

Solar Photovoltaic Glint and Glare Study

Heolddu Solar Farm

Qualitas Energy

August 2025



PLANNING SOLUTIONS FOR:

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EXECUTIVE SUMMARY

Report Purpose

Pager Power has been retained to assess the potential effects of glint and glare from the proposed solar photovoltaic (PV) development 'Heolddu Solar Farm', which will be located approximately 1km east of Ferryside, Carmarthenshire, Wales. The assessment pertains to the potential impact upon surrounding road safety, residential amenity, and aviation activity associated with Pembrey Airport. The modelling scenario considers 100% sunlight during daylight hours, and therefore this assessment represents a conservative approach.

Overall Conclusions

No significant impacts are predicted on surrounding road safety and aviation activity associated with Pembrey Airport.

A moderate impact is predicted on two dwellings under baseline conditions because solar reflections are geometrically possible for **more** than three months per year and **less** than 60 minutes per any one day, and views of reflecting panels are expected to be possible. Mitigation has been implemented into the landscape scheme through the provision of screening (planting) that is predicted to remove views of the reflecting panel areas (see section 5.3.4 for further details). No further mitigation is required.

An overview of the assessment results is presented on the following pages.

Guidance and Studies

Guidelines exist in the UK (produced by the Civil Aviation Authority) and in the USA (produced by the Federal Aviation Administration) with respect to solar developments and aviation activity. The UK CAA guidance is relatively high-level and does not prescribe a formal methodology. Pager Power has, however, produced guidance for glint and glare and solar photovoltaic developments, which was first published in early 2017, with the fourth edition produced in 2022¹. The guidance document sets out the methodology for assessing road safety, residential amenity and aviation safety with respect to solar reflections from solar panels.

Pager Power's approach 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/ façades. 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 available studies have measured the intensity of reflections from solar panels with respect to other naturally occurring and manmade surfaces. The results show that the reflections

¹[Solar Photovoltaic Development Glint and Glare Guidance, Fourth Edition, August 2022. Pager Power.](#)

produced are of intensity similar to or less than those produced from still water and significantly less than reflections from glass and steel².

Assessment Conclusions – Roads

The modelling predicts that solar reflections are geometrically possible towards a 1.4km section of road.

A low impact is predicted at two points along the assessed section because visible solar reflections predicted to originate from **outside** of a road user's primary horizontal field of view. Mitigation is not recommended.

No significant impacts are predicted on the remaining sections of the road because there is significant existing screening such that views of reflecting panels are not expected to be possible in practice. Mitigation is not required.

Assessment Conclusions – Dwellings

The modelling has shown that solar reflections are geometrically possible towards 29 of the 34 assessed dwelling receptors.

No impacts are predicted on 23 dwellings because there is significant existing screening such that views of reflecting panels are not expected to be possible in practice. Mitigation is not required.

A low impact is predicted on four dwellings:

- For one dwelling, there is significant existing screening such that views of reflecting panels are not expected to be possible in practice from the ground floor;
- For two dwellings, although solar reflections are geometrically possible for **more** than three months per year and **less** than 60 minutes per any one day, there are sufficient mitigating factors that reduce the level of impact, including a significant distance between the observer and the closest reflecting panels and incidence of reflections with direct sunlight;
- For one dwelling, although solar reflections are geometrically possible for **more** than three months per year and **less** than 60 minutes per any one day, there is significant existing screening such that reflections received in practice are predicted to be reduced to **less** than three months per year;
- Therefore, mitigation is not recommended for any of these four dwellings.

A moderate impact is predicted on two dwellings (18 and 21) under baseline conditions because solar reflections are geometrically possible for **more** than three months per year and **less** than 60 minutes per any one day, and views of reflecting panels are expected to be possible. Mitigation has been implemented into the landscape scheme through the provision of screening

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

(planting) that is predicted to remove views of the reflecting panel areas (see section 5.3.4 for further details). No further mitigation is required.

Assessment Conclusions – Pembrey Airport

Significant impacts are not predicted on aviation activity at Pembrey Airport based on the associated guidance and industry best practice. This is because:

- Solar reflections towards the Air Traffic Control Tower are unlikely to be geometrically possible based on the location of the receptor relative to the proposed development (considering distance, height, and orientation). Any reflections that are geometrically possible are likely to be screened by intervening terrain, buildings, and/or vegetation;
- Any solar reflections geometrically possible towards aircraft on the final one-mile splayed approach towards runway 22 would be outside of a pilot's primary horizontal field of view (50 degrees either side of the approach bearing). At worst, a low impact is predicted on pilots on this approach path based on the associated guidance and industry best practice for licensed airfields;
- Any solar reflections geometrically possible towards aircraft on the final one-mile splayed approach towards runway 04 are predicted to have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths, it can be reliably determined that this level of glare is acceptable for these receptors;
- Any solar reflections geometrically possible towards aircraft on the final sections of the visual circuits and joins are predicted to have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths, it can be reliably determined that this level of glare is acceptable for these receptors.

Technical modelling is not recommended.

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 62 countries internationally.

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 potential effects of glint and glare from the proposed solar photovoltaic (PV) development 'Heolddu Solar Farm', which will be located approximately 1km east of Ferryside, Carmarthenshire, Wales. The assessment pertains to the potential impact upon surrounding road safety, residential amenity, and aviation activity associated with Pembrey Airport.

This report contains the following:

- Solar development details;
- Explanation of glint and glare;
- Overview of relevant guidance and relevant studies;
- Overview of Sun movement;
- Assessment methodology;
- Identification of receptors;
- Glint and glare assessment for identified receptors;
- High-level assessment of effects on Pembrey Airport;
- Results discussion.

1.2 Pager Power's Experience

Pager Power has undertaken over 1,600 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 is as follows:

- 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.

These definitions are aligned with those presented within the National Policy Statement for Renewable Energy Infrastructure (EN-3)³ and the Federal Aviation Administration in the USA.

The term 'solar reflection' is used in this report to refer to both reflection types.

³ Published by the Department for Energy Security and Net Zero in November 2023 and came into force on 17 January 2024. There is no alternative specific definition for glint and glare in planning policy and guidance in Wales.

2 PROPOSED SOLAR DEVELOPMENT LOCATION AND DETAILS

2.1 Reflector Areas

Figure 1 below shows the assessed reflector areas that have been used for modelling purposes.



Figure 1 Assessed reflector areas - aerial image

A resolution of 10m has been chosen for this assessment. This means that a geometric calculation is undertaken for each identified receptor from a point every 10m from within the defined areas. This resolution is sufficiently high to maximise the accuracy of the results; increasing the resolution further would not significantly change the modelling output. The number of modelled reflector points are determined by the size of the reflector areas and the assessment resolution. The bounding coordinates for the proposed solar development have been extrapolated from the site plans. The data can be provided on request.

2.2 Proposed Development Site Plan

The proposed development site plan⁴ is shown in Figure 2 on the following page.

⁴ Source: Heolddu_Site_Layout_Plan_Overall (cropped)

2.3 Solar Panel Technical Information

The technical information used for the modelling is presented in Table 1 below. The centre of the solar panel has been used as the assessed height in metres above ground level (agl).

Solar Panel Technical Information	
Azimuth angle ⁵	180°
Elevation (tilt) angle ⁶	25°
Assessed height ⁷ (agl)	1.83 metres

Table 1 Solar panel information

⁵ Clockwise orientation the panels are facing relative to True North (0°)

⁶ Relative to the horizontal

⁷ Minimum height 0.8m agl, maximum height 2.853m agl

3 GLINT AND GLARE ASSESSMENT METHODOLOGY

3.1 Overview

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

- Specular reflections of the Sun from solar panels and glass 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 still water and similar to those from glass. It also shows that reflections from solar panels are significantly less intense than many other reflective surfaces, which are common in an outdoor environment, including steel⁸.

3.2 Background

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

3.3 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, studies and Pager Power's practical experience. The methodology for this glint and glare assessment is as follows:

- Identify receptors in the area surrounding the proposed development;
- Consider direct solar reflections from the proposed development towards the identified receptors by undertaking geometric calculations;
- Consider the visibility of the reflectors from the receptor's location. If the reflectors 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 the solar reflection intensity, if appropriate;
- Consider both the solar reflection from the proposed 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 Appendix D.

⁸ SunPower, 2009, SunPower Solar Module Glare and Reflectance (appendix to Solargen Energy,2010).

Within the Pager Power model, the reflector 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 Appendices E and F.

4 IDENTIFICATION OF RECEPTORS

4.1 Overview

The following sections present the relevant receptors assessed within this report. Terrain data has been interpolated based on Ordnance Survey of Great Britain (OSGB) 50 Digital Terrain Model (DTM) data. The receptor details for all receptors are presented in Appendix G.

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 extensive experience over a significant number of glint and glare assessments undertaken show that consideration of receptors within 1km of panel areas is appropriate for glint and glare effects on roads and dwellings. The panels are fixed south facing and solar reflections at ground level towards the north at this latitude are highly unlikely. Therefore, the assessment area (shown as the white polygon on following figures) has been designed accordingly as a 1km boundary from solar panels (blue polygons) for roads and dwellings. The area to the north of the northern-most solar panels has been excluded.

Potential receptors are identified based on mapping and aerial photography of the region. The initial judgement is made based on 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.

4.2 Road Receptors

4.2.1 Road Receptors Overview

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 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.

Technical modelling is not recommended for local roads, where traffic densities are likely to be relatively low. Any solar reflections from the Proposed Development that are experienced by a

road user along a local road would be considered low impact in the worst case in accordance with the guidance presented in Appendix D.

The analysis considers any major national, national, and regional roads that:

- Are within the one-kilometre assessment area;
- Have a potential view of the panels.

A height of 1.5 metres above ground level has been taken as a typical eye-level for a road user⁹. This height has therefore been added to the ground height at each receptor location. Visibility and direction of travel are considered in the assessment of all receptors.

4.2.2 Road Receptors Identification

24 receptors have been identified distanced circa 100m apart across one unnamed road section 2.3km long.

The road section is shown in light blue in Figure 3 on the following page.

⁹ This height is chosen for modelling purposes, elevated drivers are considered in the results discussion where appropriate.

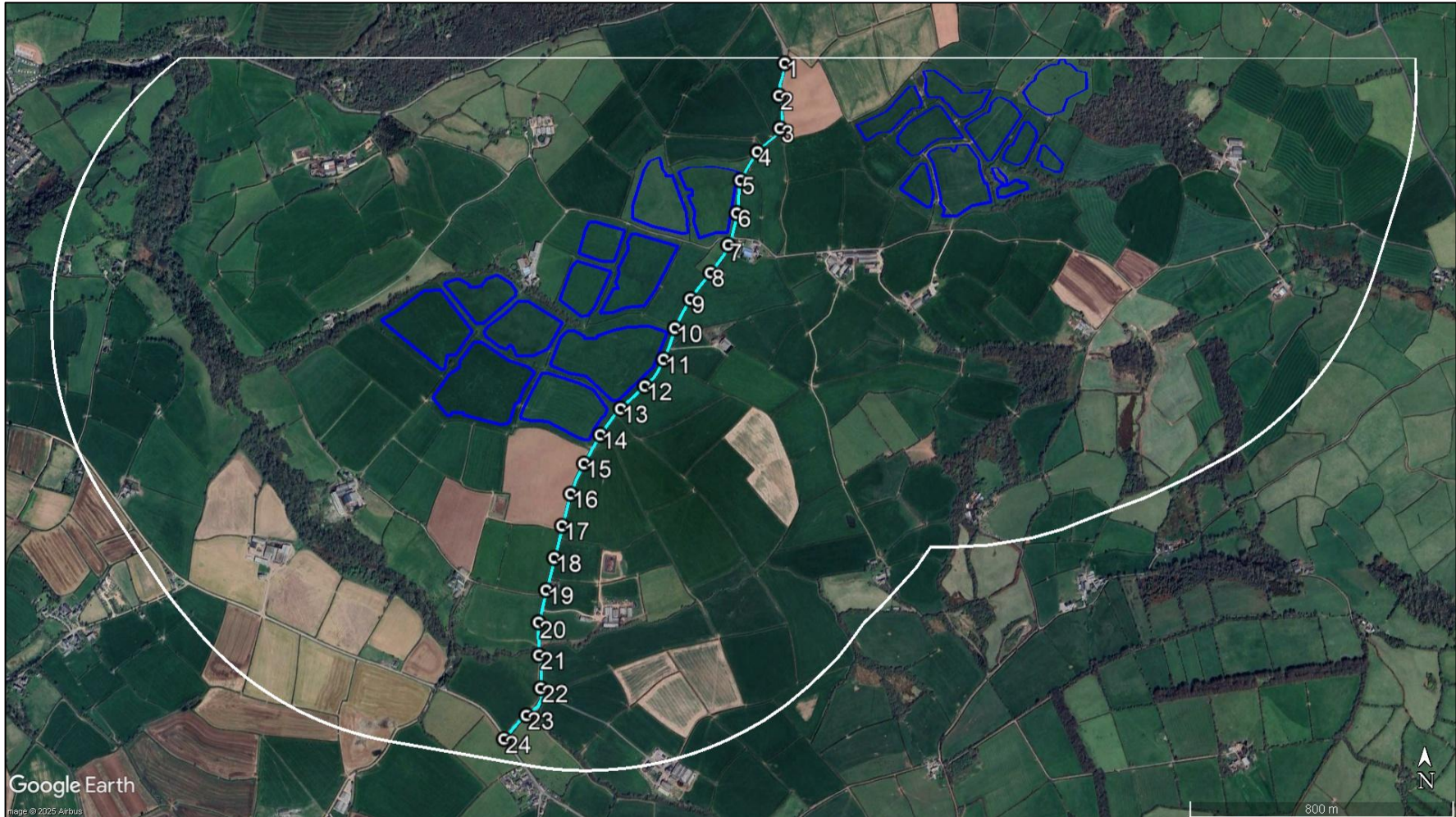


Figure 3 Assessed road section (light blue line) – aerial image

4.3 Dwelling Receptors

4.3.1 Dwelling Receptors Overview

The analysis typically considers dwellings that:

- Are within the one-kilometre assessment area;
- Have a potential view of the panels.

In residential areas with multiple layers of dwellings, only the outer dwellings have been considered for assessment. This is because they will mostly obscure views of the solar panels to the dwellings behind them, which will therefore not be impacted by the proposed development because line of sight will be removed, or they will experience comparable effects to the closest assessed dwelling.

In some cases, one physical structure is split into multiple separate addresses. In such cases, the results for the assessed location will be applicable to all associated addresses. The sampling resolution is sufficiently high to capture the level of effect for all potentially affected dwellings.

A height of 1.8 metres above ground level has been taken as typical eye level for an observer on the ground floor¹⁰ of the dwelling since this is typically the most occupied floor of a dwelling throughout the day.

4.3.2 Dwelling Receptors Identification

In total, 34 dwellings were identified for assessment, as shown in Figure 4 to Figure 19 on the following pages.

¹⁰ This fixed height for the dwelling receptors is for modelling purposes. Small changes to the modelling height by a few metres is not expected to significantly change the modelling results. Views above ground floor are considered in the results discussion where necessary.

