PAGERPOWER
Urban & Renewables

Solar Photovoltaic Glint and Glare Study

St Asaph

Anesco Limited

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ADMINISTRATION PAGE

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EXECUTIVE SUMMARY

Report Purpose

Pager Power has been retained to assess the possible effects of glint and glare from a solar photovoltaic (PV) development located south of St Asaph in Denbighshire, Wales, UK. This assessment pertains to the possible 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 existing 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 published in 2022[1]. The guidance document sets out the methodology for assessing roads and dwellings with respect to solar reflections from solar panels.

Pager Power's approach is to undertake geometric reflection calculations and, where a solar reflection is predicted, consider the screening (existing and/or proposed) between the receptor and the reflecting solar panels. 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].

Assessment Conclusions - Roads

Solar reflections towards the B5381 are predicted to be obstructed by existing vegetation and intervening terrain, such that no impact is predicted upon road users. No impact is predicted, and mitigation is not required.

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

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

Assessment Conclusions - Dwellings

Solar reflections are geometrically possible towards 40 of 48 assessed dwellings. Screening in the form of existing vegetation, buildings and intervening terrain is predicted to significantly obstruct views of reflecting panels for 36 dwellings, such that no impact is predicted. Mitigation is not required for these dwellings.

For the remaining four dwellings, solar reflections are geometrically possible for more than three months per year but less than 60 minutes on any given day. Screening in the form of existing vegetation is predicted to partially obstruct views of reflecting panels, with marginal views from above ground level considered possible. The resultant duration of effects is predicted to be reduced to less than three months per year. A low impact is predicted for these three dwellings, and mitigation is not recommended in accordance with the assessment methodology (Appendix D).

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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 South Africa, Europe, America, Asia and Australasia. The company comprises a team of experts to provide technical expertise and guidance on a range of planning issues for large and small developments.

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

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

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

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

1 INTRODUCTION

1.1 Overview

Pager Power has been retained to assess the possible effects of glint and glare from a solar photovoltaic (PV) development located south of St Asaph in Denbighshire, Wales, UK. This assessment pertains to the possible effects upon ground-based receptors (roads and dwellings). This report contains the following:

- Details of the proposed solar development;
- Explanation of glint and glare;
- Overview of relevant guidance;
- Overview of relevant studies;
- Identification of receptors;
- Assessment methodology;
- Glint and glare assessment for:
    - Roads;
    - Dwellings.
- Results discussion;
- Overall conclusions.

1.2 Pager Power's Experience

Pager Power has undertaken over 1,400 Glint and Glare assessments internationally. The studies have included assessment of civil and military aerodromes, railway infrastructure and other ground-based receptors including roads and dwellings.

1.3 Glint and Glare Definition

The definition of glint and glare is as follows[3]:

- 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.

[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 PROPOSED DEVELOPMENT LOCATION AND DETAILS

2.1 Proposed Development Site Layout

The Proposed Development site layout[4] is shown in Figure 1 on the following page.

The modelled reflector areas for this assessment are shown in Figure 2 on page 12. Further information regarding the modelled reflector areas is presented in Section 5.1.

[4] Source: Anesco, April 2025, 'C0002452_02 Site Layout PL_RevV4'

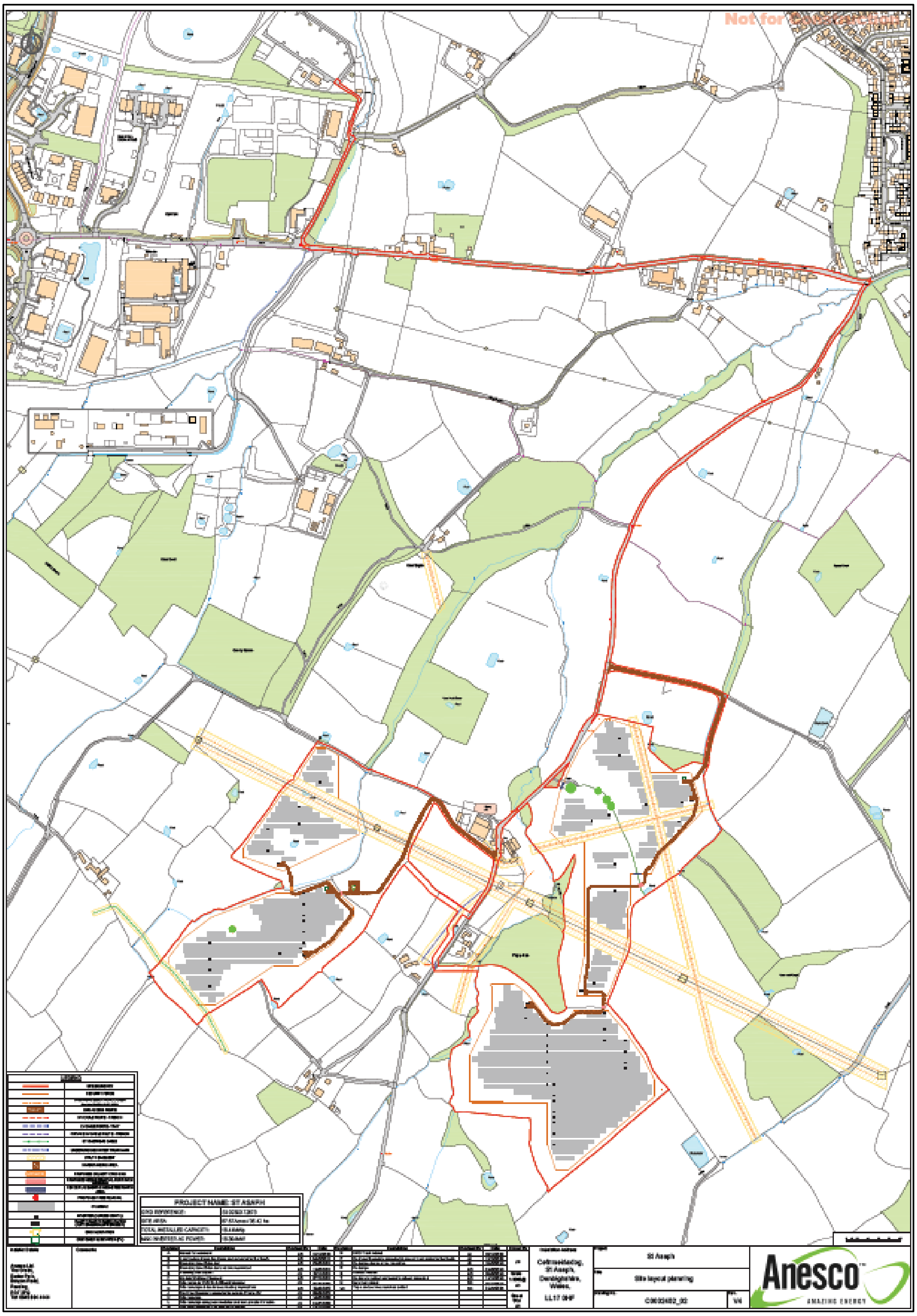

Figure 1 – Proposed Development site layout

Figure 2 – Proposed Development: aerial image

2.2 Solar Panel Details

The solar panel cross section[5] is shown in Figure 3 below.

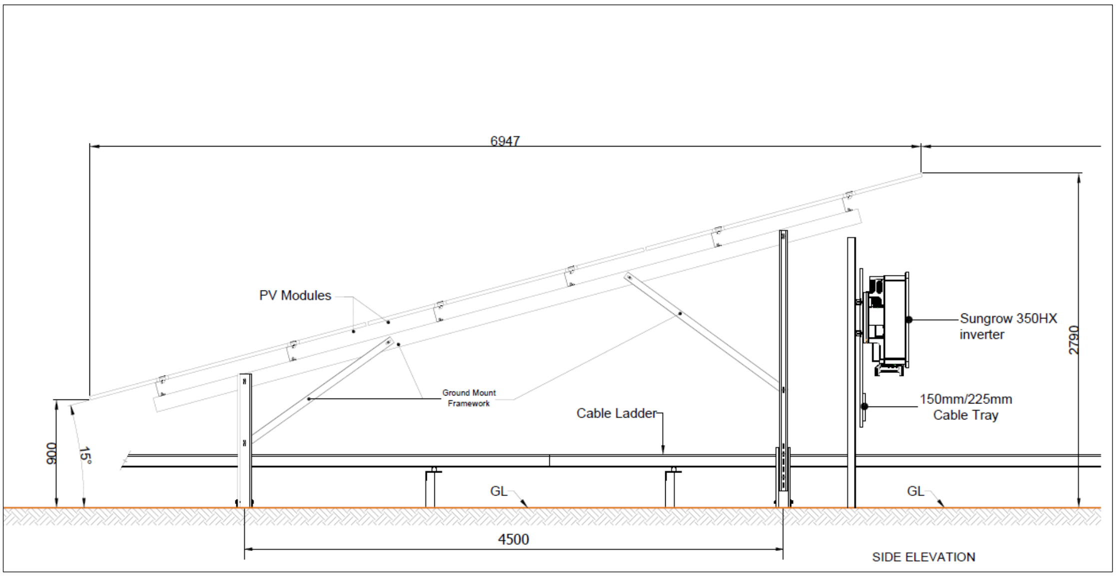

Figure 3 – Solar panel cross section

The solar panels as modelled in this assessment are presented in Table 1 below.

