PAGERPOWER
Urban & Renewables

Solar Photovoltaic Glint and Glare Study

Waterman Infrastructure & Environment Ltd

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EXECUTIVE SUMMARY

Report Purpose

The potential effects of glint and glare from a fixed ground-mounted solar photovoltaic development located in Llangunnor, Carmarthenshire, Wales. This assessment pertains to the potential impacts upon road safety and residential amenity.

Overall Conclusions

No significant impacts are predicted upon road safety and residential amenity. Mitigation is not recommended.

Guidance and Studies

There is no formal planning guidance for the assessment of solar reflections from solar panels towards roads and nearby dwellings. Pager Power has however produced guidance for glint and glare and solar photovoltaic developments, which was published in early 2017, with the fourth edition[1] published in 2022. This methodology defines a comprehensive process for determining the impact upon road safety and residential amenity.

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

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[1] Pager Power Glint and Glare Guidance, Fourth Edition, September 2022.

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

Assessment Conclusions – Road Safety

Solar reflections are geometrically possible towards a 1.1km section of Heol Llangynnwr Road. For a 1.0km section, screening in the form of existing vegetation is predicted to significantly obstruct views of reflecting panels such that solar reflections are not predicted to be experienced in practice. No impact is predicted, and mitigation is not required.

For the remaining 100m section, fleeting views within the primary field-of-view (50 degrees either side relative to the direction of travel) for elevated drivers are considered possible. Therefore, a low impact is predicted, and mitigation is not recommended.

Assessment Conclusions – Residential Amenity

Solar reflections are geometrically possible towards three of the 20 assessed dwelling receptors. Screening in the form of existing vegetation is predicted to significantly obstruct views of reflecting panels, such that solar reflections will not be experienced in practice. No impact is predicted, and mitigation is not required.

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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

This report contains the following:

- Solar development details;
- Explanation of glint and glare;
- Overview of relevant guidance and studies;
- Overview of Sun movement;
- Assessment methodology;
- Identification of receptors;
- Glint and glare assessment for identified receptors;
- Results discussion;
- High-level assessment of aviation activity;
- Overall conclusions and recommendations.

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[3] 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.

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

[3]These definitions are aligned with those presented within the National Policy Statement for Renewable Energy Infrastructure (EN-3) – published by the Department for Energy Security and Net Zero and the Federal Aviation Administration in the USA.

2 SOLAR DEVELOPMENT LOCATION AND DETAILS

2.1 Proposed Development Site Layout

Figure 1 below shows the site layout[4] for the proposed development.

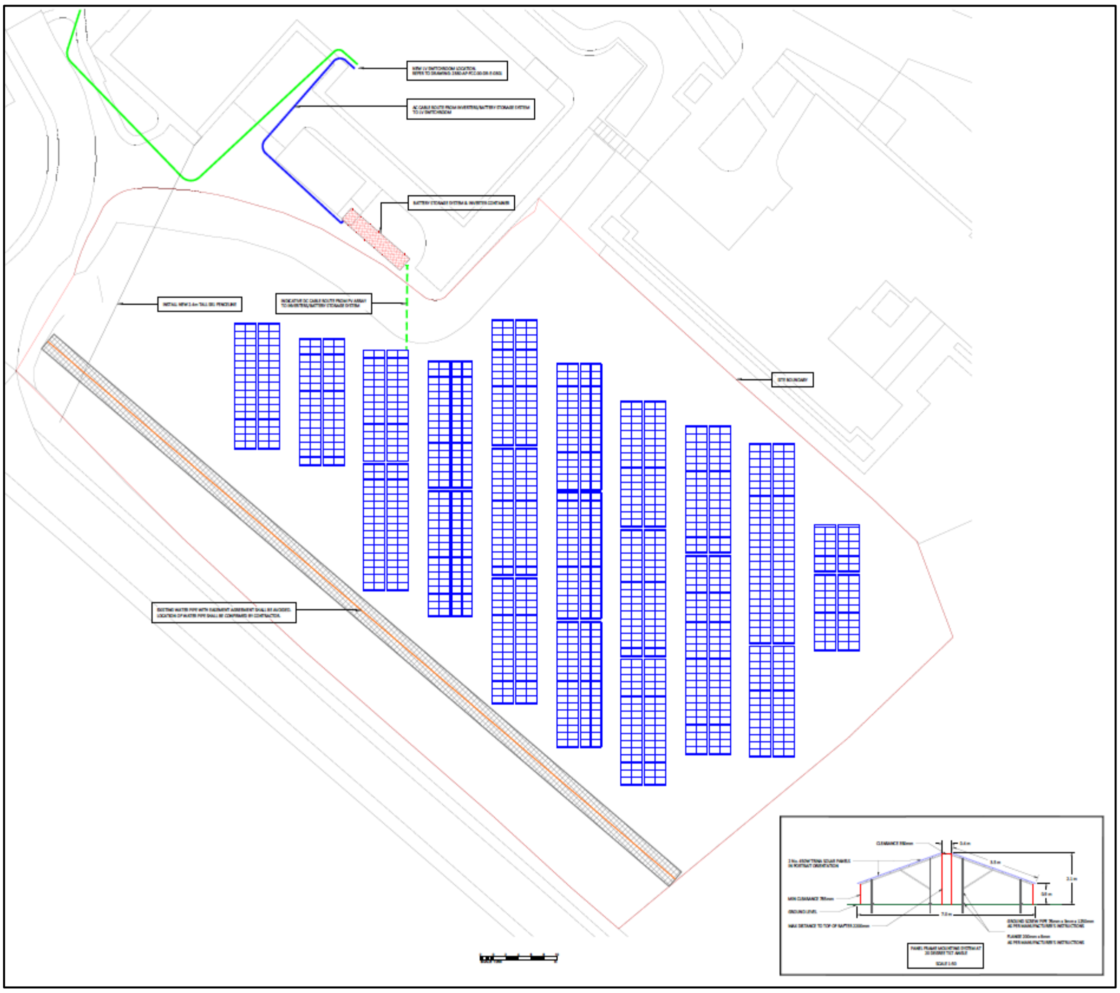

Figure 1 *Site layout*

[4] Source: 2380-AP-XX-XX-DR-E-0300 (cropped)

2.2 Reflector Areas

The bounding coordinates for the proposed development have been extrapolated from the site plans. The data can be found in Appendix G. Figure 2 below shows the assessed reflector areas that have been used for modelling purposes.

Figure 2 *Assessed reflector areas*

The Pager Power model has used a resolution of 1m for this assessment. This means that a geometric calculation is undertaken for each identified receptor every 1m 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. If a reflection is experienced from an assessed panel location, then it is likely that a reflection will be viewable from similarly located panels within the proposed solar development.

2.3 Solar Panel Technical Information

The technical information of the modelled solar panels used in this assessment is summarised below:

- Azimuth angles[5]: 90/270° (i.e. east- and west-facing panels);
- Elevation angle[6]: 17.5°;
- Assessed centre height[7]: 1.50m above ground level.

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[5] Direction the panels are facing relative to True North (0°)

[6] Pitch above horizontal. The midpoint between the lowest (15°) and highest (20°) angles above the horizontal has been modelled and is representative of the geometric results for either inclination angle. The overall assessment and conclusions are not expected to change.

[7] Relative to the lowest (0.80m) and highest (2.20m) points above ground level.

3 GLINT AND GLARE ASSESSMENT METHODOLOGY

3.1 Guidance and Studies

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

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

3.2 Background

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

3.3 Methodology

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

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

3.4 Assessment Methodology and Limitations

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

4.2 Ground Based Receptors Overview

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

The above parameters and industry experience over a significant number of glint and glare assessments undertaken, shows that a 1km assessment area from the proposed development is considered appropriate for glint and glare effects on road users and dwellings.

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

4.3 Road Receptors

4.3.1 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 a one or more carriageways with a maximum speed limit 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;
- 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 has also considered major national, national, and regional roads that:

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

Receptors are placed circa 100m apart. A height of 1.5 metres above ground level has been used to model the typical eye-level[8] of a road user.

4.3.2 Identified Road Receptors

Table 1 below summarises the assessed roads and receptors, illustrated in Figure 3 below.

Road	Assessed Section	Receptors
Heol Llangynnwr Road	2.20km	1 – 23

Table 1 *Assessed roads and modelled receptors*

Figure 3 *Assessed road receptors*

4.4 Dwelling Receptors

4.4.1 Dwelling Receptors Overview

The analysis has considered dwellings that:

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

[8] This fixed height for the road 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 for elevated drivers are also considered in the results discussion, where appropriate.

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.

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

An additional height of 1.8m above ground is used in the modelling to simulate the typical viewing height of an observer on the ground floor[9].

4.4.2 Identified Dwelling Receptors

The assessed dwelling receptors are shown in Figure 4 below. In total, 20 dwellings have been assessed.