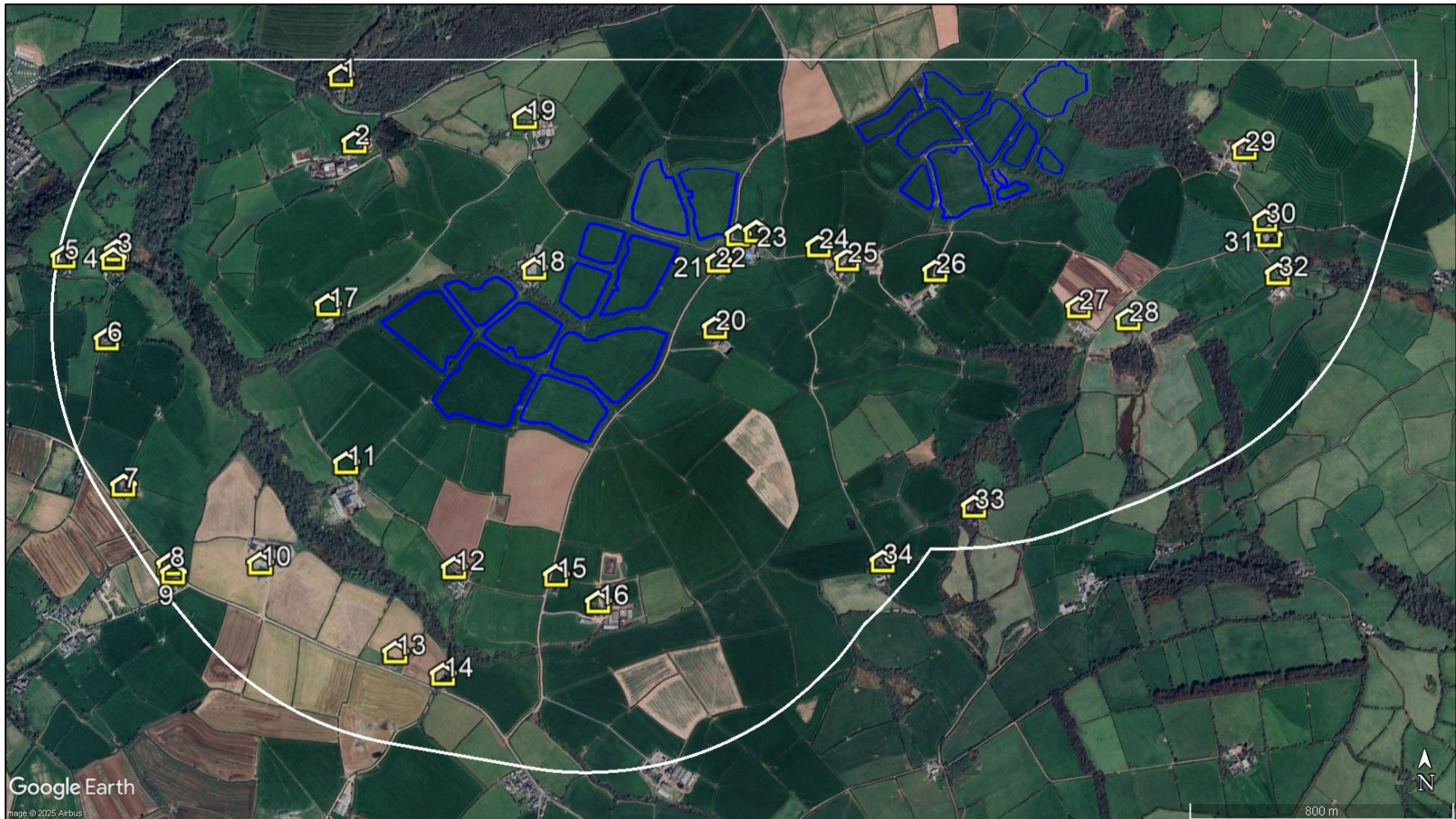


Figure 4 Assessed dwelling receptor locations



Figure 5 Assessed dwelling receptors 1 and 2

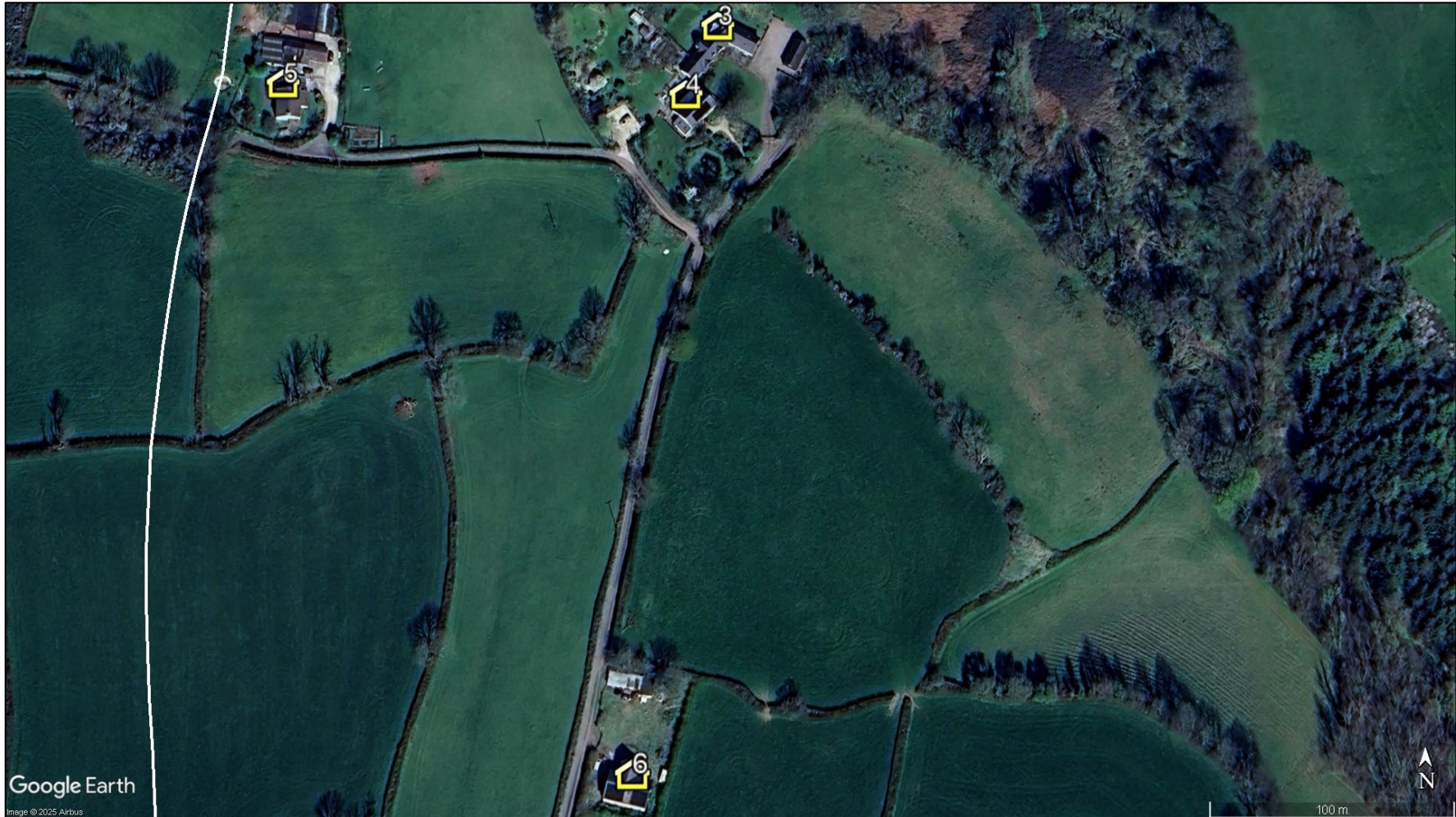


Figure 6 Assessed dwelling receptors 3 to 6



Figure 7 Assessed dwelling receptors 7 to 10



Figure 8 Assessed dwelling receptors 11 to 12



Figure 9 Assessed dwelling receptors 13 to 14



Figure 10 Assessed dwelling receptors 15 to 16



Figure 11 Assessed dwelling receptors 17 to 18



Figure 12 Assessed dwelling receptor 19



Figure 13 Assessed dwelling receptor 20



Figure 14 Assessed dwelling receptors 21 to 23



Figure 15 Assessed dwelling receptors 24 to 26



Figure 16 Assessed dwelling receptors 27 and 28



Figure 17 Assessed dwelling receptor 29



Figure 18 Assessed dwelling receptors 30 to 32



Figure 19 Assessed dwelling receptors 33 and 34

5 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

5.1 Overview

The following sub-sections present the modelling results as well as the significance of any predicted impact in the context of existing screening, as well as the relevant criteria set out in the next subsection. The criteria are determined by the assessment process for each receptor, which are set out in Appendix D.

When determining the visibility of the reflecting panels for an observer, a conservative review of the available imagery is undertaken, whereby it is assumed views of the panels are possible if it cannot be reliably determined that existing screening will remove effects.

The modelling output showing the precise predicted times and the reflecting panel areas are presented in Appendix H.

5.2 Roads

5.2.1 Impact Significance Methodology

The key considerations for road users along major national, national, and regional roads are:

- Whether a reflection is predicted to be experienced in practice; and
- The location of the reflecting panel relative to a road user's direction of travel.

Where the reflecting panels are predicted to be significantly obstructed from view, no impact is predicted, and mitigation is not required.

Where solar reflections are not experienced as a sustained source of glare, originate from outside of a road user's primary horizontal field of view (50 degrees either side of the direction of travel), or the closest reflecting panel is over 1km from the road user, the impact significance is low, and mitigation is not recommended.

Where sustained solar reflections are predicted to be experienced from inside of a road user's primary field of view, an expert assessment of the following factors is required to determine the impact significance and mitigation requirement:

- Whether the solar reflection originates from directly in front of a road user – a solar reflection that is directly in front of a road user is more hazardous than a solar reflection to one side;
- Whether visibility is likely for elevated drivers (applicable to dual carriageways and motorways only) – there is typically a higher density of elevated drivers along dual carriageways and motorways compared to other types of road;
- The separation distance to the panel area – larger separation distances reduce the proportion of an observer's field of view that is affected by glare;
- The position of the Sun – effects that coincide with direct sunlight appear less prominent than those that do not.

If following consideration of the relevant factors, the solar reflections do not remain significant, the impact significance is low, and mitigation is not recommended.

If following consideration of the relevant factors, the solar reflections remain significant, then the impact significance is moderate, and mitigation is recommended.

Where solar reflections originate from directly in front of a road user and there are no mitigating factors, the impact significance is high, and mitigation is required.

5.2.2 Geometric Modelling Results

The modelling predicts that solar reflections are geometrically possible towards a 1.4km section of road.

The modelling results for road receptors are analysed in Table 2 on the following pages.

Road Receptor	Geometric modelling results from panel areas (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening) ¹¹	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
1 - 2	Solar reflections predicted to originate from outside of a road user's primary horizontal field of view	Terrain screening Views of reflecting panels are not expected to be possible in practice	N/A	N/A	No impact	No
3	Solar reflections predicted to originate from outside of a road user's primary horizontal field of view	No significant screening identified Views of reflecting panels are expected to be possible	No	N/A	Low impact	No

¹¹ Assessment scenario may include an initial conservative qualitative consideration of screening. The reflecting area of the solar development may be partially screened such that it does not meet the key criteria i.e. whether the solar reflection occurs within a road users' main field of view.

Road Receptor	Geometric modelling results from panel areas (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening) ¹¹	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
4 - 5	Solar reflections predicted to originate from inside of a road user's primary horizontal field of view	Terrain and existing vegetation screening Views of reflecting panels are not expected to be possible in practice	N/A	N/A	<u>No impact</u>	No
6	Solar reflections predicted to originate from outside of a road user's primary horizontal field of view	Terrain and existing vegetation screening Views of reflecting panels are not expected to be possible in practice	N/A	N/A	<u>No impact</u>	No
7 - 8	Solar reflections predicted to originate from outside of a road user's primary horizontal field of view	No significant screening identified Views of reflecting panels are expected to be possible	No	N/A	<u>Low impact</u>	No

Road Receptor	Geometric modelling results from panel areas (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening) ¹¹	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
15	Solar reflections predicted to originate from <u>outside</u> of a road user's primary horizontal field of view	Terrain and existing vegetation screening Views of reflecting panels are not expected to be possible in practice	N/A	N/A	<u>No impact</u>	No
16 - 22	Solar reflections are not geometrically possible	N/A	N/A	N/A	<u>No impact</u>	No

Table 2 Geometric modelling results, assessment of impact significance, and mitigation recommendation/requirement - road receptors

5.2.3 Desk-Based Review of Imagery

The figures on the following pages show a selection of imagery with particular relevance to road receptors where solar reflections are predicted to originate from inside of a road user's primary horizontal field of view, and screening is significant in determining the possible impact. The yellow icons are used to show the location of reflecting points within the solar panel areas.



Figure 20 Reflecting points for road receptor 4 (inset street view image from white arrow viewpoint showing screening) – aerial image



Figure 21 Reflecting points for road receptor 5 (inset street view image from white arrow viewpoint showing screening) – aerial image

5.3 Dwellings

5.3.1 Impact Significance Methodology

The key considerations for residential dwellings are:

- Whether a reflection is predicted to be experienced in practice;
- The duration of the predicted effects, relative to thresholds of:
 - 3 months per year;
 - 60 minutes on any given day.

Where solar reflections are not geometrically possible or the reflecting panels are predicted to be significantly obstructed from view, no impact is predicted, and mitigation is not required.

Where solar reflections are experienced for less than three months per year and less than 60 minutes on any given day, or the closest reflecting panel is over 1km from the dwelling, the impact significance is low, and mitigation is not recommended.

Where reflections are predicted to be experienced for more than three months per year **and/or** for more than 60 minutes on any given day, expert assessment of the following mitigating factors is required to determine the impact significance and mitigation requirement:

- Whether visibility is likely from all storeys – the ground floor is typically considered the main living space and has a greater significance with respect to residential amenity;
- The separation distance to the panel area – larger separation distances reduce the proportion of an observer's field of view that is affected by glare;
- Whether the dwelling appears to have windows facing the reflecting area – factors that restrict potential views of a reflecting area reduce the level of impact;
- The position of the Sun – effects that coincide with direct sunlight appear less prominent than those that do not.

If following consideration of the relevant factors, the solar reflections do not remain significant, the impact significance is low, and mitigation is not recommended. If following consideration of the relevant factors, the solar reflections remain significant, then the impact significance is moderate, and mitigation is recommended.

If effects last for more than three months per year and for more than 60 minutes on any given day, and there are no mitigating factors, the impact significance is high, and mitigation is required.

5.3.2 Geometric Modelling Results

The modelling has shown that solar reflections are geometrically possible towards 29 of the 34 assessed dwelling receptors.

The modelling results for dwelling receptors are analysed in Table 3 on the following pages.

Dwelling Receptor	Geometric modelling results from panel areas (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects ¹² (with consideration of screening) ¹³	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
1 - 5	Solar reflections are geometrically possible for: <u>Less</u> than three months per year <u>Less</u> than 60 minutes per any one day	Existing vegetation, buildings and/or terrain predicted to significantly obstruct views of reflecting panels such that views are not possible in practice	None	N/A	<u>No impact</u>	No

¹² With respect to the ground floor only

¹³ Assessment scenario may include an initial conservative qualitative consideration of screening in determining the duration of predicated effects in practice. The reflecting area of the solar development may be partially screened such that it does not meet the two key criteria i.e. 1) The solar reflection occurs for more than 3 months per year. 2) and/or for more than 60 minutes on any given day.

Dwelling Receptor	Geometric modelling results from panel areas (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects ¹² (with consideration of screening) ¹³	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
6 – 7	<p>Solar reflections are geometrically possible for:</p> <p><u>More</u> than three months per year</p> <p><u>Less</u> than 60 minutes per any one day</p>	<p>No significant screening identified</p> <p>Views of reflecting panels are expected to be possible</p>	<p><u>More</u> than three months per year</p> <p><u>Less</u> than 60 minutes per any one day</p>	<p>Reflecting panels are more than 800m away</p> <p>Reflections predicted within 2 hours of sunrise</p>	<u>Low impact</u>	No
8 – 10	<p>Solar reflections are geometrically possible for:</p> <p><u>Less</u> than three months per year</p> <p><u>Less</u> than 60 minutes per any one day</p>	<p>Existing vegetation, buildings and/or terrain predicted to significantly obstruct views of reflecting panels such that views are not possible in practice</p>	None	N/A	<u>No impact</u>	No

Dwelling Receptor	Geometric modelling results from panel areas (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects ¹² (with consideration of screening) ¹³	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
11	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one day	Existing vegetation and terrain predicted to significantly obstruct views of reflecting panels such that views are not possible in practice	None	N/A	No impact	No
12 – 16	Solar reflections are not geometrically possible	N/A	N/A	N/A	No impact	No
17	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one day	Existing vegetation and terrain predicted to significantly obstruct views of reflecting panels such that views are not possible in practice	None	N/A	No impact	No

Dwelling Receptor	Geometric modelling results from panel areas (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects ¹² (with consideration of screening) ¹³	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
18	<p>Solar reflections are geometrically possible for:</p> <p><u>More</u> than three months per year</p> <p><u>Less</u> than 60 minutes per any one day</p>	<p>Views of reflecting panels are assumed possible under baseline conditions</p> <p>Proposed mixed native species hedgerow to be maintained at a height of 3 to 4 metres predicted to significantly obstruct views of reflecting panels such that views are not possible in practice</p>	<p>Baseline conditions:</p> <p><u>More</u> than three months per year</p> <p><u>Less</u> than 60 minutes per any one day</p> <p>With proposed landscaping:</p> <p>None</p>	None	<p>Baseline conditions:</p> <p><u>Moderate impact</u></p> <p>With proposed landscaping:</p> <p><u>No impact</u></p>	No
19	<p>Solar reflections are geometrically possible for:</p> <p><u>Less</u> than three months per year</p> <p><u>Less</u> than 60 minutes per any one day</p>	<p>Existing vegetation, buildings and/or terrain predicted to significantly obstruct views of reflecting panels such that views are not possible in practice</p>	None	N/A	<u>No impact</u>	No

Dwelling Receptor	Geometric modelling results from panel areas (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects ¹² (with consideration of screening) ¹³	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
20	<p>Solar reflections are geometrically possible for:</p> <p>More than three months per year</p> <p>Less than 60 minutes per any one day</p>	<p>Existing vegetation and terrain screening predicted to significantly obstruct views of reflecting panels such that views are not possible in practice from the ground floor</p> <p>Views from upper floors may be possible</p>	None	N/A	Low impact	No
21	<p>Solar reflections are geometrically possible for:</p> <p>More than three months per year</p> <p>Less than 60 minutes per any one day</p>	<p>Views of reflecting panels are assumed possible under baseline conditions</p> <p>Proposed native species tree and shrub planting (planted in groups of 3 to 5 of each species at 1m intervals) predicted to significantly obstruct views of reflecting panels such that views are not possible in practice</p>	<p>Baseline conditions:</p> <p>More than three months per year</p> <p>Less than 60 minutes per any one day</p> <p>With proposed landscaping:</p> <p>None</p>	None	<p>Baseline conditions:</p> <p>Moderate impact</p> <p>With proposed landscaping:</p> <p>No impact</p>	No

Dwelling Receptor	Geometric modelling results from panel areas (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects ¹² (with consideration of screening) ¹³	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
22	<p>Solar reflections are geometrically possible for:</p> <p>More than three months per year</p> <p>Less than 60 minutes per any one day</p>	<p>Existing vegetation and terrain screening predicted to significantly obstruct visibility of reflecting panels such that only minor views are possible in practice from the ground floor</p> <p>Views from upper floors may be possible</p>	<p>Less than three months per year</p> <p>Less than 60 minutes per any one day</p>	N/A	Low impact	No
23 – 33	<p>Solar reflections are geometrically possible for:</p> <p>More than three months per year</p> <p>Less than 60 minutes per any one day</p>	<p>Existing vegetation, buildings and/or terrain predicted to significantly obstruct visibility of reflecting panels such that views are not possible in practice</p>	None	N/A	No impact	No

Dwelling Receptor	Geometric modelling results from panel areas (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects ¹² (with consideration of screening) ¹³	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
34	Solar reflections are geometrically possible for: Less than three months per year Less than 60 minutes per any one day	Existing vegetation, buildings and/or terrain predicted to significantly obstruct visibility of reflecting panels such that views are not possible in practice	None	N/A	No impact	No

Table 3 Geometric modelling results, assessment of impact significance, and mitigation recommendation/requirement – dwelling receptors

5.3.3 Desk-Based Review of Imagery

The figures on the following pages show a selection of imagery with particular relevance to dwelling receptors where solar reflections are geometrically possible for **more** than three months per year, and screening is significant in determining the possible impact. The yellow icons are used to show the location of reflecting points within the solar panel areas. Green polygons are used to outline vegetation screening. Google Earth Viewshed imagery is used to analyse terrain screening for 5m agl (to represent upper floors).

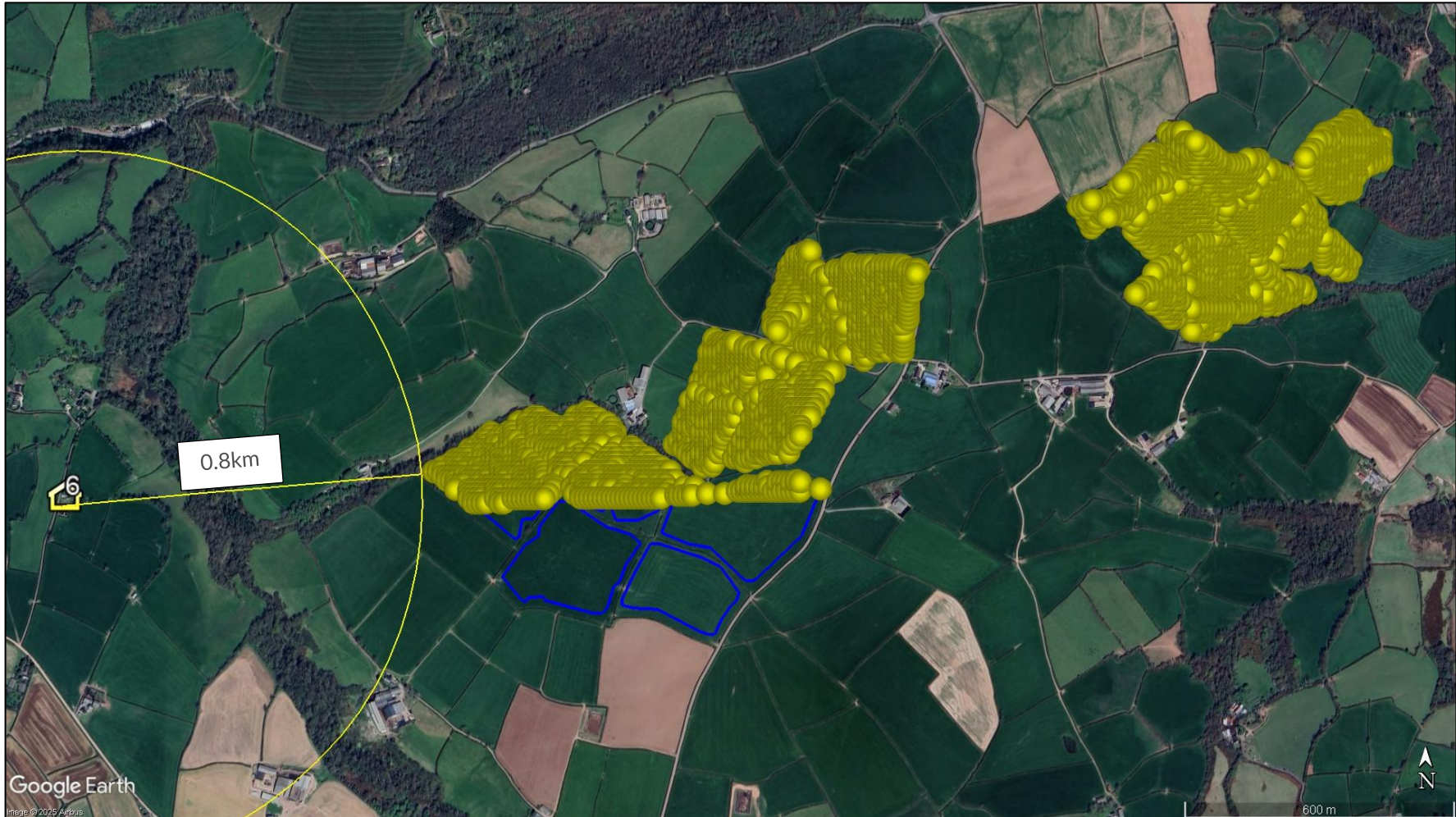


Figure 22 Distance to reflecting points from dwelling receptor 6



Figure 23 Google Earth viewed imagery showing predicted visibility of terrain (green shaded areas) for dwelling receptor 11 at 5m agl (inset street view image from black arrow)



Figure 24 Existing vegetation screening relevant to dwelling receptor 17 (green polygon) and closest reflecting points within proposed development



Figure 25 Reflecting points for dwelling receptor 20 (inset street view image from white arrow viewpoint showing screening) – aerial image



Figure 26 Existing vegetation screening relevant to dwelling receptor 22 (green polygon)

5.3.4 High-Level Mitigation Overview

A moderate impact is predicted for two dwellings (receptors 18 and 21) because solar reflections are geometrically possible for more than three months per year in the absence of sufficient mitigating factors.