Panel Information	
Azimuth angle (°)	180
Tilt Angle (°)	15
Assessed panel height[6] (m agl[7])	1.845

Table 1 – Solar panel details

[5] Source: Typical Section Through Array, St Asaph, Anesco, date: 19/04/2022, Drawing No.: C0002452_08, (cropped).
[6] The assessed height is the midpoint of the panel.
[7] metres 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 reflective surfaces, which are common in an outdoor environment.

3.2 Background

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

3.3 Methodology

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

- Identify receptors in the area surrounding the solar development.
- Consider direct solar reflections from the solar development towards the identified receptors by undertaking geometric calculations and intensity calculations where required.
- 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.
- Assess the glare intensity if applicable.
- Consider both the solar reflection from the solar development and the location of the direct sunlight with respect to the receptor's position.
- Consider the solar reflection with respect to the published studies and guidance.
- Determine whether a significant detrimental impact is expected in line with the process presented in Appendix D.

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

3.4 Assessment 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

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. The assessment area (white outlined area in the following figures) has been designed accordingly as 1km from the proposed development.

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.

Glint and glare assessments for aviation receptors are typically undertaken for licensed aerodromes within 10km of a proposed solar development. Geometric modelling for general aviation unlicensed aerodromes is typically required within 5km of a Proposed Development. At ranges of 10-20km, the requirement for assessment is much less common for unlicensed aerodromes, 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.

Considering the size of the Proposed Development, distance to the nearest licensed and unlicensed aerodromes, and Pager Power's industry experience, no significant aviation receptors are identified for geometric assessment.

4.2 Dwellings

Dwellings have been identified within approximately 1km of the proposed solar development that are most likely to have visual line of sight to the solar panels (based on an initial high-level review of aerial photography[8] plus local topography).

[8] The aerial and street view imagery may not provide the most up to date information of the surrounding area.

If visual line of sight exists between the proposed solar development and the dwellings, then a solar reflection could be experienced if it is geometrically possible. If there is no line of sight, then a reflection cannot be experienced.

In total, 48 dwelling receptors points[9] have been identified for the assessment. The assessed dwellings are shown in Figure 4 below. A height above ground level of 1.8 metres has been taken as the typical eye level for an observer on the ground floor of each dwelling[10].

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.

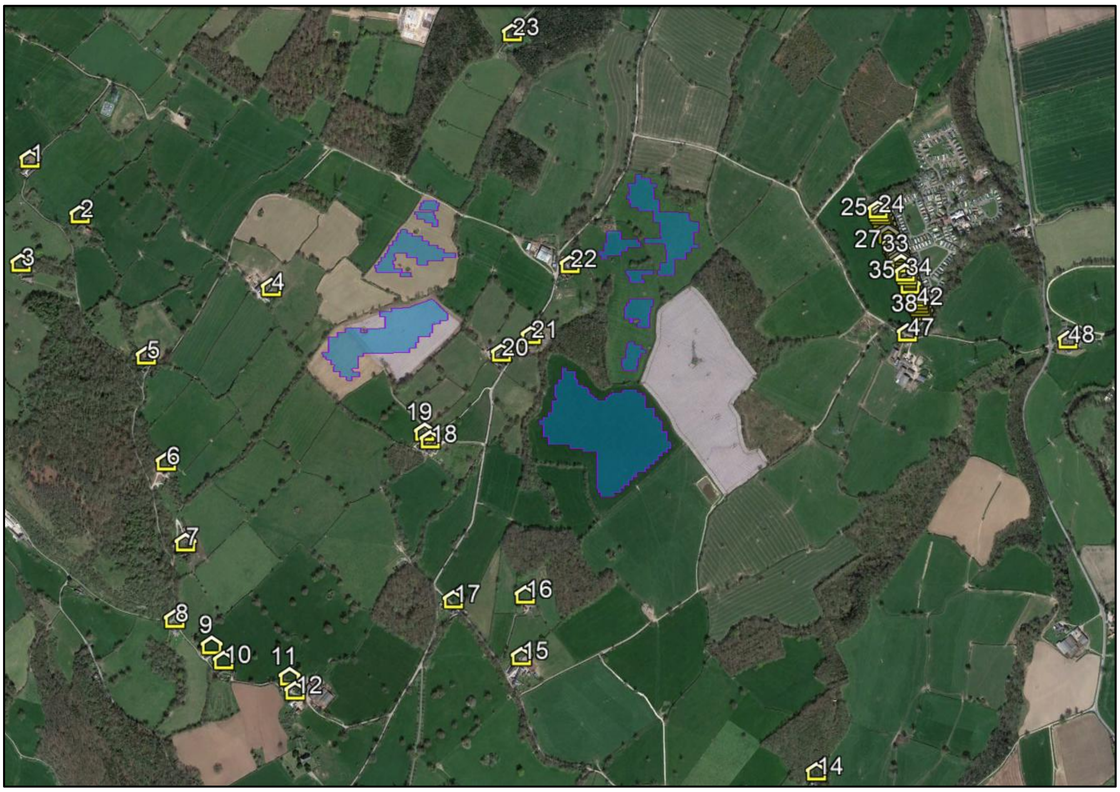

Figure 4 – Assessed dwelling receptors

[9] The co-ordinates of the dwelling receptor points are presented in Appendix G.

[10] In the results discussion the views from each floor have been considered. Glint and glare modelling results are not expected to change depending on the floor.

4.3 Road Receptors

Road types can generally be categorised as:

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

Most of the roads surrounding the Proposed Development are considered local roads where traffic densities are likely to be relatively low. Local roads have not been taken forward for geometric modelling 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.

The analysis has therefore considered major national, national, and regional roads that:

- Are within the one kilometre assessment area (i.e. 1km from panel areas);
- Have a potential view of the panels.

A 900m-section of the B5381 is located within 1km of the Proposed Development; however, does not have potential views of the Proposed Development. Screening in the form of existing vegetation and terrain significantly obstruct views of any reflecting panels, such that no impact would be possible upon road users. No impact is predicted, and mitigation is not required.

Figure 5 on the following page shows the B5381 (orange line) and the identified vegetation (outlined green) obstructing views of the Proposed Development.

Figure 5 – B5381 relative to the Proposed Development

5 GLINT AND GLARE ASSESSMENT RESULTS

5.1 Overview

A number of representative panel locations are selected within the proposed reflector areas with the number of modelled points being determined by the size of the reflector area and the assessment resolution. The bounding coordinates for the proposed solar farm development have been extrapolated from the site plans. The data can be found in Appendix G.

A resolution of 10m has been chosen 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 farm development.

5.2 Impact Significance Methodology – Dwelling Receptors

The key considerations for residential dwellings are:

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

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

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

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

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

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

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

5.3 Geometric Calculation Results – Dwelling Receptors

The results of the geometric calculations for the identified dwelling receptors are presented in Table 2 on the following page.