Figure 4 *Overview of all dwelling receptors*

[9] Small changes to this height are not significant, and views above the ground floor are considered where appropriate

5 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

5.1 Overview

The following sub-sections summarise the results of the assessment:

- The key considerations for each receptor type. The criteria are determined by the assessment process for each receptor, which are set out in Appendix D;
- Geometric modelling results of the assessment based solely on bare-earth terrain i.e., without consideration of screening in the form of buildings, dwellings, (existing or proposed) vegetation, and/or terrain. The modelling output for receptors, shown in Appendix H, presents the precise predicted times and the reflecting panel areas;
- Whether a reflection will be experienced in practice. When determining the visibility of the reflecting panels for an observer, a conservative review of the available imagery, landscape strategy plan, google earth viewshed (high-level terrain analysis), and/or site photography (if available) is undertaken, whereby it is assumed views of the panels are possible if it cannot be reliably determined that existing and/or proposed screening will remove effects. Detailed screening analysis may be undertaken to determine visibility, where appropriate;
- The impact significance and any mitigation recommendations/requirements;
- The desk-based review of the available imagery, where appropriate.

Appendix H presents the results charts showing specific times and dates.

5.2 Assessment Results – Road Receptors

5.2.1 Key Considerations

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 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 originate from outside of a road user's primary horizontal field-of-view (FOV), defined as 50 degrees either side relative to 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 solar reflections are predicted to be experienced from inside of a road user's primary field-of-view, 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 (relevant to dual carriageways and motorways[10]);
- 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 a solar reflection is fleeting in nature. Small gap/s in screening, e.g. an access point to the site, may not result in a sustained reflection for a road user;
- The position of the Sun. Effects that coincide with direct sunlight appear less prominent than those that do not. The Sun is a far more significant source of light.

Following consideration of these relevant factors, where the solar reflection is not deemed significant, a low impact is predicted, and mitigation is not recommended. Where the solar reflection is deemed significant, 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 and Discussion

Table 2 on the following page presents the geometric modelling results and predicted impact significance for the assessed road receptors.

[10] There is typically a higher density of elevated drivers (such as HGVs) along dual carriageways and motorways compared to other types of road.

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening)	Mitigating Factors	Predicted Impact Classification
1 – 9	Solar reflections are geometrically possible **inside** a road user's field-of-view	Existing vegetation and intervening terrain predicted to significantly obstruct views	None	N/A	No impact
10 – 11	Solar reflections are geometrically possible **inside** a road user's field-of-view	Existing vegetation and intervening terrain predicted to obstruct views, with views for elevated drivers (i.e. HGVs) considered possible	**Inside** a road user's field-of-view	Views limited to elevated road users Solar reflections do not occur directly in front of a road user Effects will be fleeting in nature due to existing vegetation screening	Low impact
12 – 23	Solar reflections are not geometrically possible	N/A	None	N/A	No impact

Table 2 *Geometric modelling results and predicted impact - road receptors*

5.2.3 Desk-Based Review of Available Imagery

A desk-based review of the available imagery is presented in Figures 5 to 6 on the following pages:

- The cumulative reflecting panel areas are indicated by regions of yellow;
- Screening in the form of existing vegetation is outlined in blue;
- The point-of-view from a road receptor is indicated by a blue triangle with a white arrow indicating the direction of travel.

Figure 5 *Screening for road receptors 1 to 9*

Figure 6 *Screening for road receptors 10 to 11*

5.3 Assessment Results – Dwelling Receptors

5.3.1 Key Considerations

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:
  - Three 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 effects occur 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:

- 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;
- 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;
- 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.

Following consideration of these mitigating factors, where the solar reflection is not deemed significant, a low impact is predicted, and mitigation is not recommended. Where the solar reflection is deemed significant, 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 and Discussion

Table 3 on the following page presents the geometric modelling results and predicted impact significance for the assessed dwelling receptors.

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[11]	Mitigating Factors	Predicted Impact Classification
1 – 3	Solar reflections are geometrically possible for **less** than three months per year and **less** than 60 minutes on any given day	Existing vegetation is predicted to significantly obstruct views of reflecting panels	None	N/A	No impact
4 – 20	Solar reflections are not geometrically possible	N/A	None	N/A	No impact

Table 3 *Geometric modelling results and predicted impact - dwelling receptors*

5.3.3 Desk-Based Review of Available Imagery

A desk-based review of the available imagery is presented in Figures 7 to 8 on the following pages:

- The cumulative reflecting panel areas are indicated by regions of yellow;
- Screening in the form of existing vegetation is outlined in blue.

[11] 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 three months per year 2) and/or for more than 60 minutes on any given day.

Figure 7 *Screening for dwelling receptors 1 to 2*

Figure 8 *Screening for dwelling receptor 3*

APPENDIX A – OVERVIEW OF GLINT AND GLARE GUIDANCE

Overview

This section presents details regarding the relevant guidance and studies with respect to the considerations and effects of solar reflections from solar panels, known as 'Glint and Glare'.

This is not a comprehensive review of the data sources, rather it is intended to give an overview of the important parameters and considerations that have informed this assessment.

UK Planning Policy

Renewable and Low Carbon Energy

The National Planning Policy Framework under the planning practice guidance for Renewable and Low Carbon Energy[12] (specifically regarding the consideration of solar farms, paragraph 013) states:

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

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

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

…

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

…

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

[12] Renewable and low carbon energy, Ministry of Housing, Communities & Local Government, date: 14 August 2023, accessed on: 14/08/2023

National Policy Statement for Renewable Energy Infrastructure

The National Policy Statement for Renewable Energy Infrastructure (EN-3)[13] 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.[14] 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.

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[13] National Policy Statement for Renewable Energy Infrastructure (EN-3), Department for Energy Security & Net Zero, date: January 2024.

[14] *'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 document[15] which was produced due to the absence of existing guidance and a specific standardised assessment methodology.

[15] Solar Photovoltaic Development Glint and Glare Guidance, Fourth Edition, March 2022. Pager Power.

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

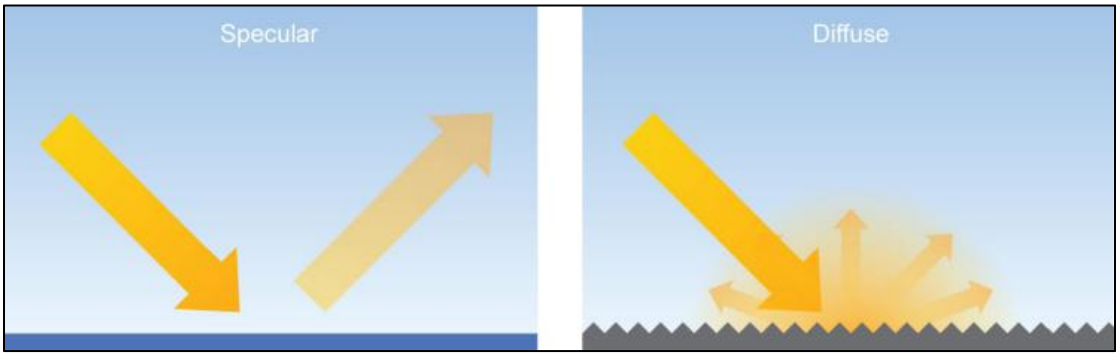
Overview

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

The guidelines presented are related to aviation safety. The results are applicable for the purpose of this analysis.

Reflection Type from Solar Panels

Based on the surface conditions reflections from light can be specular and diffuse. A specular reflection has a reflection characteristic similar to that of a mirror; a diffuse will reflect the incoming light and scatter it in many directions. The figure below, taken from the FAA guidance[16], 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

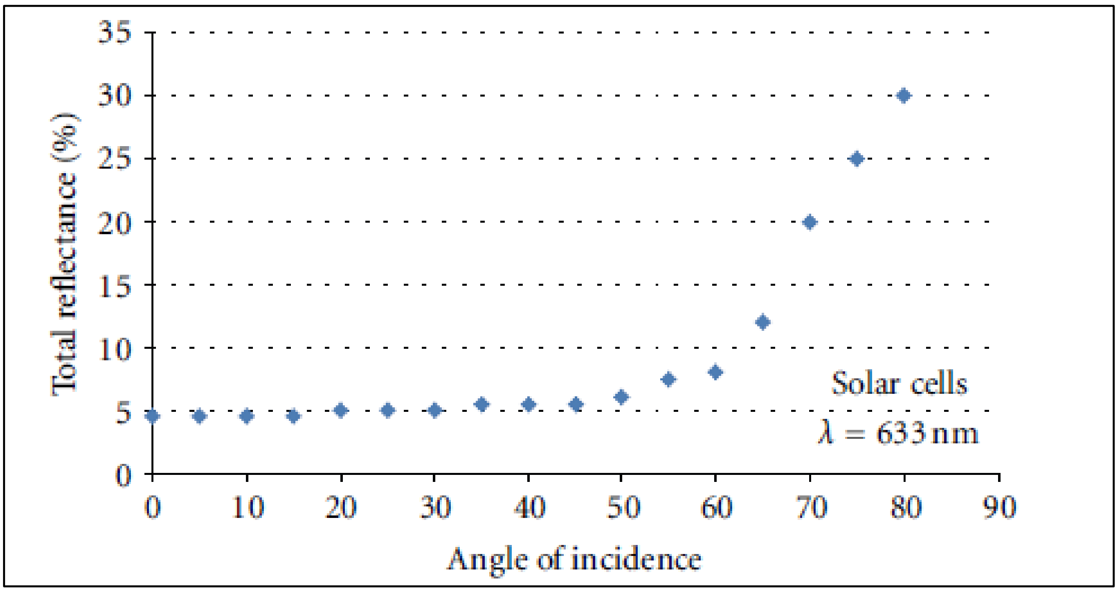
[16] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 08/12/2021.

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 Systems*[17]". 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.