Mitigation has been implemented into the landscape scheme through the provision of screening (planting) that is predicted to remove views of the reflecting panel areas.

The reflecting areas that should be screened, and suggested screening locations, are presented in Figure 27 and Figure 28 on the following pages.

The relevant extract of the landscape plans¹⁴ is presented in Figure 29 on page 61.

No further mitigation is required.

¹⁴ Source: Heolddu_LEDS_Plan (1).pdf (cropped).



Figure 27 Suggested screening locations (pink lines) for dwelling receptor 18 and closest reflecting points within proposed development

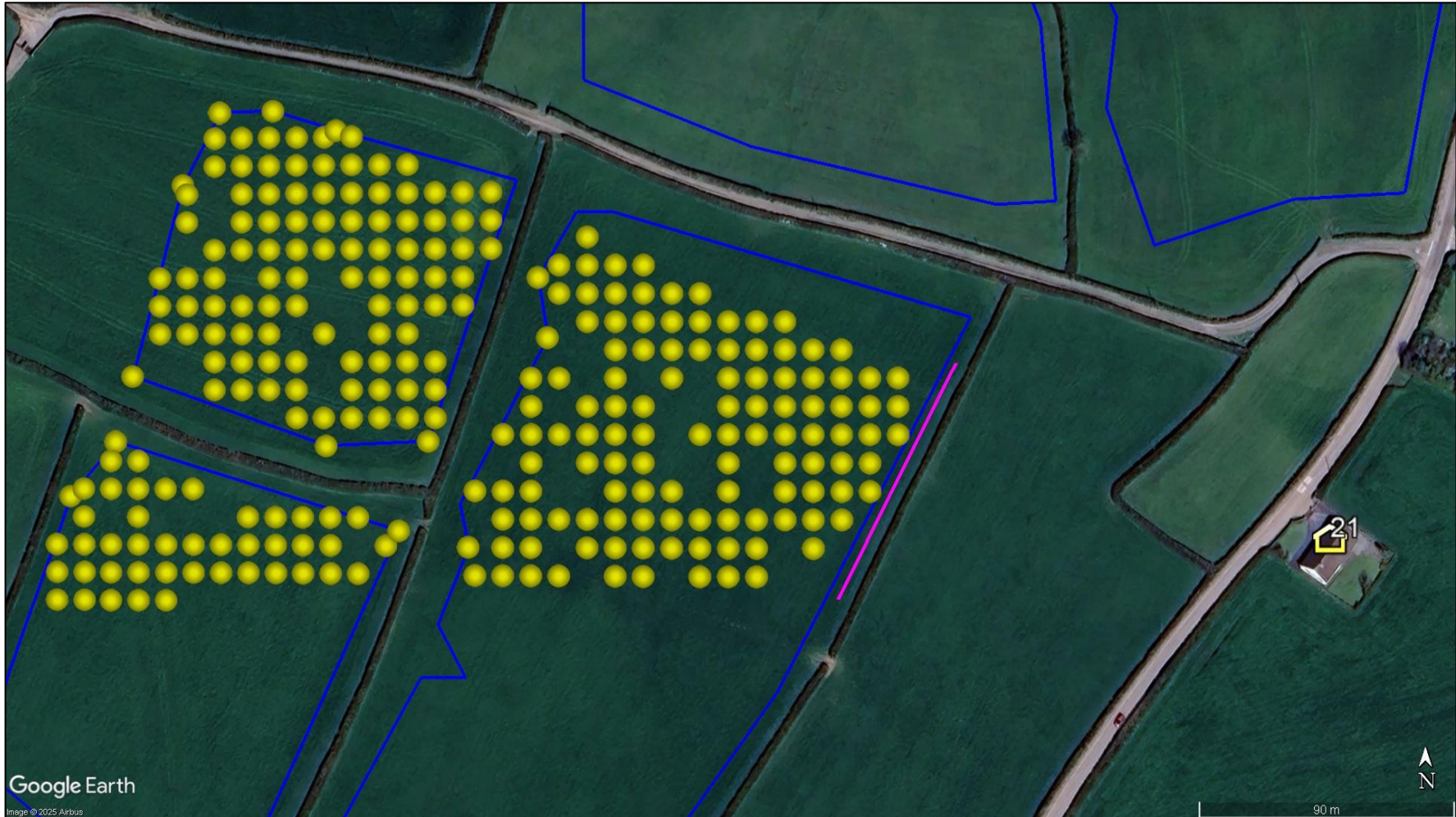


Figure 28 Suggested screening locations (pink line) for dwelling receptor 21 and closest reflecting points within proposed development



Figure 29 Extract of Landscape and Ecological Design Scheme - Solar Area West

6 HIGH-LEVEL AVIATION ASSESSMENT

6.1 Overview

Glint and glare analysis is often undertaken for solar developments that are adjacent to large aerodromes. The most common concerns are:

1. Potential reflections towards an Air Traffic Control (ATC) tower;
2. Potential reflections towards approaching pilots of powered aircraft for the final two miles of the approach.

With regard to Point 2, these reflections are typically evaluated in the context of:

- Whether they are in a pilot's primary horizontal field of view (50° either side of the direction of travel);
- The intensity of the solar reflection.

There is no formal distance within which aviation effects must be modelled. However, in practice, concerns are most often raised for developments within 10km of a licensed airport. Requests for modelling at ranges of 10-20km are far less common. Assessment of aviation effects for developments over 20km away is a very unusual requirement.

Pembrey Airport is an unlicensed aerodrome located approximately 6km from the proposed development. This has been considered within this high-level assessment. An ATC Tower has been identified. The location of the aerodrome and the runway approach paths¹⁵ (pink coloured polygons) are shown in Figure 30 on the following page.

¹⁵ 1-mile splayed approach paths for unlicensed general aviation airfields as per Pager Power's typical assessment methodology



Figure 30 Locations of aerodrome, ATC Tower, and splayed approaches considered

6.2 Pembrey Airport

Significant impacts are not predicted on aviation activity at Pembrey Airport based on the associated guidance and industry best practice. This is because:

- Solar reflections towards the ATC Tower are unlikely to be geometrically possible based on the location of the receptor relative to the proposed development (considering distance, height, and orientation). Any reflections that are geometrically possible are likely to be screened by intervening terrain, buildings, and/or vegetation;
- Any solar reflections geometrically possible towards aircraft on the final one-mile splayed approach towards runway 22 would be outside of a pilot's primary horizontal field of view (50 degrees either side of the approach bearing). At worst, a low impact is predicted on pilots on this approach path based on the associated guidance and industry best practice for licensed airfields;
- Any solar reflections geometrically possible towards aircraft on the final one-mile splayed approach towards runway 04 are predicted to have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths, it can be reliably determined that this level of glare is acceptable for these receptors;
- Any solar reflections geometrically possible towards aircraft on the final sections of the visual circuits and joins are predicted to have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths, it can be reliably determined that this level of glare is acceptable for these receptors.

Technical modelling is not recommended.

7 CONCLUSIONS

7.1 Overall Conclusions

No significant impacts are predicted on surrounding road safety and aviation activity associated with Pembrey Airport.

A moderate impact is predicted on two dwellings because solar reflections are geometrically possible for **more** than three months per year and **less** than 60 minutes per any one day, and views of reflecting panels are expected to be possible. Mitigation is recommended due to the absence of sufficient mitigating factors.

An overview of the assessment results is presented below and on the following page.

7.2 Assessment Conclusions – Roads

The modelling predicts that solar reflections are geometrically possible towards a 1.4km section of road.

A low impact is predicted at two points along the assessed section because visible solar reflections predicted to originate from **outside** of a road user's primary horizontal field of view. Mitigation is not recommended.

No significant impacts are predicted on the remaining sections of the road because there is significant existing screening such that views of reflecting panels are not expected to be possible in practice. Mitigation is not required.

7.3 Assessment Conclusions – Dwellings

The modelling has shown that solar reflections are geometrically possible towards 29 of the 34 assessed dwelling receptors.

No impacts are predicted on 23 dwellings (1-5, 8-11, 17, 19, 23-34) because there is significant existing screening such that views of reflecting panels are not expected to be possible in practice. Mitigation is not required.

A low impact is predicted on four dwellings:

- For one dwelling (20), there is significant existing screening such that views of reflecting panels are not expected to be possible in practice from the ground floor;
- For two dwellings (6-7), although solar reflections are geometrically possible for **more** than three months per year and **less** than 60 minutes per any one day, there are sufficient mitigating factors that reduce the level of impact, including a significant distance between the observer and the closest reflecting panels and incidence of reflections with direct sunlight;
- For one dwelling (22), although solar reflections are geometrically possible for **more** than three months per year and **less** than 60 minutes per any one day, there is significant existing screening such that reflections received in practice are predicted to be reduced to **less** than three months per year;

- Therefore, mitigation is not recommended for any of these four dwellings.

A moderate impact is predicted on two dwellings (18 and 21) under baseline conditions because solar reflections are geometrically possible for **more** than three months per year and **less** than 60 minutes per any one day, and views of reflecting panels are expected to be possible. Mitigation has been implemented into the landscape scheme through the provision of screening (planting) that is predicted to remove views of the reflecting panel areas (see section 5.3.4 for further details). No further mitigation is required.

7.4 Assessment Conclusions – Pembrey Airport

Significant impacts are not predicted on aviation activity at Pembrey Airport based on the associated guidance and industry best practice. This is because:

- Solar reflections towards the ATC Tower are unlikely to be geometrically possible based on the location of the receptor relative to the proposed development (considering distance, height, and orientation). Any reflections that are geometrically possible are likely to be screened by intervening terrain, buildings, and/or vegetation;
- Any solar reflections geometrically possible towards aircraft on the final one-mile splayed approach towards runway 22 would be outside of a pilot's primary horizontal field of view (50 degrees either side of the approach bearing). At worst, a low impact is predicted on pilots on this approach path based on the associated guidance and industry best practice for licensed airfields;
- Any solar reflections geometrically possible towards aircraft on the final one-mile splayed approach towards runway 04 are predicted to have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths, it can be reliably determined that this level of glare is acceptable for these receptors;
- Any solar reflections geometrically possible towards aircraft on the final sections of the visual circuits and joins are predicted to have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths, it can be reliably determined that this level of glare is acceptable for these receptors.

Technical modelling is not recommended.

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.

Welsh Planning Policy

Future Wales

Future Wales Policies 17 and 18¹⁶ are relevant in the context of potential glint and glare effects.

Policies 17 and 18 state:

‘All proposals should demonstrate that they will not have an unacceptable adverse impact on the environment’

...

‘There are no unacceptable adverse impact by way of shadow flicker, noise, reflected light, air quality or electromagnetic disturbance’.

Planning Policy Wales

Planning Policy Wales – Edition 12¹⁷ is relevant in the context of potential glint and glare effects:

‘Prevent glare and respect the amenity of neighbouring land uses’.

UK Planning Policy

Renewable and Low Carbon Energy

The National Planning Policy Framework under the planning practice guidance for Renewable and Low Carbon Energy¹⁸ (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?’

¹⁶ Future Wales: The National Plan 2040, Welsh Government, date: 21 February 2021, accessed on: 08/10/2024.

¹⁷ Planning Policy Wales – Edition 12, Welsh Government, date: February 2024, accessed on: 07/08/2025.

¹⁸ [Renewable and low carbon energy](#), Ministry of Housing, Communities & Local Government, last updated: 14 August 2023, accessed on: 17/05/2024

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.'

National Policy Statement for Renewable Energy Infrastructure

The National Policy Statement for Renewable Energy Infrastructure (EN-3)¹⁹ sets out the primary policy for decisions by the Secretary of State for nationally significant renewable energy infrastructure. Sections 2.10.102-106 state:

'2.10.102 Solar panels are specifically designed to absorb, not reflect, irradiation.²⁰ However, solar panels may reflect the sun's rays at certain angles, causing glint and glare. Glint is defined as a momentary flash of light that may be produced as a direct reflection of the sun in the solar panel. Glare is a continuous source of excessive brightness experienced by a stationary observer located in the path of reflected sunlight from the face of the panel. The effect occurs when the solar panel is stationed between or at an angle of the sun and the receptor.'

2.10.103 Applicants should map receptors to qualitatively identify potential glint and glare issues and determine if a glint and glare assessment is necessary as part of the application.

2.10.104 When a quantitative glint and glare assessment is necessary, applicants are expected to consider the geometric possibility of glint and glare affecting nearby receptors and provide an assessment of potential impact and impairment based on the angle and duration of incidence and the intensity of the reflection.

2.10.105 The extent of reflectivity analysis required to assess potential impacts will depend on the specific project site and design. This may need to account for 'tracking' panels if they are proposed as these may cause differential diurnal and/or seasonal impacts.

2.10.106 When a glint and glare assessment is undertaken, the potential for solar PV panels, frames and supports to have a combined reflective quality may need to be assessed, although the glint and glare of the frames and supports is likely to be significantly less than the panels.'

The EN-3 does not state which receptors should be considered as part of a quantitative glint and glare assessment. Based on Pager Power's extensive project experience, typical receptors include residential dwellings, road users, aviation infrastructure, and railway infrastructure.

Sections 2.10.134-136 state:

'2.10.134 Applicants should consider using, and in some cases the Secretary of State may require, solar panels to comprise of (or be covered with) anti-glare/anti-reflective coating with a specified angle of maximum reflection attenuation for the lifetime of the permission.

2.10.135 Applicants may consider using screening between potentially affected receptors and the reflecting panels to mitigate the effects.

2.10.136 Applicants may consider adjusting the azimuth alignment of or changing the elevation tilt angle of a solar panel, within the economically viable range, to alter the angle of incidence.

¹⁹ National Policy Statement for Renewable Energy Infrastructure (EN-3), Department for Energy Security & Net Zero, date: January 2024, accessed on: 17/01/2024.

²⁰ 'Most commercially available solar panels are designed with anti-reflective glass or are produced with anti-reflective coating and have a reflective capacity that is generally equal to or less hazardous than other objects typically found in the outdoor environment, such as bodies of water or glass buildings.'

In practice this is unlikely to remove the potential impact altogether but in marginal cases may contribute to a mitigation strategy.'

The mitigation strategies listed within the EN-3 are relevant strategies that are frequently utilised to eliminate or reduce glint and glare effects towards surrounding observers. The most common form of mitigation is the implementation of screening along the site boundary.

Sections 2.10.158-159 state:

2.10.158 Solar PV panels are designed to absorb, not reflect, irradiation. However, the Secretary of State should assess the potential impact of glint and glare on nearby homes, motorists, public rights of way, and aviation infrastructure (including aircraft departure and arrival flight paths).

2.10.159 Whilst there is some evidence that glint and glare from solar farms can be experienced by pilots and air traffic controllers in certain conditions, there is no evidence that glint and glare from solar farms results in significant impairment on aircraft safety. Therefore, unless a significant impairment can be demonstrated, the Secretary of State is unlikely to give any more than limited weight to claims of aviation interference because of glint and glare from solar farms.

The EN-3 goes some way in acknowledging that the issue is more complex than presented in the early draft issues; though, this is still unlikely to be welcomed by aviation stakeholders, who will still request a glint and glare assessment on the basis that glare may lead to a potentially significant impact upon aviation safety.

Finally, the EN-3 relates solely to nationally significant renewable energy infrastructure and therefore does not apply to all planning applications for solar farms.

Assessment Process – Ground-Based Receptors

No process for determining and contextualising the effects of glint and glare has been determined when 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 document²¹ which was produced due to the absence of existing guidance and a specific standardised assessment methodology.

²¹ Solar Photovoltaic Development Glint and Glare Guidance, Fourth Edition, March 2022. Pager Power.

Aviation Assessment Guidance

The UK Civil Aviation Authority (CAA) issued interim guidance relating to Solar Photovoltaic Systems (SPV) on 17 December 2010 and was subject to a CAA information alert 2010/53. The formal policy was cancelled on September 7th, 2012²² however the advice is still applicable²³ until a formal policy is developed. The relevant aviation guidance from the CAA is presented in the section below.

CAA Interim Guidance

This interim guidance makes the following recommendations (p.2-3):

'8. It is recommended that, as part of a planning application, the SPV developer provide safety assurance documentation (including risk assessment) regarding the full potential impact of the SPV installation on aviation interests.

9. Guidance on safeguarding procedures at CAA licensed aerodromes is published within CAP 738 Safeguarding of Aerodromes and advice for unlicensed aerodromes is contained within CAP 793 Safe Operating Practices at Unlicensed Aerodromes.

10. Where proposed developments in the vicinity of aerodromes require an application for planning permission the relevant LPA normally consults aerodrome operators or NATS when aeronautical interests might be affected. This consultation procedure is a statutory obligation in the case of certain major airports, and may include military establishments and certain air traffic surveillance technical sites. These arrangements are explained in Department for Transport Circular 1/2003 and for Scotland, Scottish Government Circular 2/2003.

11. In the event of SPV developments proposed under the Electricity Act, the relevant government department should routinely consult with the CAA. There is therefore no requirement for the CAA to be separately consulted for such proposed SPV installations or developments.

12. If an installation of SPV systems is planned on-aerodrome (i.e. within its licensed boundary) then it is recommended that data on the reflectivity of the solar panel material should be included in any assessment before installation approval can be granted. Although approval for installation is the responsibility of the ALH²⁴, as part of a condition of a CAA Aerodrome Licence, the ALH is required to obtain prior consent from CAA Aerodrome Standards Department before any work is begun or approval to the developer or LPA is granted, in accordance with the procedures set out in CAP 791 Procedures for Changes to Aerodrome Infrastructure.

13. During the installation and associated construction of SPV systems there may also be a need to liaise with nearby aerodromes if cranes are to be used; CAA notification and permission is not required.

14. The CAA aims to replace this informal guidance with formal policy in due course and reserves the right to cancel, amend or alter the guidance provided in this document at its discretion upon receipt of new information.

²² Archived at Pager Power

²³ Reference email from the CAA dated 19/05/2014.

²⁴ Aerodrome Licence Holder.

15. Further guidance may be obtained from CAA's Aerodrome Standards Department via aerodromes@caa.co.uk.'

FAA Guidance

The most comprehensive guidelines available for the assessment of solar developments near aerodromes has been produced by the United States Federal Aviation Administration (FAA). The first guidelines were produced initially in November 2010 and updated in 2013. A final policy was released in 2021, which superseded the interim guidance.

The 2010 document is entitled '*Technical Guidance for Evaluating Selected Solar Technologies on Airports*'²⁵, the 2013 update is entitled '*Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports*'²⁶, and the 2021 final policy is entitled '*Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports*'²⁷.

Key excerpts from the final policy are presented below:

Initially, FAA believed that solar energy systems could introduce a novel glint and glare effect to pilots on final approach. FAA has subsequently concluded that in most cases, the glint and glare from solar energy systems to pilots on final approach is similar to glint and glare pilots routinely experience from water bodies, glass-façade buildings, parking lots, and similar features. However, FAA has continued to receive reports of potential glint and glare from on-airport solar energy systems on personnel working in ATCT cabs. Therefore, FAA has determined the scope of agency policy should be focused on the impact of on-airport solar energy systems to federally-obligated towered airports, specifically the airport's ATCT cab.

The policy in this document updates and replaces the previous policy by encouraging airport sponsors to conduct an ocular analysis of potential impacts to ATCT cabs prior to submittal of a Notice of Proposed Construction or Alteration Form 7460-1 (hereinafter Form 7460-1). Airport sponsors are no longer required to submit the results of an ocular analysis to FAA. Instead, to demonstrate compliance with 14 CFR 77.5(c), FAA will rely on the submittal of Form 7460-1 in which the sponsor confirms that it has analyzed the potential for glint and glare and determined there is no potential for ocular impact to the airport's ATCT cab. This process will enable FAA to evaluate the solar energy system project, with assurance that the system will not impact the ATCT cab.

