PAGERPOWER
Urban & Renewables

Solar Photovoltaic Glint and Glare Study

Econergy International Ltd

Solar Farm on Land South of Berrington

August 2022





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 proposed solar photovoltaic (PV) development located at Land South of Berrington, Shrewsbury, Shropshire, SY5 6HA. The assessment pertains to the possible impact upon surrounding road users and dwellings.

Pager Power

Pager Power has undertaken over 900 glint and glare assessments in the UK, Europe and internationally. The company's own glint and glare guidance is based on industry experience and extensive consultation with industry stakeholders including airports and aviation regulators.

Conclusions

No impacts requiring mitigation are predicted for the surrounding road users or dwellings.

The assessment results are presented on the following page.

Guidance and Studies

Guidelines exist in the UK (produced by the Civil Aviation Authority) and in the USA (produced by the Federal Aviation Administration) with respect to solar developments and aviation activity. The UK CAA guidance is relatively high-level and does not prescribe a formal methodology. Pager Power has reviewed existing guidelines and the available studies in the process of defining its own glint and glare assessment guidance document and methodology[1]. This methodology defines a comprehensive process for determining the impact upon road safety and residential amenity.

Pager Power's approach is to undertake geometric reflection calculations and, where a solar reflection is predicted, consider the screening (existing and/or proposed) between the receptor and the reflecting solar panels. For aviation activity, where a solar reflection is predicted, solar intensity calculations are undertaken in line with the Sandia National Laboratories' FAA methodology[2]. 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[3].

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[1] Pager Power Glint and Glare Guidance, Third Edition (3.1), April 2021.

[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 Results – Roads

All roads within the 1km assessment area for consideration of glint and glare effects are local roads. 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.

Overall, no significant impacts upon road users are predicted and no mitigation is required.

Assessment Results – Dwellings

Views of the reflecting panels are considered possible for 10 dwellings; however, a mitigation recommendation has not been identified because:

- The duration of effects is not significant; and/or
- The separation distance between the dwelling and the closest reflecting panel is sufficiently large; and/or
- Due to existing screening views are likely to be possible for observers above the ground floor only, i.e. the first floor or above[4]; and/or
- Solar reflections would occur within approximately 2 hours of sunrise/sunset; therefore, effects would mostly coincide with direct sunlight.

[4] The ground floor is typically considered the main living space and therefore has a greater significance with respect to residential amenity.

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 53 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 possible effects of glint and glare from a proposed solar photovoltaic (PV) development located at Land South of Berrington, Shrewsbury, Shropshire, SY5 6HA. The assessment pertains to the possible impact upon surrounding road users and dwellings.

This report contains the following:

- Solar development details.
- Explanation of glint and glare.
- Overview of relevant guidance.
- Overview of relevant studies.
- Overview of Sun movement.
- Assessment methodology.
- Identification of receptors.
- Glint and glare assessment for identified receptors.
- Results discussion.

1.2 Pager Power's Experience

Pager Power has undertaken over 900 Glint and Glare assessments in the UK and internationally. The studies have included assessment of civil and military aerodromes, railway infrastructure and other ground-based receptors including roads and dwellings.

1.3 Glint and Glare Definition

The definition of glint and glare is as follows[5]:

- 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.

[5] These definitions are aligned with those of the Draft National Policy Statement for Renewable Energy Infrastructure.

2 SOLAR DEVELOPMENT LOCATION AND DETAILS

2.1 Overview

The following section presents the solar development location and key details pertaining to this assessment.

2.2 Proposed Development Site Layout

Figure 1[6] below shows the proposed development site layout[7]. The grey vertical lines denote the solar panel locations.