[17] 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"[18]

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[19]
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).

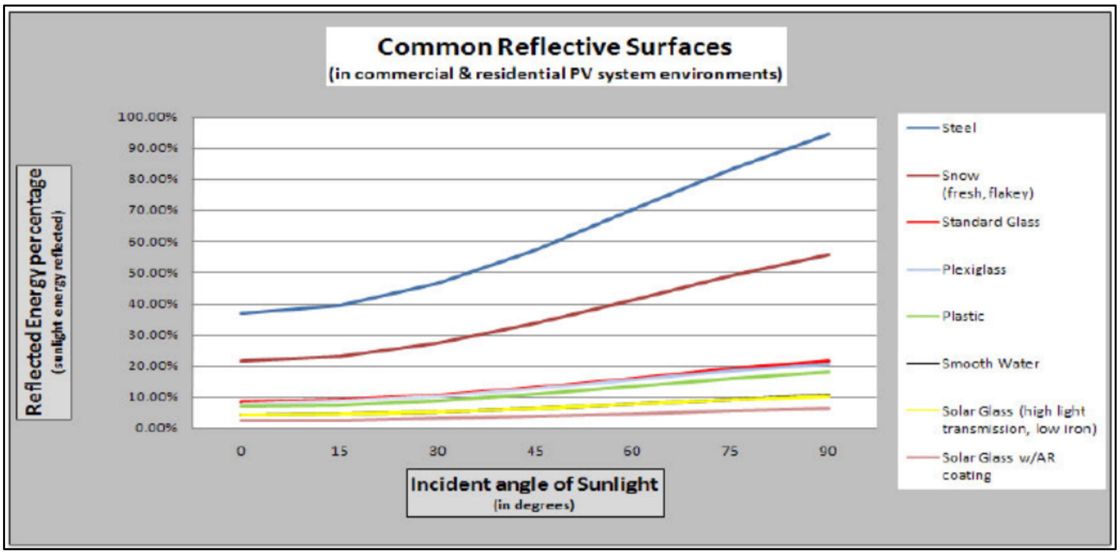
An important comparison in this table is the reflectivity compared to water which will produce a reflection of very similar intensity when compared to that from a solar panel. The study by Riley and Olsen study (2011) also concludes that still water has a very similar reflectivity to solar panels.

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

SunPower Technical Notification (2009)

SunPower published a technical notification[20] 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.

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

APPENDIX C – OVERVIEW OF SUN MOVEMENTS AND RELATIVE REFLECTIONS

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

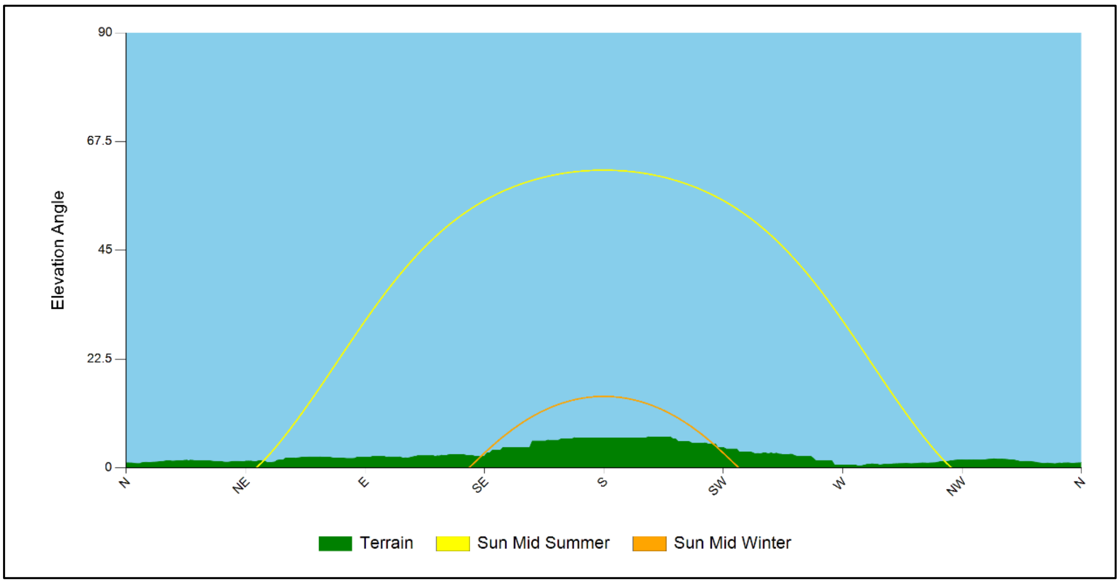
The Sun's position can be accurately calculated for a specific location. The following data being used for the calculation:

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

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

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

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



Terrain at the visible horizon and sun paths

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

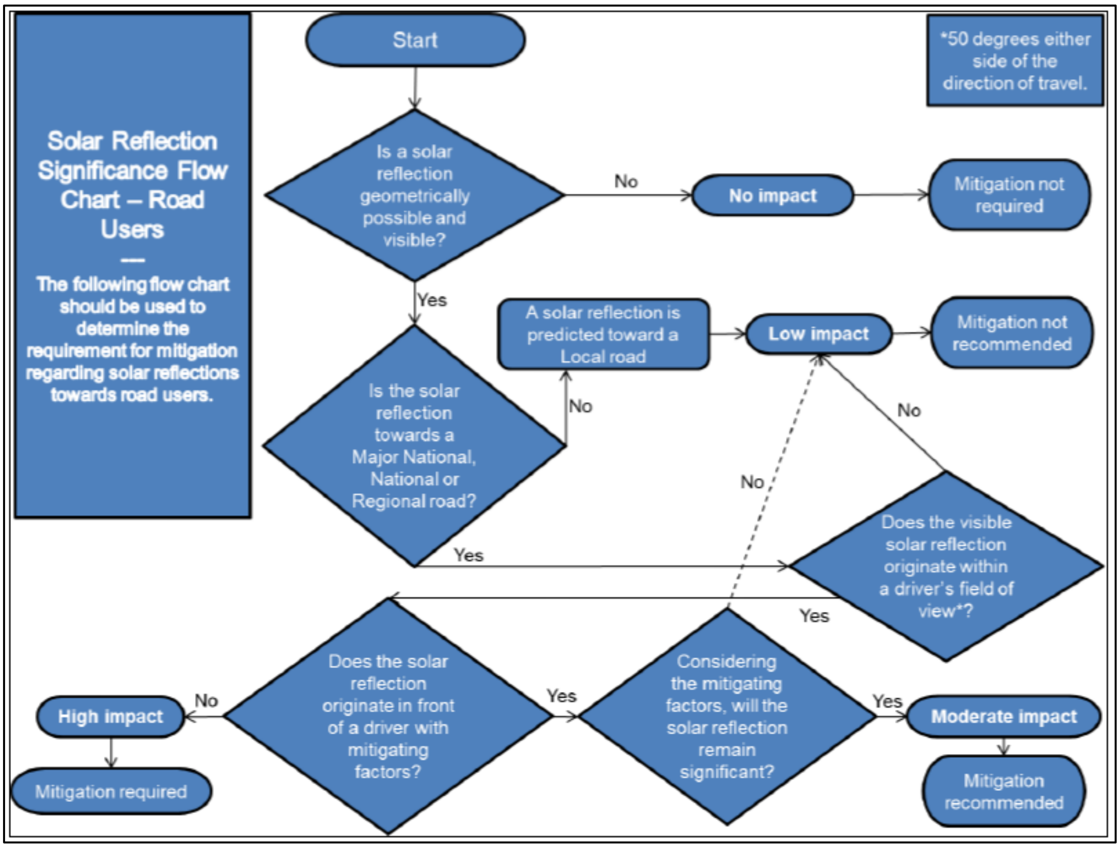
The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