FAA encourages airport sponsors of federally-obligated towered airports to conduct a sufficient analysis to support their assertion that a proposed solar energy system will not result in ocular impacts. There are several tools available on the open market to airport sponsors that can analyze potential glint and glare to an ATCT cab. For proposed systems that will clearly not impact ATCT cabs (e.g., on-airport solar energy systems that are blocked from the ATCT cab's view by another structure), the use

²⁵ Archived at Pager Power

²⁶ [Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports](#), Department of Transportation, Federal Aviation Administration (FAA), date: 10/2013, accessed on: 08/12/2021.

²⁷ [Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports](#), Federal Aviation Administration, date: May 2021, accessed on: 08/12/2021.

of such tools may not be necessary to support the assertion that a proposed solar energy system will not result in ocular impacts.

The excerpt above states where a solar PV development is to be located on a federally obligated aerodrome with an ATC Tower, it will require a glint and glare assessment to accompany its application. It states that pilots on approach are no longer a specific assessment requirement due to effects from solar energy systems being similar to glint and glare pilots routinely experience from water bodies, glass-façade buildings, parking lots, and similar features. Ultimately it comes down to the specific aerodrome to ensure it is adequately safeguarded, and it is on this basis that glint and glare assessments are routinely still requested.

The policy also states that several different tools and methodologies can be used to assess the impacts of glint and glare, which was previously required to be undertaken by the Solar Glare Hazard Analysis Tool (SGHAT) using the Sandia National Laboratories methodology.

In 2018, the FAA released the latest version (Version 1.1) of the '*Technical Guidance for Evaluating Selected Solar Technologies on Airports*'²⁸. Whilst the 2021 final policy also supersedes this guidance, many of the points are still relevant because aerodromes are still safeguarding against glint and glare irrespective of the FAA guidance. The key points are presented below for reference:

- *Reflectivity refers to light that is reflected off surfaces. The potential effects of reflectivity are glint (a momentary flash of bright light) and glare (a continuous source of bright light). These two effects are referred to hereinafter as "glare," which can cause a brief loss of vision, also known as flash blindness*²⁹.
- *The amount of light reflected off a solar panel surface depends on the amount of sunlight hitting the surface, its surface reflectivity, geographic location, time of year, cloud cover, and solar panel orientation.*
- *As illustrated on Figure 16*³⁰, *flat, smooth surfaces reflect a more concentrated amount of sunlight back to the receiver, which is referred to as specular reflection. The more a surface is polished, the more it shines. Rough or uneven surfaces reflect light in a diffused or scattered manner and, therefore, the light will not be received as bright.*
- *Because the FAA has no specific standards for airport solar facilities and potential glare, the type of glare analysis may vary. Depending on site specifics (e.g., existing land uses, location and size of the project) an acceptable evaluation could involve one or more of the following levels of assessment:*
 - *A qualitative analysis of potential impact in consultation with the Control Tower, pilots and airport officials;*

²⁸ *Technical Guidance for Evaluating Selected Solar Technologies on Airports*, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 08/12/2021.

²⁹ Flash Blindness, as described in the FAA guidelines, can be described as a temporary visual interference effect that persists after the source of illumination has ceased. This occurs from many reflective materials in the ambient environment.

³⁰ First figure in Appendix B.

- A demonstration field test with solar panels at the proposed site in coordination with FAA Tower personnel;
 - A geometric analysis to determine days and times when an impact is predicted.
- The extent of reflectivity analysis required to assess potential impacts will depend on the specific project site and system design.
- **1. Assessing Baseline Reflectivity Conditions** – Reflection in the form of glare is present in current aviation operations. The existing sources of glare come from glass windows, auto surface parking, rooftops, and water bodies. At airports, existing reflecting surfaces may include hangar roofs, surface parking, and glassy office buildings. To minimize unexpected glare, windows of air traffic control towers and airplane cockpits are coated with anti-reflective glazing. Operators also wear polarized eye wear. Potential glare from solar panels should be viewed in this context. Any airport considering a solar PV project should first review existing sources of glare at the airport and the effectiveness of measures used to mitigate that glare.
- **2. Tests in the Field** – Potential glare from solar panels can easily be viewed at the airport through a field test. A few airports have coordinated these tests with FAA Air Traffic Controllers to assess the significance of glare impacts. To conduct such a test, a sponsor can take a solar panel out to proposed location of the solar project, and tilt the panel in different directions to evaluate the potential for glare onto the air traffic control tower. For the two known cases where a field test was conducted, tower personnel determined the glare was not significant. If there is a significant glare impact, the project can be modified by ensuring panels are not directed in that direction.
- **3. Geometric Analysis** – Geometric studies are the most technical approach for reflectivity issues. They are conducted when glare is difficult to assess through other methods. Studies of glare can employ geometry and the known path of the sun to predict when sunlight will reflect off of a fixed surface (like a solar panel) and contact a fixed receptor (e.g., control tower). At any given site, the sun moves across the sky every day and its path in the sky changes throughout year. This in turn alters the destination of the resultant reflections since the angle of reflection for the solar panels will be the same as the angle at which the sun hits the panels. The larger the reflective surface, the greater the likelihood of glare impacts.
- Facilities placed in remote locations, like the desert, will be far from receptors and therefore potential impacts are limited to passing aircraft. Because the intensity of the light reflected from the solar panel decreases with increasing distance, an appropriate question is how far you need to be from a solar reflected surface to avoid flash blindness. It is known that this distance is directly proportional to the size of the array in question³¹ but still requires further research to definitively answer.
- **Experiences of Existing Airport Solar Projects** – Solar installations are presently operating at a number of airports, including megawatt-sized solar facilities covering multiple acres. Air

³¹ Ho, Clifford, Cheryl Ghanbari, and Richard Diver. 2009. Hazard Analysis of Glint and Glare From Concentrating Solar Power Plants. SolarPACES 2009, Berlin Germany. Sandia National Laboratories.

traffic control towers have expressed concern about glint and glare from a small number of solar installations. These were often instances when solar installations were sited between the tower and airfield, or for installations with inadequate or no reflectivity analysis. Adequate reflectivity analysis and alternative siting addressed initial issues at those installations.

Air Navigation Order (ANO) 2016

In some instances, an aviation stakeholder can refer to the ANO 2016³² with regard to safeguarding. Key points from the document are presented below.

Lights liable to endanger

224. (1) A person must not exhibit in the United Kingdom any light which—

- (a) by reason of its glare is liable to endanger aircraft taking off from or landing at an aerodrome; or
- (b) by reason of its liability to be mistaken for an aeronautical ground light is liable to endanger aircraft.

(2) If any light which appears to the CAA to be a light described in paragraph (1) is exhibited, the CAA may direct the person who is the occupier of the place where the light is exhibited or who has charge of the light, to take such steps within a reasonable time as are specified in the direction—

- (a) to extinguish or screen the light; and
- (b) to prevent in the future the exhibition of any other light which may similarly endanger aircraft.

(3) The direction may be served either personally or by post, or by affixing it in some conspicuous place near to the light to which it relates.

(4) In the case of a light which is or may be visible from any waters within the area of a general lighthouse authority, the power of the CAA under this article must not be exercised except with the consent of that authority.

Lights which dazzle or distract

225. A person must not in the United Kingdom direct or shine any light at any aircraft in flight so as to dazzle or distract the pilot of the aircraft.'

The document states that no 'light', 'dazzle' or 'glare' should be produced which will create a detrimental impact upon aircraft safety.

Endangering safety of an aircraft

240. A person must not recklessly or negligently act in a manner likely to endanger an aircraft, or any person in an aircraft.

Endangering safety of any person or property

³² The Air Navigation Order 2016. [online] Available at: <https://www.legislation.gov.uk/uksi/2016/765/contents/made> [Accessed 4 February 2022].

241. A person must not recklessly or negligently cause or permit an aircraft to endanger any person or property.

Civil Aviation Authority consolidation of UK Regulation 139/2014

The Civil Aviation Authority (CAA) published a consolidating document³³ of UK regulations, (Implementing Rules, Acceptable Means of Compliance and Guidance Material), in 2023. A summary of material relevant to aerodrome safeguarding is presented below:

(a) The aerodrome operator should have procedures to monitor the changes in the obstacle environment, marking and lighting, and in human activities or land use on the aerodrome and the areas around the aerodrome, as defined in coordination with the CAA. The scope, limits, tasks and responsibilities for the monitoring should be defined in coordination with the relevant air traffic services providers, and with the CAA and other relevant authorities.

(b) The limits of the aerodrome surroundings that should be monitored by the aerodrome operator are defined in coordination with the CAA and should include the areas that can be visually monitored during the inspections of the manoeuvring area.

(c) The aerodrome operator should have procedures to mitigate the risks associated with changes on the aerodrome and its surroundings identified with the monitoring procedures. The scope, limits, tasks, and responsibilities for the mitigation of risks associated to obstacles or hazards outside the perimeter fence of the aerodrome should be defined in coordination with the relevant air traffic services providers, and with the CAA and other relevant authorities.

(d) The risks caused by human activities and land use which should be assessed and mitigated should include:

1. obstacles and the possibility of induced turbulence;
2. the use of hazardous, confusing, and misleading lights;
3. the dazzling caused by large and highly reflective surfaces;
4. sources of non-visible radiation, or the presence of moving, or fixed objects which may interfere with, or adversely affect, the performance of aeronautical communications, navigation and surveillance systems;
5. and non-aeronautical ground light near an aerodrome which may endanger the safety of aircraft and which should be extinguished, screened, or otherwise modified so as to eliminate the source of danger.

³³ <https://regulatorylibrary.caa.co.uk/139-2014-pdf/PDF.pdf>

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

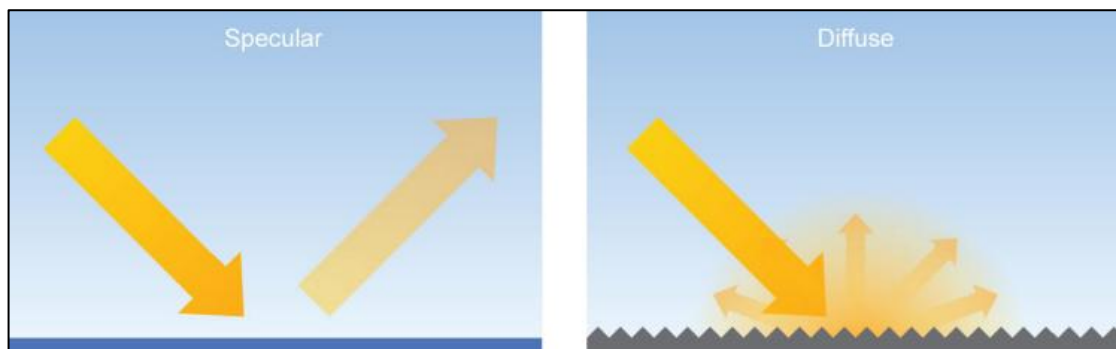
Overview

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 guidance³⁴, 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

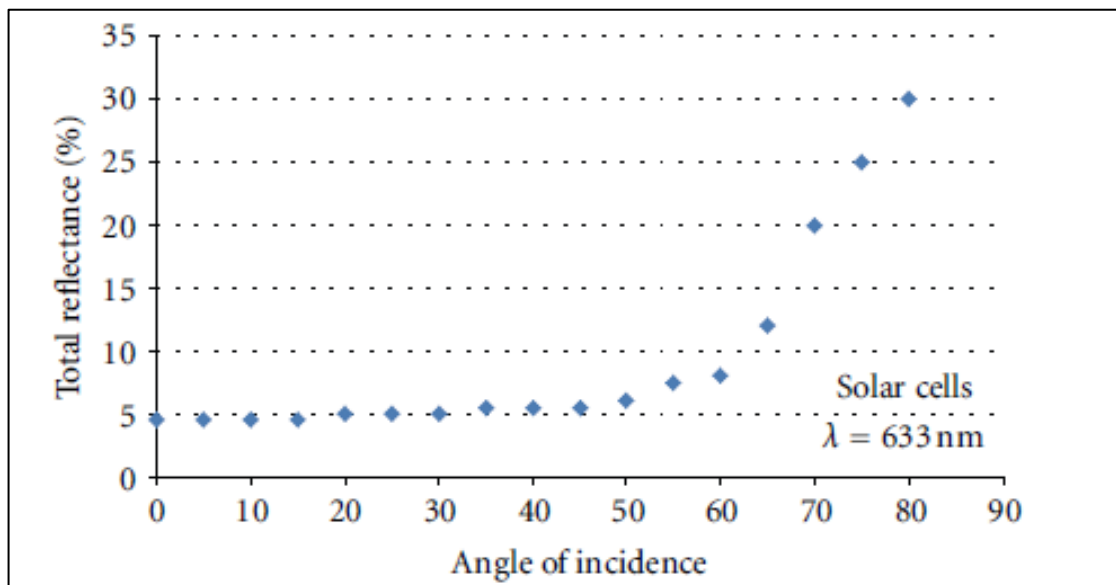
³⁴Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 08/12/2021.

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 Systems³⁵. 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.

³⁵ 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”³⁶

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 ³⁷
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.

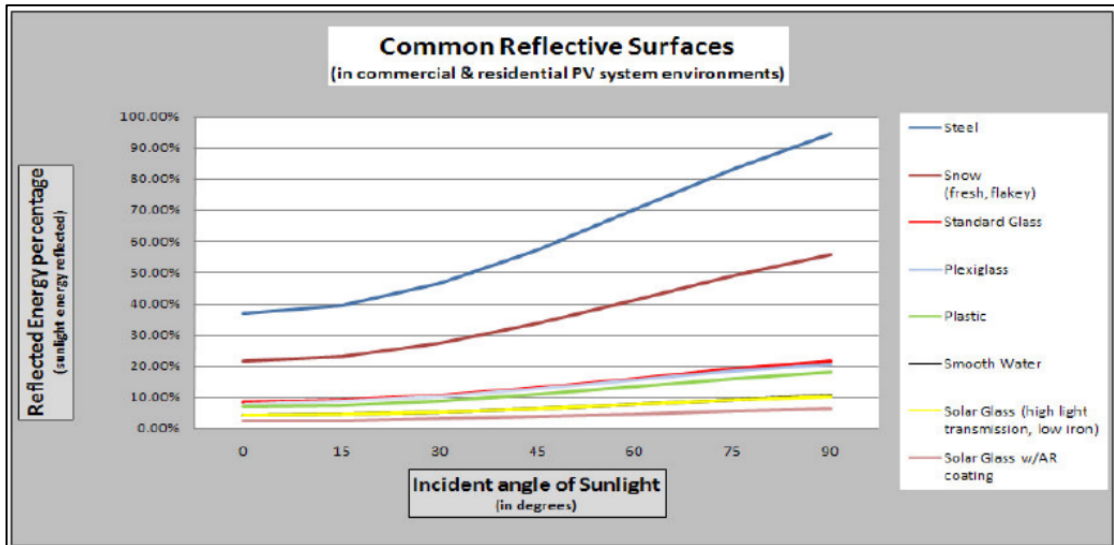
³⁶ [Technical Guidance for Evaluating Selected Solar Technologies on Airports](#), Federal Aviation Administration (FAA), date: 04/2018, accessed on: 08/12/2021.

³⁷ Extrapolated data, baseline of 1,000 W/m² for incoming sunlight.

SunPower Technical Notification (2009)

SunPower published a technical notification³⁸ 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.

³⁸ 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).

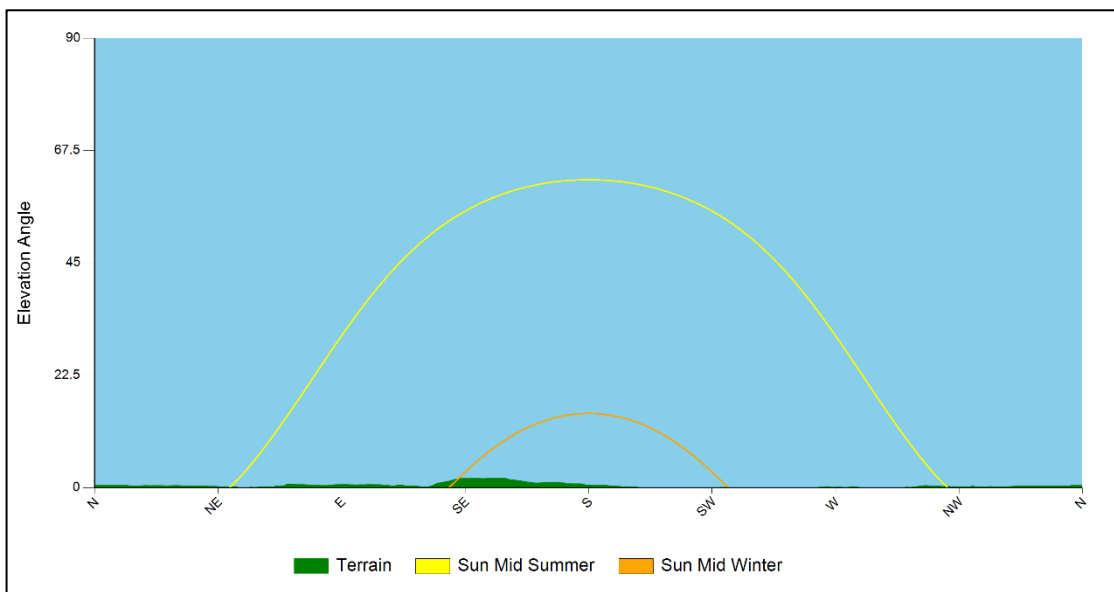
The Sun's position can be accurately calculated for a specific location. The following data being used for the calculation:

- 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 from the proposed development location as well as the sunrise and sunset curves throughout the year.



Terrain at the visible horizon and sun path

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

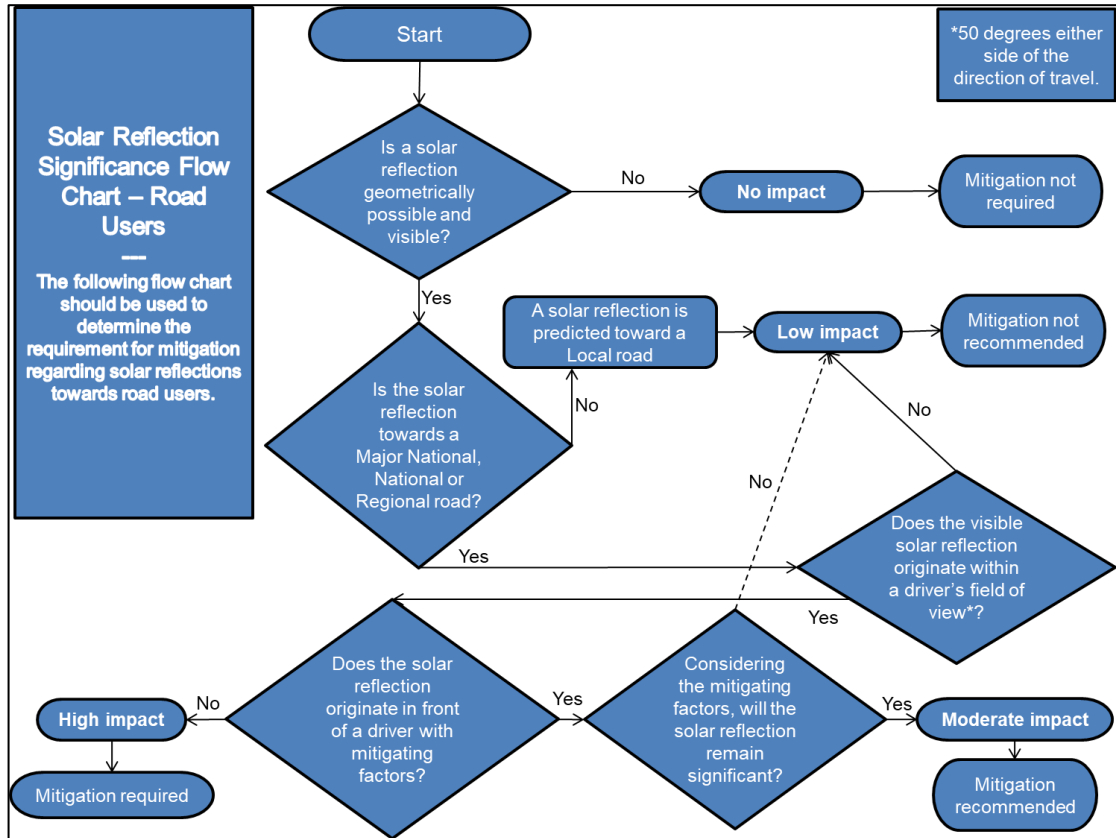
The table below presents the recommended definition of ‘impact significance’ in glint and glare terms and the requirement for mitigation under each.