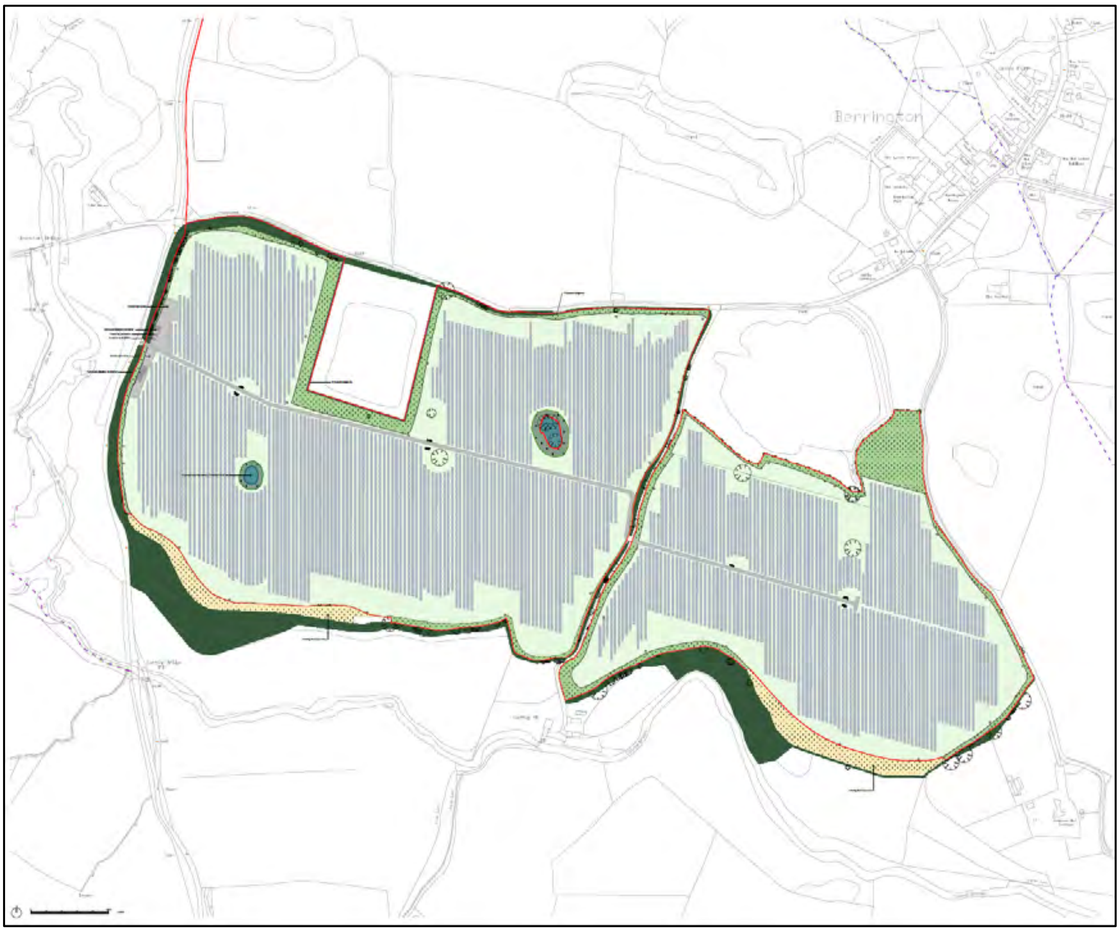

Figure 1 *Proposed development site layout*

[6] Source: BERRINGTON LAYOUT PLAN_ISSUE03.pdf

[7] Analysis is based on a previous layout. The layout change does not affect the significance of the results, with the panel footprint mostly reducing across the whole site.

2.3 Solar Panel Technical Information

The technical information used for the modelling are presented in Table 1 below.

Solar Panel Technical Information	
Assessed centre-height	2m agl (above ground level)
Tracking	Horizontal Single Axis tracks Sun East to West
Tilt of tracking axis (°)	0
Orientation of tracking axis (°)	180
Offset angle of module (°)	0
Tracker Range of Motion (°)	±60
Resting angle (°)	0
Surface material	Smooth glass without an ARC (anti-reflective coating)

Table 1 *Solar panel technical information*

2.3.1 Solar Panel Backtracking

Shading considerations dictate the panel tilt. This is affected by:

- The elevation angle of the Sun;
- The vertical tilt of the panels;
- The spacing between the panel rows.