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

Impact Significance Determination for Road Receptors

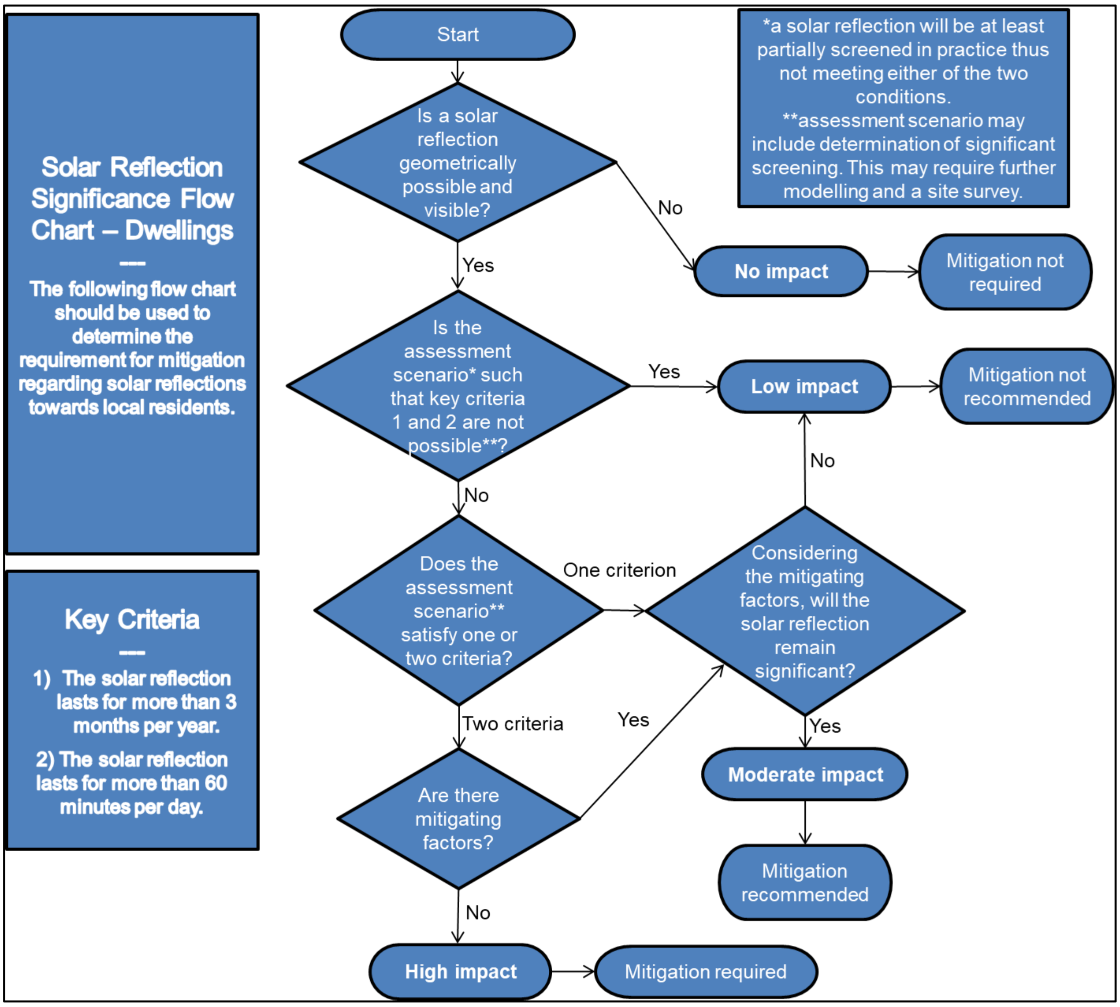
The flow chart presented below has been followed when determining the impact significance for road receptors.



Road receptor impact significance flow chart

Impact Significance Determination for Dwelling Receptors

The flow chart presented below has been followed when determining the impact significance for dwelling receptors.



Dwelling receptor impact significance flow chart

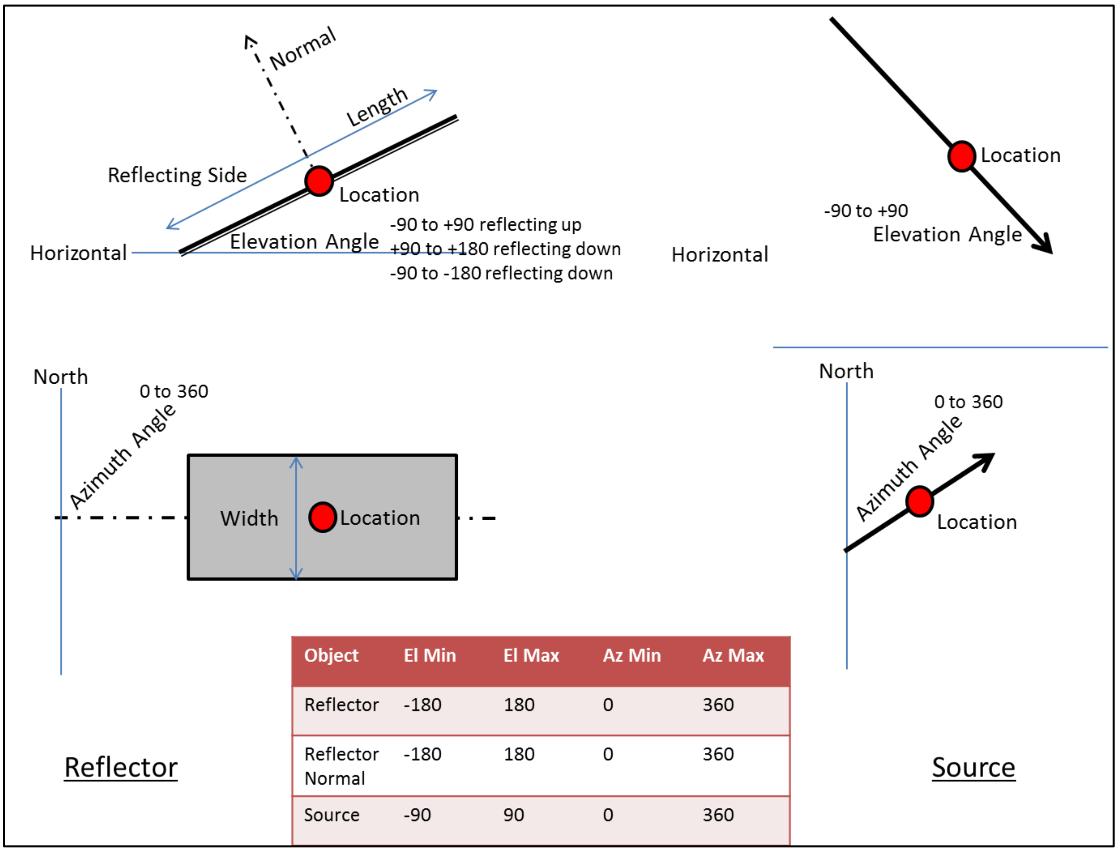
APPENDIX E – REFLECTION CALCULATIONS METHODOLOGY

Pager Power Methodology

The calculations are three dimensional and complex, accounting for:

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

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



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

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)[21].

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

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

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

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

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

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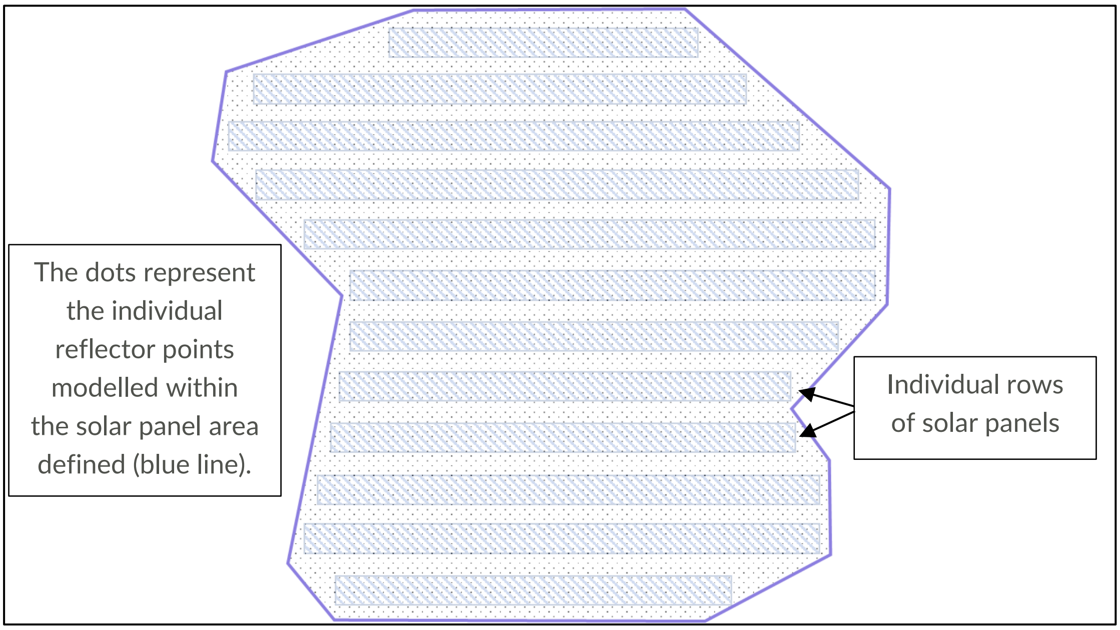
[21] UK only.



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

Overview

Coordinate data and terrain heights are ascertained from OSGB 36 and 50 DTM data.