Impact Significance	Definition	Mitigation
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 significantly.	No mitigation recommended.
Moderate	A solar reflection is geometrically possible and visible however it occurs under conditions that do not represent a worst-case given individual receptor criteria.	Mitigation recommended.
High	A solar reflection is geometrically possible and visible under worst-case conditions that will produce a significant impact given individual receptor criteria	Mitigation will be required if the proposed development is to proceed.

Impact significance definition

Assessment Process for Road Receptors

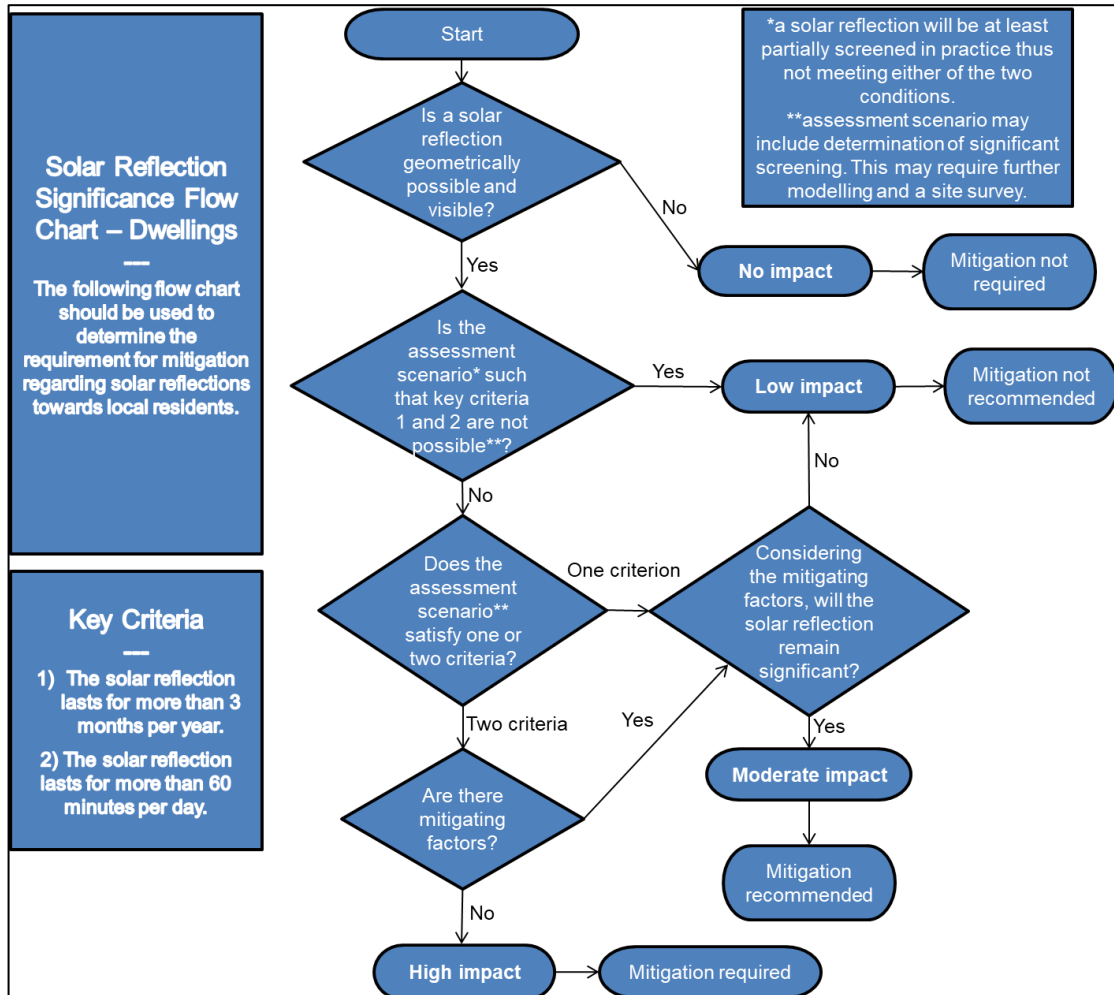
The flow chart presented below has been followed when determining the mitigation requirement for road receptors.



Road receptor mitigation requirement flow chart

Assessment Process for Dwelling Receptors

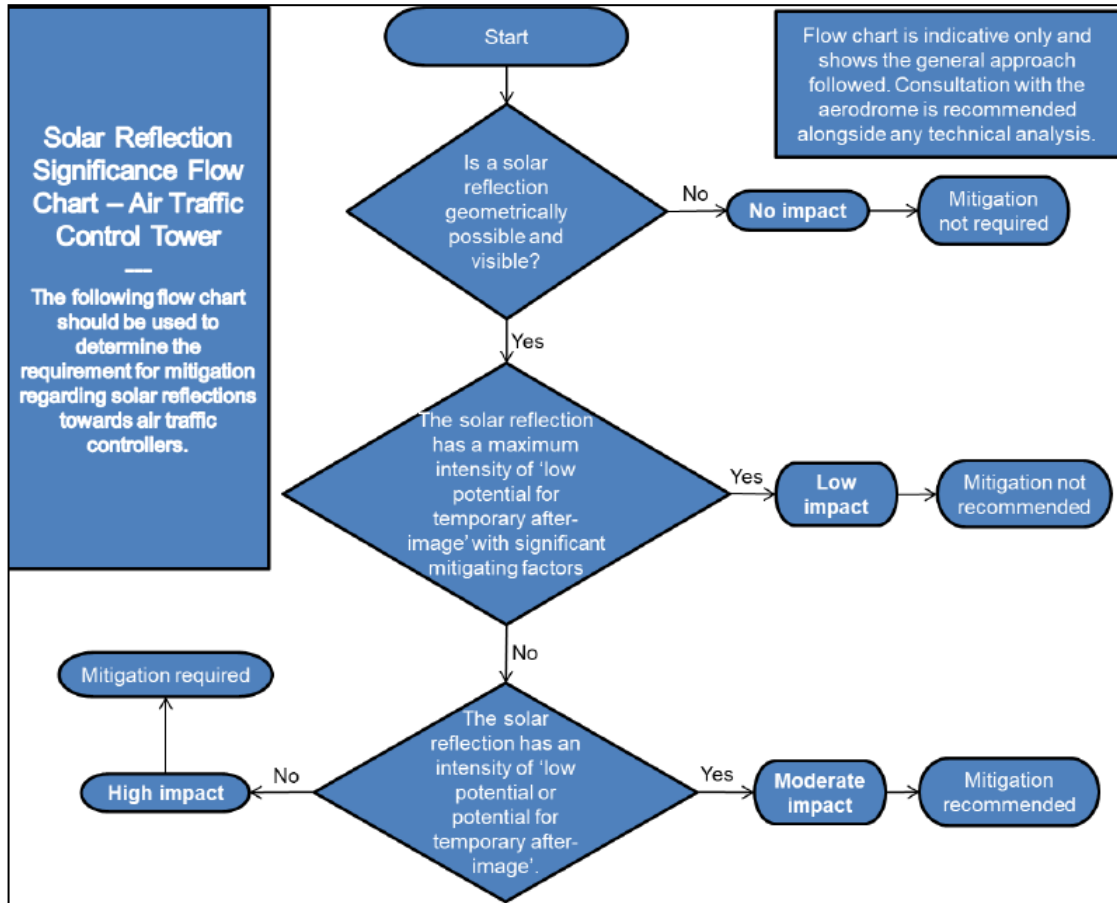
The flow chart presented below has been followed when determining the mitigation requirement for dwelling receptors.



Dwelling receptor mitigation requirement flow chart

Impact Significance Determination for ATC Tower

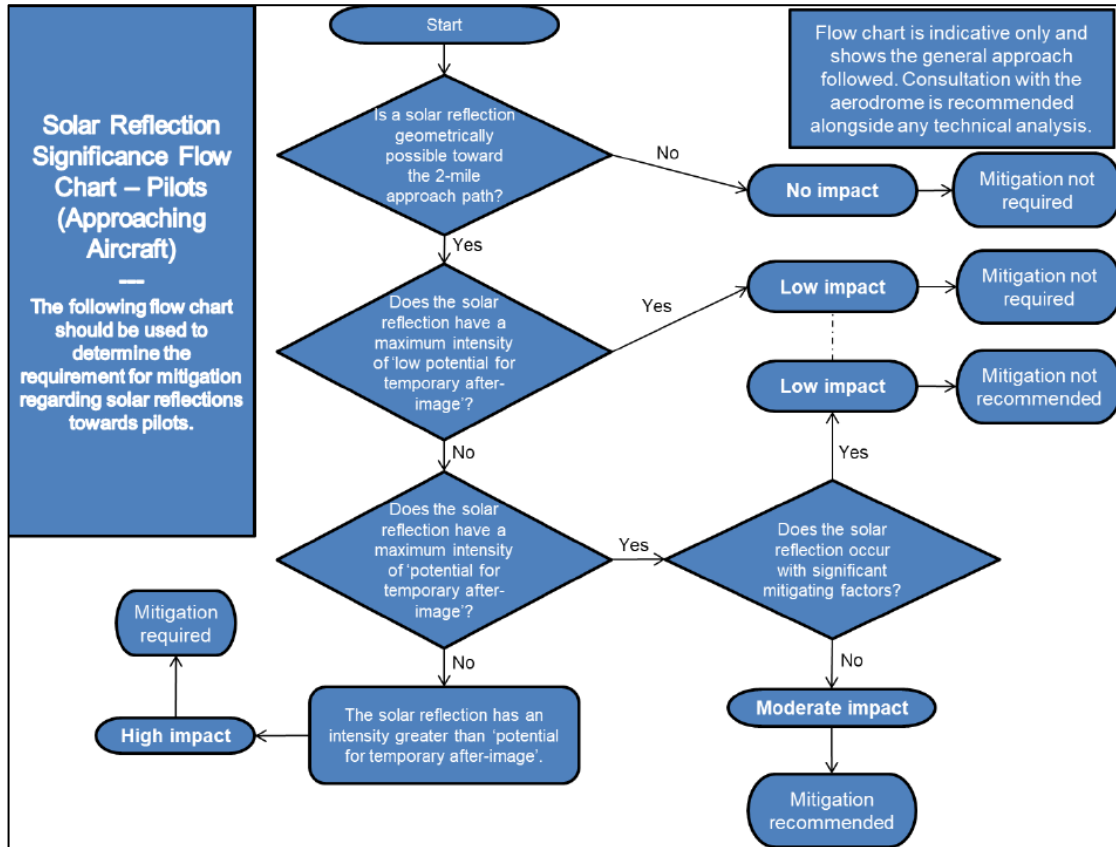
The flow chart presented below has been followed when determining the impact significance and mitigation requirement for ATC Tower receptors.



ATC Tower receptor mitigation requirement flow chart

Impact Significance Determination for Approaching Aircraft

The flow chart presented below has been followed when determining the mitigation requirement for approaching aircraft.



Approach path receptor mitigation requirement flow chart

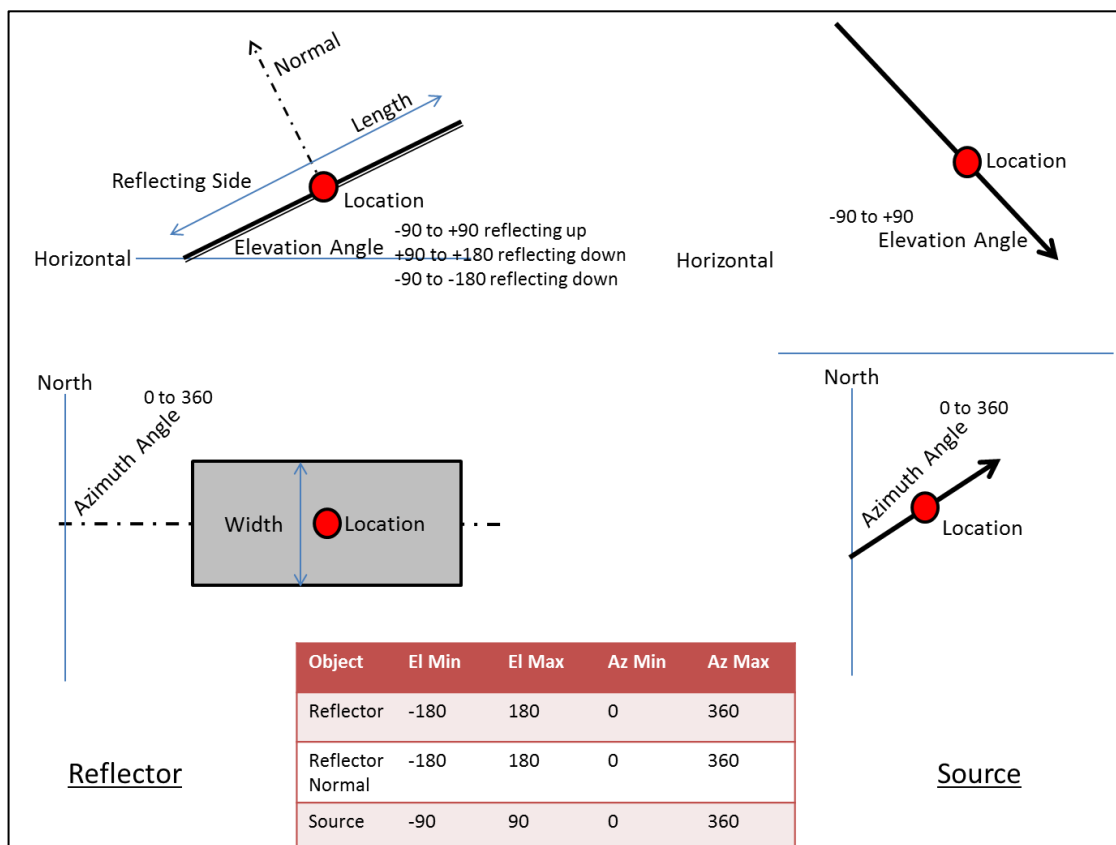
APPENDIX E – REFLECTION CALCULATIONS METHODOLOGY

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.



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)³⁹.

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

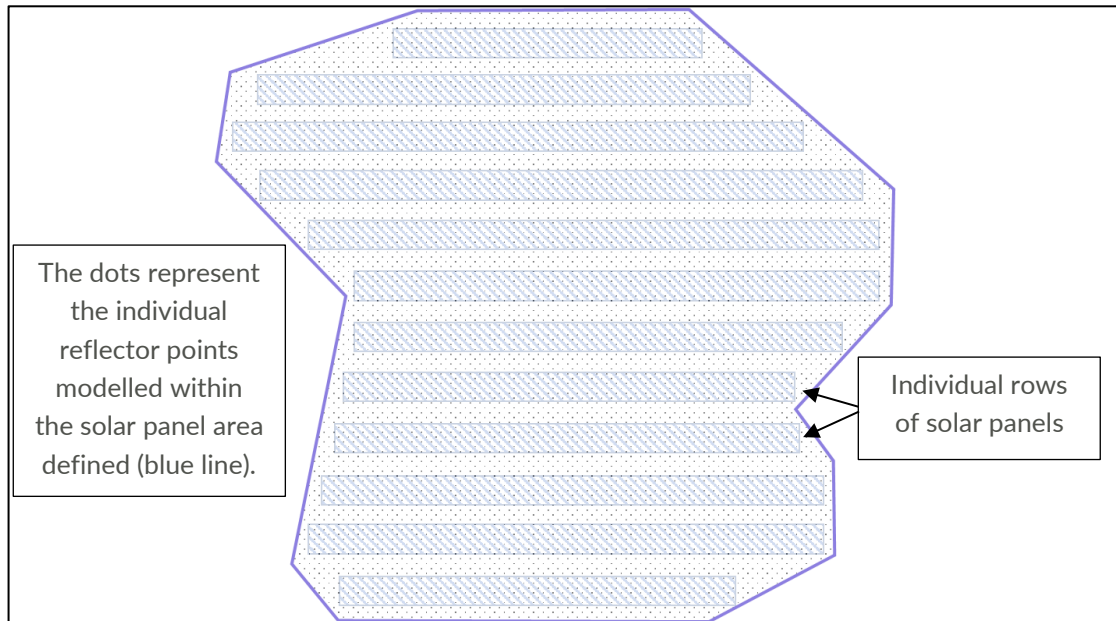
It is assumed that the panel azimuth angle assessed represents the azimuth angle for all of the panels within each solar panel area defined.

Only a reflection from the face of the panel has been considered. The frame or the reverse of the 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.

³⁹ UK only.



Solar panel area modelling overview

A single reflection point is chosen for the geometric calculations. This suitably determines whether a solar reflection can be experienced at a receptor location and the time of year and duration of the solar 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.

The available street view imagery, satellite mapping, terrain and any site imagery provided by the developer has been used to assess line of sight from the assessed receptors to the modelled solar panel area, unless stated otherwise. 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 within the modelling unless stated otherwise. The terrain profile at the horizon is considered if stated.

APPENDIX G – RECEPTOR AND REFLECTOR AREA DETAILS

Road Receptor Data

The table below presents the coordinates for the assessed road receptors. Terrain Height was calculated from Pager Power's database (established on OSGB 50m) based on the coordinates of the point of interest.

Location	Latitude (°)	Longitude (°)
1	51.77524	-4.32648
2	51.774361	-4.326735
3	51.773474	-4.326692
4	51.772833	-4.327679
5	51.772063	-4.328423
6	51.771172	-4.32859
7	51.770306	-4.328968
8	51.76955	-4.329744
9	51.768834	-4.330623
10	51.768042	-4.331306
11	51.767197	-4.331806
12	51.766468	-4.332628
13	51.765854	-4.333691
14	51.765147	-4.334584
15	51.764363	-4.335299
16	51.763543	-4.335887
17	51.762674	-4.336265
18	51.7618	-4.33661
19	51.760927	-4.336963

Location	Latitude (°)	Longitude (°)
20	51.760051	-4.337297
21	51.759157	-4.337281
22	51.75826	-4.337202
23	51.757521	-4.337826
24	51.75688	-4.338814

Road Receptor Data

Dwelling Receptor Data

The table below presents the coordinates for the assessed dwelling receptors. Terrain Height was calculated from Pager Power's database (established on OSGB 50m) based on the coordinates of the point of interest.

Location	Latitude (°)	Longitude (°)
1	51.774548	-4.34602
2	51.772738	-4.345424
3	51.769796	-4.355872
4	51.769564	-4.356042
5	51.769615	-4.358215
6	51.767382	-4.356313
7	51.763411	-4.355588
8	51.761265	-4.353562
9	51.761027	-4.353399
10	51.761289	-4.349567
11	51.764022	-4.345768
12	51.76117	-4.341043
13	51.758876	-4.343628
14	51.758275	-4.341534
15	51.760965	-4.336565

Location	Latitude (°)	Longitude (°)
16	51.760241	-4.334715
17	51.768312	-4.346592
18	51.769296	-4.337509
19	51.773402	-4.337928
20	51.767699	-4.329571
21	51.769489	-4.329424
22	51.770207	-4.328573
23	51.770311	-4.32777
24	51.769915	-4.325021
25	51.769538	-4.323768
26	51.769243	-4.319886
27	51.768259	-4.313593
28	51.76793	-4.311401
29	51.772562	-4.306285
30	51.770609	-4.305386
31	51.770186	-4.305223
32	51.769159	-4.30484
33	51.762839	-4.31819
34	51.761354	-4.322212

Dwelling Receptor Data

Pembrey Airport Runway Details

Runway	Longitude (°)	Latitude (°)
04	-4.314762	51.711440
22	-4.309318	51.716842

Runway details for Pembrey Airport

APPENDIX H – DETAILED MODELLING RESULTS

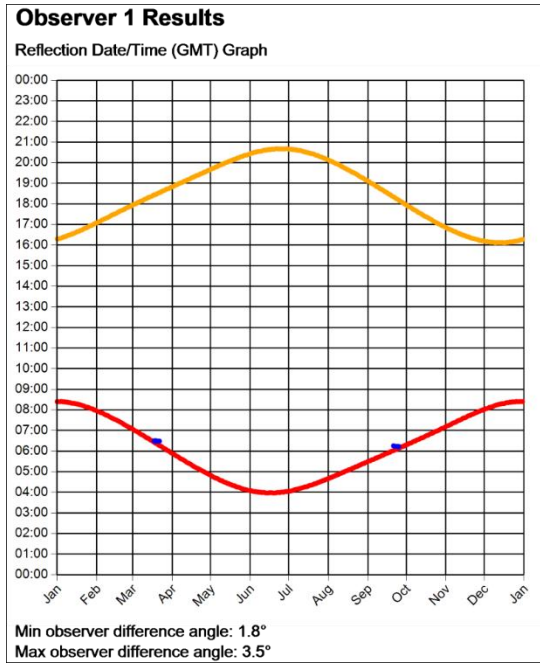
The results charts are shown on the following pages.

