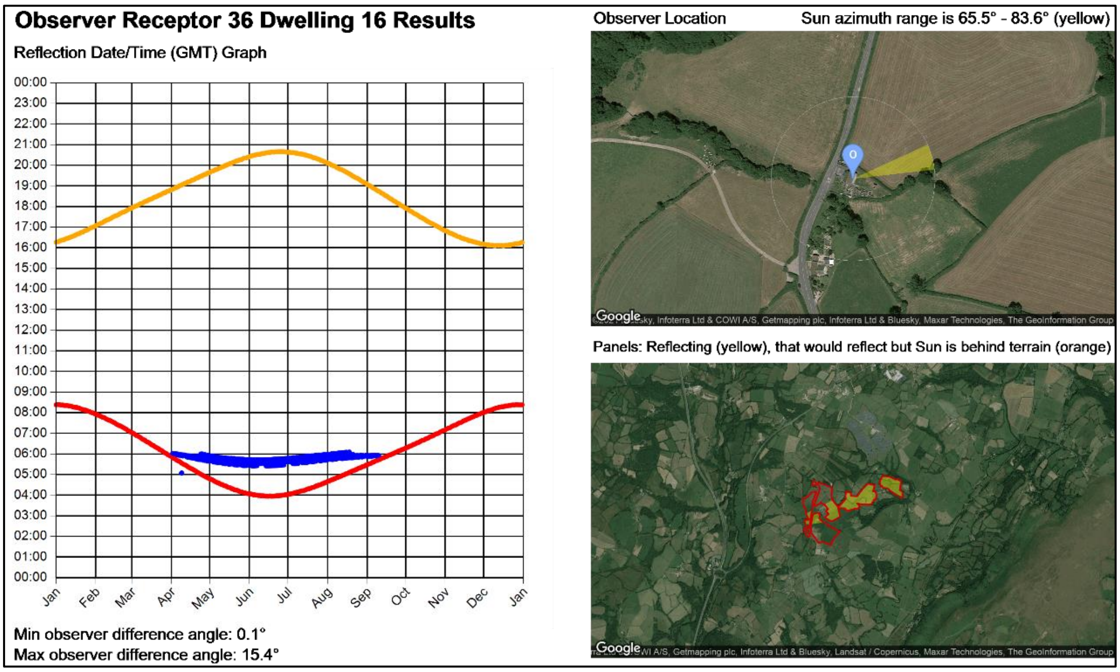

Observer Receptor 31 Dwelling 11 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 0.2°
Max observer difference angle: 13.4°
Observer Location
Sun azimuth range is 65.1° - 86° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

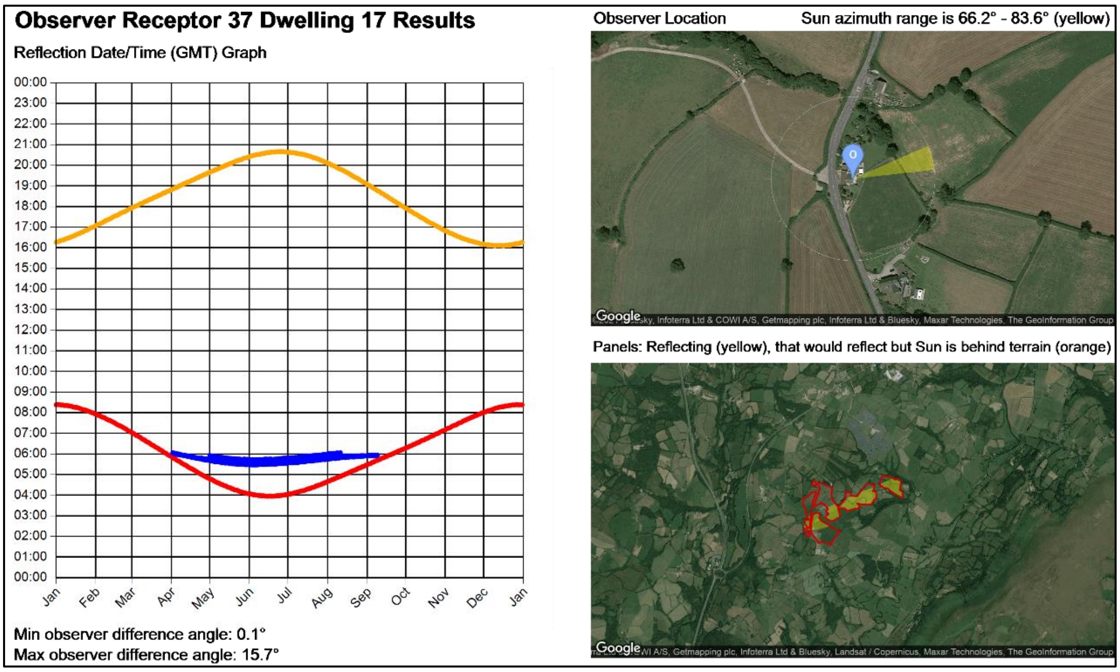

Observer Receptor 32 Dwelling 12 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 0.1°
Max observer difference angle: 13.5°
Observer Location
Sun azimuth range is 65.5° - 85.7° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

