

Solar Photovoltaic Glint and Glare Study

Studley (Atworth) Solar Farm

Melksham Calne Green Limited

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PLANNING SOLUTIONS FOR:

- Solar
- Defence
- Airports
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- Wind
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EXECUTIVE SUMMARY

Report Purpose

Pager Power has been retained to assess the potential effects of glint and glare from a fixed ground-mounted solar photovoltaic development located south of Atworth, Wiltshire, UK. This assessment pertains to the potential impacts upon road safety, residential amenity and aviation activity associated with South Wraxall Private Airfield and Craymarsh Farm Airfield.

Overall Conclusions

No significant impacts are predicted upon road safety, residential amenity and aviation activity associated with South Wraxall Private Airfield and Craymarsh Farm Airfield. Mitigation is not recommended.

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. 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 edition¹ published in 2022. This methodology defines a comprehensive process for determining the impact upon road safety, residential amenity, and aviation activity.

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. For aviation activity, where a solar reflection is predicted, solar intensity calculations are undertaken where appropriate in line with the Sandia National Laboratories' FAA methodology². 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 steel³.

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

² Formerly mandatory for on-airfield solar developments in the USA under the FAA's interim policy, superseded in 2021 with a policy that effectively requires individual airports to sign off on their on-airfield development as they see fit.

³ SunPower, 2009, SunPower Solar Module Glare and Reflectance (appendix to Solargen Energy, 2010).

Assessment Conclusions – Road Safety

The A365 is located within 1km of the proposed development; however, it is located north of the panels and therefore solar reflections would not be geometrically possible.

The remaining roads within 1km of the proposed development are considered local roads where traffic densities are likely to be relatively low. Assessment is not recommended for local roads as any solar reflections from the proposed development that are experienced by a road user would be considered low impact in accordance with the guidance presented in Appendix D.

No significant impacts upon road users are predicted.

Assessment Conclusions – Residential Amenity

Solar reflections are geometrically possible towards 21 of the 57 assessed dwellings.

For eight dwellings, solar reflection are geometrically possible for less than three months of the year and less than 60 minutes on any given day.

For seven of these dwellings, screening in the form of existing vegetation is predicted partially obstruct the views of reflecting panels such that views may still be possible. A low impact is predicted for these dwellings and mitigation is not recommended.

For one dwelling, screening in form of existing vegetation and terrain has been identified which would significantly obstruct views of reflecting panels, such that views are not possible in practice. No impact is predicted, and mitigation is not required.

For 13 dwellings, the solar reflections are predicted to occur for more than three months of the year but less than 60 minutes on any given day.

For 12 of these dwellings, partial screening in the form of existing vegetation and/or buildings has been identified for the dwellings. Mitigating factors in the form of reflections coinciding with direct sunlight, and a significant separation distance between the dwelling and reflecting panels which reduce the significance of reflections. A low impact is predicted, and mitigation is not recommended.

For the remaining dwelling, partial screening in the form of existing vegetation has been identified, which decreases the duration of the effects. A low impact is predicted, and mitigation is not recommended.

Assessment Conclusions – High-Level Aviation

The following has been concluded for South Wraxall Private Airfield and Craymarsh Farm Airfield with regard to the proposed development:

- Solar reflections originating from the proposed development towards the 1-mile splayed approach paths for runway threshold 11 and 18/36 will be outside a pilot's primary horizontal field-of-view (50 degrees either side of the direction of travel), and would therefore not be considered significant considering the associated guidance (Appendix D) and industry best practice pertaining to the approach paths;
- Solar reflections towards the 1-mile splayed approach path for runway threshold 29 and the final sections of circuits / joins for runway thresholds for 11/29 and 18/36 will have

glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (Appendix D) and industry best practices pertaining to approach paths, which states this level of glare is acceptable, and therefore it can be reliably concluded that this level of glare is also acceptable for the visual circuits.

No significant impacts upon aviation activity associated with South Wraxall Private Airfield and Craymarsh Farm Airfield are predicted, and mitigation is not required. Detailed 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 60 countries within Europe, Africa, America, Asia, and Australasia.

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

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

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

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

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

1 INTRODUCTION

1.1 Overview

Pager Power has been retained to assess the potential effects of glint and glare from a fixed ground-mounted solar photovoltaic development located at Atworth, Wiltshire, UK. This assessment pertains to the potential impacts upon road safety, residential amenity and aviation activity associated with South Wraxall Private Airfield and Craymarsh Farm Airfield.

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;
- Overall conclusions and recommendations.

1.2 Pager Power's Experience

Pager Power has undertaken over 1,500 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 definition⁴ 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.

⁴These 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 in January 2024 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 layout⁵ for the proposed development, the proposed locations for solar panels are indicated by blue and pink rectangles.

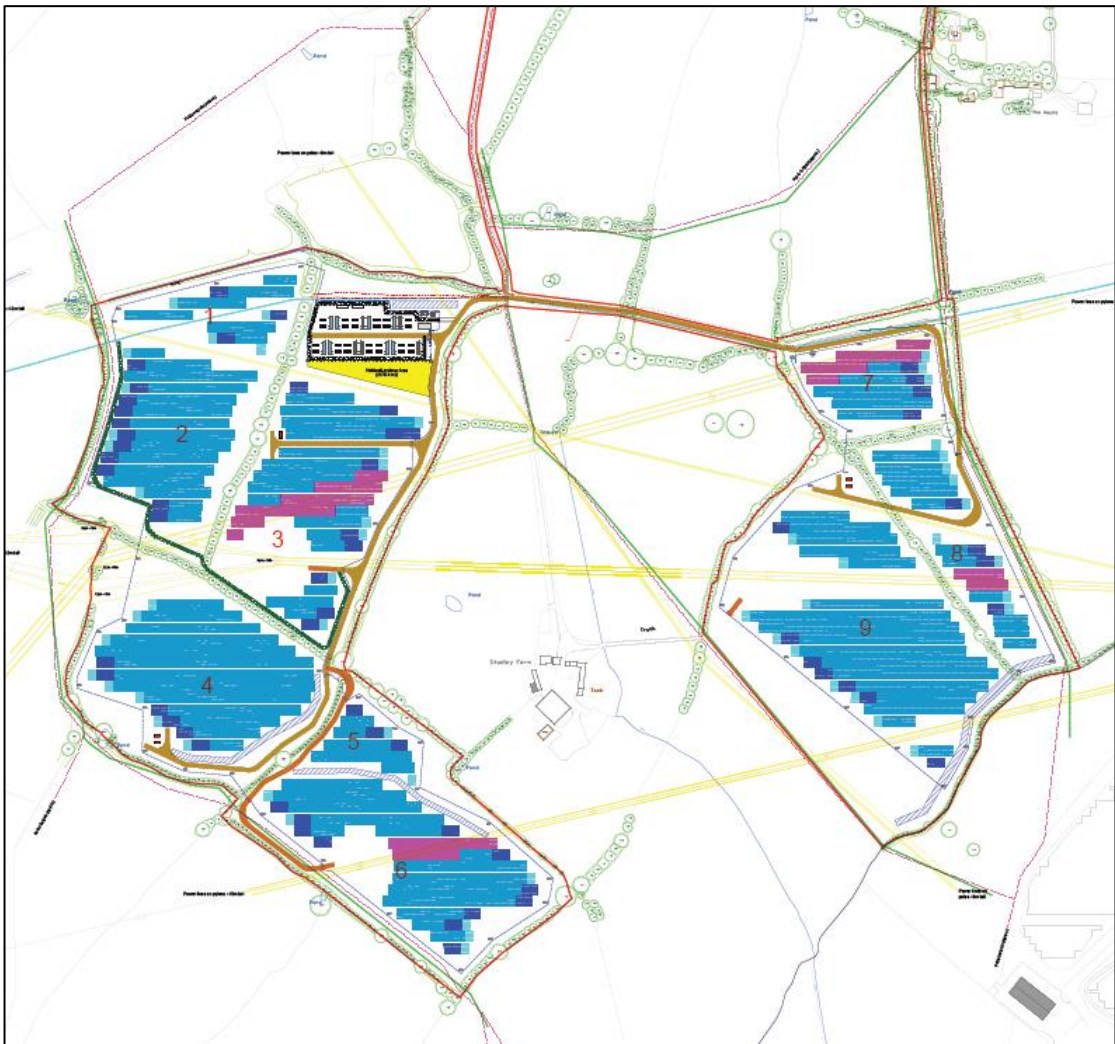


Figure 1 Proposed Site layout

⁵ Source: GB-MEL01&CLD104_R03_OVERALL SITE LAYOUT.pdf (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 has been used for modelling purposes.