Each results chart shows:

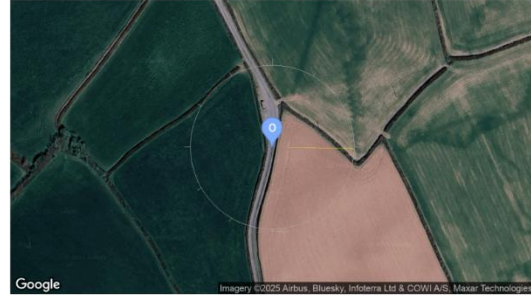
- The receptor (observer) location – top right image. This also shows the azimuth range of the Sun itself at times when reflections are possible. If sunlight is experienced from the same direction as the reflecting panels, the overall impact of the reflection is reduced as discussed within the body of 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).

Road Receptors

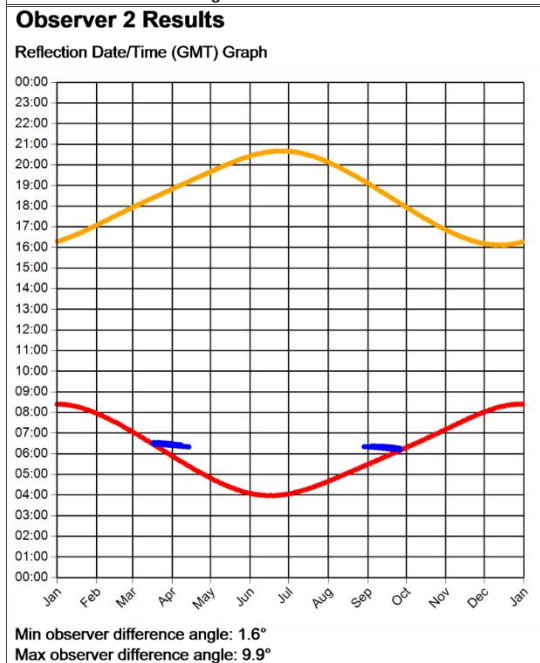
Modelling results are presented for receptors where a solar reflection is geometrically possible.



Observer Location Sun azimuth range is 90.5° - 91.5° (yellow)



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



Observer Location Sun azimuth range is 84.6° - 92.5° (yellow)

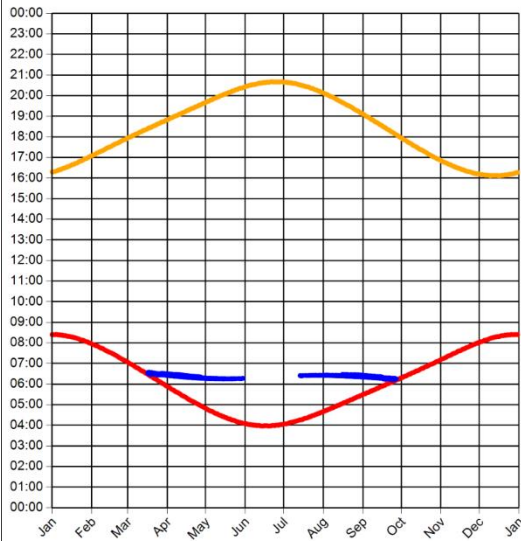


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 3 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 2°
Max observer difference angle: 20.2°

Observer Location Sun azimuth range is 76.5° - 92.5° (yellow)

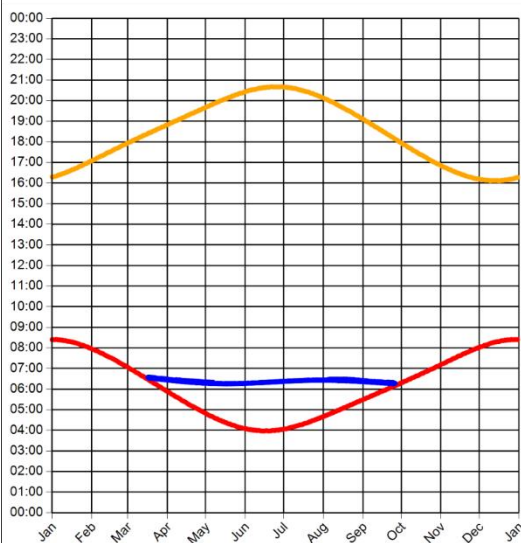


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 4 Results

Reflection Date/Time (GMT) Graph



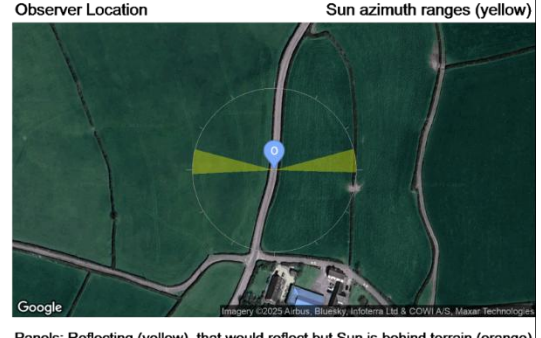
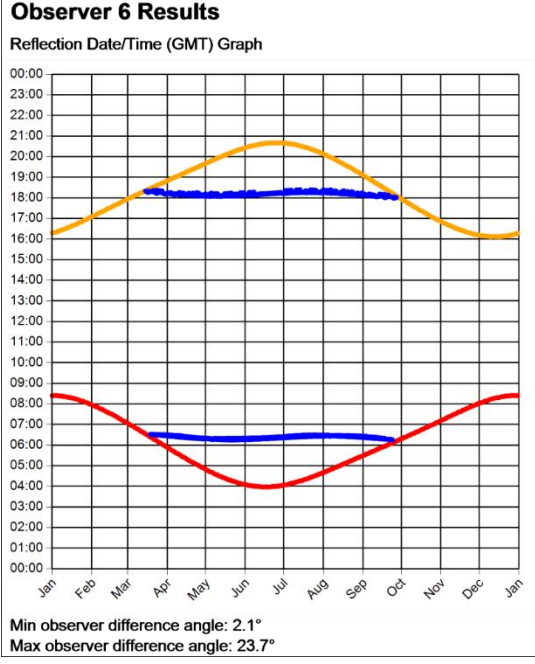
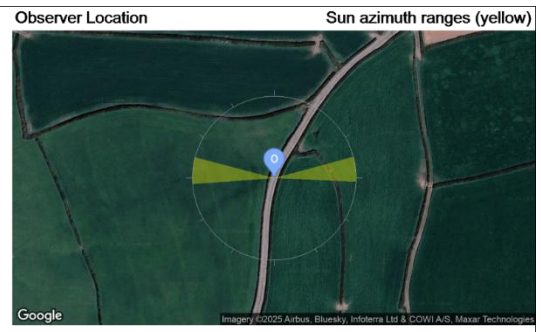
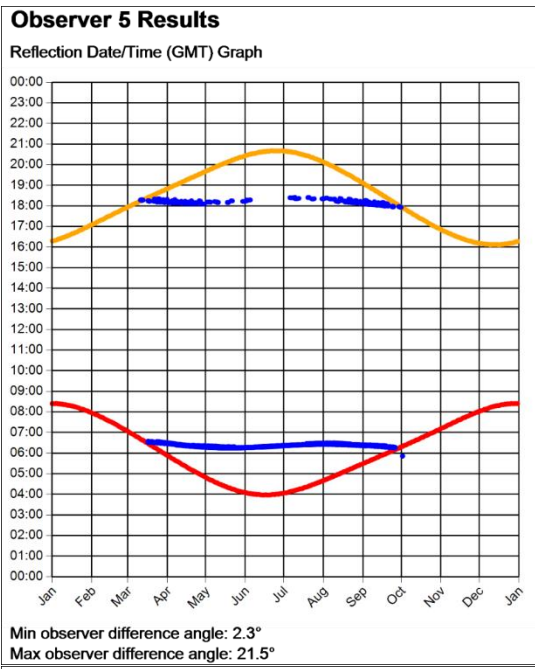
Min observer difference angle: 2.9°
Max observer difference angle: 21.7°

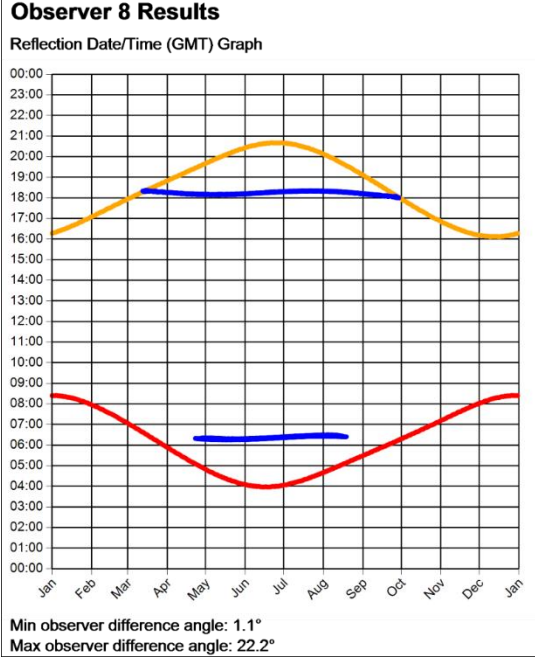
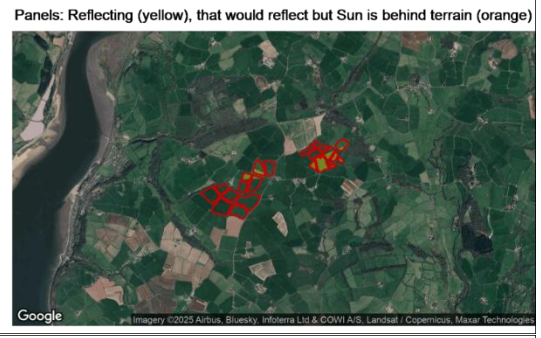
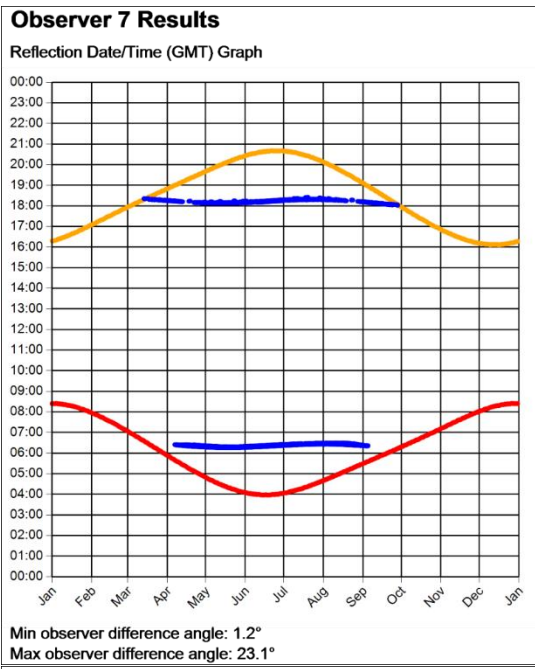
Observer Location Sun azimuth range is 75.2° - 92.6° (yellow)

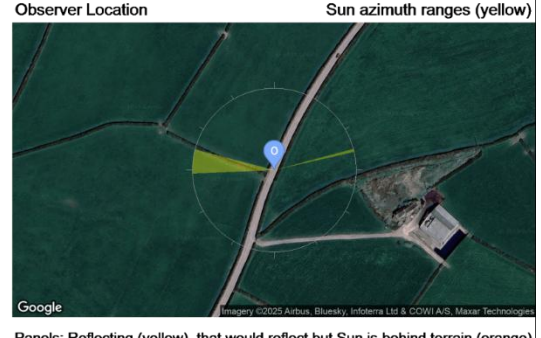
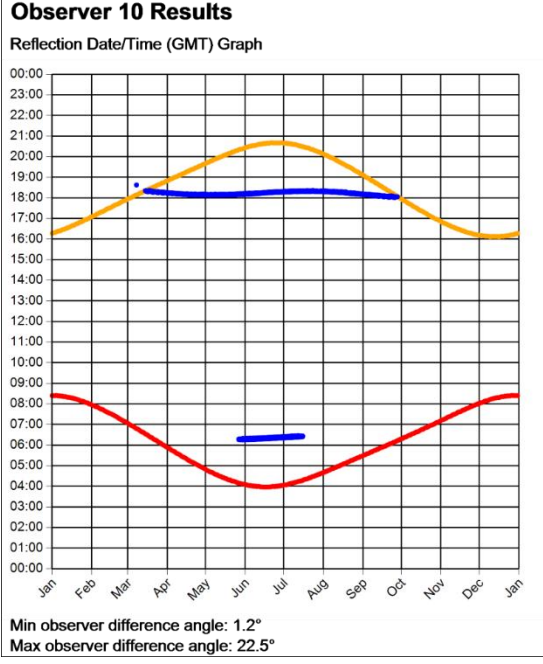
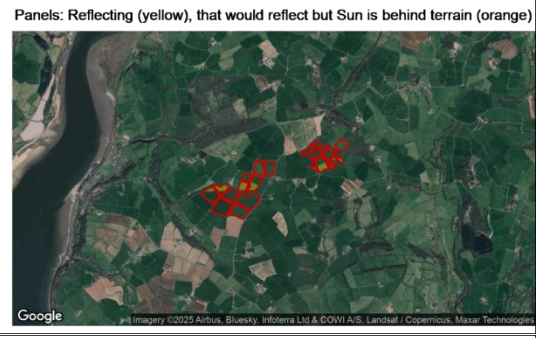
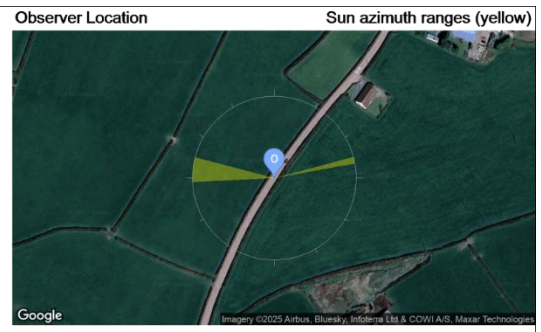
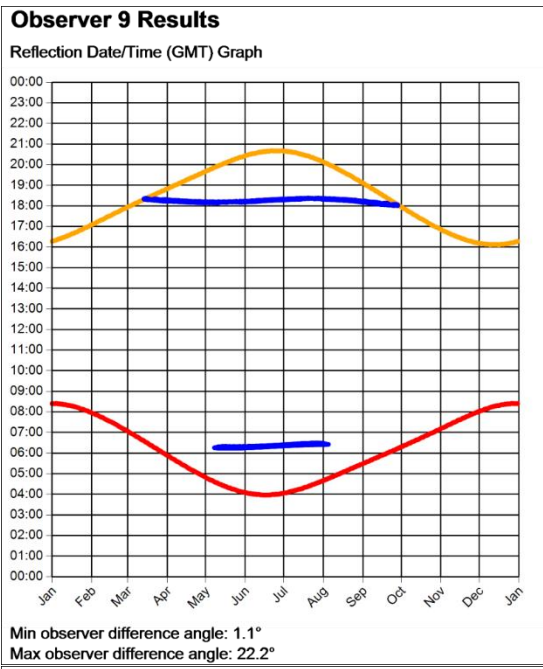


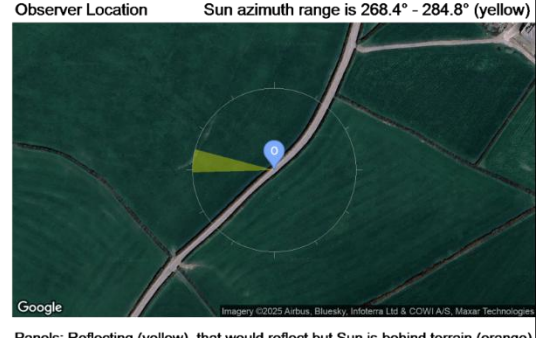
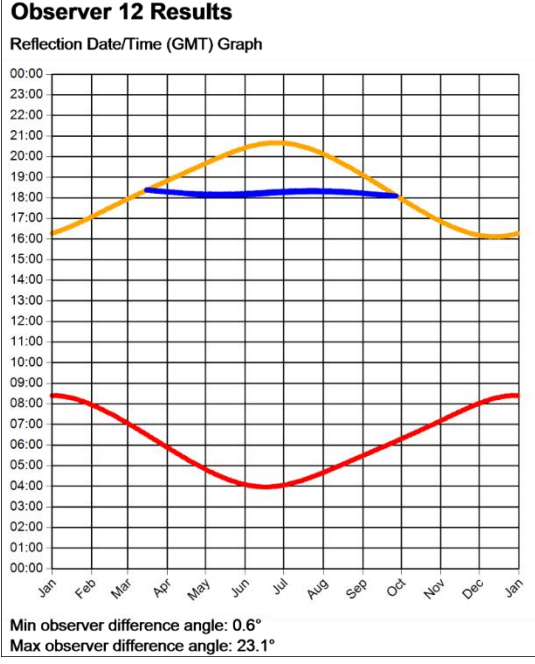
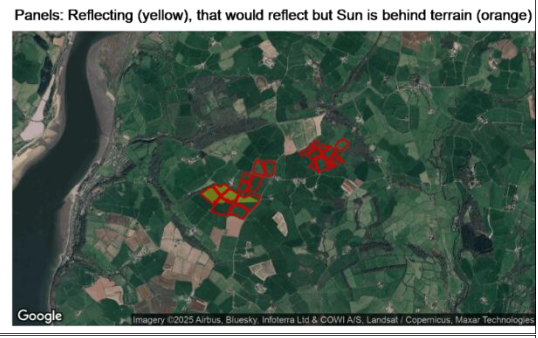
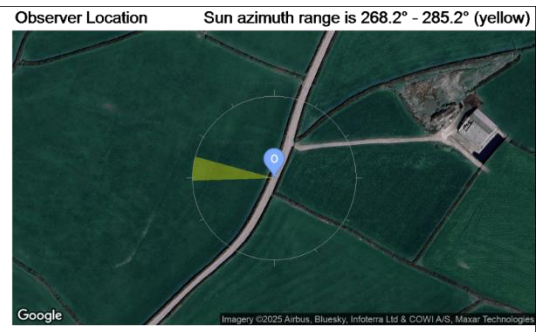
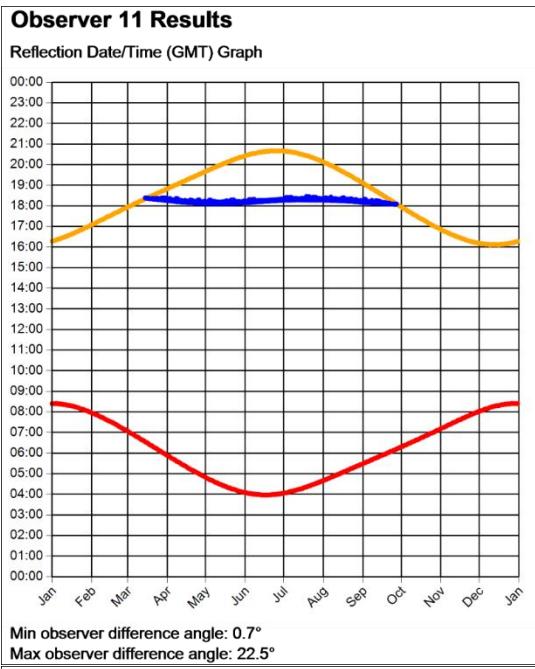
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