Modelled Reflector Areas

Panel Area 1

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-4.28208	51.85002	3	-4.28203	51.85019
2	-4.28203	51.85002	4	-4.28208	51.85019

Panel Area 1

Panel Area 2

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-4.28203	51.85002	3	-4.28198	51.85019
2	-4.28198	51.85002	4	-4.28203	51.85019

Panel Area 2

Panel Area 3

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-4.28197	51.84998	3	-4.28191	51.85017
2	-4.28191	51.84998	4	-4.28196	51.85016

Panel Area 3

Panel Area 4

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-4.28191	51.84998	3	-4.28186	51.85017
2	-4.28186	51.84998	4	-4.28191	51.85017

Panel Area 4

Panel Area 5

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-4.28184	51.84991	3	-4.28180	51.85012
2	-4.28179	51.84991	4	-4.28184	51.85012

Panel Area 5

Panel Area 6

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-4.28179	51.84991	3	-4.28175	51.85012
2	-4.28174	51.84991	4	-4.28179	51.85012

Panel Area 6

Panel Area 7

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-4.28173	51.84986	3	-4.28167	51.85006
2	-4.28168	51.84986	4	-4.28173	51.85006

Panel Area 7

Panel Area 8

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-4.28167	51.84986	3	-4.28163	51.85006
2	-4.28163	51.84986	4	-4.28167	51.85006

Panel Area 8

Panel Area 9

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-4.28161	51.84981	3	-4.28156	51.85006
2	-4.28156	51.84980	4	-4.28161	51.85006

Panel Area 9

Panel Area 10

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-4.28155	51.84981	3	-4.28151	51.85006
2	-4.28151	51.84981	4	-4.28155	51.85006

Panel Area 10

Panel Area 11

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-4.28149	51.84976	3	-4.28144	51.85011
2	-4.28144	51.84976	4	-4.28149	51.85012

Panel Area 11

Panel Area 12

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-4.28144	51.84976	3	-4.28139	51.85011
2	-4.28139	51.84976	4	-4.28144	51.85011

Panel Area 12

Panel Area 13

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-4.28138	51.84970	3	-4.28133	51.85014
2	-4.28133	51.84970	4	-4.28137	51.85014

Panel Area 13

Panel Area 14

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-4.28132	51.84970	3	-4.28127	51.85014
2	-4.28127	51.84970	4	-4.28132	51.85014

Panel Area 14

Panel Area 15

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-4.28126	51.84968	3	-4.28121	51.85010

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
2	-4.28121	51.84968	4	-4.28126	51.85010

Panel Area 15

Panel Area 16

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-4.28120	51.84968	3	-4.28116	51.85010
2	-4.28116	51.84968	4	-4.28121	51.85010

Panel Area 16

Panel Area 17

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-4.28114	51.84966	3	-4.28109	51.85006
2	-4.28109	51.84966	4	-4.28114	51.85006

Panel Area 17

Panel Area 18

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-4.28109	51.84966	3	-4.28104	51.85005
2	-4.28104	51.84966	4	-4.28109	51.85005

Panel Area 18

Panel Area 19

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-4.28102	51.84968	3	-4.28097	51.84999
2	-4.28097	51.84967	4	-4.28102	51.84999

Panel Area 19

Panel Area 20

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-4.28097	51.84968	3	-4.28092	51.84999
2	-4.28092	51.84967	4	-4.28097	51.84999

Panel Area 20

Panel Area 21

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-4.28091	51.84973	3	-4.28086	51.84995
2	-4.28086	51.84973	4	-4.28090	51.84995

Panel Area 21

Panel Area 22

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-4.28085	51.84973	3	-4.28081	51.84995
2	-4.28081	51.84973	4	-4.28085	51.84995

Panel Area 22

Road Receptor Data

The road receptor data is presented in the table below. An additional 1.5m height has been added to the terrain elevation to account for the eye-level of an observer at these locations.

No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)	No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)
1	51.85355	-4.29520	10.03	13	51.84899	-4.28049	60.30
2	51.85330	-4.29380	12.60	14	51.84844	-4.27934	65.46
3	51.85307	-4.29239	13.90	15	51.84793	-4.27815	70.85
4	51.85288	-4.29097	19.15	16	51.84717	-4.27741	75.39
5	51.85298	-4.28953	24.11	17	51.84648	-4.27649	78.19
6	51.85305	-4.28808	29.92	18	51.84593	-4.27535	80.15
7	51.85271	-4.28676	32.43	19	51.84544	-4.27413	79.24
8	51.85199	-4.28590	37.78	20	51.84506	-4.27280	70.16
9	51.85130	-4.28496	43.87	21	51.84482	-4.27140	62.94
10	51.85071	-4.28386	48.71	22	51.84469	-4.26996	55.81
11	51.85013	-4.28275	52.10	23	51.84466	-4.26926	53.40

No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)	No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)
12	51.84956	-4.28162	58.08				

Road receptor data

Dwelling Receptor Data

The dwelling receptor data is presented in the table below. An additional 1.8m height has been added to the terrain elevation to account for the eye-level of an observer at these dwellings.

No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)	No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)
1	51.85163	-4.28468	42.96	11	51.84743	-4.28537	86.86
2	51.85128	-4.28525	42.45	12	51.84747	-4.28495	86.67
3	51.85019	-4.29113	62.75	13	51.84725	-4.28446	90.38
4	51.84989	-4.29095	66.13	14	51.84735	-4.28398	88.99
5	51.84954	-4.29092	71.30	15	51.84730	-4.28328	90.92
6	51.84913	-4.29094	78.34	16	51.84729	-4.28271	90.27
7	51.84873	-4.29093	83.54	17	51.84728	-4.28217	89.93
8	51.84866	-4.29063	81.85	18	51.84736	-4.28161	88.62
9	51.84856	-4.29031	81.60	19	51.84719	-4.28105	90.86
10	51.84745	-4.28594	85.14	20	51.84755	-4.27970	81.23

Dwelling receptor data

APPENDIX H – DETAILED MODELLING RESULTS

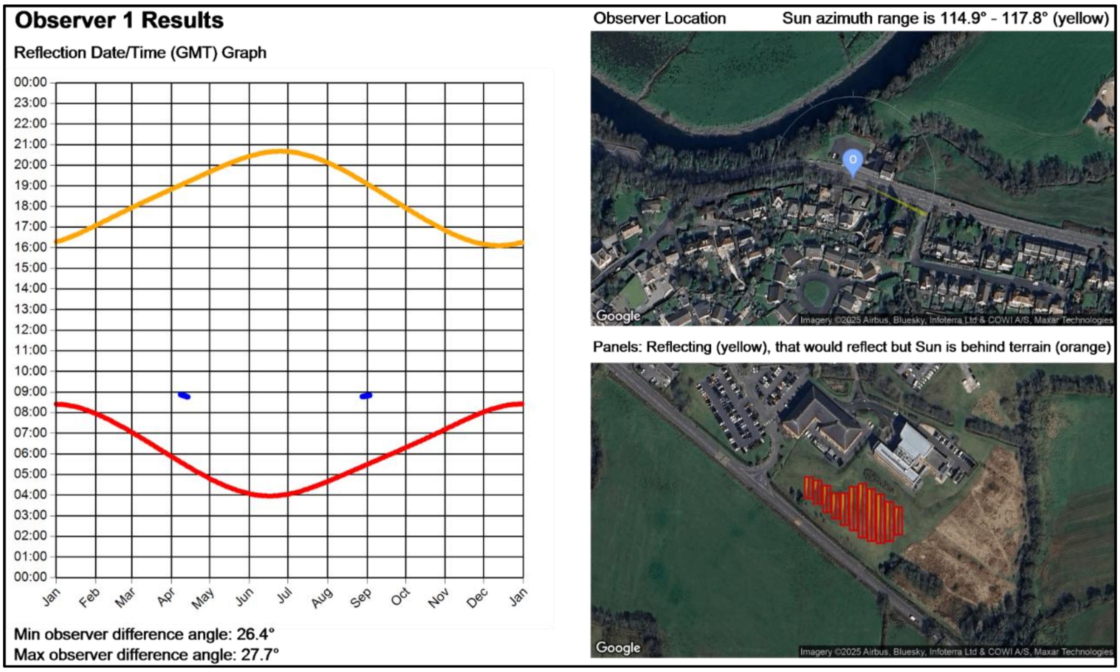
Overview

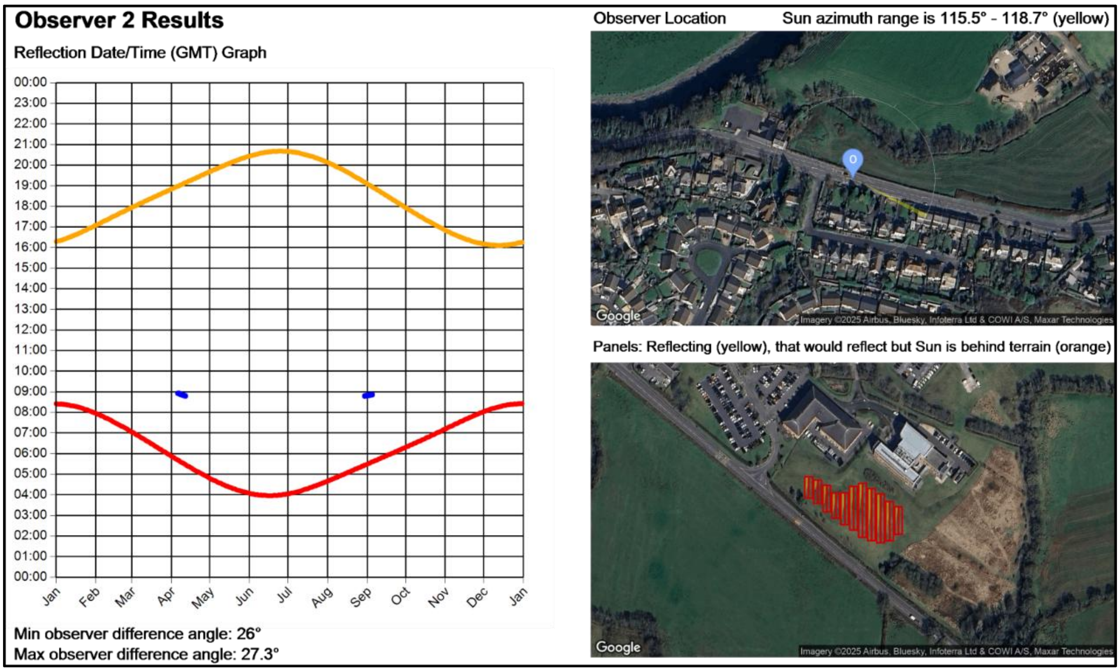
The Pager Power charts for the receptors are shown below and on the following pages. Each chart shows:

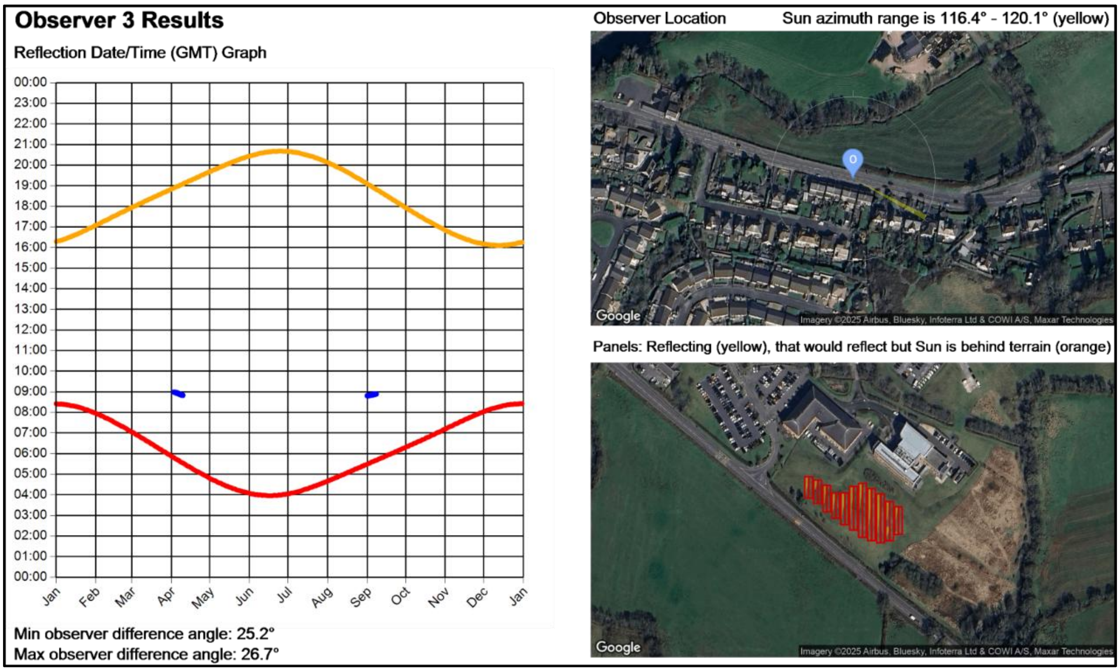
- The receptor (observer) location – top right image. This also shows the azimuth range of the Sun itself at times when reflections are possible. If sunlight is experienced from the same direction as the reflecting panels, the overall impact of the reflection is reduced as discussed within the body of the report;
- The reflecting panels – bottom right image. The reflecting area is shown in yellow. 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 for all receptors where a solar reflection is geometrically possible are presented.

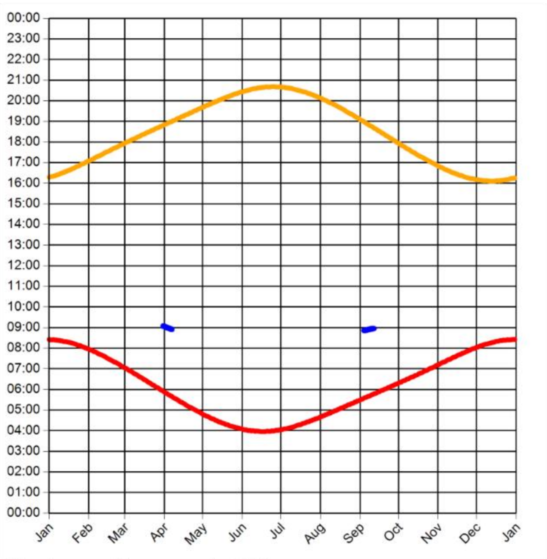



Observer 2 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 26°
Max observer difference angle: 27.3°
Observer Location
Sun azimuth range is 115.5° - 118.7° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 3 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 25.2°
Max observer difference angle: 26.7°
Observer Location
Sun azimuth range is 116.4° - 120.1° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

Observer 4 Results

Reflection Date/Time (GMT) Graph



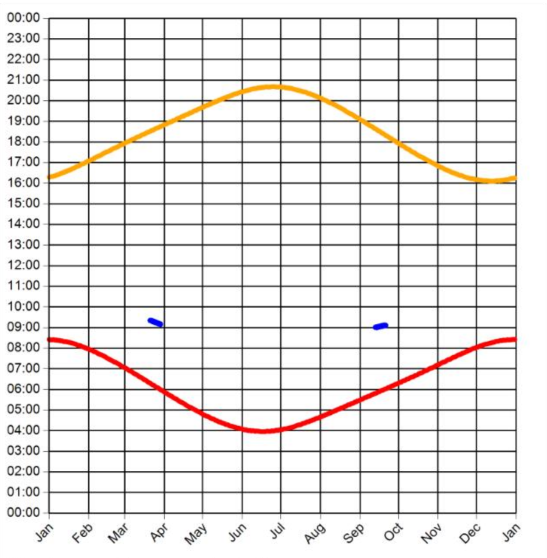
Min observer difference angle: 24.7°
Max observer difference angle: 26.4°

Observer Location — Sun azimuth range is 118.1° - 122.1° (yellow)