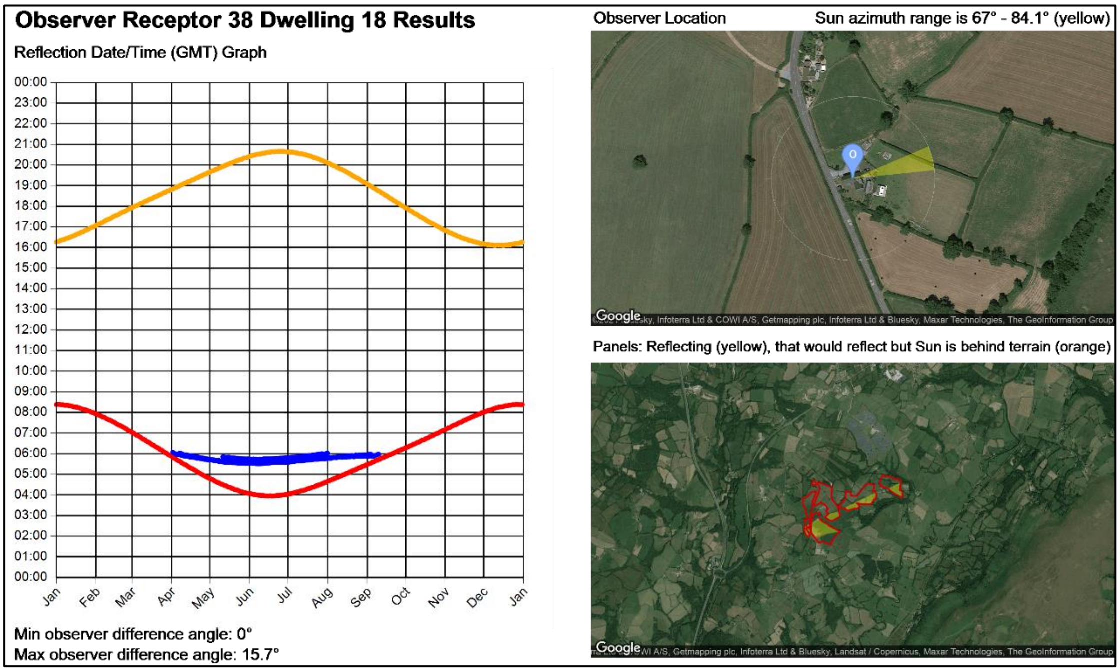

Observer Receptor 33 Dwelling 13 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 0.1°
Max observer difference angle: 14°
Observer Location
Sun azimuth range is 64.5° - 85.8° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

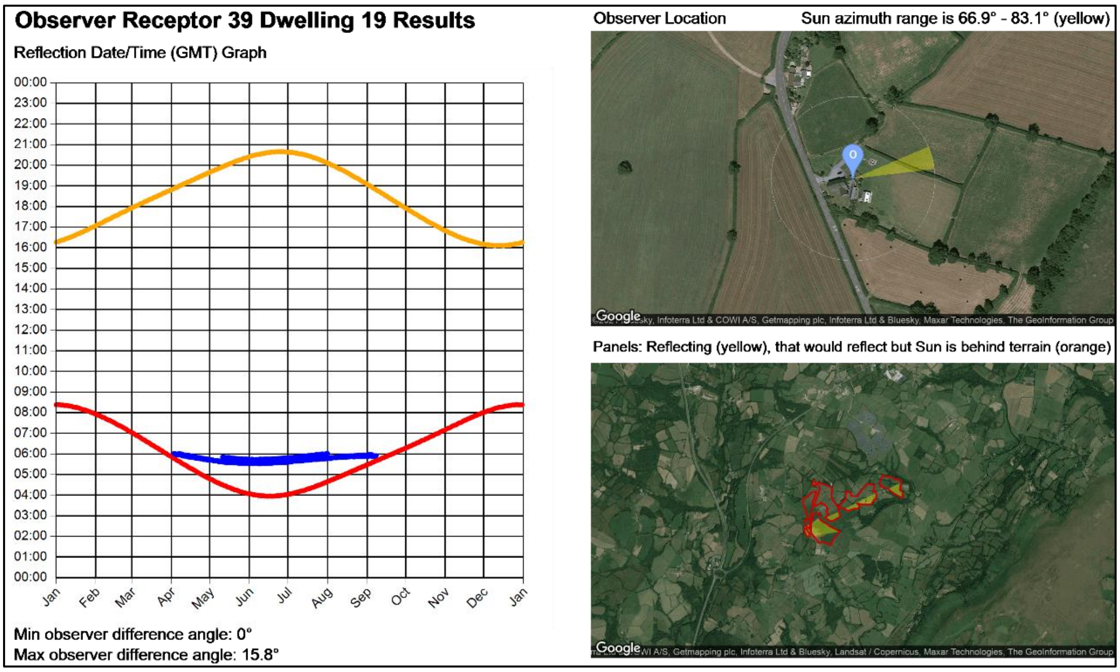

Observer Receptor 34 Dwelling 14 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 0.3°
Max observer difference angle: 14.7°
Observer Location
Sun azimuth range is 65° - 85.7° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