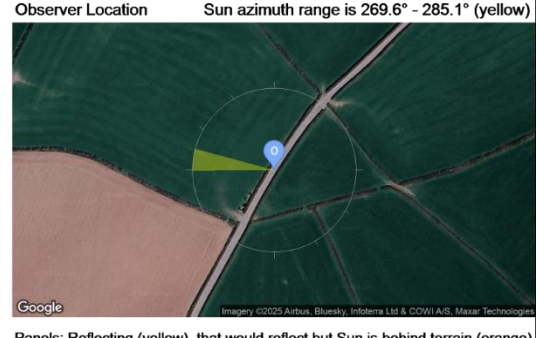
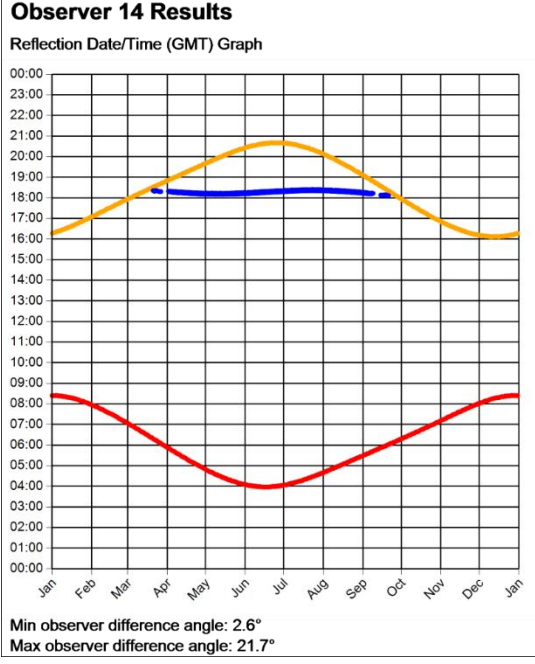
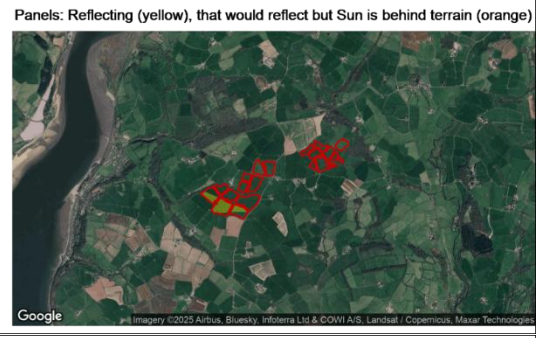
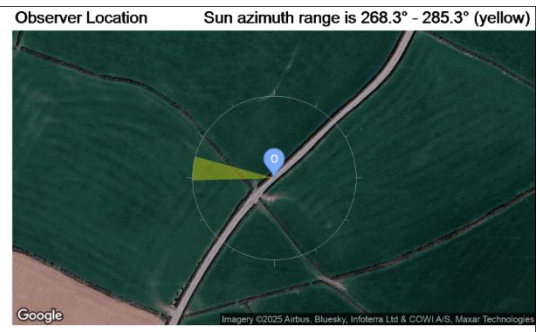
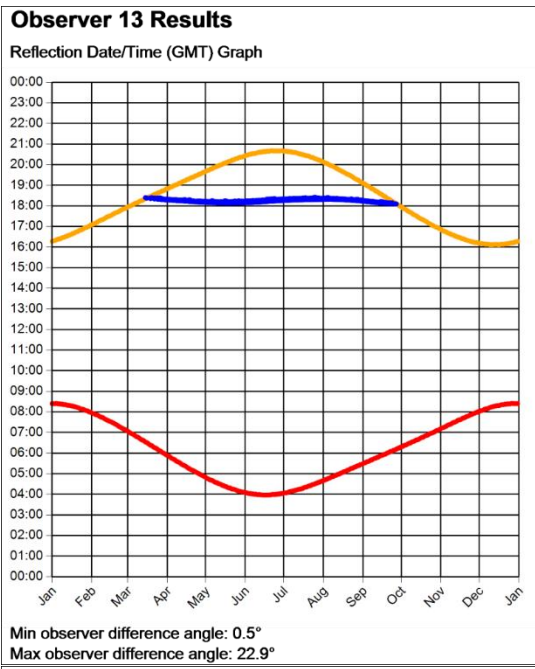


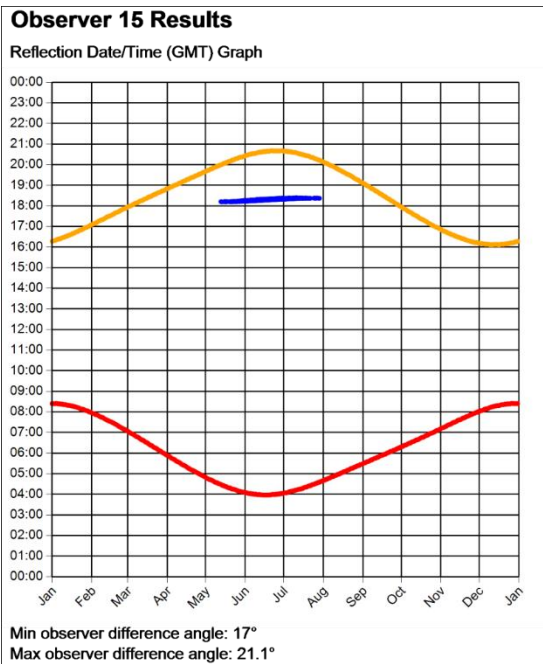












Observer Location Sun azimuth range is 281.5° - 285.3° (yellow)

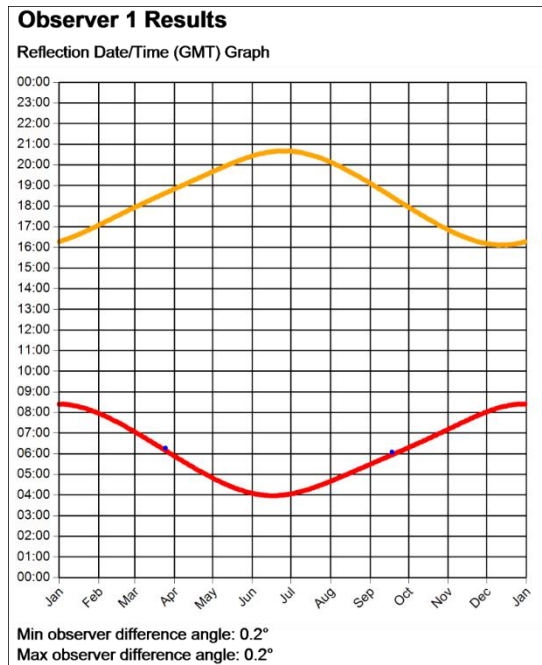


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Dwelling Receptors

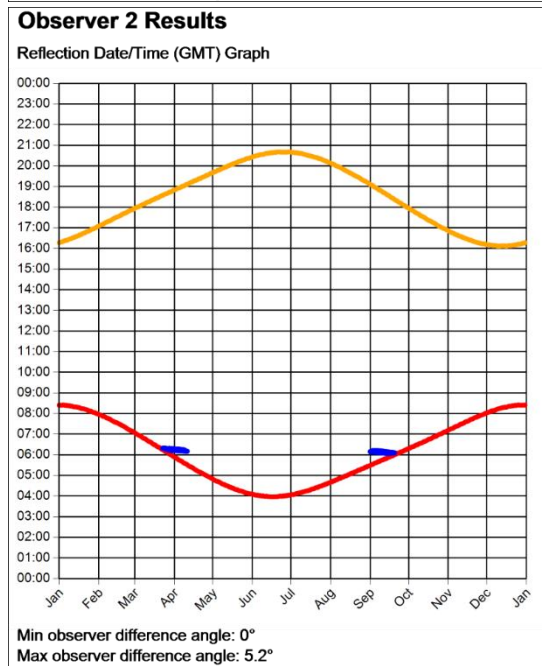
Modelling results are presented for receptors where a solar reflection is geometrically possible.



Observer Location Sun azimuth range is 87.6° - 87.6° (yellow)



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



Observer Location Sun azimuth range is 83.2° - 88.4° (yellow)

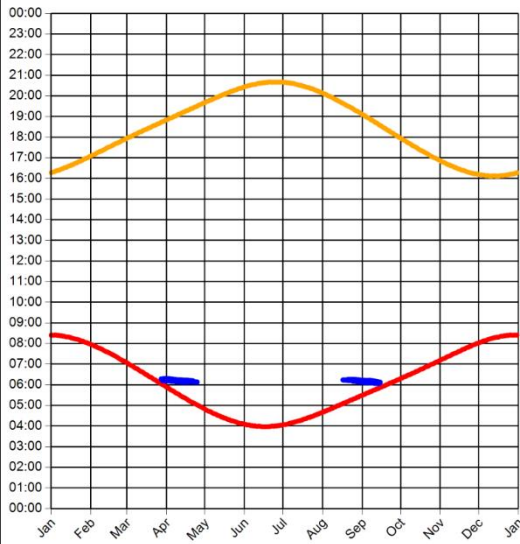


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



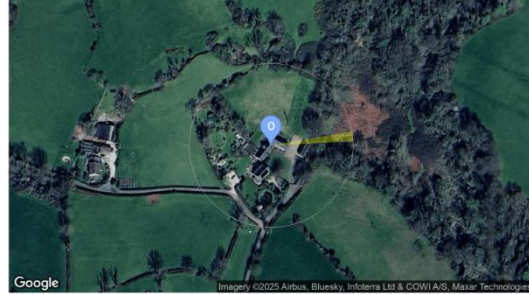
Observer 3 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0°
Max observer difference angle: 9.3°

Observer Location Sun azimuth range is 80.2° - 87.1° (yellow)

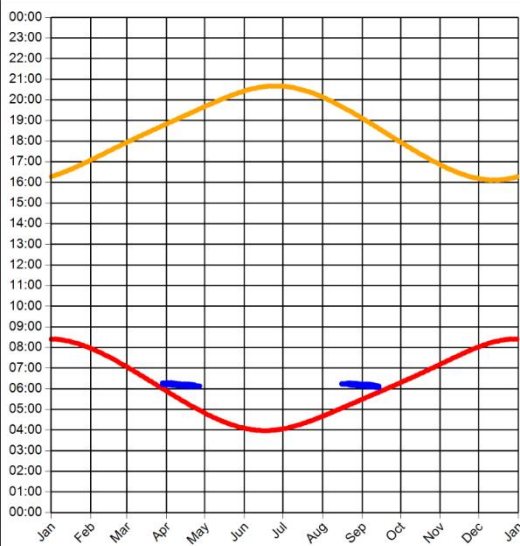


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 4 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.1°
Max observer difference angle: 9.6°

Observer Location Sun azimuth range is 80° - 86.9° (yellow)

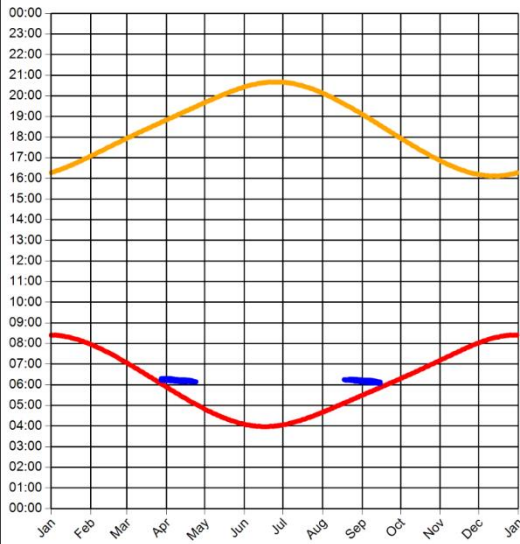


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 5 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.1°
 Max observer difference angle: 9.1°

Observer Location Sun azimuth range is 80.6° - 87.2° (yellow)

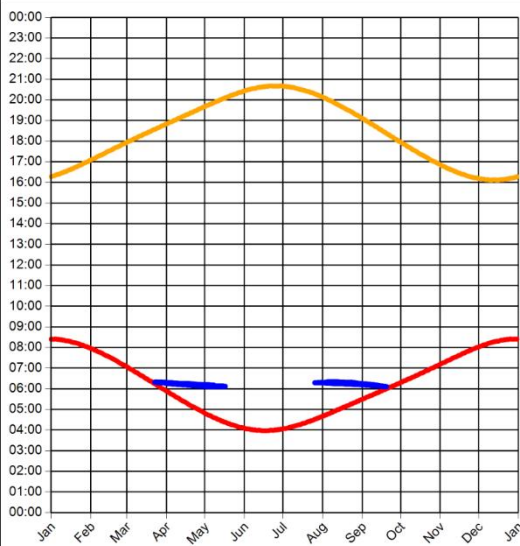


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 6 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0°
 Max observer difference angle: 14.8°

Observer Location Sun azimuth range is 76.5° - 88.5° (yellow)

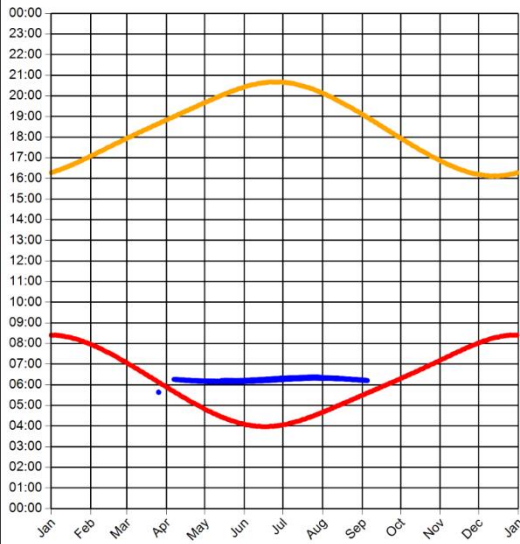


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 7 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 5°
 Max observer difference angle: 20.2°

Observer Location Sun azimuth range is 73.8° - 85.1° (yellow)

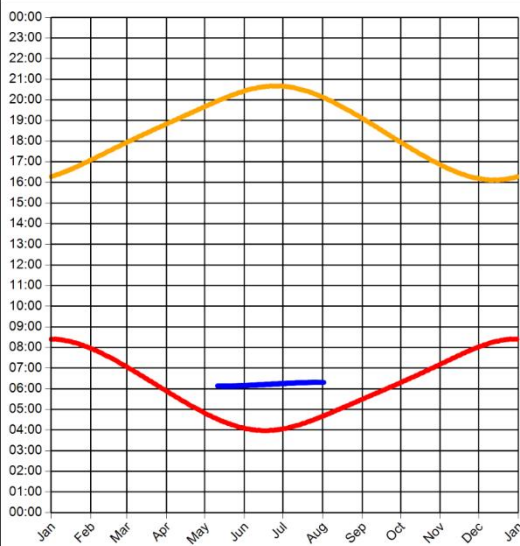


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 8 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 14°
 Max observer difference angle: 18.7°

Observer Location Sun azimuth range is 73.8° - 77.8° (yellow)

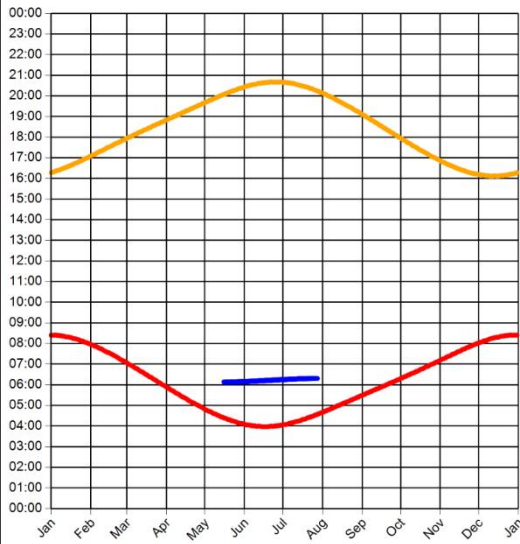


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 9 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 14.9°
 Max observer difference angle: 18.6°

Observer Location Sun azimuth range is 73.8° - 77° (yellow)

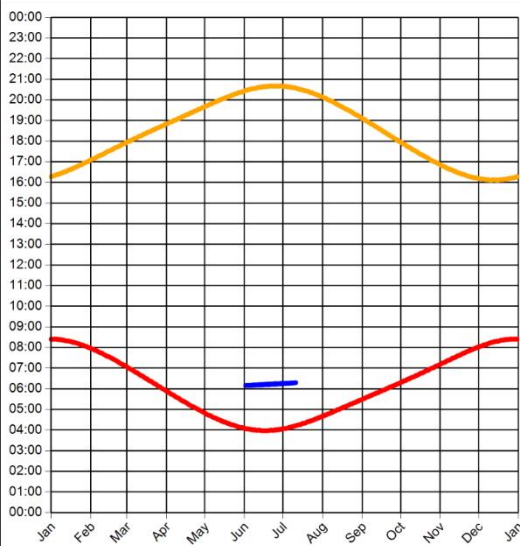


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 10 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 17.6°
 Max observer difference angle: 18.7°

Observer Location Sun azimuth range is 73.9° - 75° (yellow)

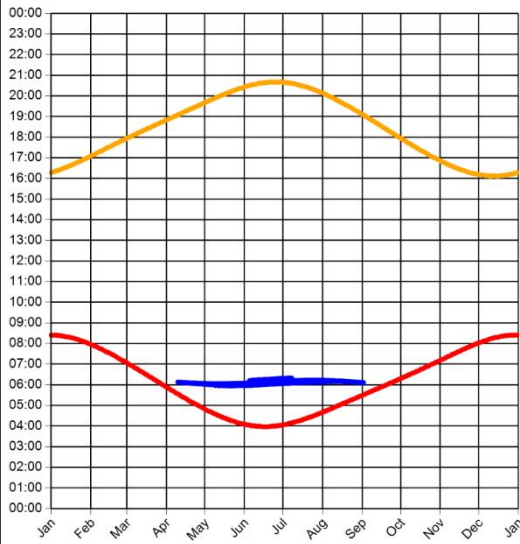


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 11 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 3°
Max observer difference angle: 19.8°

Observer Location Sun azimuth range is 71.8° - 83.1° (yellow)

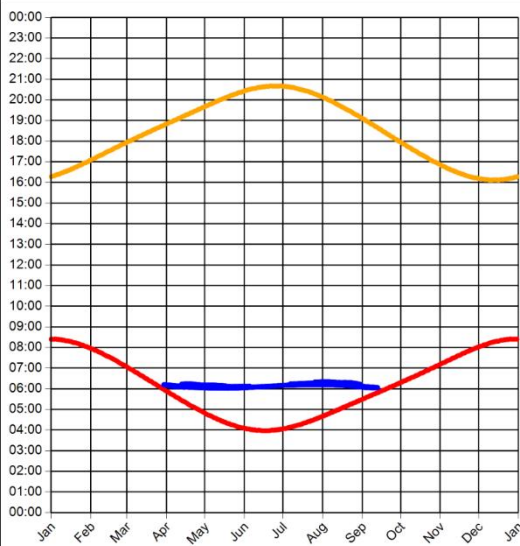


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 17 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0°
Max observer difference angle: 16.8°

Observer Location Sun azimuth range is 72.8° - 85.8° (yellow)

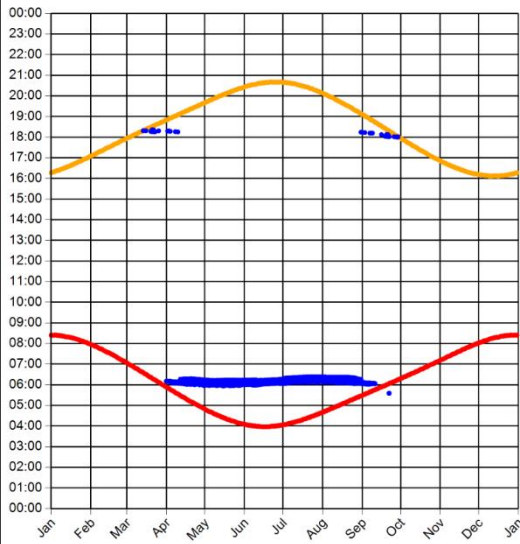


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 18 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.1°
Max observer difference angle: 19.5°

Observer Location

Sun azimuth ranges (yellow)