Figure 2 Assessed reflector areas

The Pager Power model has used a resolution of 10m for this assessment. This means that a geometric calculation is undertaken for each identified receptor 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. 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 information⁶ of the modelled solar panels used in this assessment is summarised below. The centre of the solar panel has been used as the assessed height in metres above ground level (agl).

- Azimuth angle⁷: 180°;
- Elevation angle⁸: 10°;
- Assessed centre height⁹: 1.645m above ground level.

⁶ Confirmed via GB-MEL01&CLD104_R03_OVERALL SITE LAYOUT.pdf.

⁷ Direction the panels are facing clockwise from True North (0°).

⁸ Tilt angle relative to horizontal.

⁹ Relative to the lowest (0.8m) and highest (2.49m).

3 GLINT AND GLARE ASSESSMENT METHODOLOGY

3.1 Overview

The following sub-sections provide a general overview with respect to the guidance, studies and methodology which inform this report. Pager Power has also produced its own Glint and Glare Guidance which draws on assessment experience, consultation, and industry expertise.

3.2 Guidance and Studies

Appendix 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 steel¹⁰.

3.3 Background

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

3.4 Methodology

3.4.1 Pager Power's Methodology

The glint and glare assessment methodology has been derived from the information provided to Pager Power through consultation with stakeholders and by reviewing the available guidance, 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;

¹⁰ SunPower, 2009, SunPower Solar Module Glare and Reflectance (appendix to Solargen Energy, 2010).

- 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.

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.

3.5 Assessment Methodology and Limitations

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

4 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.

A 1km assessment area is considered appropriate for glint and glare effects on ground-based receptors (road users and dwellings), bounded by the orange (semicircle in Figure 3 on the following page) outlined area. Receptors within this distance are identified based on mapping and aerial photography of the region. Receptors to the north of the development are not included because solar reflections would not be geometrically possible towards the north when the azimuth angle is considered.

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.



Figure 3 1km assessment area

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.

The initial review of the aerial and Streetview imagery of Coombe Lane shows that it is a local road. The remaining roads surrounding the proposed development are deemed local roads where traffic densities are likely to be relatively low. Any solar reflections from the proposed

development experienced by a road user along a local road would be considered low impact in the worst case in accordance with glint and glare guidance presented in Appendix D.

The A365 is located within 1km of the proposed development; however, it is located north of the panels and therefore solar reflections would not be geometrically possible.

Considering the above, none of the surrounding roads have therefore been taken forward for detailed modelling, and no significant impacts upon road users are predicted.

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.

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.

4.4.2 Identified Dwelling Receptors

The assessed dwelling receptors are shown in Figure 4 on the following page. In total, 57 dwellings have been assessed. An additional 1.8m height above ground is used in the modelling to simulate the typical viewing height of an observer on the ground floor¹¹.

¹¹ This fixed height for the dwelling receptors is for modelling purposes. 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 Overview of dwelling receptors

5 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

5.1 Overview

The following sections present:

- 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.

5.2 Assessment Results – Dwelling Receptors

5.2.1 Key Considerations - Dwellings

The key considerations for quantifying the impact significance for dwelling receptors 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 no solar reflections are geometrically possible or where solar reflections are predicted to be significantly screened, no impact is predicted, and mitigation is not required.

Where effects are predicted to be experienced for less than three months per year and less than 60 minutes on any given day, or where the separation distance to the nearest visible reflecting panel is over 1km, the impact significance is low, and mitigation is not recommended.

Where effects 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 relevant factors is required to determine the impact significance:

- Whether solar reflections will be experienced from all storeys. The ground floor is typically considered the main living space and therefore 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;
- 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;
- Whether the dwelling appears to have windows facing the reflecting areas. An observer may need to look from a wide angle to observe the reflecting areas.

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

5.2.2 Geometric Modelling Results and Discussion

Table 1 on the following pages presents the following:

- Geometric modelling results (bare earth terrain i.e. without consideration of screening);
- Desk-based review of identified screening;
- Consideration of any relevant factors present, where appropriate;
- Predicted impact significance.

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening) ¹²	Relevant Factors	Predicted Impact Classification
1 – 28	Solar reflections are <u>not geometrically possible</u>	N/A	N/A	N/A	No impact
29 – 32	Solar reflections <u>are geometrically possible</u> for: <u>Less</u> than three months <u>Less</u> than 60 minutes	Existing vegetation screening Views of the reflecting panels may be <u>possible</u> despite the partial screening	<u>Less</u> than three months <u>Less</u> than 60 minutes	N/A	Low impact
33 – 35, 38	Solar reflections <u>are geometrically possible</u> for: <u>More</u> than three months <u>Less</u> than 60 minutes	Existing vegetation screening Views of the reflecting panels may be <u>possible</u> despite the partial screening	<u>More</u> than three months <u>Less</u> than 60 minutes	The distance to the closest reflecting panel is at least 350 metres Effects would mostly coincide with direct sunlight	Low impact

¹² 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 (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening) ¹²	Relevant Factors	Predicted Impact Classification
36 – 37, 39	Solar reflections are <u>not geometrically possible</u>	N/A	N/A	N/A	No impact
40 – 42	Solar reflections <u>are geometrically possible</u> for: <u>Less</u> than three months <u>Less</u> than 60 minutes	Existing vegetation screening Views of the reflecting panels may be <u>possible</u> despite the partial screening	<u>Less</u> than three months <u>Less</u> than 60 minutes	N/A	Low impact
43 – 44	Solar reflections <u>are geometrically possible</u> for: <u>More</u> than three months <u>Less</u> than 60 minutes	Existing vegetation screening Views of the reflecting panels may be <u>possible</u> despite the partial screening	<u>More</u> than three months <u>Less</u> than 60 minutes	The distance to the closest reflecting panel is at least 930 metres Effects would mostly coincide with direct sunlight	Low impact

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening) ¹²	Relevant Factors	Predicted Impact Classification
45	Solar reflections <u>are geometrically possible</u> for: <u>More</u> than 3 months <u>Less</u> than 60 minutes	Existing vegetation screening Views of the reflecting panels may be <u>possible</u> despite the partial screening	<u>Less</u> than three months <u>Less</u> than 60 minutes	N/A	Low impact
46 - 49	Solar reflections are <u>not geometrically possible</u>	N/A	N/A	N/A	No impact
50	Solar reflections <u>are geometrically possible</u> for: <u>Less</u> than three months <u>Less</u> than 60 minutes	Existing vegetation and intervening terrain screening Predicted to significantly obstruct views of reflecting panels such that views are <u>not possible</u> in practice	None	N/A	No impact

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening) ¹²	Relevant Factors	Predicted Impact Classification
51	Solar reflections <u>are geometrically possible</u> for: <u>Less</u> than three months <u>Less</u> than 60 minutes	Existing vegetation screening Views of the reflecting panels may be <u>possible</u> despite the partial screening	<u>Less</u> than three months <u>Less</u> than 60 minutes	N/A	Low impact
52 - 57	Solar reflections <u>are geometrically possible</u> for: <u>More</u> than three months <u>Less</u> than 60 minutes	Existing vegetation and/or buildings screening Views of the reflecting panels may be <u>possible</u> despite the partial screening	<u>More</u> than three months <u>Less</u> than 60 minutes	The distance to the closest reflecting panel is at least 750 metres Effects would mostly coincide with direct sunlight	Low impact

Table 1 Geometric modelling results and predicted impact classification - dwelling receptors

5.2.3 Desk-Based Review of Available Imagery

A desk-based review of the available imagery is presented in Figures 5 to 12 on the following pages. The cumulative reflecting panel areas are indicated by regions of yellow. The identified screening in the form of existing vegetation and buildings are outlined in green and blue respectively. High-level Zones of Theoretical Visibility (ZTV Viewshed) generated¹³ by Google Earth have been used to show the intervening terrain between the proposed development and relevant dwelling receptors.

¹³ The green highlighted extents show the areas of terrain from the relevant receptor point that is visible to an observer. From a height above ground of 5m to consider views above ground level.