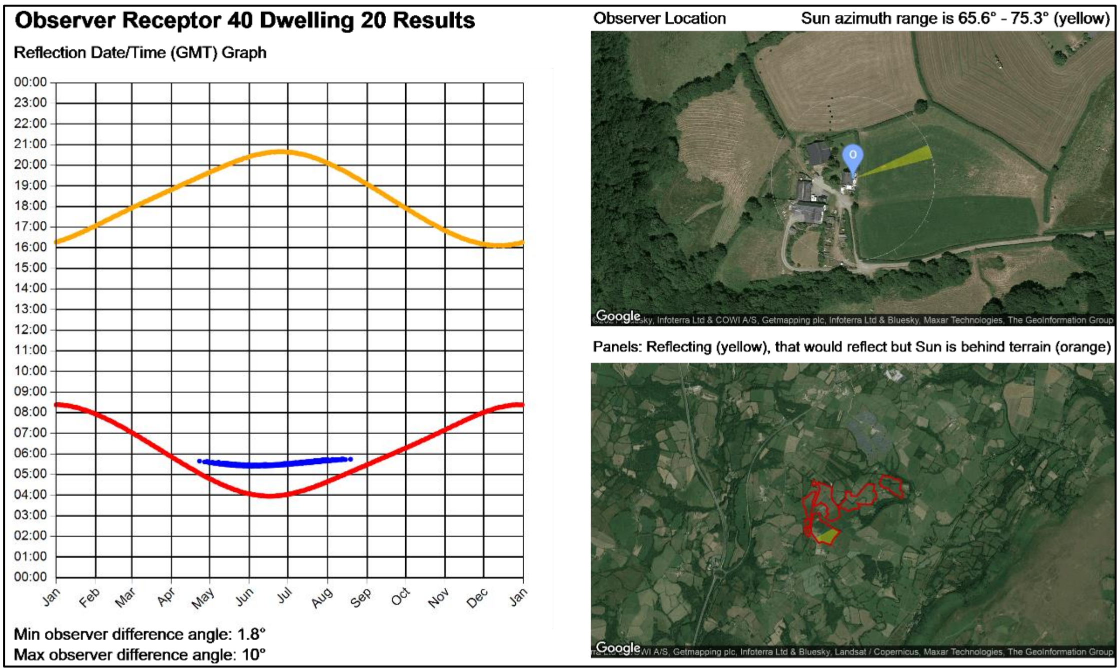

Observer Receptor 35 Dwelling 15 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth range is 65.7° - 83.8° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Min observer difference angle: 0°
Max observer difference angle: 15.3°

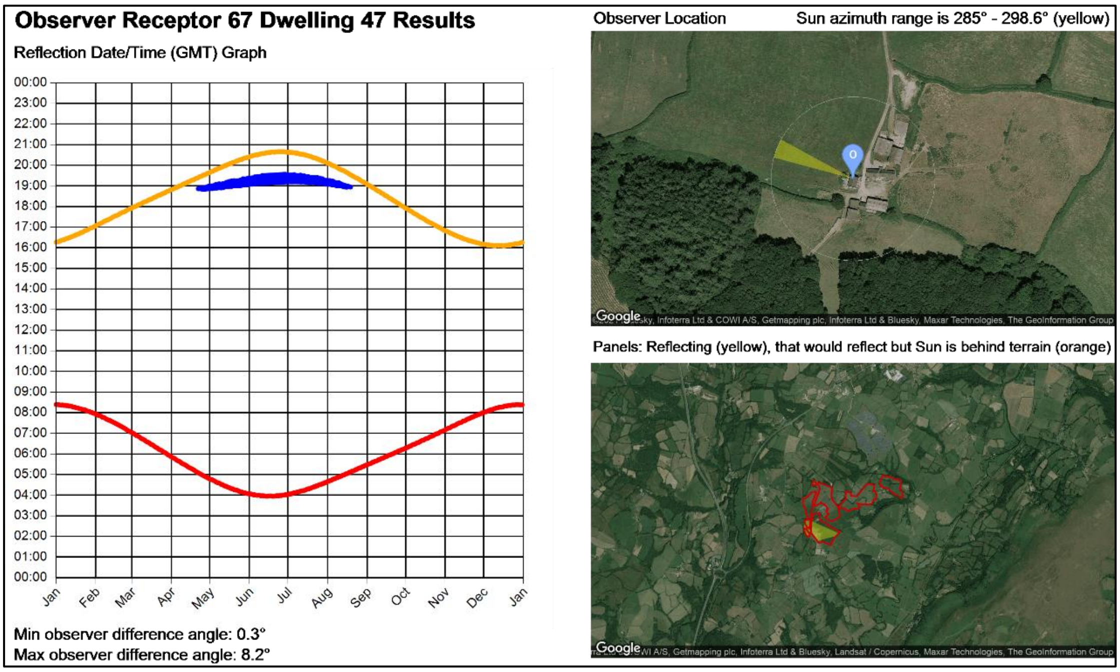

Observer Receptor 36 Dwelling 16 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth range is 65.5° - 83.6° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Min observer difference angle: 0.1°
Max observer difference angle: 15.4°