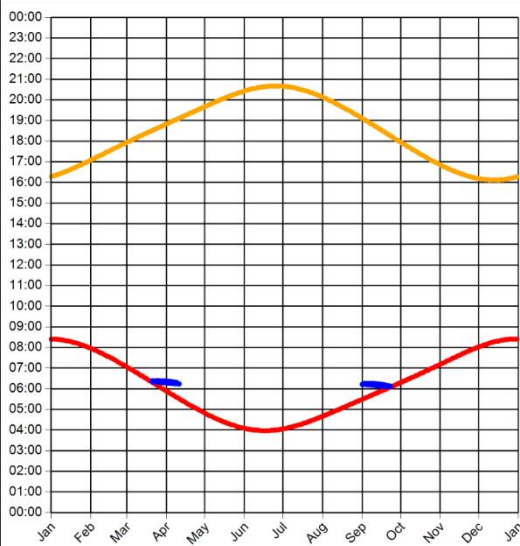


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 19 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.1°
Max observer difference angle: 7.1°

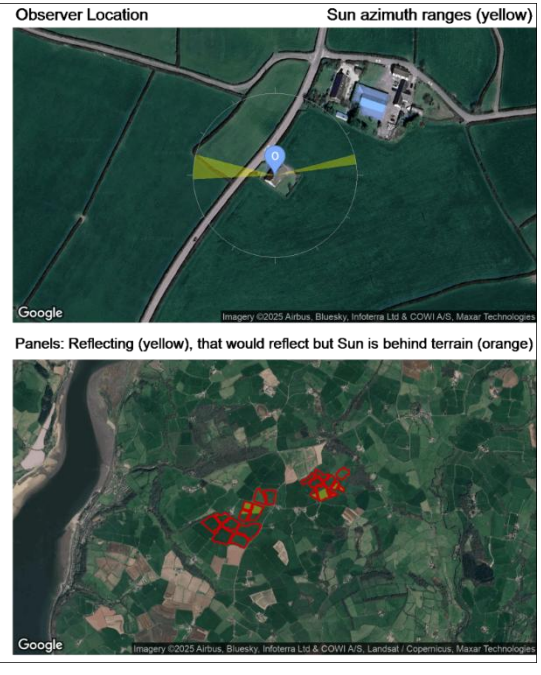
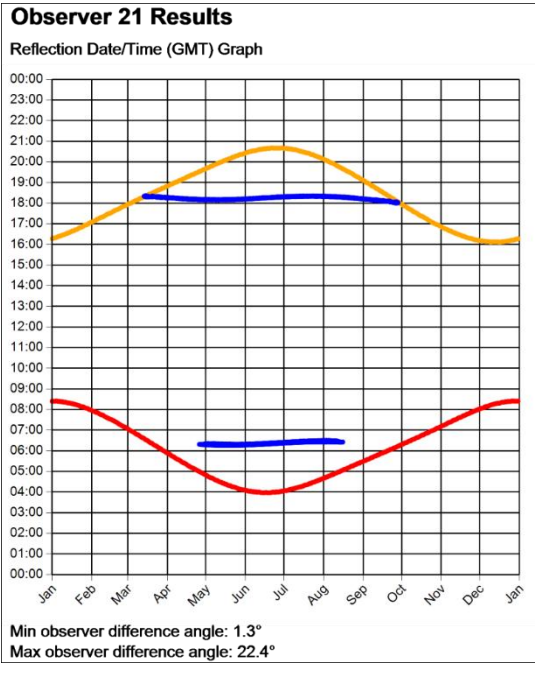
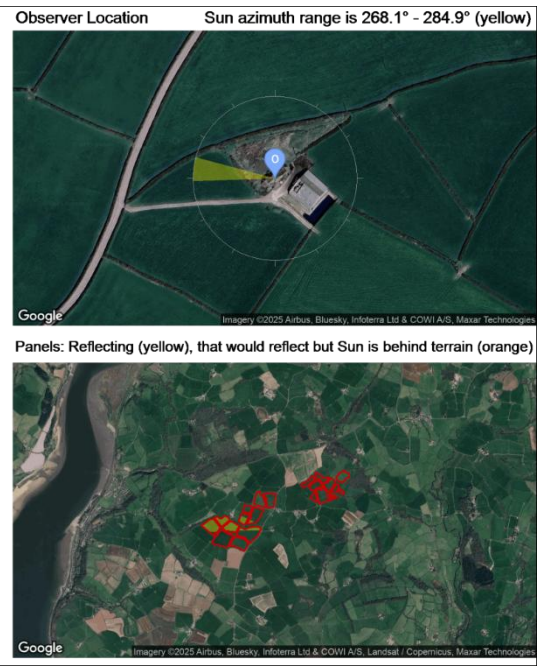
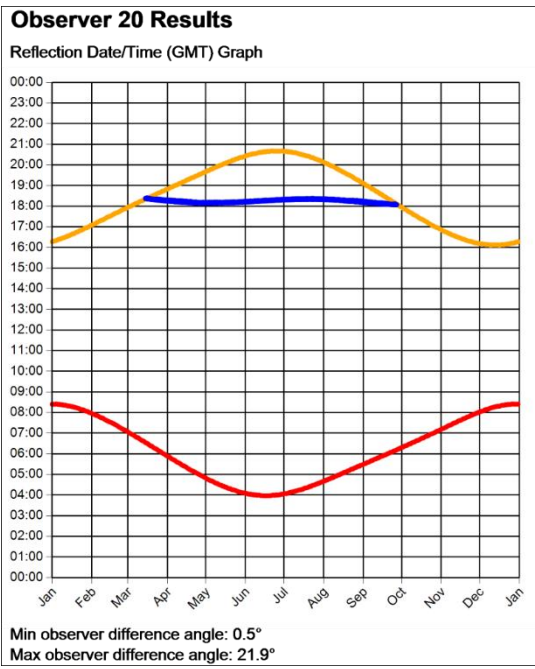
Observer Location

Sun azimuth range is 83.9° - 89.7° (yellow)



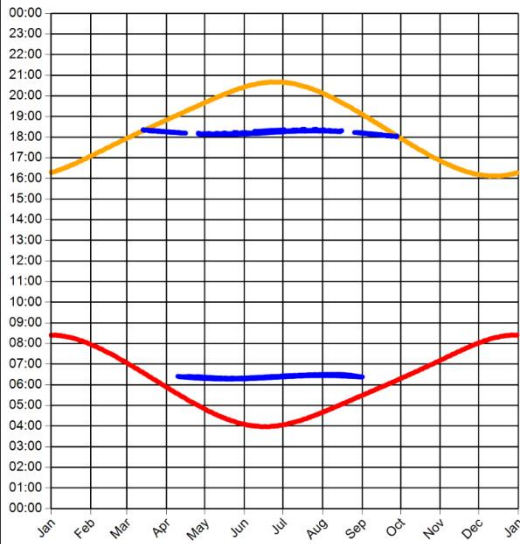
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)





Observer 22 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 1.1°
Max observer difference angle: 22.9°

Observer Location

Sun azimuth ranges (yellow)

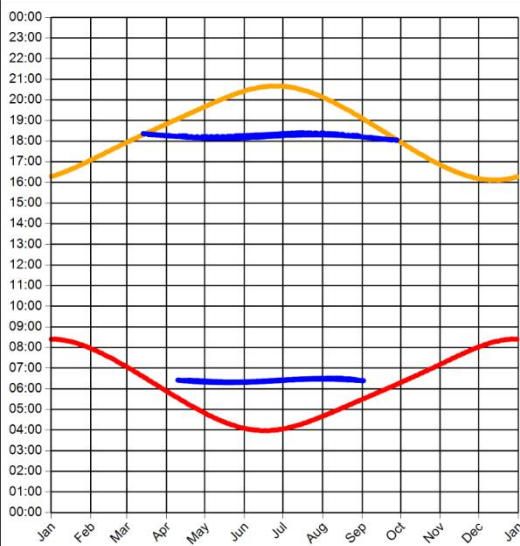


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 23 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 1°
Max observer difference angle: 23°

Observer Location

Sun azimuth ranges (yellow)

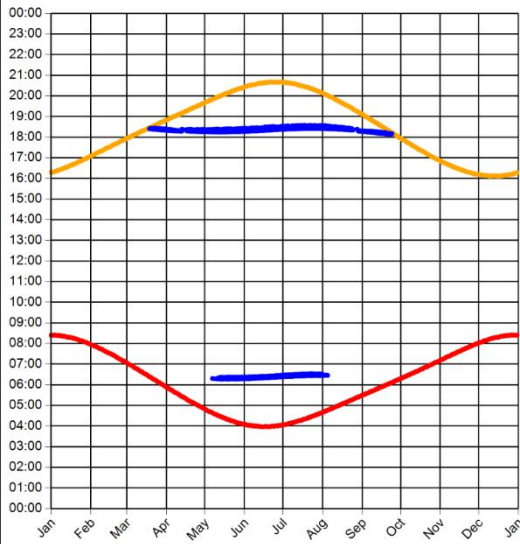


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 24 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.3°
 Max observer difference angle: 23.6°

Observer Location

Sun azimuth ranges (yellow)

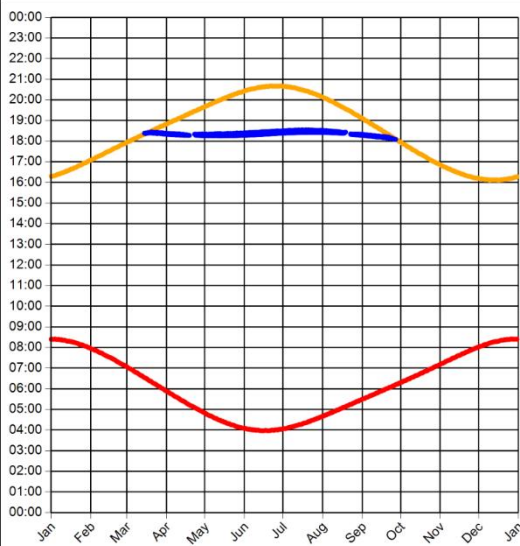


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 25 Results

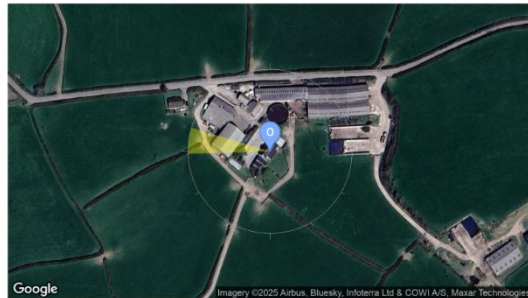
Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.3°
 Max observer difference angle: 19.6°

Observer Location

Sun azimuth range is 268.3° - 286.8° (yellow)

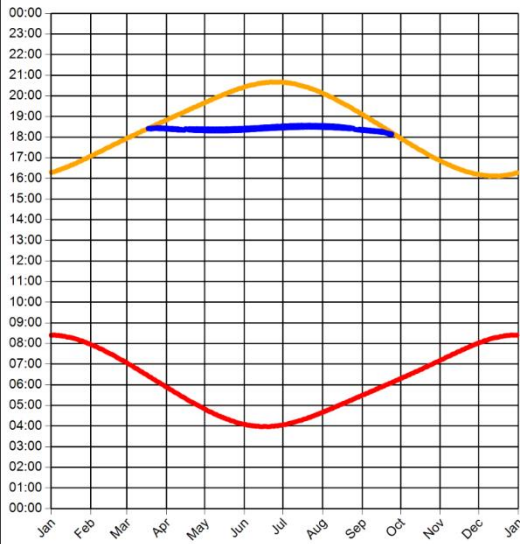


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 26 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.2°
Max observer difference angle: 18°

Observer Location Sun azimuth range is 269.5° - 287.2° (yellow)

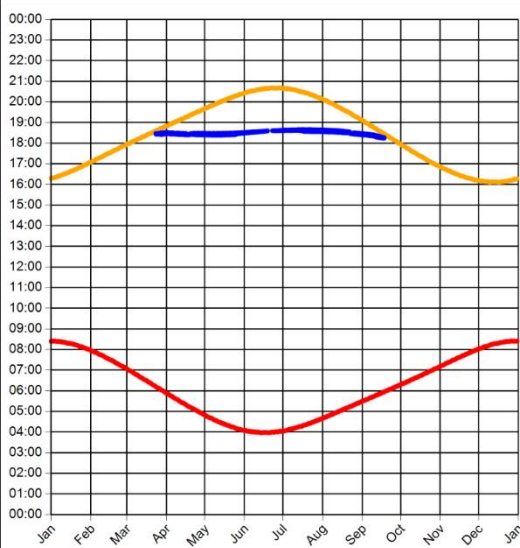


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 27 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.3°
Max observer difference angle: 13.8°

Observer Location Sun azimuth range is 271.7° - 288.1° (yellow)

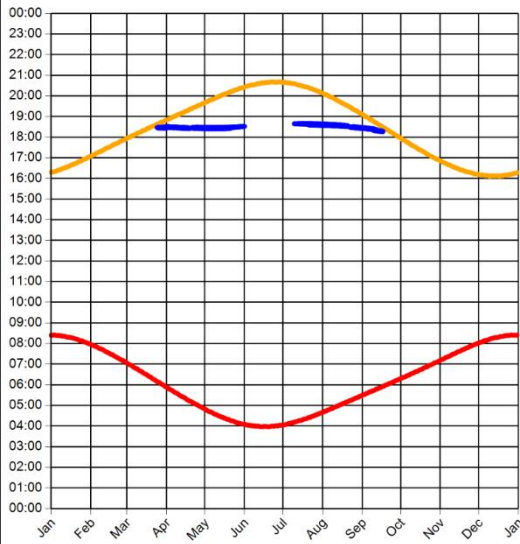


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 28 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.3°
Max observer difference angle: 12.8°

Observer Location Sun azimuth range is 272.1° - 287.2° (yellow)

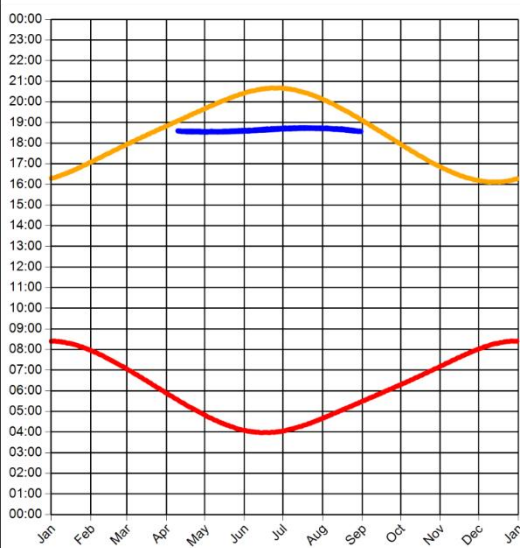


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 29 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.3°
Max observer difference angle: 12.5°

Observer Location Sun azimuth range is 278.4° - 289.3° (yellow)

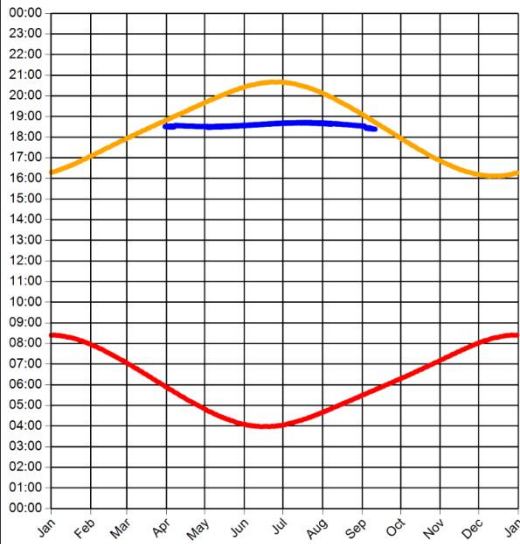


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 30 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.2°
 Max observer difference angle: 12.8°

Observer Location Sun azimuth range is 274.5° - 288.8° (yellow)

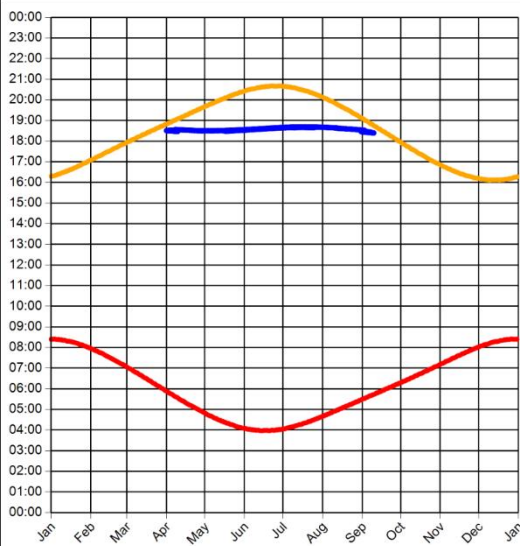


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 31 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.3°
 Max observer difference angle: 13.5°

Observer Location Sun azimuth range is 274.7° - 288.7° (yellow)

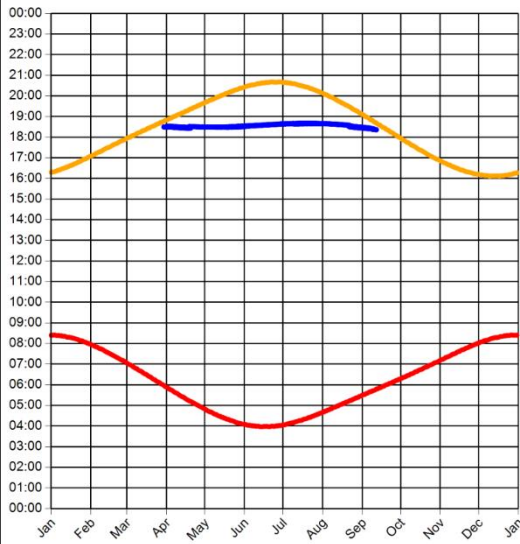


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 32 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.3°
 Max observer difference angle: 13.6°

Observer Location Sun azimuth range is 274° - 288.4° (yellow)

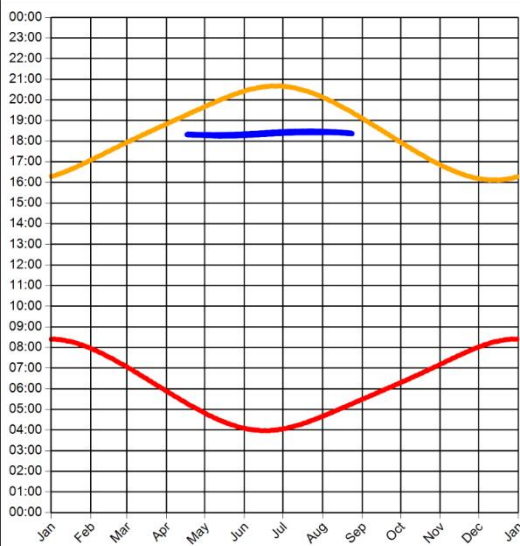


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 33 Results

Reflection Date/Time (GMT) Graph



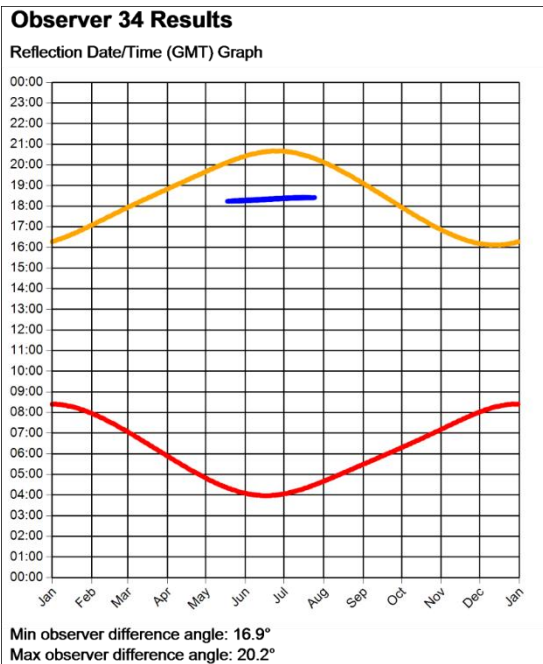
Min observer difference angle: 8.1°
 Max observer difference angle: 19.9°

Observer Location Sun azimuth range is 277.1° - 286.4° (yellow)



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





Observer Location Sun azimuth range is 282.6° - 285.6° (yellow)



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



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