Figure 5 Reflecting panels and Screening for dwellings 29 to 35 and 38, with representative sunlight illustration from dwelling 38



Figure 6 Reflecting panels and Screening for dwellings 40 to 42

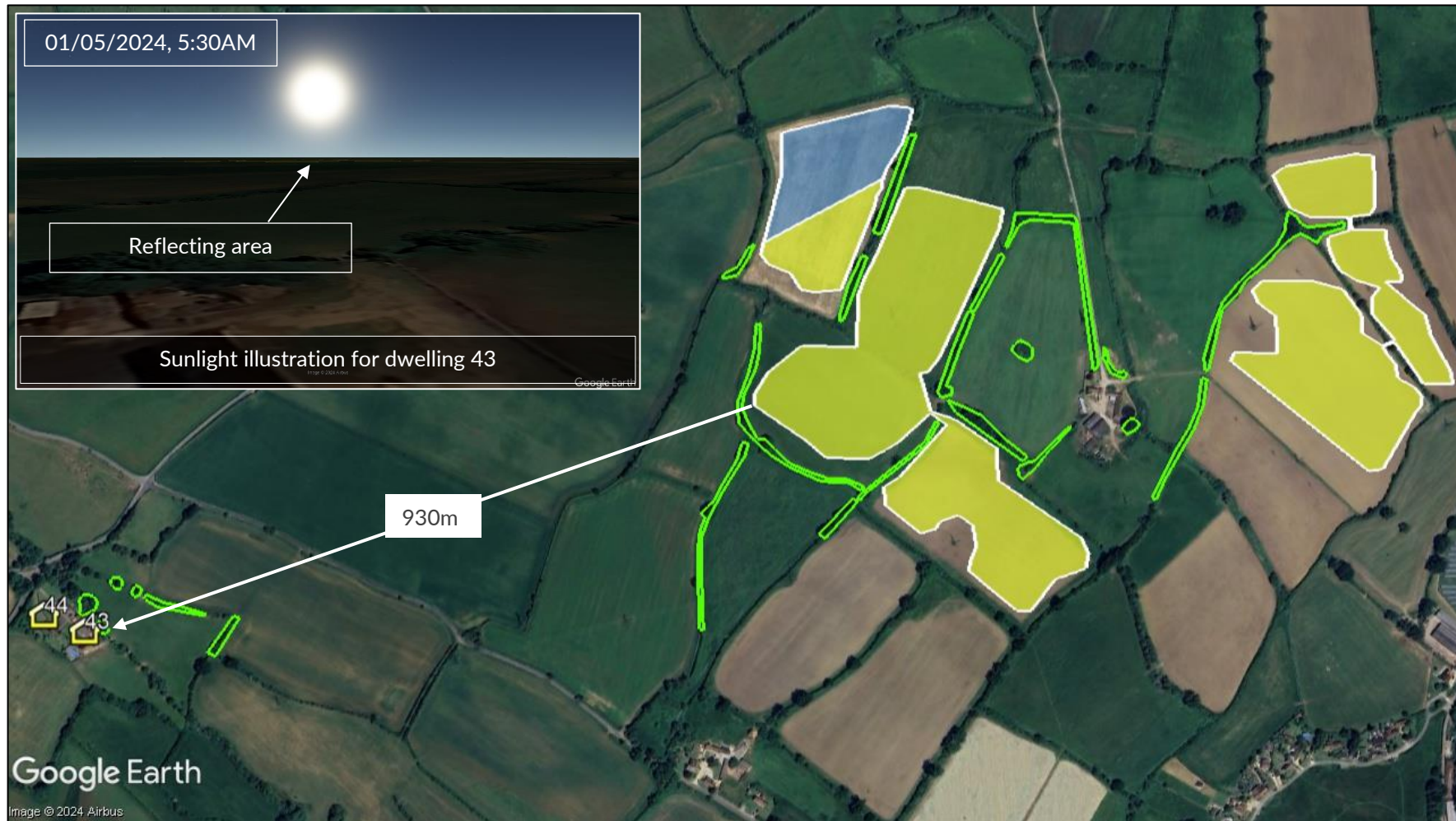


Figure 7 Reflecting panels and Screening for dwellings 43 and 44, with representative sunlight illustration from dwelling 43



Figure 8 Reflecting panels and Screening for dwelling 45



Figure 9 Reflecting panels and Screening for dwelling 50, with ZTV viewshed the dwelling

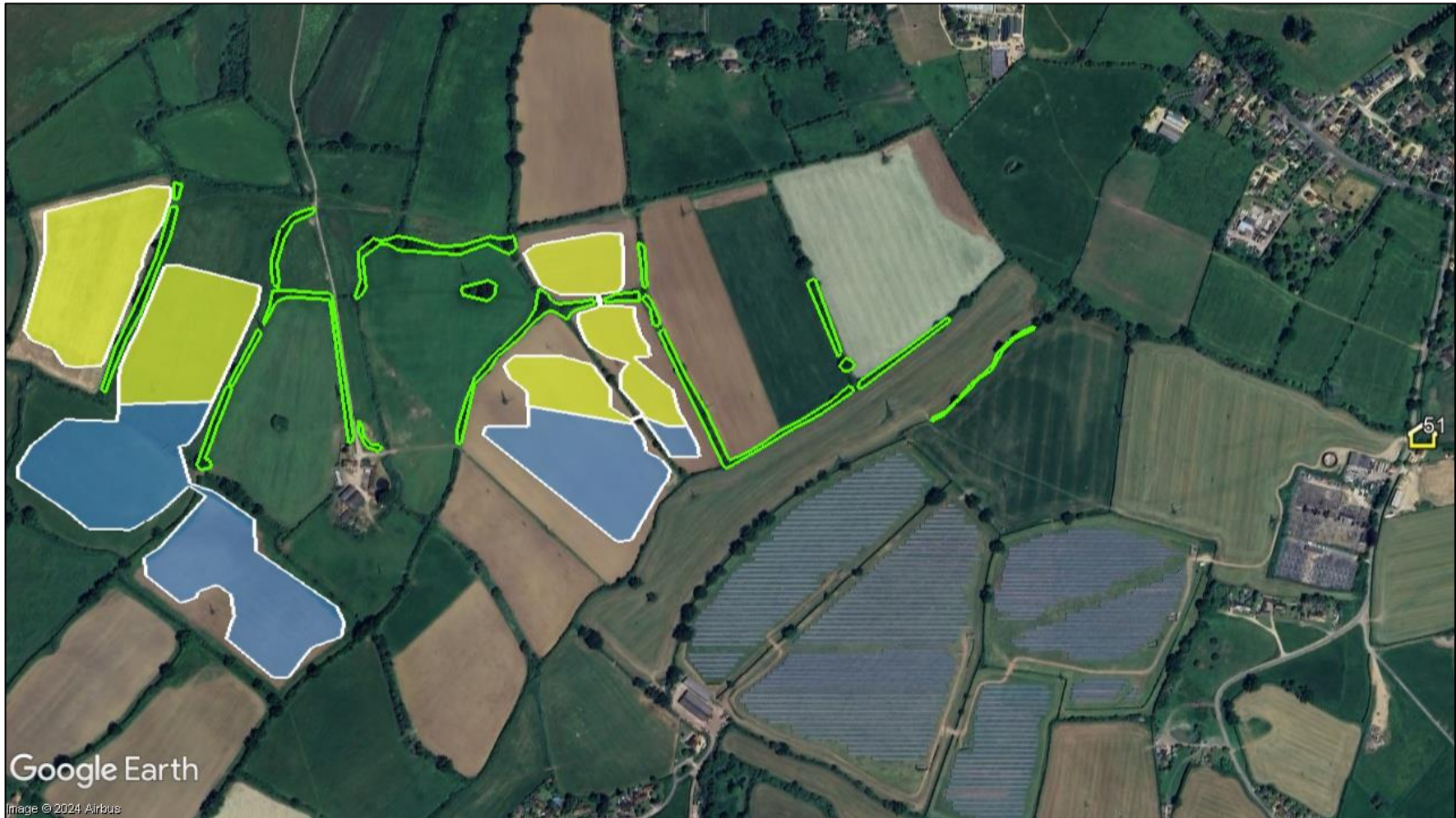


Figure 10 Reflecting panels and Screening for dwelling 51



Figure 11 Reflecting panels and Screening for dwellings 52 and 53, with representative sunlight illustration from dwelling 53



Figure 12 Reflecting panels and Screening for dwellings 54 to 57, with representative sunlight illustration from dwelling 54

6 HIGH-LEVEL AVIATION ASSESSMENTS

6.1 Overview

Glint and glare assessment for aviation receptors are typically undertaken for licensed aerodromes within 10km of a proposed solar development. Geometric modelling for unlicensed general aviation aerodromes is typically required within 5km of a proposed development. At ranges of 10 - 20km, the requirement for assessment is much less common, with typically assessment only being undertaken for licensed aerodromes at these ranges. Assessment of any aviation effects for developments over 20km is not a usual requirement.

The proposed development size, distance between the aerodrome and proposed development, and industry experience are considered to determine the impact during the assessment.

6.2 High-Level Assessment of South Wraxall Private Airfield

6.2.1 Airfield details

The solar reflections for runway thresholds are predicted to be predominately outside a pilot's primary field-of-view or will have glare intensities no greater than 'low potential for temporary after-image'. Hence, a high-level assessment of South Wraxall Private Airfield was conducted.

Reference to a pilot's primary field-of-view is made when determining the predicted impact significance, which is defined as 50 degrees either side of the direction of travel.

South Wraxall Private Airfield is an unlicensed airfield approximately 3.9km west of the proposed development with one operational runway and is understood to not have an Air Traffic Control (ATC) Tower. The runway details¹⁴ are presented below:

- 11/29 measuring 389 x 7 metres long (grass).