This means that early in the morning and late in the evening, the panels will not be directed exactly towards the Sun, as the loss from shading of the panels (caused by facing the sun directly when the Sun is low in the horizon), would be greater than the loss from lowering the panels to a less direct angle in order to avoid the shading Figure 2 on the following page illustrates this.

The graphics in Figure 2 on the following page show two lines illustrating the paths of light from the Sun towards the solar panels. In reality, the lines from the Sun to each panel would be effectively parallel due to the large separation distance. The figure is for illustrative purposes only.

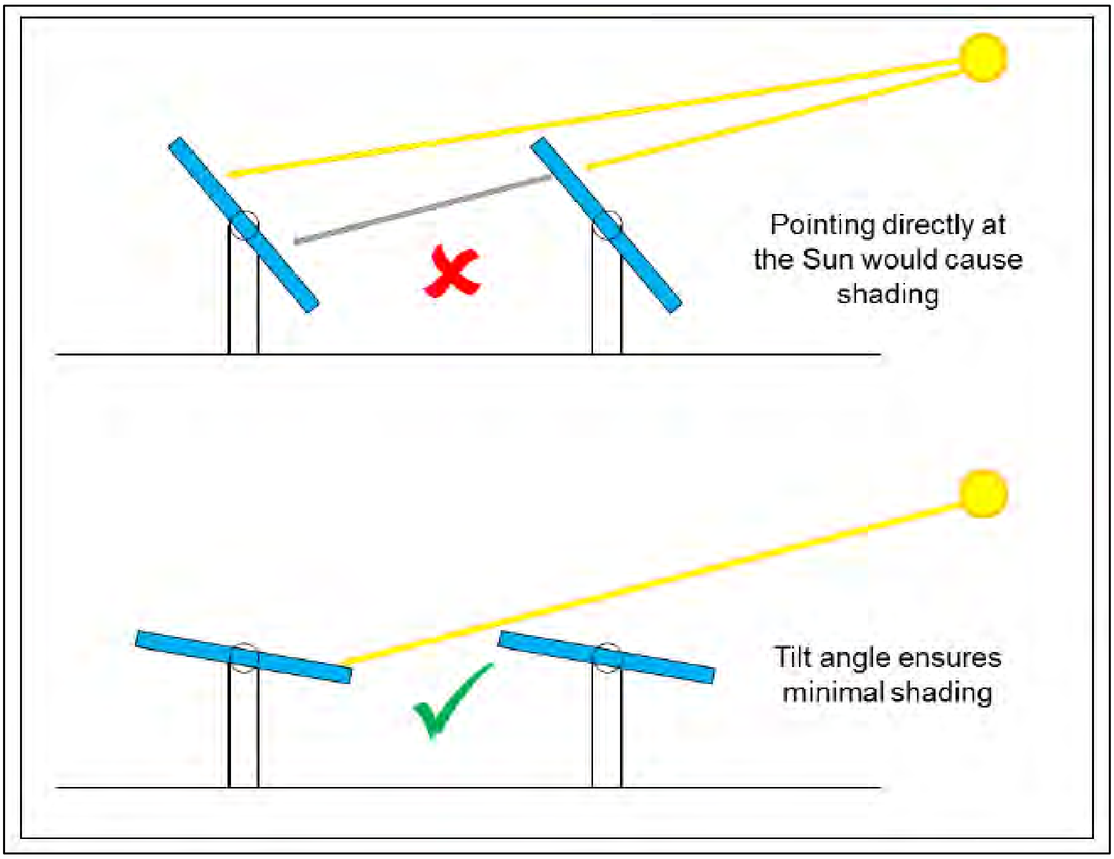

Figure 2 *Shading Considerations*

Later in the day, the panels can be directed towards the Sun without any shading issues. This is illustrated in Figure 3 below.