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

Observer 5 Results

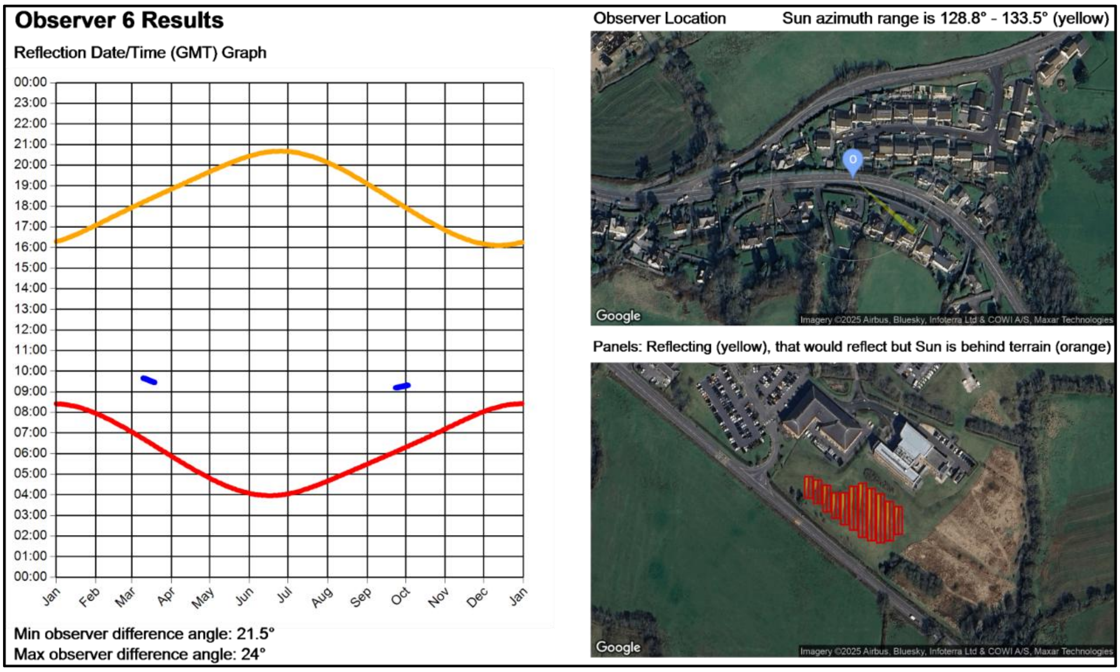
Reflection Date/Time (GMT) Graph

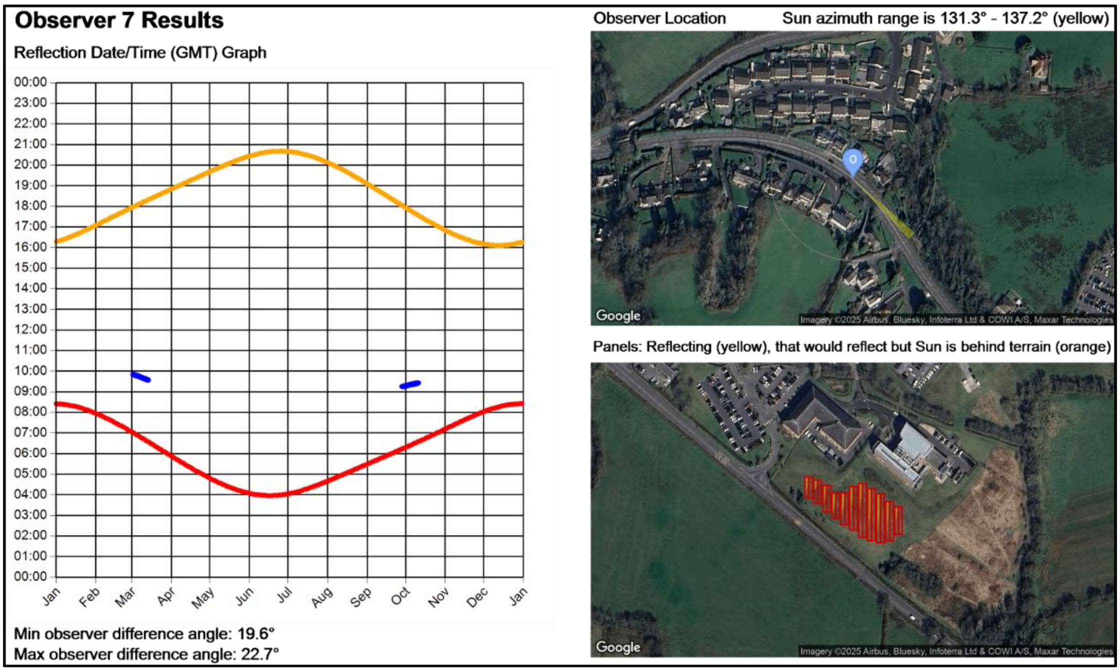


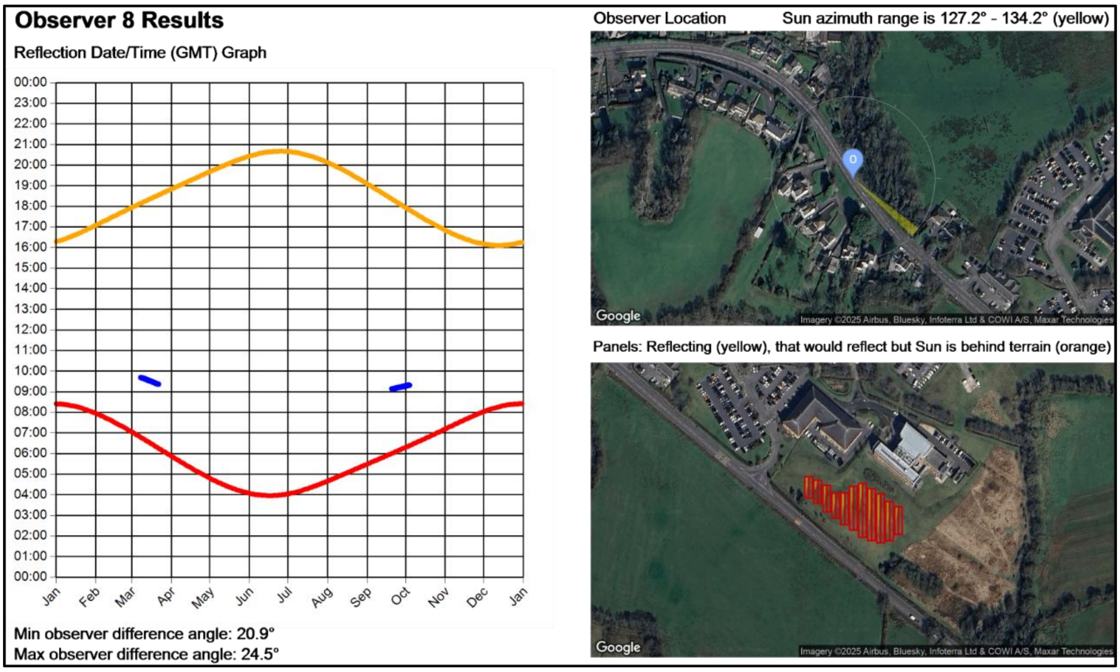
Min observer difference angle: 23.3°
Max observer difference angle: 25.3°

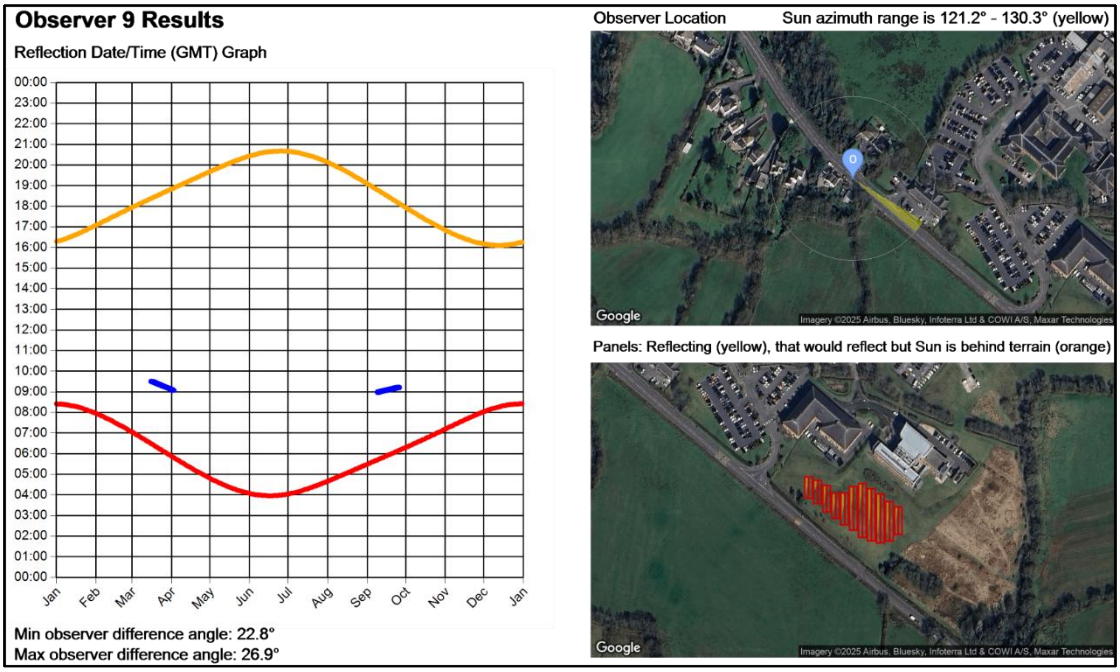
Observer Location — Sun azimuth range is 123.1° - 127.2° (yellow)