The location of South Wraxall Private Airfield and 1-mile splayed approach paths for each runway threshold relative to the proposed development is shown in Figure 13 on the following page.

¹⁴ As determined from aerial imagery



Figure 13 South Wraxall Private Airfield relative to proposed development

6.2.2 Assessment

The following can be concluded for South Wraxall Private Airfield with regards to the proposed development:

- Solar reflections originating from the proposed development towards the 1-mile splayed approach path for runway threshold 11 will be outside a pilot's primary field-of-view, and would therefore not be considered significant considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths;
- Solar reflections towards the 1-mile splayed approach path for runway threshold 29 and final sections of circuits / joins for runway thresholds 11/29 will 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, the glare intensity is considered acceptable, and therefore it can be reliably concluded that this level of glare is also acceptable for the visual circuits.

6.3 High-Level Assessment of Craymarsh Farm Airfield

6.3.1 Airfield details

Craymarsh Farm Airfield is an unlicensed airfield approximately 6.8km southeast of the proposed development with one operational runway and is understood to not have an ATC Tower. The runway details¹⁵ are presented below:

- 18/36 measuring 463 x 9 metres long (grass).

¹⁵ As determined from aerial imagery

The location of Craymarsh Farm Airfield and 1-mile splayed approach paths for each runway threshold relative to the proposed development is shown in Figure 14 below.



Figure 14 Craymarsh Farm Airfield relative to proposed development

6.3.2 Assessment

The following can be concluded for Craymarsh Farm Airfield with regards to the proposed development:

- Solar reflections originating from the proposed development towards the 1-mile splayed approach path for runway threshold 18/36 will be outside a pilot's primary field-of-view, and would therefore not be considered significant considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths;
- Solar reflections towards the final sections of circuits / joins for runway thresholds 18/36 will 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, the glare intensity is considered acceptable, and therefore it can be reliably concluded that this level of glare is also acceptable for the visual circuits.

6.4 Conclusions

No significant impacts upon aviation activity associated with South Wraxall Private Airfield and Craymarsh Farm Airfield are predicted, and mitigation is not required. Detailed modelling is not recommended.

7 OVERALL CONCLUSIONS

7.1 Assessment Conclusions – Road Safety

The A365 is located within 1km of the proposed development; however, it is located north of the panels and therefore solar reflections would not be geometrically possible.

The remaining roads within 1km of the proposed development are considered local roads where traffic densities are likely to be relatively low. Assessment is not recommended for local roads as any solar reflections from the proposed development that are experienced by a road user would be considered low impact in accordance with the guidance presented in Appendix D.

No significant impacts upon road users are predicted.

7.2 Assessment Conclusions – Residential Amenity

Solar reflections are geometrically possible towards 21 of the 57 assessed dwellings.

For eight dwellings, solar reflection are geometrically possible for less than three months of the year and less than 60 minutes on any given day.

For seven of these dwellings, screening in the form of existing vegetation is predicted partially obstruct the views of reflecting panels such that views may still be possible. A low impact is predicted for these dwellings and mitigation is not recommended.

For one dwelling, screening in form of existing vegetation and terrain has been identified which would significantly obstruct views of reflecting panels, such that views are not possible in practice. No impact is predicted, and mitigation is not required.

For 13 dwellings, the solar reflections are predicted to occur for more than three months of the year but less than 60 minutes on any given day.

For 12 of these dwellings, partial screening in the form of existing vegetation and/or buildings has been identified for the dwellings. Mitigating factors in the form of reflections coinciding with direct sunlight, and a significant separation distance between the dwelling and reflecting panels which reduce the significance of reflections. A low impact is predicted, and mitigation is not recommended.

For the remaining dwelling, partial screening in the form of existing vegetation has been identified, which decreases the duration of the effects. A low impact is predicted, and mitigation is not recommended.

7.3 Assessment Conclusions – High-Level Aviation

The following has been concluded for South Wraxall Private Airfield and Craymarsh Farm Airfield with regard to the proposed development:

- Solar reflections originating from the proposed development towards the 1-mile splayed approach paths for runway threshold 11 and 18/36 will be outside a pilot's primary horizontal field-of-view (50 degrees either side of the direction of travel), and would

therefore not be considered significant considering the associated guidance (Appendix D) and industry best practice pertaining to the approach paths;

- Solar reflections towards the 1-mile splayed approach path for runway threshold 29 and the final sections of circuits / joins for runway thresholds for 11/29 and 18/36 will have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (Appendix D) and industry best practices pertaining to approach paths, which states this level of glare is acceptable, and therefore it can be reliably concluded that this level of glare is also acceptable for the visual circuits.

No significant impacts upon aviation activity associated with South Wraxall Private Airfield and Craymarsh Farm Airfield are predicted, and mitigation is not required. Detailed modelling is not recommended.

7.4 Overall Conclusions

No significant impacts are predicted upon road safety, residential amenity and aviation activity associated with South Wraxall Private Airfield and Craymarsh Farm Airfield. Mitigation 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.

UK Planning Policy

Renewable and Low Carbon Energy

The National Planning Policy Framework under the planning practice guidance for Renewable and Low Carbon Energy¹⁶ (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.'

¹⁶ [Renewable and low carbon energy](#), Ministry of Housing, Communities & Local Government, date: 18 June 2015, accessed on: 01/11/2021

National Policy Statement for Renewable Energy Infrastructure

The National Policy Statement for Renewable Energy Infrastructure (EN-3)¹⁷ 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.¹⁸ 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.

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

¹⁸ 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 an 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 document¹⁹ which was produced due to the absence of existing guidance and a specific standardised assessment methodology.

¹⁹ Solar Photovoltaic Development Glint and Glare Guidance, Fourth Edition, September 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, 2012²⁰ however the advice is still applicable²¹ 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 ALH²², 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.

²⁰ Archived at Pager Power

²¹ Reference email from the CAA dated 19/05/2014.

²² Aerodrome Licence Holder.

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.

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'²³, the 2013 update is entitled 'Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports'²⁴, and the 2021 final policy is entitled 'Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports'²⁵.

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.

²³ Archived at Pager Power

²⁴ [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.

²⁵ [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.

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 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'²⁶. 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 blindness²⁷.
- 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 16²⁸, 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

²⁶ Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 08/12/2021.

²⁷ 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.

²⁸ First figure in Appendix B.

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;
- 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 question²⁹ 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 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 2016³⁰ 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.

²⁹ 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.

³⁰ The Air Navigation Order 2016. [online] Available at: <<https://www.legislation.gov.uk/uksi/2016/765/contents/made>> [Accessed 4 February 2022].

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

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 document³¹ 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; and
 - 5. 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.

³¹ <https://regulatorylibrary.caa.co.uk/139-2014-pdf/PDF.pdf>

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

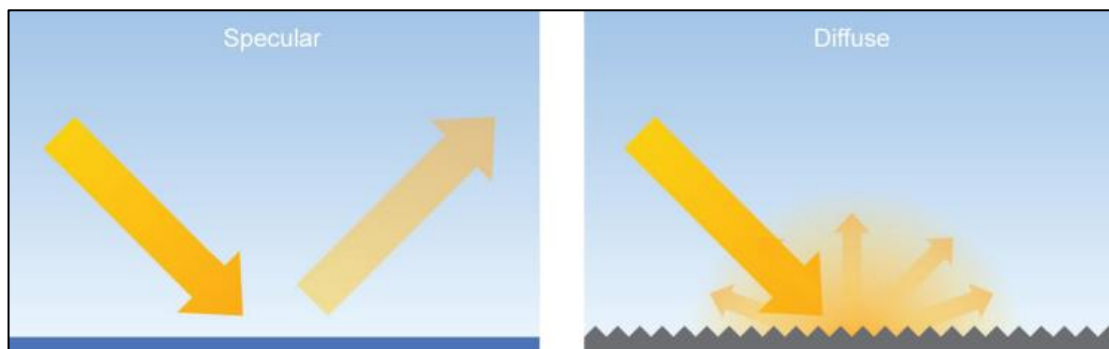
Overview

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 guidance³², 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