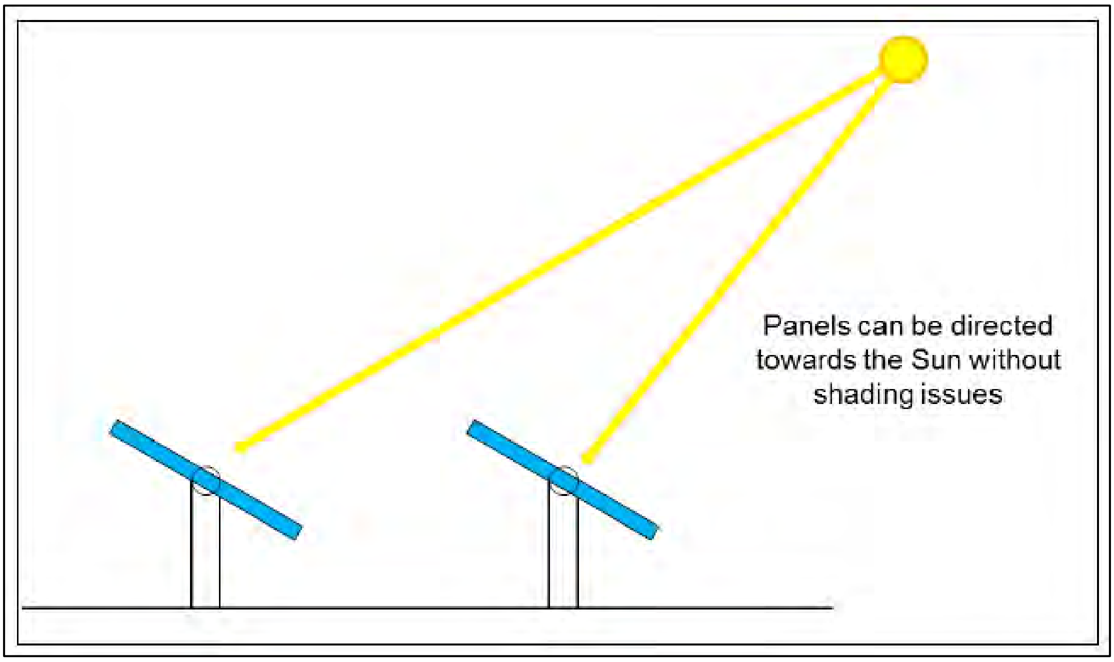

Figure 3 *Panel alignment at high solar angles*

The solar panels backtrack (where the panel angle gradually declines to prevent shading) by reverting to 0 degrees (flat) once the maximum elevation angle of the panels (60 degrees) becomes ineffective due to the low height of the Sun above the horizon and to avoid shading.

2.3.2 Back Tracking Solar Panel Model

Back tracking systems are sensitive to panel length, row spacing, topography and the level of shading which varies throughout the year. The Forge Solar model used in this assessment is a widely accepted model within this area. The model approximates a backtracking system by assuming the panels instantaneously revert to its resting angle of 0 degrees whenever the sun is outside the rotation range (60 degrees in this instance). Panels with a maximum tracking angle of 60 degrees and resting angle of 0 degrees would therefore lie horizontally from sunrise until the Sun enters the rotation range, and immediately after the sun leaves the rotation range until sunset daily. This definition is taken from Forge (see Appendix E) and by rotation range it is assumed the panels remain at 0 degrees until the Sun reaches 30 degrees above the horizon – when the Sun is at right angles to the panels at 60 degrees. It is understood that this option was created specifically to account for backtracking to the extent possible.

Whilst this model simplifies the backtracking process to be used by the solar panels within the solar development, panels that revert back to their resting angle immediately in many cases present a worst-case scenario for reflectors. This is because flatter panels can produce solar reflections in a much greater range of azimuth angles at ground level. The results would in most cases be more conservative than modelling a detailed back tracking system.