Dwelling Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	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, buildings and intervening terrain are predicted to significantly obstruct views	N/A	No impact
4	Solar reflections are geometrically possible for **more** than three months per year but **less** than 60 minutes on any given day	Existing vegetation and intervening terrain are predicted to obstruct majority of views with marginal views considered possible	Duration of effects due to screening is predicted to decrease to less than three months per year Views limited to above ground floor levels Effects coincide with the sun	Low impact

Dwelling Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Mitigating Factors	Predicted Impact Classification
5 – 7	Solar reflections are geometrically possible for **more** than three months per year but **less** than 60 minutes on any given day	Existing vegetation, buildings and intervening terrain are predicted to significantly obstruct views	N/A	No impact
8 – 10	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	N/A	No impact
11 – 17	Solar reflections are **not** geometrically possible	N/A	N/A	No impact
18 – 19	Solar reflections are geometrically possible for **more** than three months per year but **less** than 60 minutes on any given day	Existing vegetation is predicted to significantly obstruct views	N/A	No impact

Dwelling Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Mitigating Factors	Predicted Impact Classification
20 – 22	Solar reflections are geometrically possible for **more** than three months per year but **less** than 60 minutes on any given day	Existing vegetation and intervening terrain are predicted to obstruct majority of views with marginal views considered possible	Duration of effects due to screening is predicted to decrease to less than three months per year Effects coincide with the sun	Low impact
23	Solar reflections are **not** geometrically possible	N/A	N/A	No impact
24 – 40	Solar reflections are geometrically possible for **less** than three months per year and **less** than 60 minutes on any given day	Existing vegetation and intervening terrain are predicted to significantly obstruct views	N/A	No impact
41 – 48	Solar reflections are geometrically possible for **more** than three months per year but **less** than 60 minutes on any given day	Existing vegetation and intervening terrain are predicted to significantly obstruct views	N/A	No impact

Table 2 – Geometric analysis results for the identified dwelling receptors

5.4 Desk-Based Review of Available Imagery

A desk-based review of the available imagery is presented in Figures 6 to 13 below and on the following pages. The cumulative reflecting panel areas are indicated by regions of yellow (non-reflecting panels are shown in blue). The identified screening in the form of existing vegetation and buildings is outlined in pink and blue respectively.

Figure 6 Screening for dwelling receptors 1 to 3

Figure 7 Screening for dwelling receptor 4

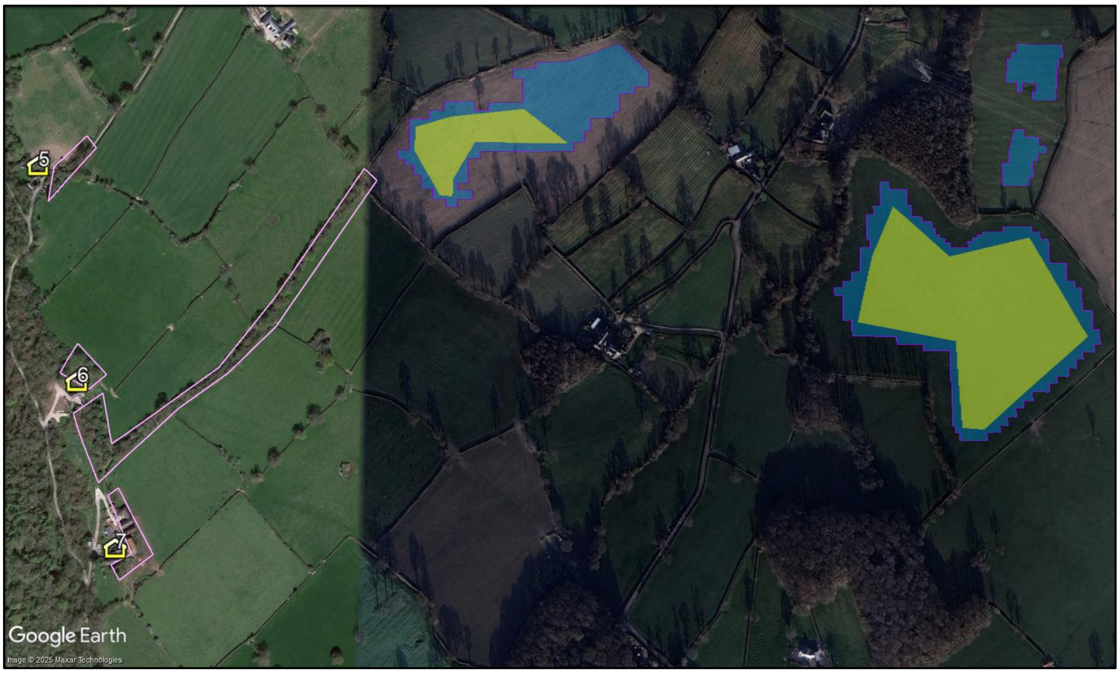

Figure 8 Screening for dwelling receptors 5 to 7

Figure 9 Screening for dwelling receptors 8 to 10

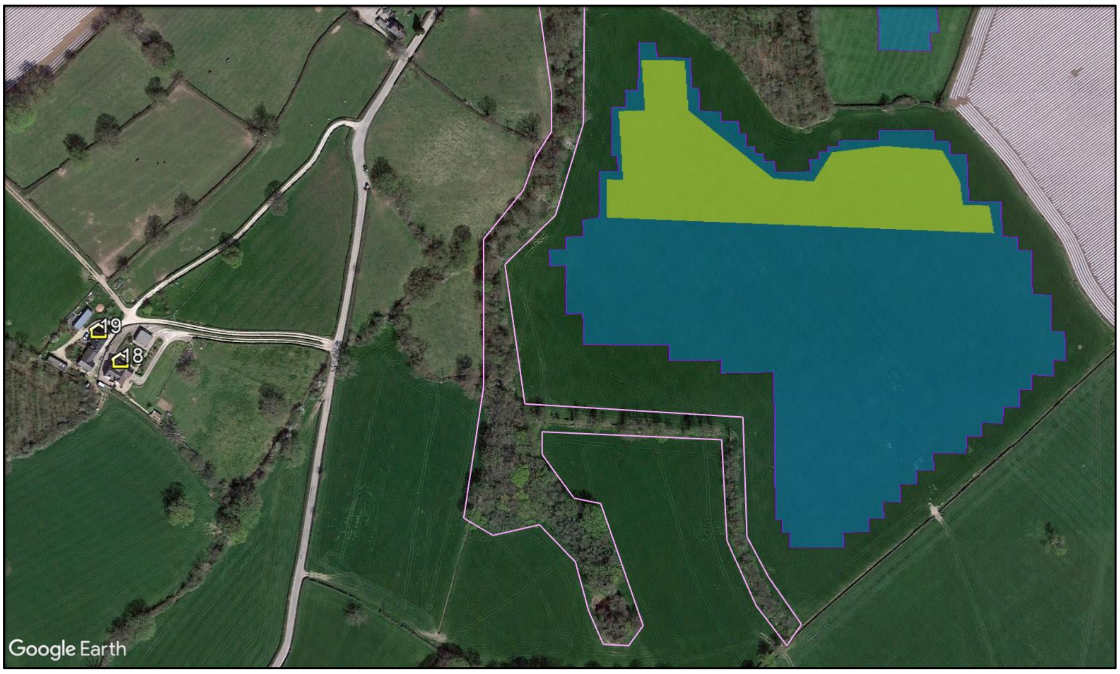

Figure 10 Screening for dwelling receptors 18 to 19

Figure 11 Screening for dwelling receptor 20

Figure 12 Screening for dwelling receptors 21 to 22

Figure 13 Screening for dwelling receptors 24 to 48

6 OVERALL CONCLUSIONS

6.1 Assessment Conclusions – Roads

Solar reflections towards the B5381 are predicted to be obstructed by existing vegetation and intervening terrain, such that no impact is predicted upon road users. No impact is predicted, and mitigation is not required.

6.2 Assessment Conclusions – Dwellings

Solar reflections are geometrically possible towards 40 of 48 assessed dwellings. Screening in the form of existing vegetation, buildings and intervening terrain is predicted to significantly obstruct views of reflecting panels for 36 dwellings, such that no impact is predicted. Mitigation is not required for these dwellings.

For the remaining four dwellings, solar reflections are geometrically possible for more than three months per year but less than 60 minutes on any given day. Screening in the form of existing vegetation is predicted to partially obstruct views of reflecting panels, with marginal views from above ground level considered possible. The resultant duration of effects is predicted to be reduced to less than three months per year. A low impact is predicted for these three dwellings, and mitigation is not recommended in accordance with the assessment methodology (Appendix D).

APPENDIX A – OVERVIEW OF GLINT AND GLARE GUIDANCE

Overview

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

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

Welsh Planning Policy

Future Wales

Future Wales Policies 17 and 18[11] are relevant in the context of potential glint and glare effects.

Policies 17 and 18 state:

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

…

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

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**;

[11] Future Wales: The National Plan 2040, Welsh Government, date: 21 February 2021, accessed on: 08/10/2024.
[12] Renewable and low carbon energy, Ministry of Housing, Communities & Local Government, date: 18 June 2015, accessed on: 01/11/2021

- the extent to which there may be additional impacts if solar arrays follow the daily movement of the sun;

…

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

National Policy Statement for Renewable Energy Infrastructure

The National Policy Statement for Renewable Energy Infrastructure (EN-3)[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:

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[13] National Policy Statement for Renewable Energy Infrastructure (EN-3), Department for Energy Security & Net Zero, date: Jan 2024, accessed on: 21/12/2023., 17/01/2024

[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.'*

'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. 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.