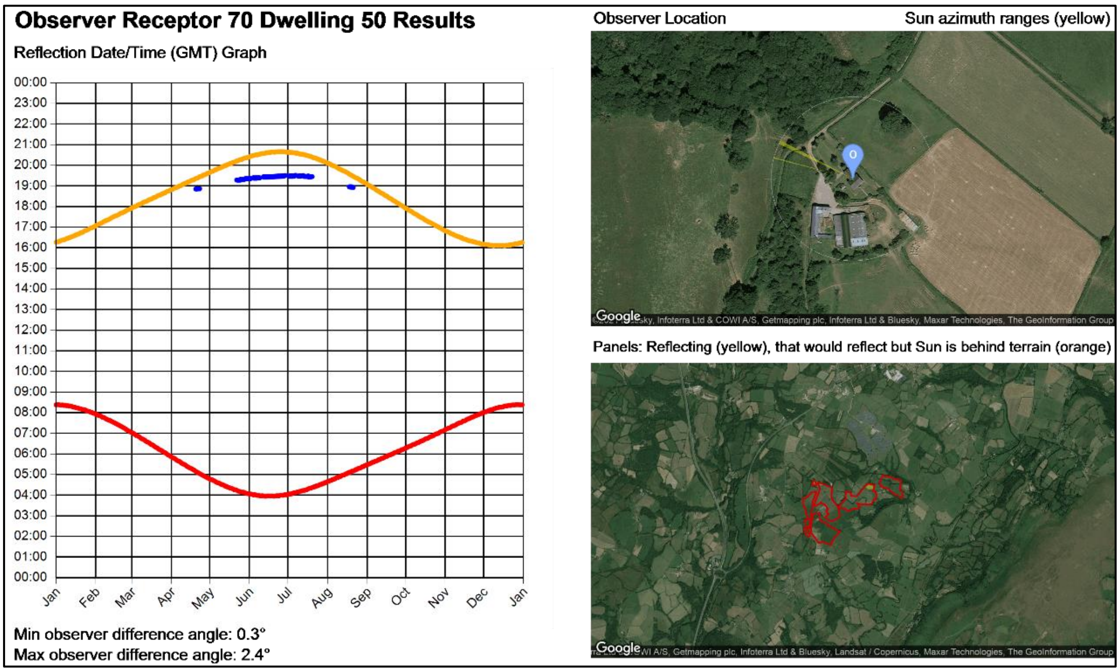

Observer Receptor 37 Dwelling 17 Results
Reflection Date/Time (GMT) Graph
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.1°
Max observer difference angle: 15.7°
Observer Location
Sun azimuth range is 66.2° - 83.6° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

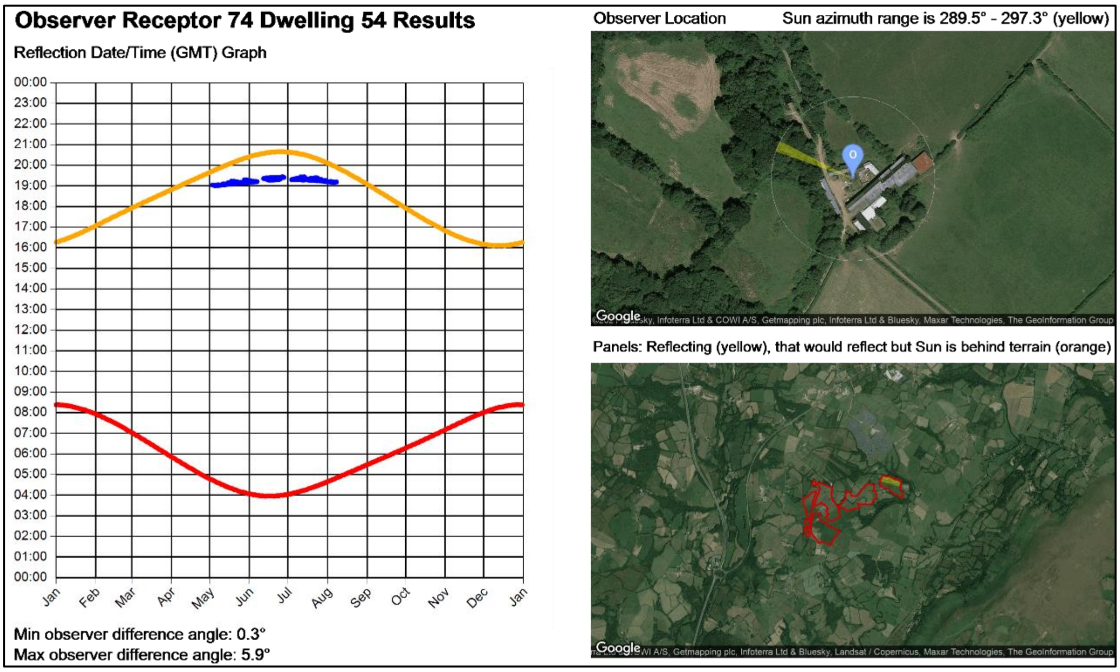

Observer Receptor 38 Dwelling 18 Results
Reflection Date/Time (GMT) Graph
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0°
Max observer difference angle: 15.7°
Observer Location
Sun azimuth range is 67° - 84.1° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