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

3.3.1 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 and studies. The methodology for a glint and glare assessments is as follows:

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

3.3.2 Sandia National Laboratories' Methodology

Sandia National Laboratories developed the Solar Glare Hazard Analysis Tool (SGHAT) which is no longer available. This methodology was formerly mandatory for on-airfield solar PV developments in the USA under the FAA's interim policy. This policy has been superseded in 2021 within the USA, however the methodology and associated guidance is widely referenced by UK aviation stakeholders and provides a meaningful starting point for determining the operational significance of any predicted glare. The following text is taken from the SGHAT model methodology.

'*This tool determines when and where solar glare can occur throughout the year from a user-specified PV array as viewed from user-prescribed observation points. The potential ocular impact from the observed glare is also determined, along with a prediction of the annual energy production.*'

The result was a chart that states whether a reflection can occur, the duration and predicted intensity for aviation receptors.

Pager Power has undertaken many aviation glint and glare assessments with both models (SGHAT and Pager Power's) producing similar results. Intensity calculations in line with Sandia National Laboratories' methodology has been completed[8]. Where required, cross checks have been completed.

3.4 Assessment Methodology and Limitations

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

[8] Currently using the Forge Solar model, based on the Sandia methodology.

4 GROUND-BASED 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 ground-based receptors. The assessment area (orange outlined area in the proceeding figure) has been designed accordingly as a 1km from the proposed development (blue outlined areas).

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.

Terrain elevation heights have been interpolated based on SRTM terrain data. Receptor details can be found in Appendix G.

4.2 Road Receptors

Road types can generally be categorised as:

- Major National – Typically a road with a minimum of two carriageways with a maximum speed limit of up to 70mph. These roads typically have fast moving vehicles with busy traffic.
- National – Typically a road with a one or more carriageways with a maximum speed limit of up to 60mph or 70mph. These roads typically have fast moving vehicles with moderate to busy traffic density.
- Regional – Typically a single carriageway with a maximum speed limit of up to 60mph. The speed of vehicles will vary with a typical traffic density of low to moderate.
- 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 assessment has therefore considered major national, national, and regional roads that:

- Are within the 1km assessment area.
- Have a potential view of the panels.

The surrounding roads have been reviewed based on the available imagery as shown in Figure 4[9] below. Considering the results of this review, no road receptors have been taken forward for geometric and detailed modelling because, all roads within the 1km assessment area are local roads and therefore would be considered low impact in the worst case.

Overall, no significant impacts upon road users are predicted and no mitigation is required.

Figure 4 *1km assessment area and roads surrounding the proposed development – aerial image*

[9] Copyright © 2022 Google.

4.3 Dwelling Receptors

The analysis has considered dwellings that:

- Are within the 1km assessment area.
- Have a potential view of the panels.

The individual assessed dwelling receptors and an overview of all dwelling receptors are shown in Figures 5 to 17[9] below and on the following pages. In total, 79 dwelling receptor locations[10,11] have been considered for the assessment. A height of 1.8 metres above ground level has been taken as typical eye level for an observer on the ground floor of the dwellings[12].

Figure 5 *Assessed dwelling receptors – 1 to 5*

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

[11] 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.

[12] 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 6 *Assessed dwelling receptors – 6 to 37*

Figure 7 *Assessed dwelling receptor – 38*

Figure 8 *Assessed dwelling receptors – 39 to 45*

Figure 9 *Assessed dwelling receptor – 46*

Figure 10 *Assessed dwelling receptor – 47*

Figure 11 *Assessed dwelling receptors – 48 to 50*

Figure 12 *Assessed dwelling receptors – 51 to 60*

Figure 13 *Assessed dwelling receptor – 61*

Figure 14 *Assessed dwelling receptors – 62 to 65*

Figure 15 *Assessed dwelling receptors – 66 to 78*

Figure 16 *Assessed dwelling receptor – 79*

Figure 17 *Dwelling receptors overview*

5 ASSESSED REFLECTOR AREAS

5.1 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 18[9] below shows the assessed reflector areas that have been used for modelling purposes.