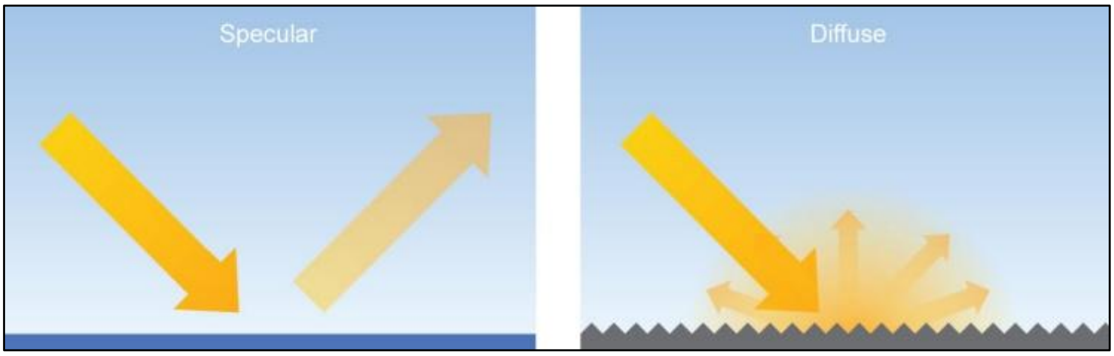
APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

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

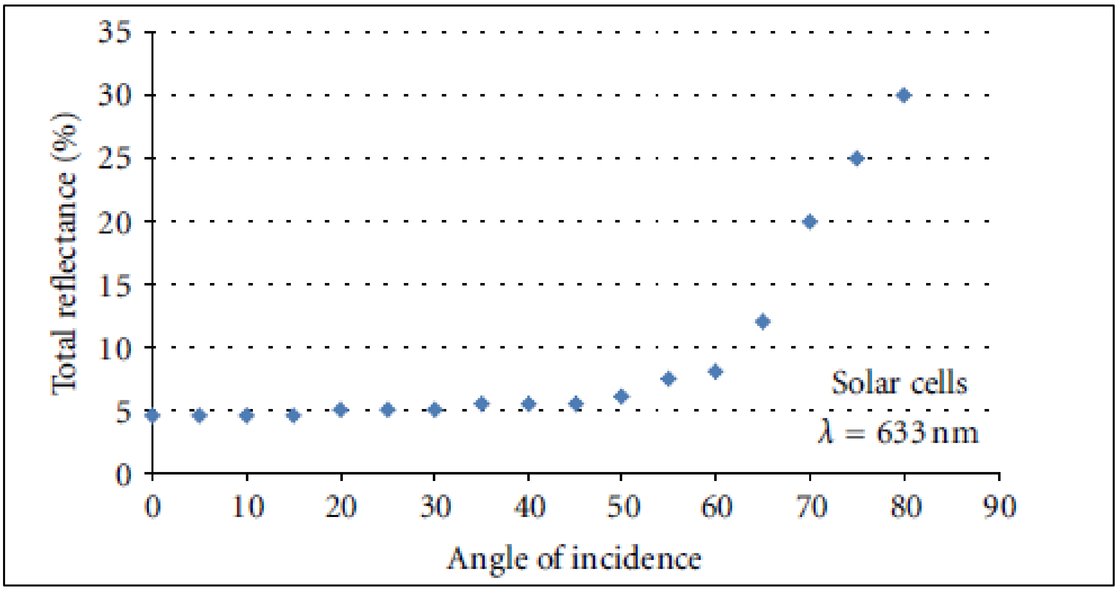
[16] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 08/12/2021.

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.

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[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 2018 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

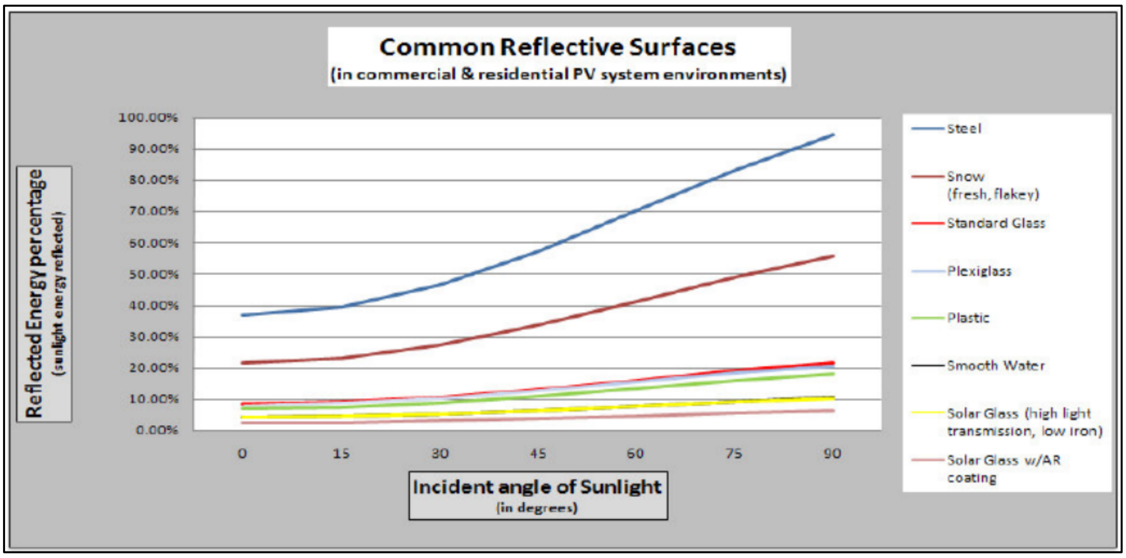
Note that the data above does not appear to consider the reflection type (specular or diffuse).
An important comparison in this table is the reflectivity compared to water which will produce a reflection of very similar intensity when compared to that from a solar panel. The study by Riley and Olsen 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: 08/12/2021.
[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 rises highest on 21 December (longest day).
- On 21 June, the maximum elevation reached by the Sun is at its lowest (shortest day).

APPENDIX D – GLINT AND GLARE IMPACT SIGNIFICANCE

Overview

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

Impact Significance Definition

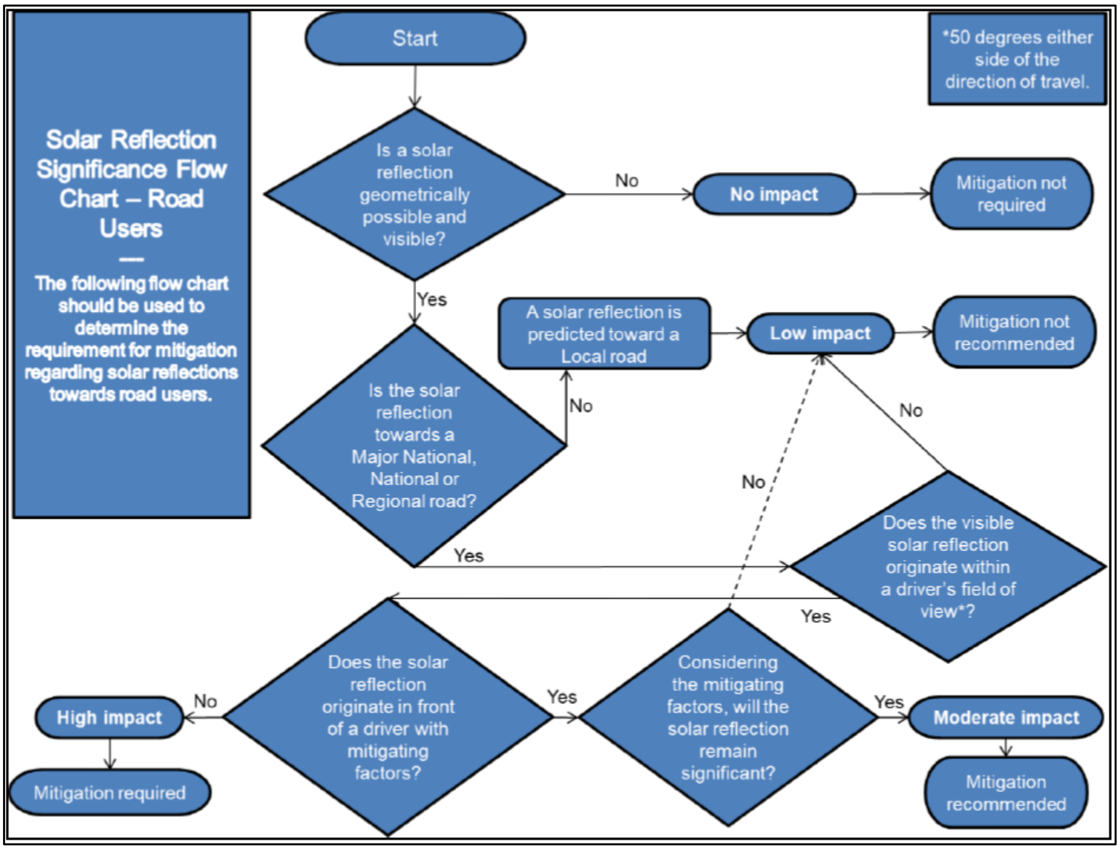
The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