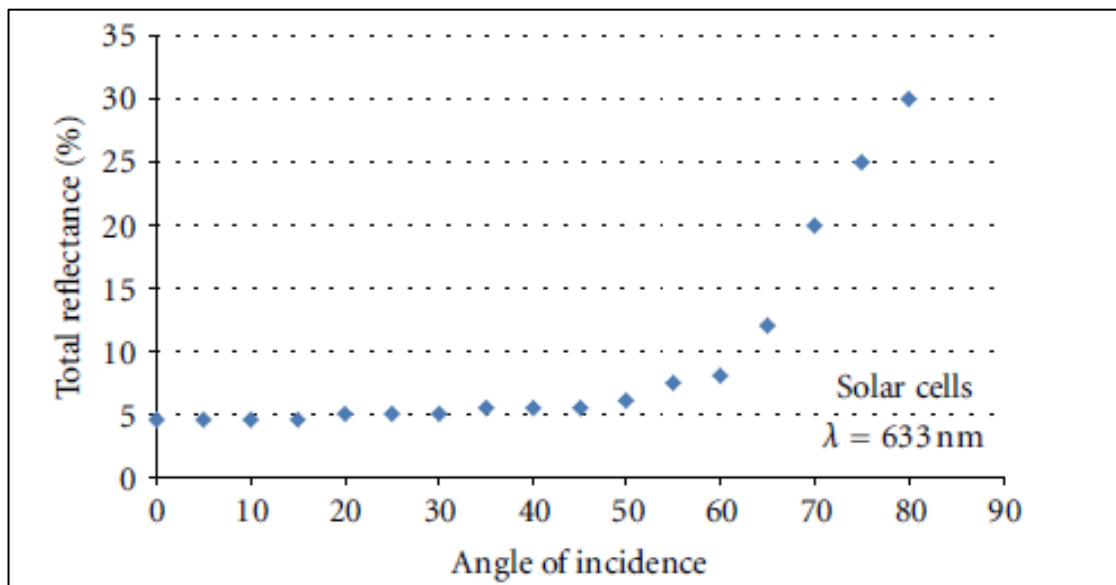
³²Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 12/09/2022.

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*³³. 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.

³³ 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”³⁴

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 ³⁵
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.

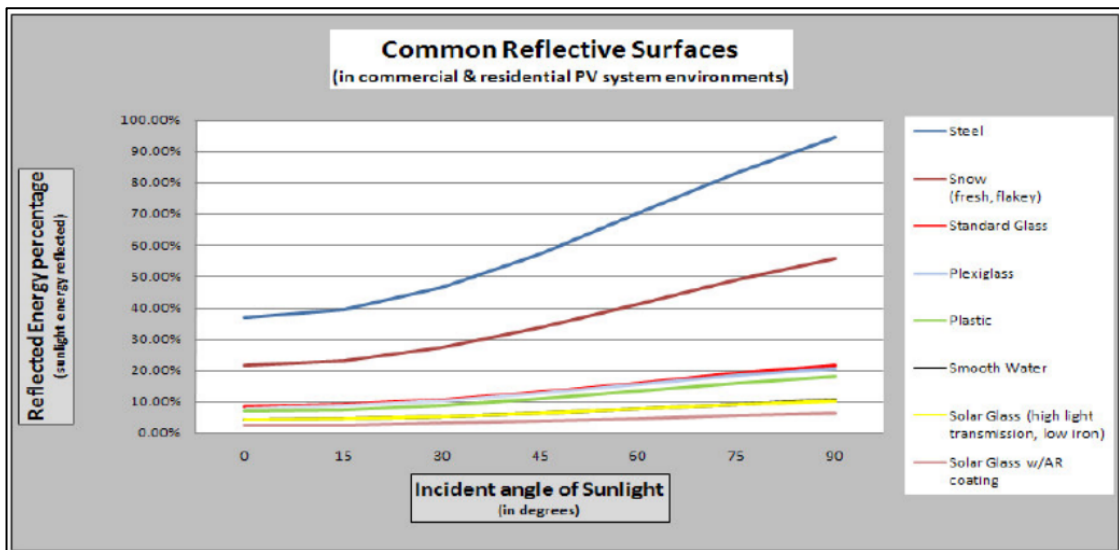
³⁴ Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 12/09/2022.

³⁵ Extrapolated data, baseline of 1,000 W/m² for incoming sunlight.

SunPower Technical Notification (2009)

SunPower published a technical notification³⁶ 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.

³⁶ 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).

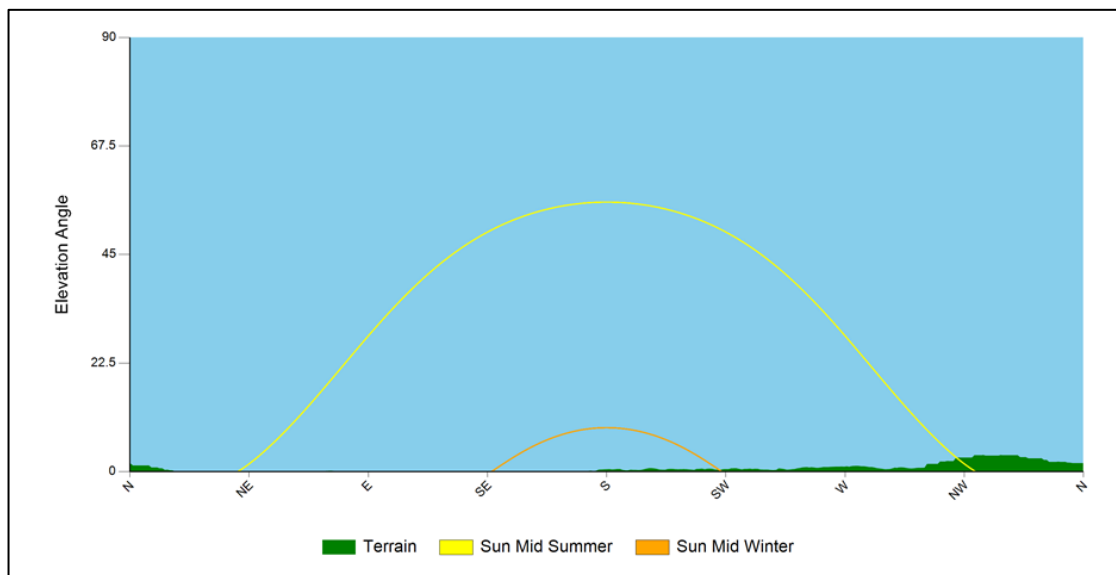
The Sun's position can be accurately calculated for a specific location. The following data being used for the calculation:

- 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.



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

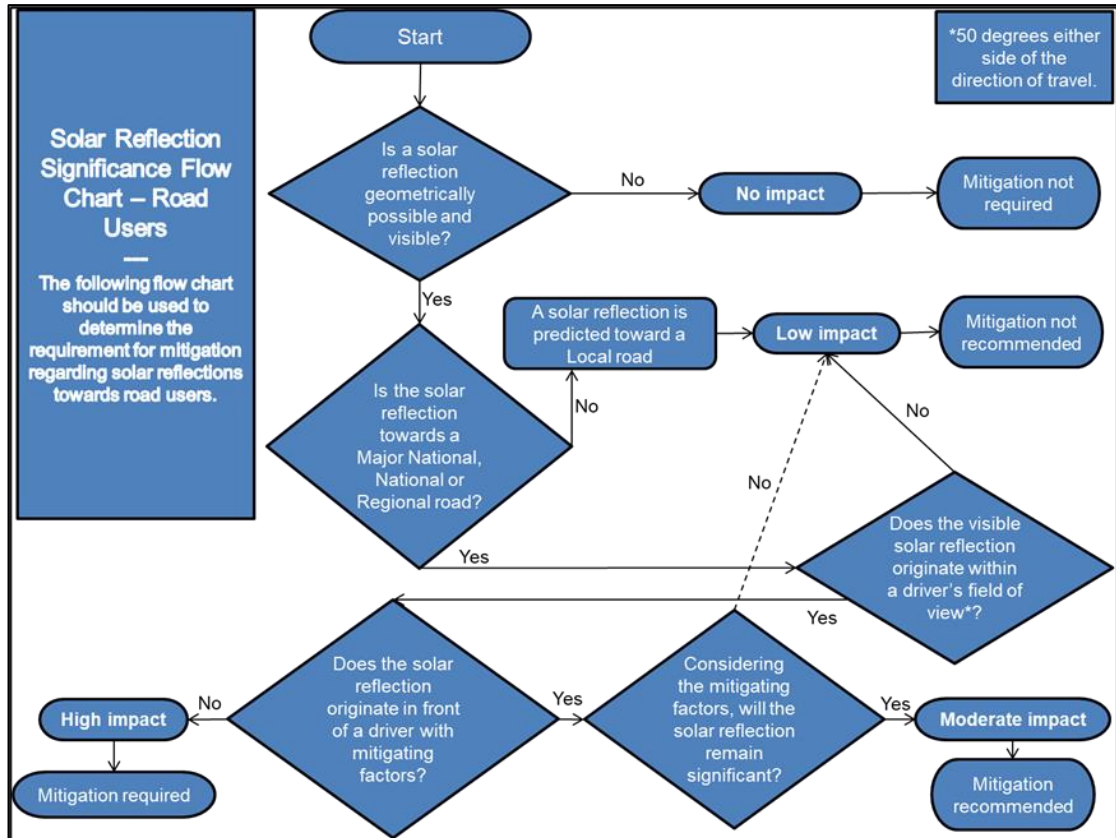
The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