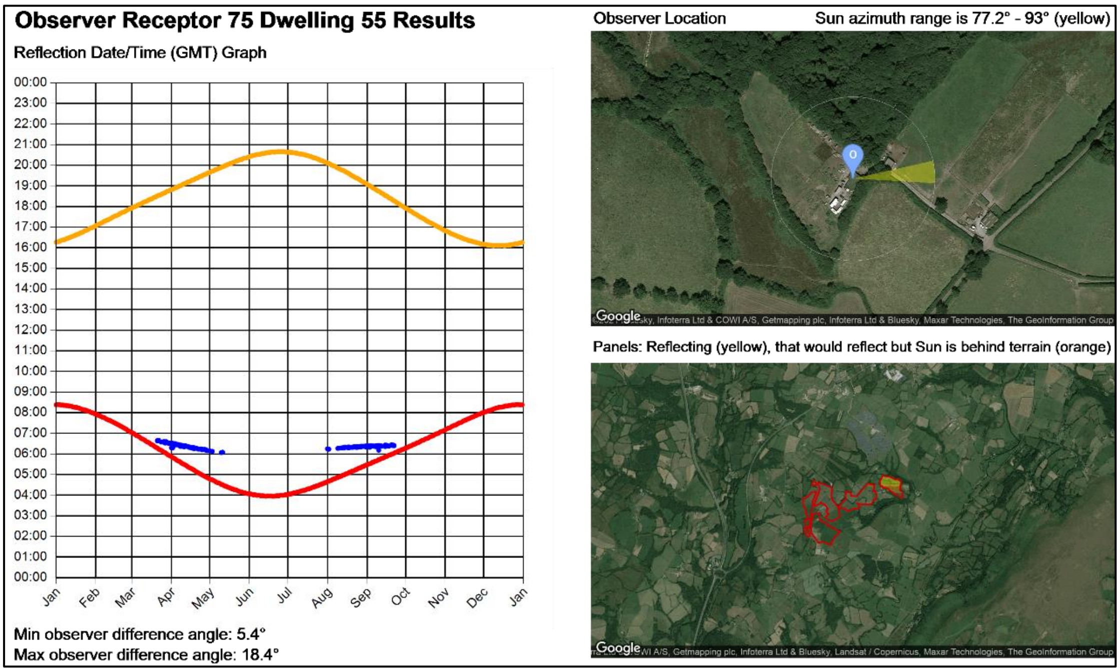

Observer Receptor 39 Dwelling 19 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 0°
Max observer difference angle: 15.8°
Observer Location
Sun azimuth range is 66.9° - 83.1° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer Receptor 40 Dwelling 20 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: 1.8°
Max observer difference angle: 10°
Observer Location
Sun azimuth range is 65.6° - 75.3° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer Receptor 67 Dwelling 47 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: 0.3°
Max observer difference angle: 8.2°
Observer Location
Sun azimuth range is 285° - 298.6° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

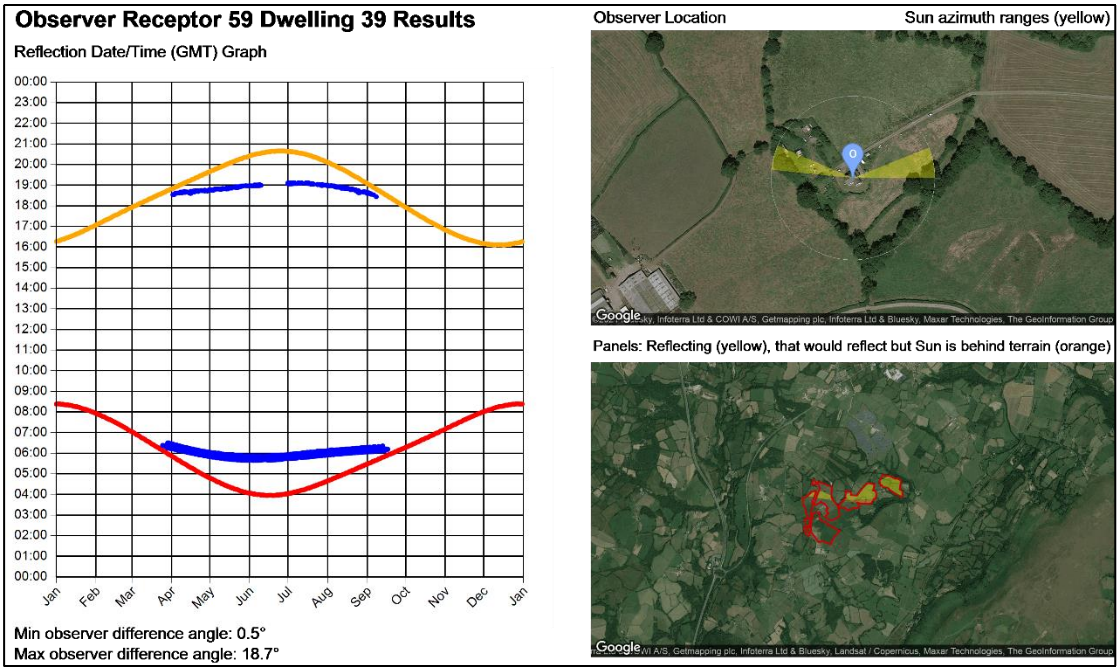

Observer Receptor 70 Dwelling 50 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 0.3°
Max observer difference angle: 2.4°
Observer Location
Sun azimuth ranges (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