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

Impact significance definition

Assessment Process for Road Receptors

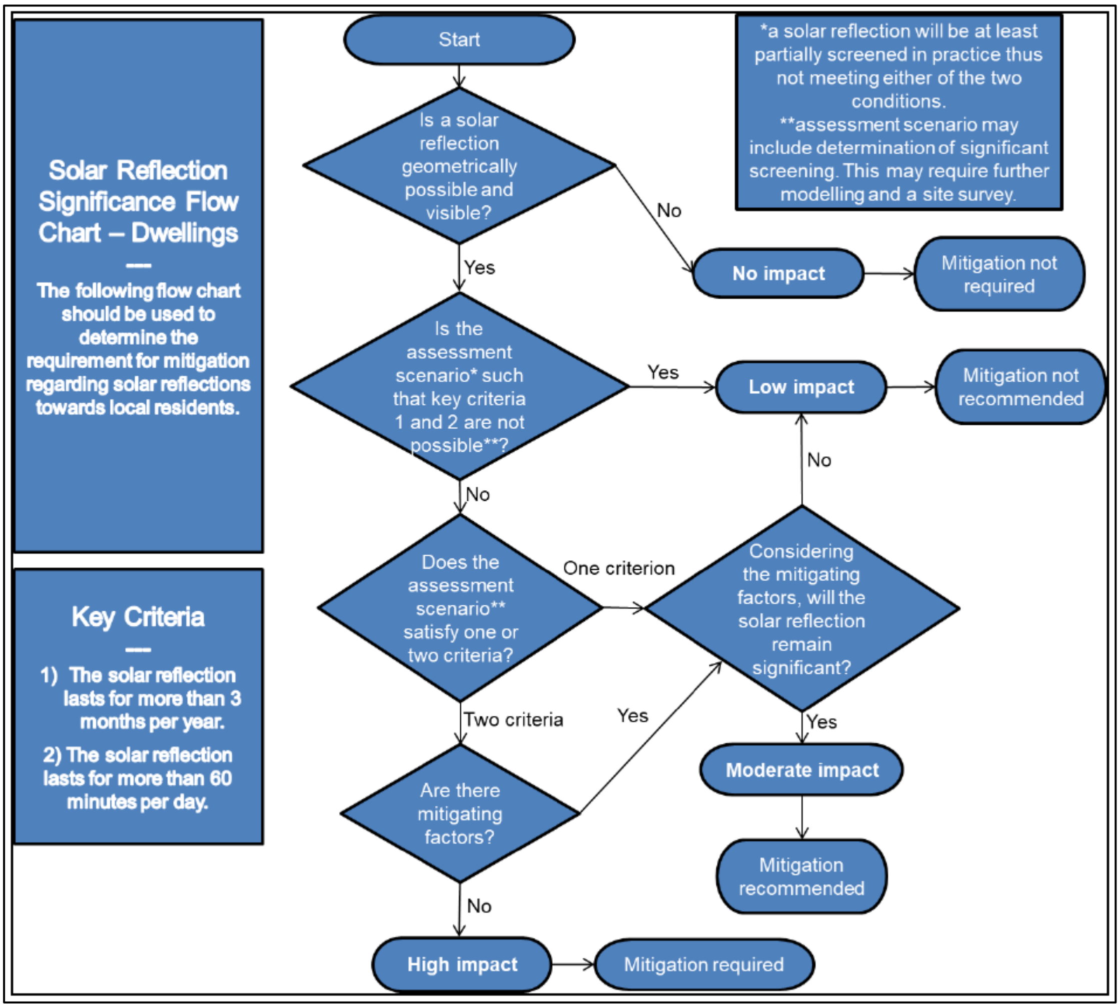
The flow chart presented below has been followed when determining the mitigation requirement for road receptors.



Road receptor mitigation requirement flow chart

Assessment Process for Dwelling Receptors

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



Dwelling receptor mitigation requirement flow chart

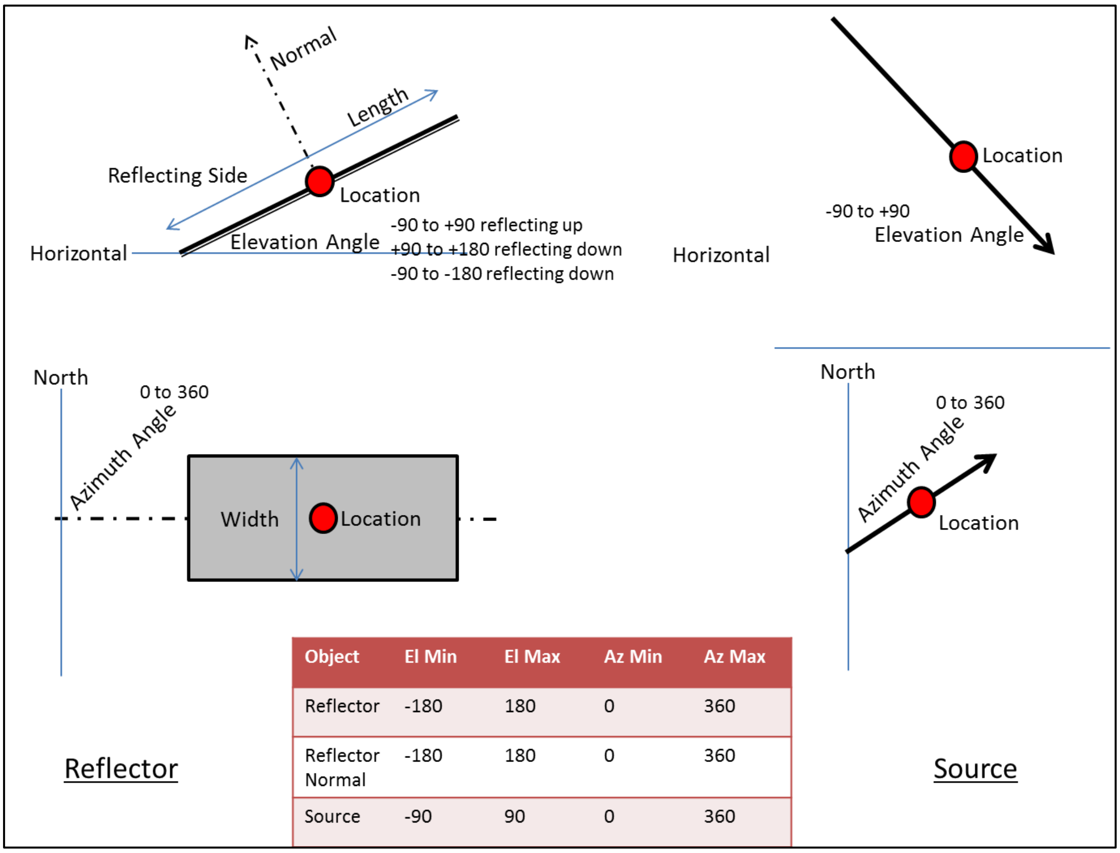
APPENDIX E – REFLECTION CALCULATIONS METHODOLOGY

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

Pager Power 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.