Figure 18 *Assessed reflectors areas*

6 GLINT AND GLARE ASSESSMENT – TECHNICAL RESULTS

6.1 Summary of Results

The tables in the following sub-sections summarise the results of the assessment. The tables are based solely on bare-earth terrain i.e., without consideration of screening from buildings and vegetation. Whether a reflection will be experienced in practice, and the significance of any impacts are discussed in the subsequent report sections.

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

6.2 Geometric Calculation Results – Dwelling Receptors

The results of the geometric calculations for the dwelling receptors are presented in Table 2 below.

Receptor	Reflection possible towards receptor? (GMT)		Modelling results (bare earth terrain i.e. **no screening considered**)
	am	pm	
1 – 3.	No.	No.	No solar reflections geometrically possible.
4 – 5.	No.	Yes.	Solar reflections predicted to originate from a north-western section of panel area A. Solar reflections predicted for **less** than 60 minutes per day and for **less** than 3 months of the year.
6 – 7.	No.	Yes.	Solar reflections predicted to originate from a central section of panel area A. Solar reflections predicted for **less** than 60 minutes per day and for **more** than 3 months of the year.
8.	No.	Yes.	Solar reflections predicted to originate from a south-eastern section of panel area A and a western section of panel area B. Solar reflections predicted for **less** than 60 minutes per day and for **more** than 3 months of the year.

Receptor	Reflection possible towards receptor? (GMT)		Modelling results (bare earth terrain i.e. **no screening considered**)
	am	pm	
9 – 27.	No.	Yes.	Solar reflections predicted to originate from a central section of panel area A. Solar reflections predicted for **less** than 60 minutes per day and for **more** than 3 months of the year.
28.	No.	Yes.	Solar reflections predicted to originate from a western section of panel area A. Solar reflections predicted for **less** than 60 minutes per day and for **more** than 3 months of the year.
29 – 37.	No.	Yes.	Solar reflections predicted to originate from a south-eastern and central section of panel area A and a central section of panel area B. Solar reflections predicted for **less** than 60 minutes per day and for **more** than 3 months of the year.
38.	No.	Yes.	Solar reflections predicted to originate from a south-western and central section of panel areas A and B. Solar reflections predicted for **less** than 60 minutes per day and for **more** than 3 months of the year.
39 – 45.	No.	Yes.	Solar reflections predicted to originate mostly from north-eastern and south-western sections of panel areas A and B. Solar reflections predicted for **less** than 60 minutes per day and for **more** than 3 months of the year.
46.	No.	Yes.	Solar reflections predicted to originate from south-western sections of panel areas A and B. Solar reflections predicted for **less** than 60 minutes per day and for **more** than 3 months of the year.

Receptor	Reflection possible towards receptor? (GMT)		Modelling results (bare earth terrain i.e. **no screening considered**)
	am	pm	
47.	No.	Yes.	Solar reflections predicted to originate from a south-western section of panel area A. Solar reflections predicted for **less** than 60 minutes per day and for **less** than 3 months of the year.
48 – 50.	Yes.	Yes.	Solar reflections predicted to originate from a south-western section of panel area A and a south-eastern section of panel area B. Solar reflections predicted for **less** than 60 minutes per day and for **more** than 3 months of the year.
51 – 54.	Yes.	No.	Solar reflections predicted to originate from a south-eastern section of panel area B. Solar reflections predicted for **less** than 60 minutes per day and for **less** than 3 months of the year.
55 – 57.	Yes.	No.	Solar reflections predicted to originate from a south-eastern section of panel area B. Solar reflections predicted for **less** than 60 minutes per day and for **more** than 3 months of the year.
58 – 60.	Yes.	No.	Solar reflections predicted to originate from a south-eastern section of panel area B. Solar reflections predicted for **less** than 60 minutes per day and for **less** than 3 months of the year.
61.	No.	No.	No solar reflections geometrically possible.
62 – 63.	Yes.	No.	Solar reflections predicted to originate from a south-eastern section of panel area B. Solar reflections predicted for **less** than 60 minutes per day and for **less** than 3 months of the year.