Impact Significance	Definition	Mitigation Requirement
No Impact	A solar reflection is not geometrically possible or will not be visible from the assessed receptor.	No mitigation required.
Low	A solar reflection is geometrically possible however any impact is considered to be small such that mitigation is not required e.g. intervening screening will limit the view of the reflecting solar panels 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

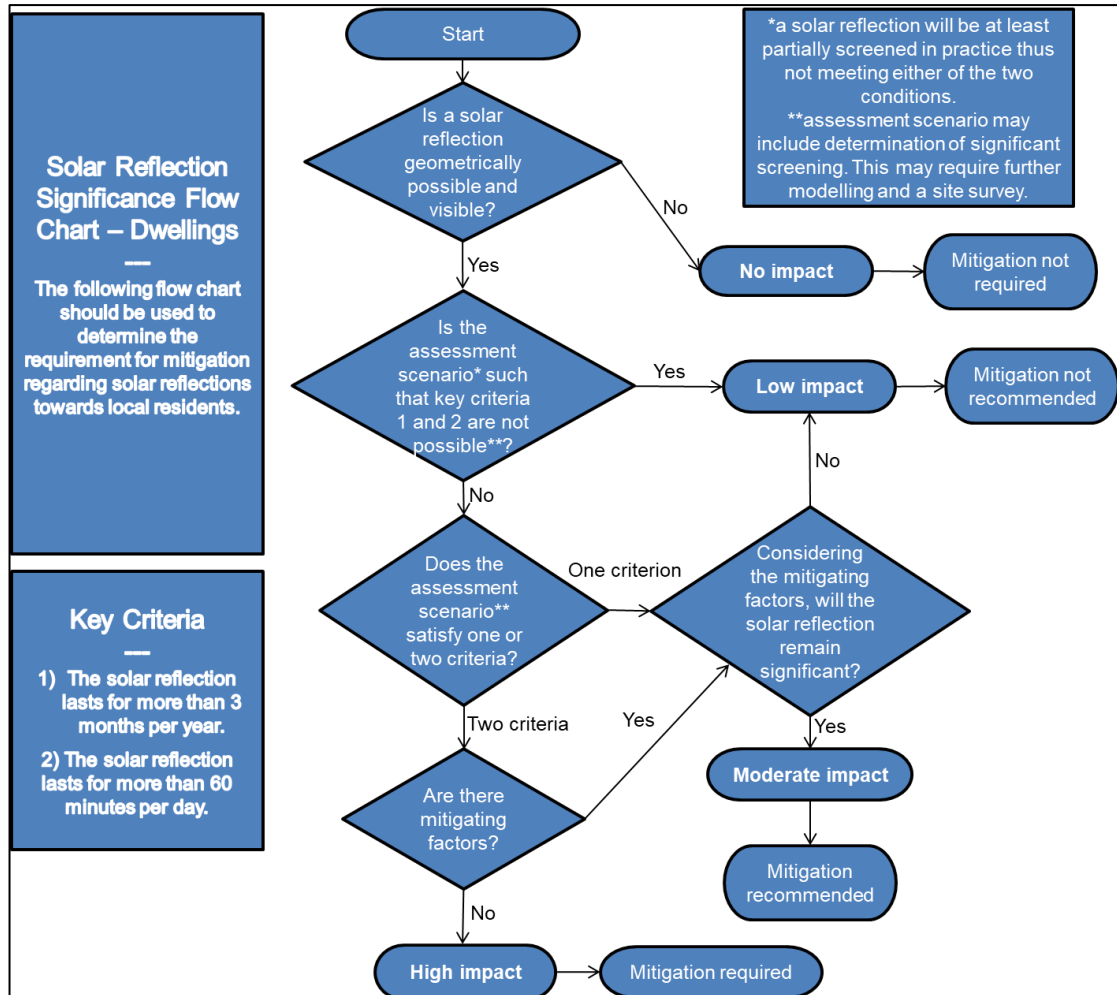
The flow chart presented below has been followed when determining the impact significance for road receptors.



Road receptor impact significance flow chart

Impact Significance Determination for Dwelling Receptors

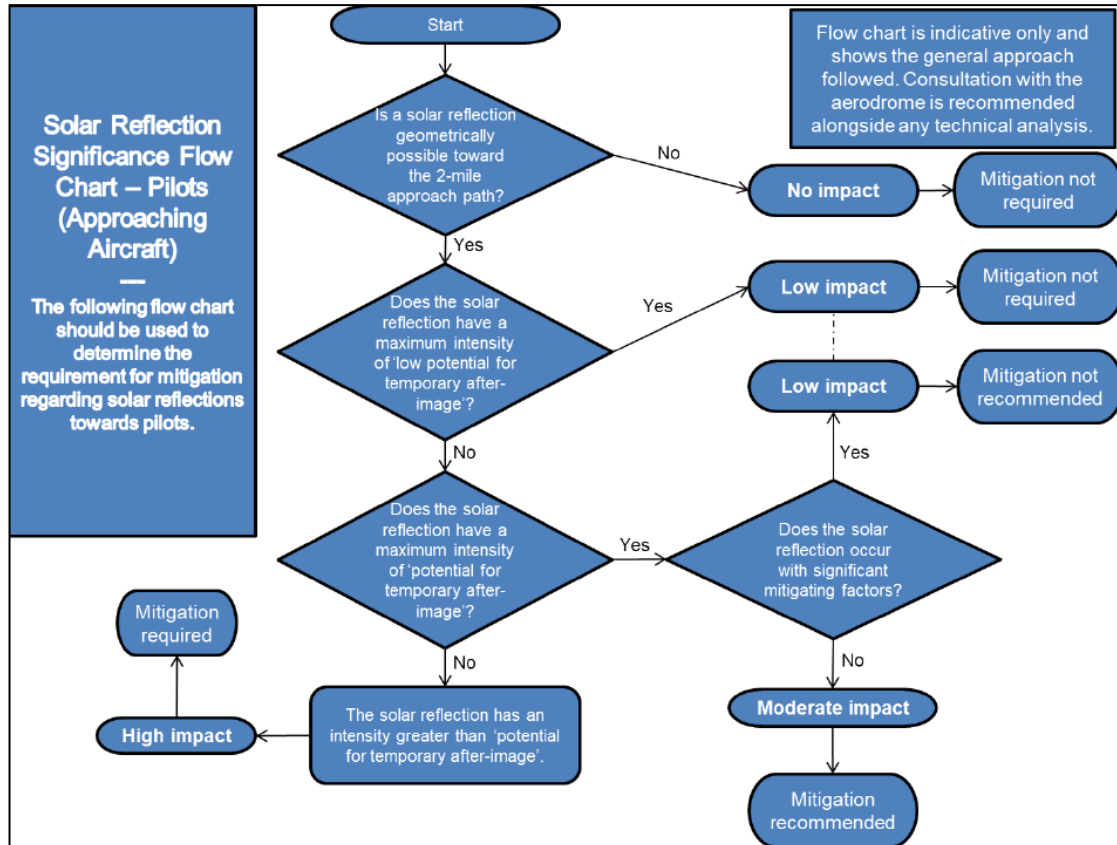
The flow chart presented below has been followed when determining the impact significance for dwelling receptors.



Dwelling receptor impact significance flow chart

Impact Significance Determination for Approaching Aircraft

The flow chart presented below has been followed when determining the impact significance for approaching aircraft.