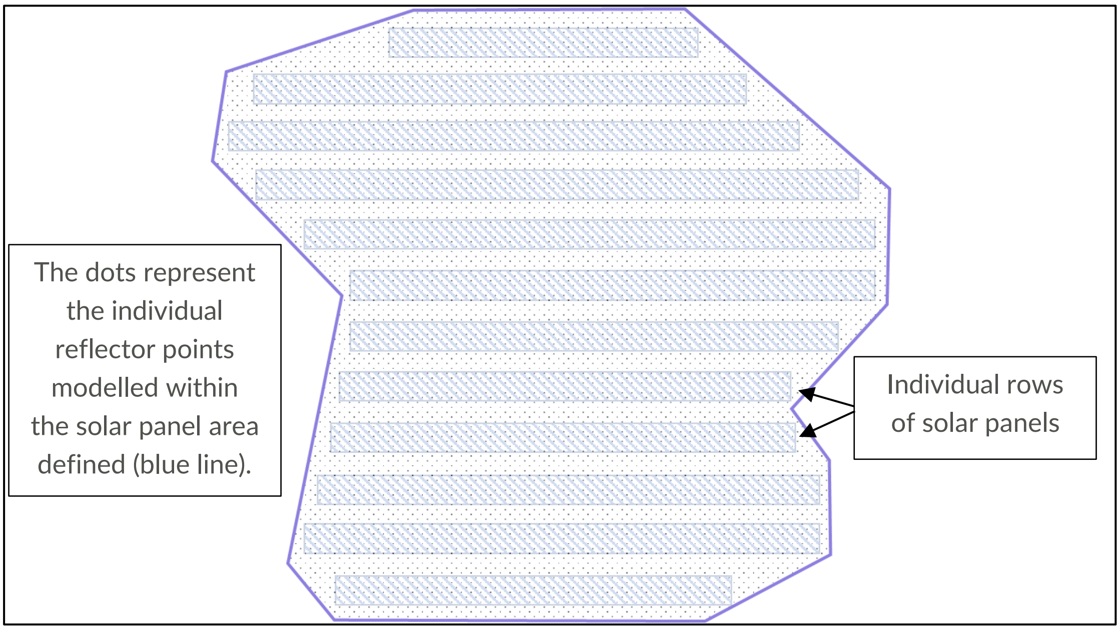
It is assumed that the panel azimuth angle assessed represents the azimuth angle for all of the panels within each solar panel area defined.

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

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

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

[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

Dwelling Receptors Details

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
1	-3.48334	53.24534	25	-3.45091	53.24415
2	-3.4814	53.24407	26	-3.45084	53.24409
3	-3.48347	53.24294	27	-3.45077	53.244
4	-3.47418	53.24243	28	-3.45073	53.24395
5	-3.47888	53.24086	29	-3.45068	53.24386
6	-3.47805	53.23846	30	-3.45063	53.24378
7	-3.4773	53.23664	31	-3.45062	53.24371
8	-3.47762	53.23495	32	-3.45057	53.24364
9	-3.4763	53.23434	33	-3.45039	53.24342
10	-3.47585	53.23399	34	-3.45031	53.24336
11	-3.4734	53.23361	35	-3.45026	53.24329
12	-3.47318	53.23329	36	-3.45019	53.24323
13	-3.45887	53.22898	37	-3.45015	53.24313
14	-3.45341	53.23138	38	-3.45012	53.24306
15	-3.46465	53.23402	39	-3.45008	53.24298
16	-3.4645	53.23541	40	-3.44992	53.24277
17	-3.46723	53.23531	41	-3.44986	53.24271
18	-3.46813	53.23895	42	-3.44979	53.24262
19	-3.46834	53.23912	43	-3.44974	53.24255
20	-3.46541	53.24093	44	-3.44974	53.24249

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
21	-3.46427	53.24134	45	-3.44968	53.2424
22	-3.46277	53.24297	46	-3.44959	53.24234
23	-3.46498	53.2483	47	-3.44956	53.24227
24	-3.45095	53.24422	48	-3.44951	53.2422

Dwelling Receptors Details

Modelled Reflector Areas

Panel Area 1

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
1	-3.46838	53.24463	7	-3.46786	53.24456
2	-3.46848	53.24463	8	-3.46781	53.24456
3	-3.46848	53.24454	9	-3.46781	53.24463
4	-3.46857	53.24454	10	-3.46790	53.24463
5	-3.46856	53.24447	11	-3.46790	53.24468
6	-3.46785	53.24447	12	-3.46839	53.24469

Panel Area 1

Panel Area 2

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
1	-3.46871	53.24437	8	-3.46783	53.24409
2	-3.46865	53.24437	9	-3.46783	53.24425
3	-3.46865	53.24426	10	-3.46796	53.24426
4	-3.46833	53.24426	11	-3.46797	53.24436
5	-3.46832	53.24418	12	-3.46801	53.24436
6	-3.46804	53.24418	13	-3.46801	53.24443
7	-3.46804	53.24409	14	-3.46871	53.24442

Panel Area 2

Panel Area 3

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
1	-3.46927	53.24394	30	-3.46957	53.24322
2	-3.46935	53.24394	31	-3.46958	53.24331
3	-3.46935	53.24385	32	-3.46949	53.24331
4	-3.46944	53.24384	33	-3.46950	53.24348
5	-3.46944	53.24376	34	-3.46903	53.24348
6	-3.46958	53.24376	35	-3.46902	53.24338
7	-3.46958	53.24366	36	-3.46865	53.24338
8	-3.46970	53.24366	37	-3.46865	53.24330
9	-3.46970	53.24355	38	-3.46862	53.24330
10	-3.46978	53.24355	39	-3.46862	53.24321
11	-3.46978	53.24347	40	-3.46824	53.24321
12	-3.46986	53.24347	41	-3.46825	53.24330
13	-3.46987	53.24337	42	-3.46767	53.24330
14	-3.47002	53.24338	43	-3.46768	53.24339
15	-3.47001	53.24328	44	-3.46718	53.24338
16	-3.47011	53.24328	45	-3.46718	53.24348
17	-3.47011	53.24321	46	-3.46761	53.24349
18	-3.47024	53.24320	47	-3.46762	53.24358
19	-3.47024	53.24313	48	-3.46785	53.24358
20	-3.47019	53.24313	49	-3.46784	53.24366
21	-3.47018	53.24304	50	-3.46821	53.24366
22	-3.46928	53.24303	51	-3.46822	53.24376
23	-3.46927	53.24294	52	-3.46843	53.24376

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
24	-3.46886	53.24294	53	-3.46843	53.24386
25	-3.46887	53.24304	54	-3.46885	53.24387
26	-3.46922	53.24303	55	-3.46884	53.24394
27	-3.46922	53.24311	56	-3.46905	53.24394
28	-3.46950	53.24311	57	-3.46905	53.24402
29	-3.46951	53.24322	58	-3.46926	53.24402

Panel Area 3

Panel Area 4

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
1	-3.46964	53.24214	28	-3.47111	53.24056
2	-3.47006	53.24213	29	-3.47112	53.24064
3	-3.47007	53.24203	30	-3.47083	53.24064
4	-3.46986	53.24203	31	-3.47084	53.24075
5	-3.46987	53.24175	32	-3.47110	53.24075
6	-3.47052	53.24175	33	-3.47111	53.24083
7	-3.47053	53.24166	34	-3.47090	53.24083
8	-3.47079	53.24166	35	-3.47091	53.24111
9	-3.47080	53.24176	36	-3.47070	53.24111
10	-3.47136	53.24175	37	-3.47069	53.24119
11	-3.47137	53.24165	38	-3.46892	53.24120
12	-3.47165	53.24165	39	-3.46892	53.24130
13	-3.47165	53.24156	40	-3.46870	53.24131
14	-3.47200	53.24156	41	-3.46871	53.24143
15	-3.47202	53.24120	42	-3.46858	53.24143

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
16	-3.47223	53.24120	43	-3.46859	53.24157
17	-3.47222	53.24110	44	-3.46816	53.24157
18	-3.47209	53.24110	45	-3.46816	53.24164
19	-3.47210	53.24104	46	-3.46803	53.24165
20	-3.47193	53.24103	47	-3.46803	53.24185
21	-3.47193	53.24093	48	-3.46776	53.24186
22	-3.47179	53.24092	49	-3.46776	53.24193
23	-3.47179	53.24076	50	-3.46749	53.24193
24	-3.47156	53.24076	51	-3.46749	53.24210
25	-3.47157	53.24065	52	-3.46806	53.24243
26	-3.47132	53.24064	53	-3.46898	53.24223
27	-3.47131	53.24056	54	-3.46963	53.24221

Panel Area 4

Panel Area 5

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
1	-3.46023	53.24509	27	-3.45879	53.24311
2	-3.46056	53.24509	28	-3.45879	53.24334
3	-3.46056	53.24501	29	-3.45833	53.24334
4	-3.46049	53.24501	30	-3.45833	53.24350
5	-3.46047	53.24481	31	-3.45816	53.24351
6	-3.46060	53.24481	32	-3.45816	53.24361
7	-3.46060	53.24473	33	-3.45786	53.24360
8	-3.46051	53.24474	34	-3.45787	53.24367
9	-3.46051	53.24465	35	-3.45807	53.24368