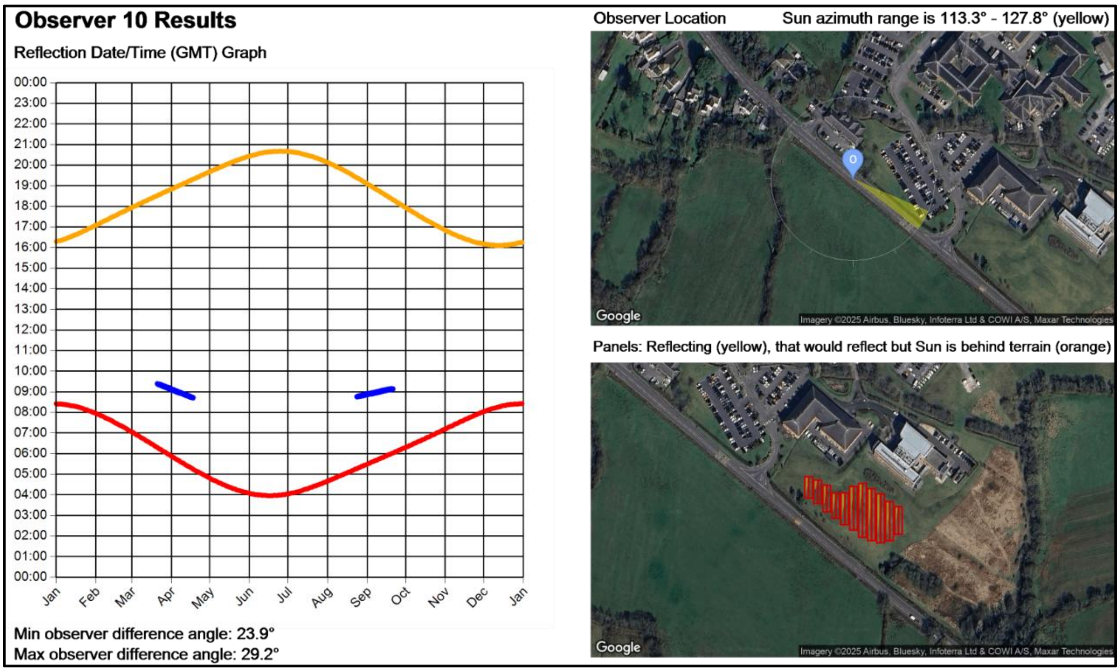
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer 6 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 21.5°
Max observer difference angle: 24°
Observer Location
Sun azimuth range is 128.8° - 133.5° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 7 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 19.6°
Max observer difference angle: 22.7°
Observer Location
Sun azimuth range is 131.3° - 137.2° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 8 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 20.9°
Max observer difference angle: 24.5°
Observer Location
Sun azimuth range is 127.2° - 134.2° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 9 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 22.8°
Max observer difference angle: 26.9°
Observer Location
Sun azimuth range is 121.2° - 130.3° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 10 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 23.9°
Max observer difference angle: 29.2°
Observer Location
Sun azimuth range is 113.3° - 127.8° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
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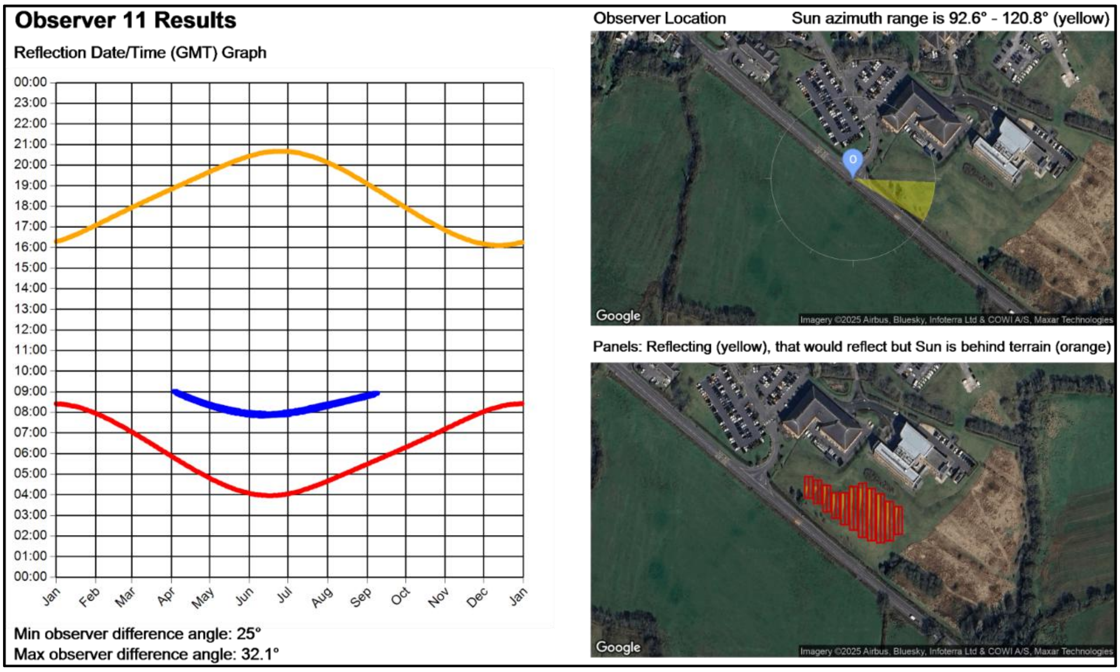
Observer 11 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 25°
Max observer difference angle: 32.1°
Observer Location
Sun azimuth range is 92.6° - 120.8° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
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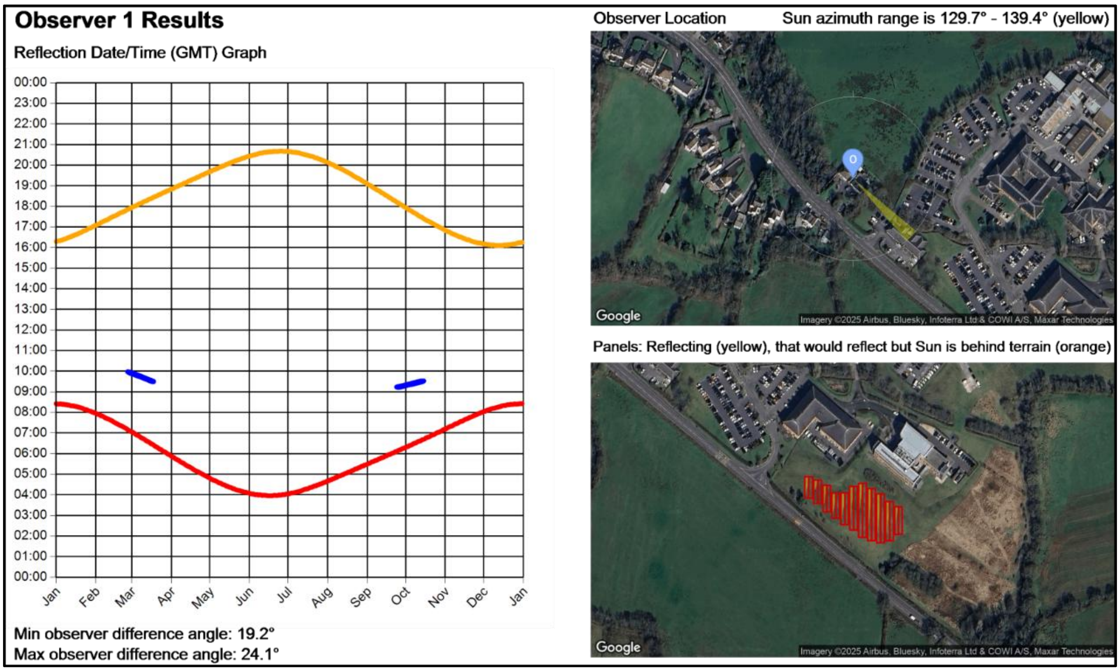
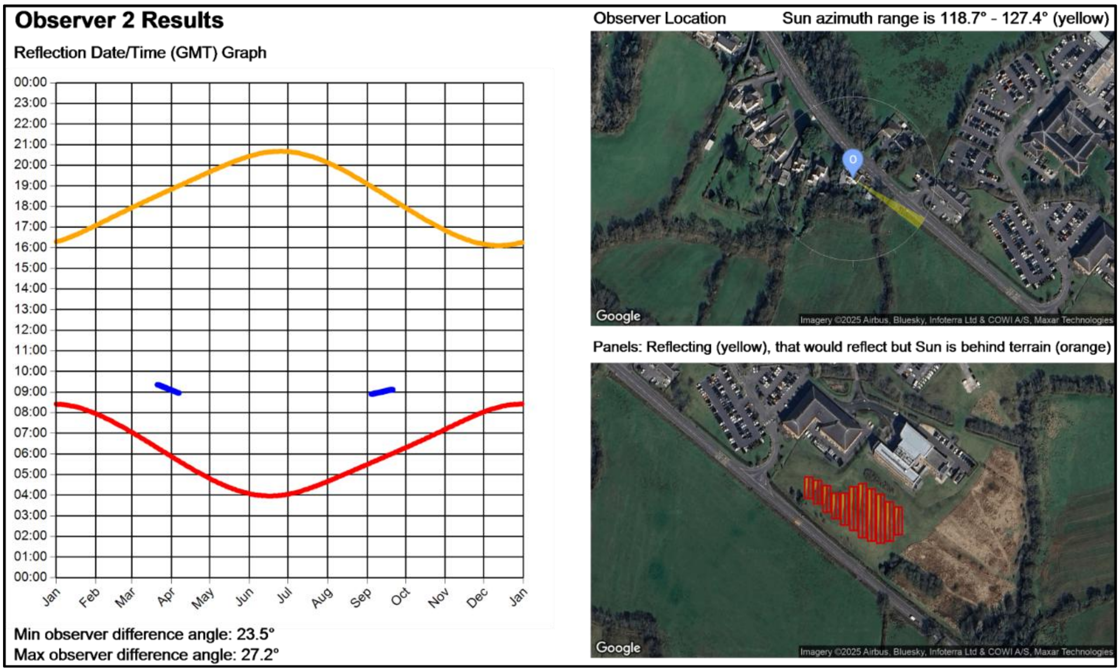
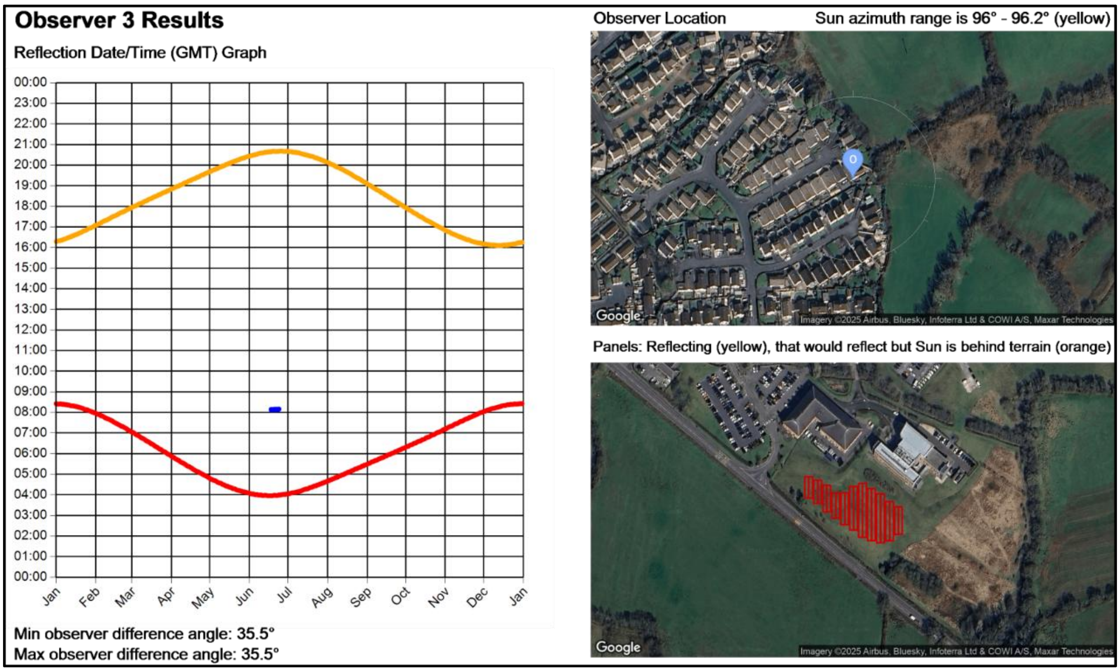
Dwelling Receptors

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






Observer 3 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 35.5°
Max observer difference angle: 35.5°
Observer Location
Sun azimuth range is 96° - 96.2° (yellow)
Google
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Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
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