Approach path receptor impact significance flow chart

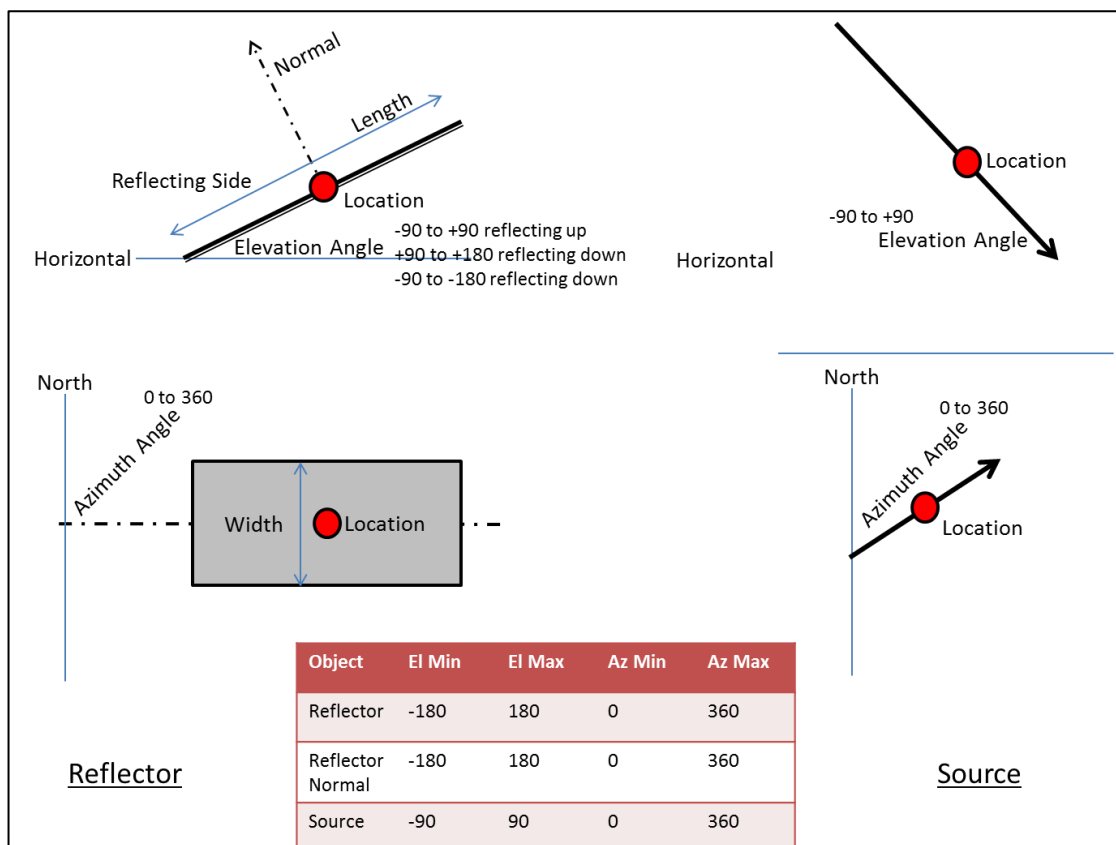
APPENDIX E – REFLECTION CALCULATIONS METHODOLOGY

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.



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)³⁷.

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

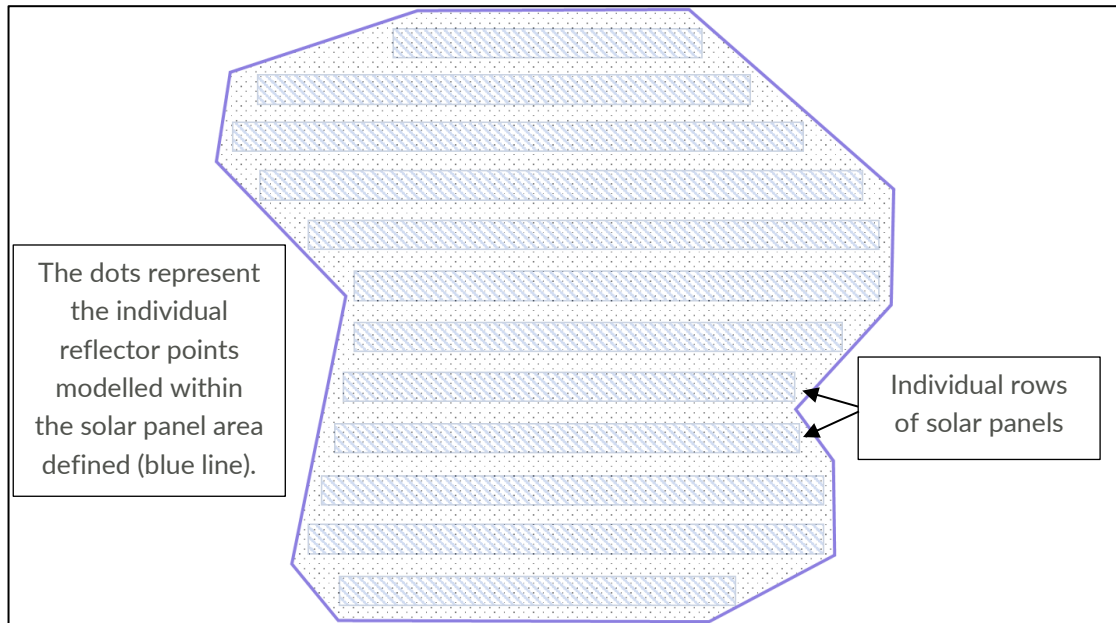
It is assumed that the panel azimuth angle assessed represents the azimuth angle for all of the panels within each solar panel area defined.

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.

³⁷ 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

Data and terrain heights are ascertained from OSGB data.

Dwelling Receptor Data

The dwelling receptor data is presented in the table below. An additional 1.8m height has been added to the 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	51.37525	-2.19385	57.8	30	51.38030	-2.18521	51.8
2	51.37469	-2.18342	51.36	31	51.38036	-2.18456	51.8
3	51.37645	-2.18461	51.8	32	51.38025	-2.18409	51.8
4	51.37677	-2.18404	51.8	33	51.38039	-2.18364	51.67
5	51.37695	-2.18482	51.8	34	51.38051	-2.18342	51.47
6	51.37717	-2.18370	51.8	35	51.38064	-2.18321	50.87
7	51.37739	-2.18418	51.8	36	51.37852	-2.18198	52.03
8	51.37732	-2.18458	51.8	37	51.37877	-2.18158	52.5
9	51.37752	-2.18450	51.8	38	51.38118	-2.18232	50.98
10	51.37740	-2.18476	51.8	39	51.37857	-2.19176	61.8
11	51.37750	-2.18505	51.8	40	51.37971	-2.19550	55.8
12	51.37754	-2.18527	51.85	41	51.37991	-2.19650	53.61
13	51.37757	-2.18564	51.9	42	51.38011	-2.19679	54.4
14	51.37772	-2.18585	51.8	43	51.38155	-2.20845	60.8
15	51.37806	-2.18760	53.92	44	51.38174	-2.20923	61.45
16	51.37820	-2.18812	53.8	45	51.38461	-2.18914	58.55

No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)	No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)
17	51.37859	-2.18868	56.25	46	51.38796	-2.17130	51.81
18	51.37851	-2.18763	54.98	47	51.38770	-2.17102	51.8
19	51.37847	-2.18669	53.8	48	51.38787	-2.17017	51.8
20	51.37868	-2.18709	54.46	49	51.38764	-2.16988	52.01
21	51.37898	-2.18696	53.96	50	51.38733	-2.16989	51.8
22	51.37913	-2.18666	54.24	51	51.38476	-2.16802	47.85
23	51.37938	-2.18645	54.38	52	51.38293	-2.17108	48.7
24	51.37960	-2.18627	53.8	53	51.38284	-2.17153	49.51
25	51.37982	-2.18589	53.8	54	51.38104	-2.17309	48.8
26	51.38014	-2.18585	52.37	55	51.38098	-2.17218	47.8
27	51.38003	-2.18559	52.56	56	51.38036	-2.17079	44.97
28	51.38012	-2.18538	52.1	57	51.38012	-2.17050	43.98
29	51.38045	-2.18538	51.8				

Dwelling receptor data

Modelled Panel Areas

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
1	51.38235	-2.18986	65	51.38591	-2.18351
2	51.38248	-2.18927	66	51.38591	-2.18320
3	51.38265	-2.18921	67	51.38605	-2.18323
4	51.38285	-2.18936	68	51.38618	-2.18338
5	51.38353	-2.19095	69	51.38638	-2.18349

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
6	51.38392	-2.19098	70	51.38653	-2.18351
7	51.38426	-2.19178	71	51.38654	-2.18416
8	51.38436	-2.19224	72	51.38668	-2.18419
9	51.38482	-2.19246	73	51.38671	-2.18380
10	51.38482	-2.19230	74	51.38682	-2.18371
11	51.38501	-2.19207	75	51.38704	-2.18372
12	51.38655	-2.19092	76	51.38742	-2.18375
13	51.38678	-2.19085	77	51.38744	-2.18410
14	51.38694	-2.19185	78	51.38729	-2.18546
15	51.38704	-2.19249	79	51.38718	-2.18569
16	51.38703	-2.19274	80	51.38679	-2.18536
17	51.38683	-2.19288	81	51.38668	-2.18498
18	51.38626	-2.19327	82	51.38668	-2.18423
19	51.38596	-2.19352	83	51.38653	-2.18420
20	51.38575	-2.19364	84	51.38645	-2.18462
21	51.38512	-2.19367	85	51.38635	-2.18463
22	51.38515	-2.19473	86	51.38614	-2.18450
23	51.38483	-2.19537	87	51.38603	-2.18438
24	51.38457	-2.19563	88	51.38592	-2.18406
25	51.38442	-2.19562	89	51.38584	-2.18363
26	51.38402	-2.19467	90	51.38573	-2.18377
27	51.38380	-2.19426	91	51.38552	-2.18378