Receptor	Reflection possible towards receptor? (GMT)		Modelling results (bare earth terrain i.e. **no screening considered**)
	am	pm	
64 – 65.	Yes.	No.	Solar reflections predicted to originate from a south-eastern section of panel area B. Solar reflections predicted for **less** than 60 minutes per day and for **more** than 3 months of the year.
66 – 77.	Yes.	No.	Solar reflections predicted to originate from a southern and central section of panel area A and a southern section of panel area B. Solar reflections predicted for **less** than 60 minutes per day and for **more** than 3 months of the year.
78.	Yes.	No.	Solar reflections predicted to originate from a southern section of panel area A. Solar reflections predicted for **less** than 60 minutes per day and for **less** than 3 months of the year.
79.	Yes.	No.	Solar reflections predicted to originate from a north-eastern section of panel area A. Solar reflections predicted for **less** than 60 minutes per day and for **less** than 3 months of the year.

Table 2 *Geometric calculation results – dwelling receptors*

7 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

7.1 Overview

The following sub-section present the significance of any predicted impact in the context of existing screening and relevant criteria. The criteria are determined by the assessment process for each receptor, which are set out in Appendix D.

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

7.2 Dwelling Receptors

The results of the modelling indicate that solar reflections are geometrically possible towards 75 of the 79 assessed dwelling receptors. The dwellings where solar reflections are geometrically possible, 4 to 60 and 62 to 79, are shown in Figure 19[9] below.

Figure 19 *Dwellings where solar reflections are geometrically possible*

The process for quantifying impact significance is defined in the report appendices. For dwelling receptors, the key considerations 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 per day.

Where effects are predicted to be experienced for less than 3 months per year and less than 60 minutes per day, or where the separation distance to the nearest visible reflecting panel is over 1km, the impact significance is low, and mitigation is not required.

Where effects are predicted to be experienced for more than 3 months per year or for more than 60 minutes per day, the impact significance is moderate and expert assessment of the following mitigating factors is required to determine the mitigation requirement:

- The separation distance to the panel area. Larger separation distances reduce the proportion of an observer's field of view that is affected by glare.
- The position of the Sun. Effects that coincide with direct sunlight appear less prominent than those that do not. The Sun is a far more significant source of light.
- 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.
- Whether the dwelling appears to have windows facing the reflecting areas. An observer may need to look at an acute angle to observe the reflecting areas.

Where effects are predicted to be experienced for more than 3 months per year and more than 60 minutes per day, the impact significance is high, and mitigation is required.

Table 3 below and on the following pages summarises the predicted impact significance and mitigation requirement for the dwelling receptors where solar reflections are geometrically possible.

Dwelling Receptor	Identified Screening (desk-based review)	Predicted Impact Classification	Relevant Factors	Mitigation Recommended?
4 – 7.	Existing vegetation. Predicted to significantly obstruct views of the reflecting panels.	No impact.	N/A.	No.

Dwelling Receptor	Identified Screening (desk-based review)	Predicted Impact Classification	Relevant Factors	Mitigation Recommended?
8.	Existing vegetation. Partial views of the reflecting panels may be possible.	Moderate.	The distance to the closest reflecting panel is approximately 360 metres. Effects would mostly coincide with direct sunlight. Due to existing screening views are likely to be possible to observers above the ground floor only i.e. the first floor or above.	No.
9 – 37.	Existing vegetation and/or terrain. Predicted to significantly obstruct views of the reflecting panels.	No impact.	N/A.	No.
38	Existing vegetation, buildings, and/or terrain. Partial views of the reflecting panels may be possible.	Moderate.	The distance to the closest reflecting panel is approximately 140 metres. Effects would mostly coincide with direct sunlight. Due to existing screening views are likely to be possible to observers above the ground floor only i.e. the first floor or above.	No.
39 – 40.	Existing vegetation and/or terrain. Predicted to significantly obstruct views of the reflecting panels.	No impact.	N/A.	No.