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
10	-3.46043	53.24465	36	-3.45807	53.24397
11	-3.46042	53.24454	37	-3.45786	53.24397
12	-3.46015	53.24454	38	-3.45787	53.24420
13	-3.46016	53.24447	39	-3.45821	53.24421
14	-3.45957	53.24446	40	-3.45824	53.24441
15	-3.45956	53.24420	41	-3.45935	53.24442
16	-3.45933	53.24420	42	-3.45936	53.24455
17	-3.45929	53.24380	43	-3.45938	53.24471
18	-3.45988	53.24381	44	-3.45956	53.24471
19	-3.45990	53.24372	45	-3.45959	53.24499
20	-3.45911	53.24370	46	-3.45947	53.24499
21	-3.45908	53.24326	47	-3.45949	53.24509
22	-3.45933	53.24325	48	-3.45970	53.24508
23	-3.45931	53.24309	49	-3.45970	53.24520
24	-3.45940	53.24308	50	-3.46004	53.24521
25	-3.45939	53.24298	51	-3.46006	53.24529
26	-3.45880	53.24298	52	-3.46025	53.24529

Panel Area 5

Panel Area 6

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
1	-3.46137	53.24371	11	-3.46081	53.24353
2	-3.46147	53.24371	12	-3.46058	53.24354
3	-3.46147	53.24352	13	-3.46059	53.24362
4	-3.46167	53.24352	14	-3.46008	53.24362

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
5	-3.46167	53.24344	15	-3.46008	53.24372
6	-3.46156	53.24343	16	-3.46019	53.24372
7	-3.46155	53.24336	17	-3.46019	53.24380
8	-3.46135	53.24336	18	-3.46084	53.24380
9	-3.46135	53.24344	19	-3.46084	53.24399
10	-3.46081	53.24344	20	-3.46138	53.24399

Panel Area 6

Panel Area 7

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
1	-3.46061	53.24298	7	-3.45994	53.24287
2	-3.46054	53.24298	8	-3.46003	53.24287
3	-3.46054	53.24292	9	-3.46003	53.24300
4	-3.46048	53.24292	10	-3.45961	53.24299
5	-3.46047	53.24281	11	-3.45961	53.24308
6	-3.45994	53.24281	12	-3.46062	53.24308

Panel Area 7

Panel Area 8

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
1	-3.46048	53.24233	11	-3.46012	53.24188
2	-3.46059	53.24233	12	-3.46020	53.24188
3	-3.46059	53.24226	13	-3.46020	53.24178
4	-3.46067	53.24226	14	-3.45974	53.24178
5	-3.46068	53.24198	15	-3.45973	53.24216
6	-3.46048	53.24198	16	-3.45969	53.24216

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
7	-3.46048	53.24188	17	-3.45969	53.24226
8	-3.46038	53.24189	18	-3.45961	53.24226
9	-3.46039	53.24198	19	-3.45962	53.24242
10	-3.46013	53.24197	20	-3.46048	53.24242

Panel Area 8

Panel Area 9

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
1	-3.46064	53.24120	10	-3.46010	53.24118
2	-3.46064	53.24107	11	-3.45992	53.24118
3	-3.46077	53.24107	12	-3.45992	53.24126
4	-3.46076	53.24081	13	-3.46008	53.24127
5	-3.46025	53.24081	14	-3.46007	53.24136
6	-3.46027	53.24091	15	-3.46036	53.24137
7	-3.46017	53.24091	16	-3.46036	53.24144
8	-3.46020	53.24109	17	-3.46054	53.24145
9	-3.46008	53.24109			

Panel Area 9

Panel Area 10

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
1	-3.46310	53.24058	50	-3.45927	53.23883
2	-3.46322	53.24058	51	-3.45927	53.23892
3	-3.46322	53.24048	52	-3.45906	53.23891
4	-3.46335	53.24048	53	-3.45907	53.23901
5	-3.46336	53.24019	54	-3.45894	53.23900

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
6	-3.46331	53.24019	55	-3.45896	53.23917
7	-3.46329	53.24010	56	-3.45908	53.23917
8	-3.46347	53.24010	57	-3.45908	53.23938
9	-3.46348	53.23984	58	-3.45927	53.23939
10	-3.46364	53.23982	59	-3.45928	53.23964
11	-3.46363	53.23973	60	-3.45941	53.23965
12	-3.46380	53.23972	61	-3.45941	53.23972
13	-3.46380	53.23965	62	-3.45956	53.23973
14	-3.46396	53.23965	63	-3.45957	53.23993
15	-3.46395	53.23955	64	-3.45989	53.23993
16	-3.46380	53.23956	65	-3.45990	53.24020
17	-3.46380	53.23927	66	-3.46006	53.24020
18	-3.46364	53.23928	67	-3.46007	53.24028
19	-3.46363	53.23910	68	-3.46023	53.24028
20	-3.46280	53.23909	69	-3.46023	53.24034
21	-3.46279	53.23900	70	-3.46076	53.24034
22	-3.46229	53.23900	71	-3.46076	53.24029
23	-3.46229	53.23893	72	-3.46115	53.24028
24	-3.46178	53.23893	73	-3.46115	53.24025
25	-3.46177	53.23808	74	-3.46125	53.24025
26	-3.46170	53.23807	75	-3.46126	53.24022
27	-3.46170	53.23800	76	-3.46134	53.24022
28	-3.46162	53.23800	77	-3.46134	53.24018

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
29	-3.46162	53.23791	78	-3.46143	53.24017
30	-3.46110	53.23791	79	-3.46142	53.24010
31	-3.46111	53.23800	80	-3.46176	53.24010
32	-3.46085	53.23801	81	-3.46177	53.24016
33	-3.46086	53.23808	82	-3.46187	53.24016
34	-3.46071	53.23808	83	-3.46188	53.24021
35	-3.46072	53.23818	84	-3.46196	53.24021
36	-3.46055	53.23818	85	-3.46196	53.24025
37	-3.46056	53.23828	86	-3.46205	53.24025
38	-3.46039	53.23828	87	-3.46205	53.24032
39	-3.46040	53.23836	88	-3.46211	53.24032
40	-3.46022	53.23836	89	-3.46212	53.24040
41	-3.46024	53.23846	90	-3.46229	53.24040
42	-3.45991	53.23846	91	-3.46229	53.24045
43	-3.45991	53.23856	92	-3.46250	53.24046
44	-3.45976	53.23856	93	-3.46251	53.24059
45	-3.45976	53.23864	94	-3.46257	53.24059
46	-3.45956	53.23863	95	-3.46259	53.24076
47	-3.45955	53.23873	96	-3.46291	53.24077
48	-3.45939	53.23873	97	-3.46293	53.24085
49	-3.45940	53.23883	98	-3.46309	53.24086

Panel Area 10

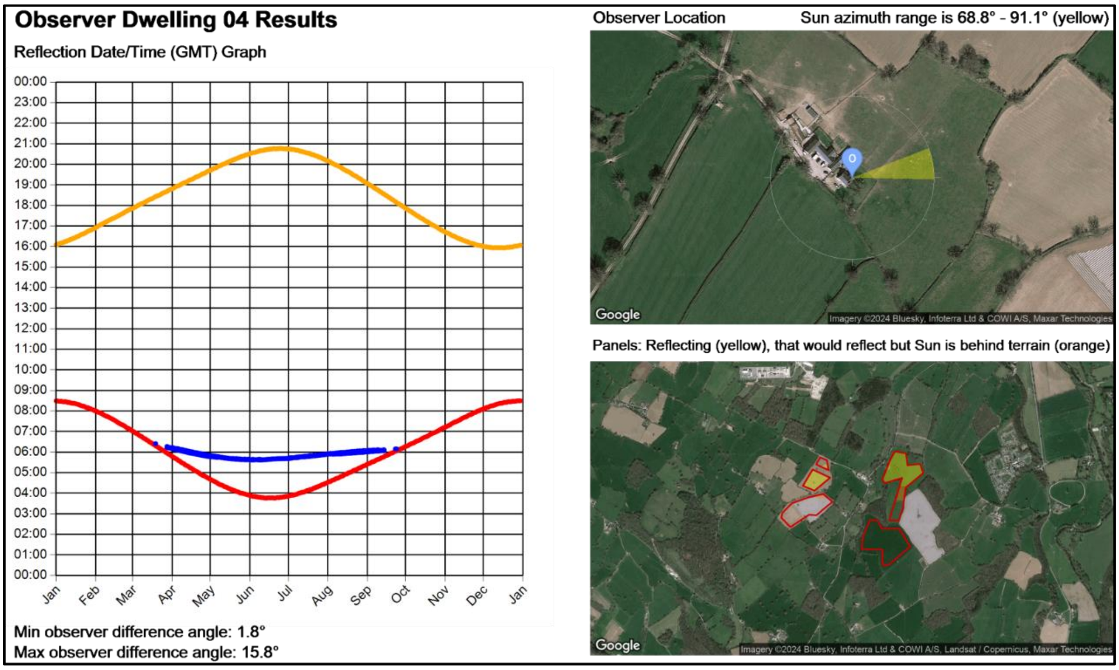
APPENDIX G – GEOMETRIC CALCULATION RESULTS