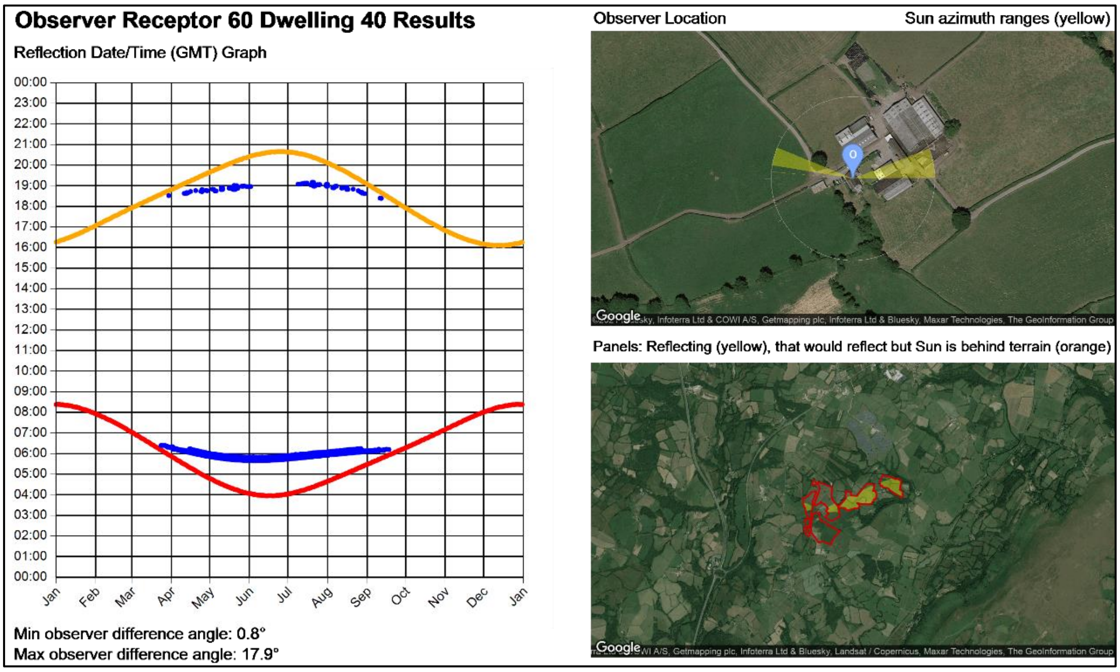

Observer Receptor 74 Dwelling 54 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 0.3°
Max observer difference angle: 5.9°
Observer Location
Sun azimuth range is 289.5° - 297.3° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

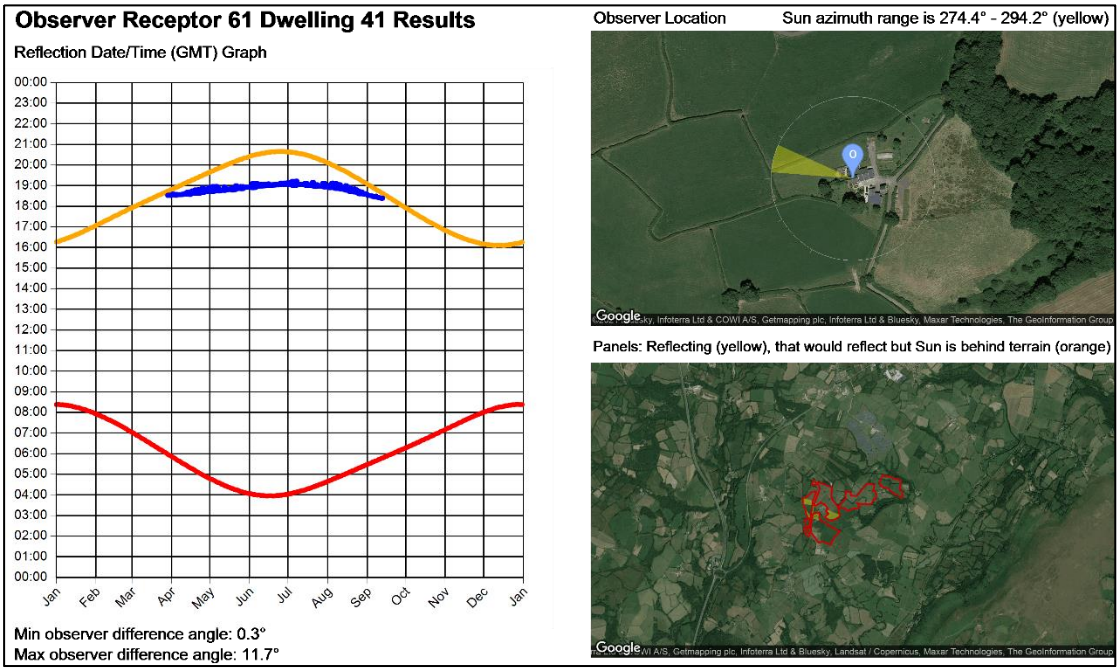

Observer Receptor 75 Dwelling 55 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 5.4°
Max observer difference angle: 18.4°
Observer Location
Sun azimuth range is 77.2° - 93° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

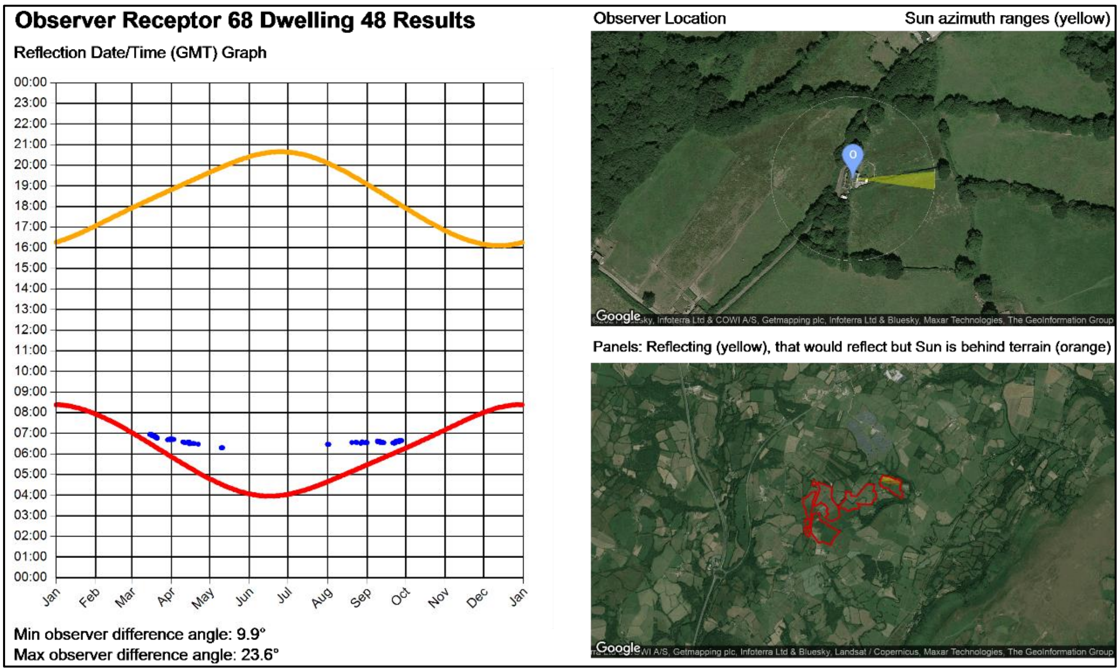
Dwelling receptors with a mitigation requirement