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
28	51.38379	-2.19342	92	51.38521	-2.18334
29	51.38389	-2.19313	93	51.38515	-2.18358
30	51.38400	-2.19283	94	51.38530	-2.18397
31	51.38433	-2.19226	95	51.38542	-2.18397
32	51.38420	-2.19194	96	51.38552	-2.18399
33	51.38356	-2.19287	97	51.38582	-2.18433
34	51.38346	-2.19315	98	51.38592	-2.18492
35	51.38324	-2.19313	99	51.38592	-2.18588
36	51.38289	-2.19244	100	51.38581	-2.18608
37	51.38296	-2.19212	101	51.38565	-2.18596
38	51.38303	-2.19209	102	51.38550	-2.18564
39	51.38311	-2.19171	103	51.38526	-2.18560
40	51.38299	-2.19144	104	51.38506	-2.18560
41	51.38273	-2.19138	105	51.38507	-2.18642
42	51.38260	-2.19147	106	51.38496	-2.18649
43	51.38245	-2.19153	107	51.38364	-2.18385
44	51.38197	-2.19060	108	51.38581	-2.19397
45	51.38197	-2.19031	109	51.38604	-2.19383
46	51.38235	-2.18986	110	51.38682	-2.19331
47	51.38364	-2.18385	111	51.38693	-2.19328
48	51.38366	-2.18356	112	51.38702	-2.19318
49	51.38432	-2.18296	113	51.38714	-2.19316

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
50	51.38443	-2.18283	114	51.38727	-2.19308
51	51.38453	-2.18281	115	51.38757	-2.19279
52	51.38466	-2.18297	116	51.38777	-2.19268
53	51.38475	-2.18327	117	51.38788	-2.19262
54	51.38493	-2.18333	118	51.38799	-2.19262
55	51.38505	-2.18348	119	51.38801	-2.19304
56	51.38513	-2.18357	120	51.38769	-2.19511
57	51.38518	-2.18334	121	51.38719	-2.19511
58	51.38479	-2.18291	122	51.38624	-2.19552
59	51.38468	-2.18279	123	51.38612	-2.19537
60	51.38469	-2.18222	124	51.38601	-2.19494
61	51.38484	-2.18227	125	51.38581	-2.19474
62	51.38527	-2.18264	126	51.38578	-2.19449
63	51.38551	-2.18275	127	51.38581	-2.19397
64	51.38563	-2.18299	128	51.38591	-2.18351

Modelled panel areas coordinates

APPENDIX H – DETAILED MODELLING RESULTS

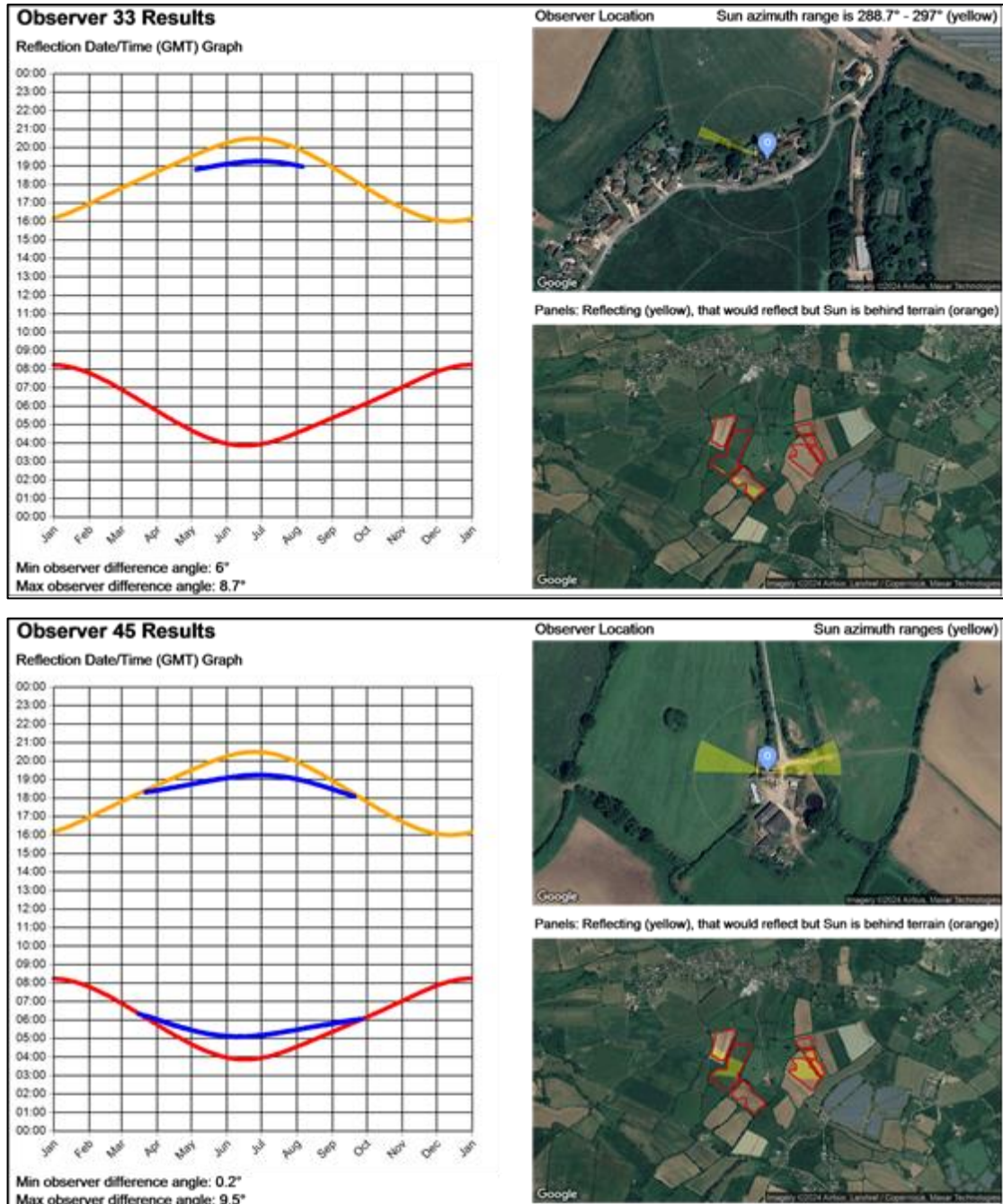
Overview

The Pager Power charts for a selection of representative receptors where solar reflections are predicted to be geometrically possible, are shown on the following pages. Full modelling results are available upon request. Each chart shows:

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

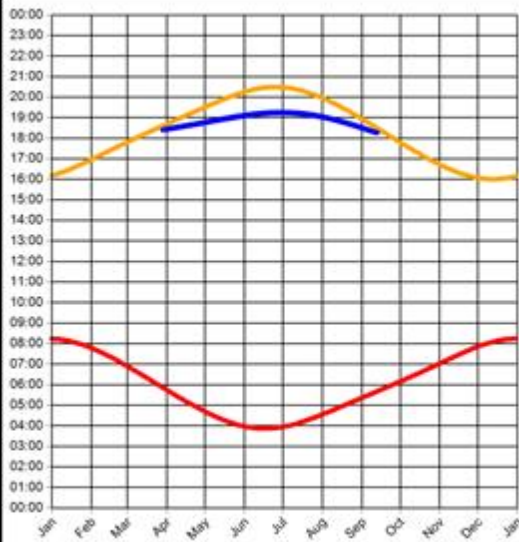
Dwelling Receptors

Selective results have been shown for completeness. Full modelling results are available upon request.



Observer 54 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 1°
Max observer difference angle: 8.9°

Observer Location Sun azimuth range is 274.4° - 297.1° (yellow)

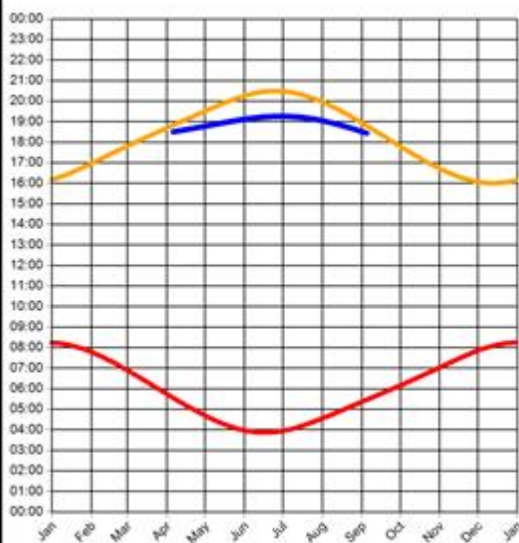


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 57 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 1.9°
Max observer difference angle: 8.6°

Observer Location Sun azimuth range is 277.8° - 297.1° (yellow)



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





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