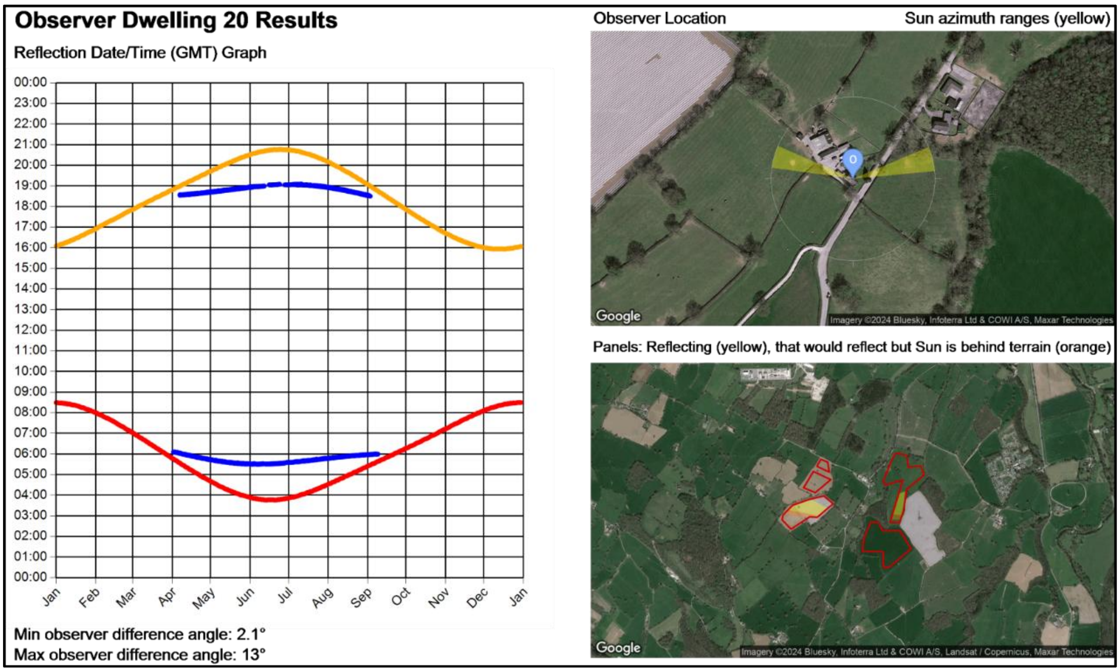
The charts for the receptors are shown on the following pages. Each chart shows:

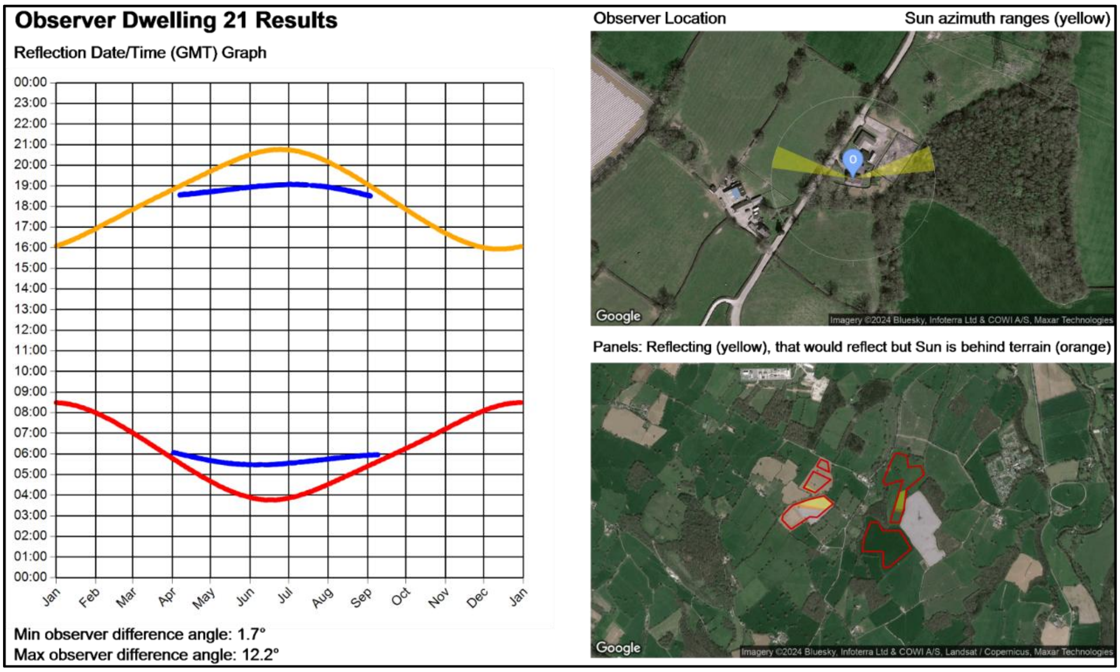
- The receptor (observer) location – top right image. This also shows the azimuth range of the Sun itself at times when reflections are possible. If sunlight is experienced from the same direction as the reflecting panels, the overall impact of the reflection is reduced as discussed within the body of the report;
- The reflecting panels – bottom right image. The reflecting area is shown in yellow. If the yellow panels are not visible from the observer location, no issues will occur in practice. Areas shown in orange are those where the Sun is obscured by terrain at the visible horizon and therefore no solar reflection could occur. 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 only;
- The yellow and red lines show sunrise and sunset times respectively.

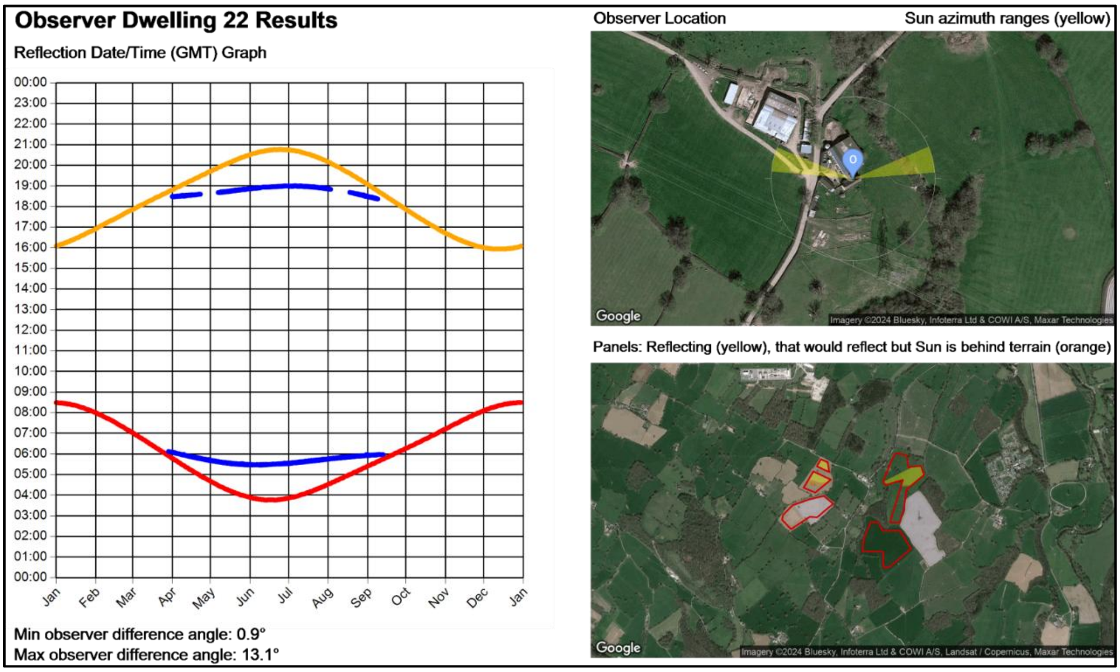
Dwellings

Modelling results for receptors where a low impact is predicted are presented. Full modelling results are available upon request.




Observer Dwelling 20 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 2.1°
Max observer difference angle: 13°
Observer Location
Sun azimuth ranges (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer Dwelling 21 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 1.7°
Max observer difference angle: 12.2°
Observer Location
Sun azimuth ranges (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google



Observer Dwelling 22 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 0.9°
Max observer difference angle: 13.1°
Observer Location
Sun azimuth ranges (yellow)
Google
Imagery ©2024 Bluesky, Infoterra Ltd & COWI A/S, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2024 Bluesky, Infoterra Ltd & COWI A/S, Landsat / Copernicus, Maxar Technologies

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