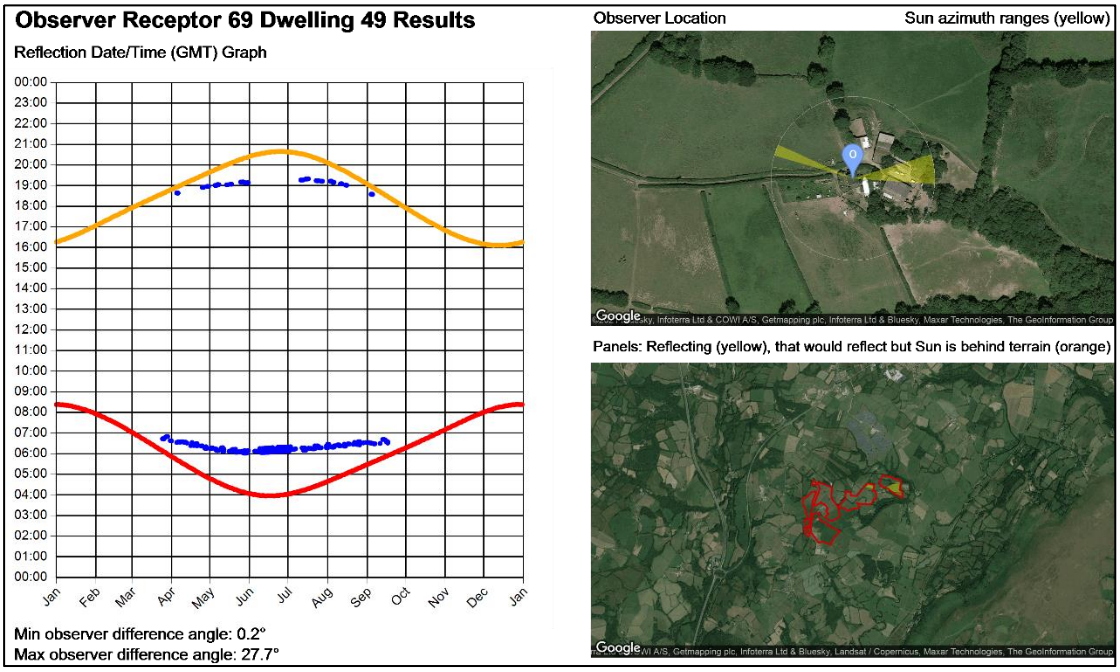
The charts below relate to the dwelling receptors where moderate impacts have been predicted and a subsequent mitigation requirement has been identified – following the assessment presented in Section 7.

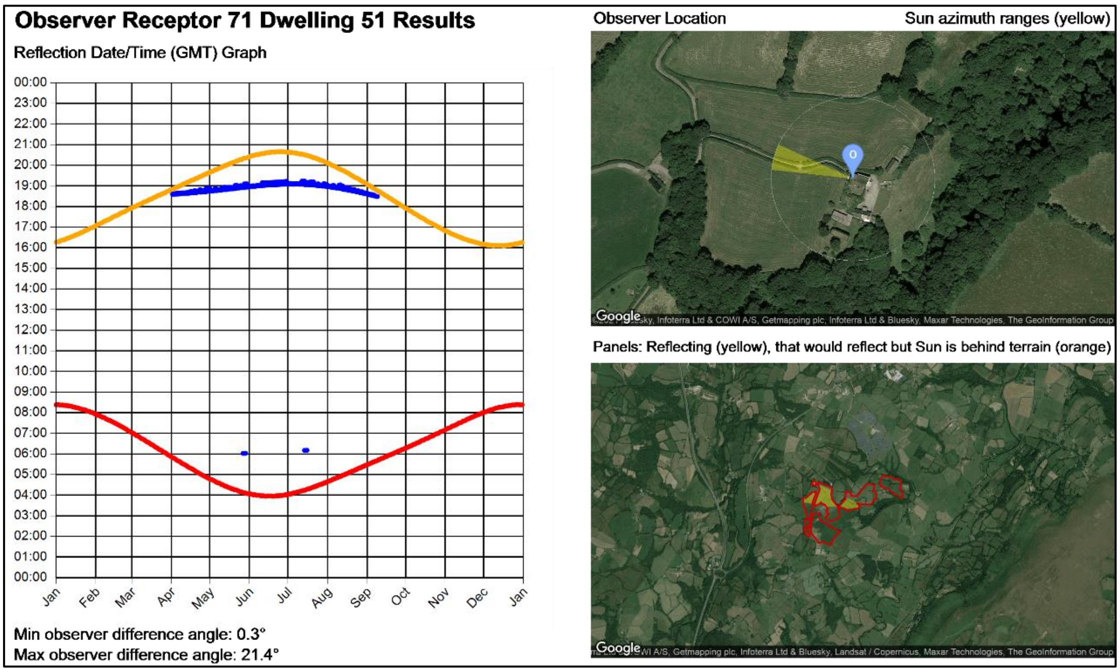


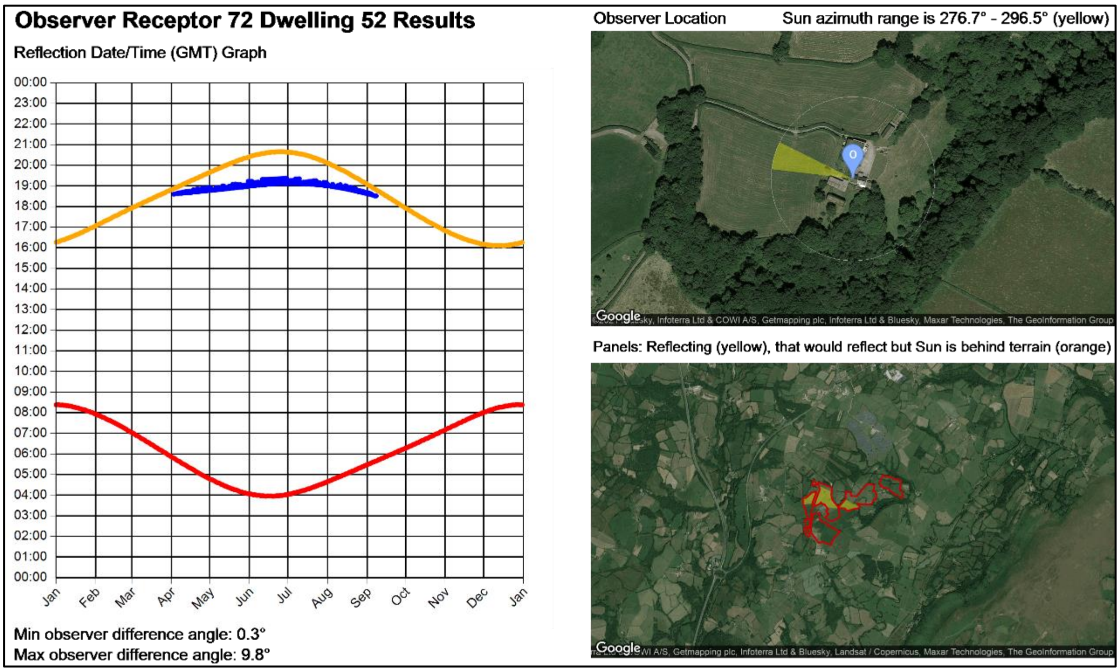


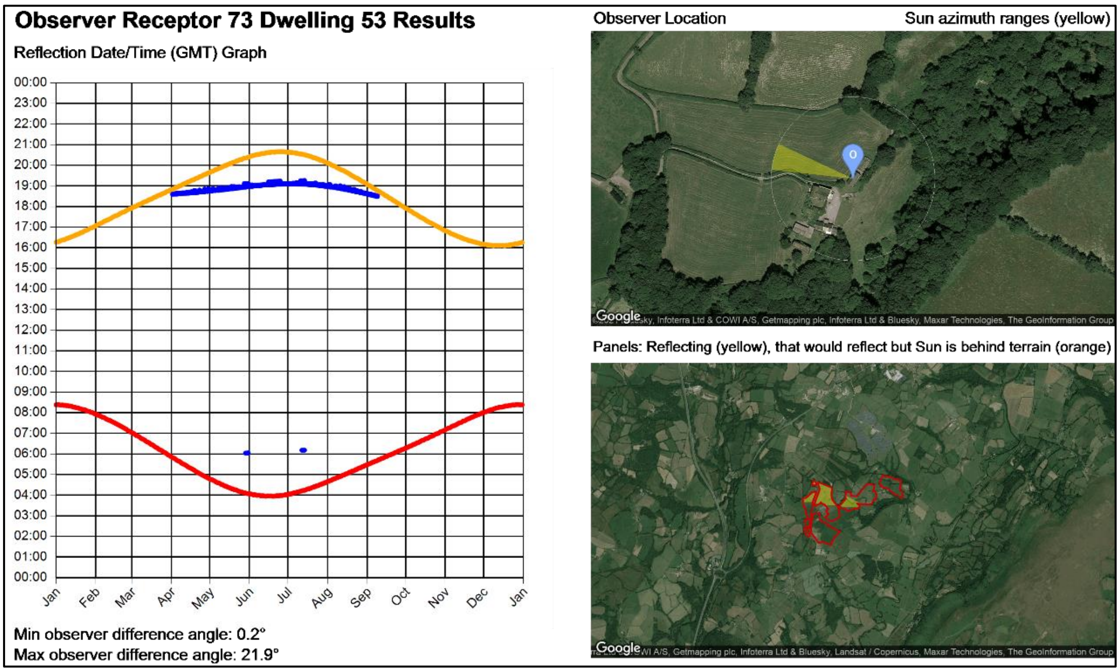

Observer Receptor 61 Dwelling 41 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 0.3°
Max observer difference angle: 11.7°
Observer Location
Sun azimuth range is 274.4° - 294.2° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer Receptor 68 Dwelling 48 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: 9.9°
Max observer difference angle: 23.6°
Observer Location
Sun azimuth ranges (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer Receptor 69 Dwelling 49 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: 27.7°
Observer Location
Sun azimuth ranges (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer Receptor 71 Dwelling 51 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: 0.3°
Max observer difference angle: 21.4°
Observer Location
Sun azimuth ranges (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer Receptor 72 Dwelling 52 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: 0.3°
Max observer difference angle: 9.8°
Observer Location
Sun azimuth range is 276.7° - 296.5° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Google


Observer Receptor 73 Dwelling 53 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: 21.9°
Observer Location
Sun azimuth ranges (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Google

Road Receptors

Significant impacts are not predicted for road receptors. The modelling output can be provided upon request.

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