Dwelling Receptor	Identified Screening (desk-based review)	Predicted Impact Classification	Relevant Factors	Mitigation Recommended?
41 – 45.	Buildings. Predicted to significantly obstruct views of the reflecting panels.	No impact.	N/A.	No.
46.	Existing vegetation and/or terrain. Predicted to significantly obstruct views of the reflecting panels.	No impact.	N/A.	No.
47.	Existing vegetation, buildings, and/or terrain. Predicted to significantly obstruct views of the reflecting panels.	No impact.	N/A.	No.
48 – 50.	Existing vegetation and/or terrain. Predicted to significantly obstruct views of the reflecting panels.	No impact.	N/A.	No.
51.	Existing vegetation and buildings. Partial views of the reflecting panels may be possible.	Low.	N/A.	No.

Dwelling Receptor	Identified Screening (desk-based review)	Predicted Impact Classification	Relevant Factors	Mitigation Recommended?
52 – 53.	Existing vegetation. Predicted to significantly obstruct views of the reflecting panels.	No impact.	N/A.	No.
54.	Existing vegetation. Views of the reflecting panels may be possible.	Low.	N/A.	No.
55 – 56.	Existing vegetation. Partial views of the reflecting panels may be possible.	Moderate.	The distance to the closest reflecting panel is approximately 520 metres. Effects would mostly coincide with direct sunlight. Due to existing screening views are likely to be possible to observers above the ground floor only i.e. the first floor or above.	No.
57 – 59.	Existing vegetation and/or dwellings. Predicted to significantly obstruct views of the reflecting panels.	No impact.	N/A.	No.
60.	Dwellings. Partial views of the reflecting panels may be possible.	Low.	N/A.	No.

Dwelling Receptor	Identified Screening (desk-based review)	Predicted Impact Classification	Relevant Factors	Mitigation Recommended?
62.	Buildings. Predicted to significantly obstruct views of the reflecting panels.	No impact.	N/A.	No.
63.	Existing vegetation. Partial views of the reflecting panels may be possible.	Low.	N/A.	No.
64 – 65.	Existing vegetation. Partial views of the reflecting panels may be possible.	Moderate.	The distance to the closest reflecting panel is approximately 850 metres. Effects would mostly coincide with direct sunlight. Due to existing screening views are likely to be possible to observers above the ground floor only i.e. the first floor or above.	No.
66 – 79.	Existing vegetation. Predicted to significantly obstruct views of the reflecting panels.	No impact.	N/A.	No.

Table 3 *Assessment of mitigation requirement – dwelling receptors*

The desk-based review is shown in Figures 20 to 42[9] below and on the following pages. The yellow outlined areas shown within the figures represent the location of the reflecting areas. Visual points (blue icons) indicating the location of street view imagery are marked on aerial imagery, where appropriate. Specifically, each figure shows:

- Figures 20 and 21: Vegetation screening for dwellings 4 to 7.
- Figures 22 and 23: Visible terrain and partial vegetation screening for dwelling 8.
- Figure 24: Vegetation screening for dwellings 9 to 27.
- Figure 25: Visible terrain for dwelling 28.
- Figure 26: Vegetation screening for dwellings 29 to 37.
- Figures 27 to 30: Visible terrain and partial vegetation/building screening for dwelling 38.
- Figure 31: Terrain screening for dwellings 39 and 40.
- Figure 32: Building screening for dwellings 41 to 45.
- Figure 33: Vegetation screening for dwelling 46.
- Figure 34: Visible terrain and vegetation/building screening for dwelling 47.
- Figures 35 and 36: Visible terrain and vegetation screening for dwellings 48 to 50.
- Figure 37: Overview of screening relevant to dwellings 51 to 60.
- Figure 38: Building screening for dwelling 62.
- Figure 39: Partial vegetation screening for dwellings 63 to 65.
- Figures 40 to 42: Vegetation screening for dwellings 66 to 79.

Figure 20 *Vegetation screening - dwellings 4 and 5*

Figure 21 *Vegetation screening – dwellings 6 and 7*

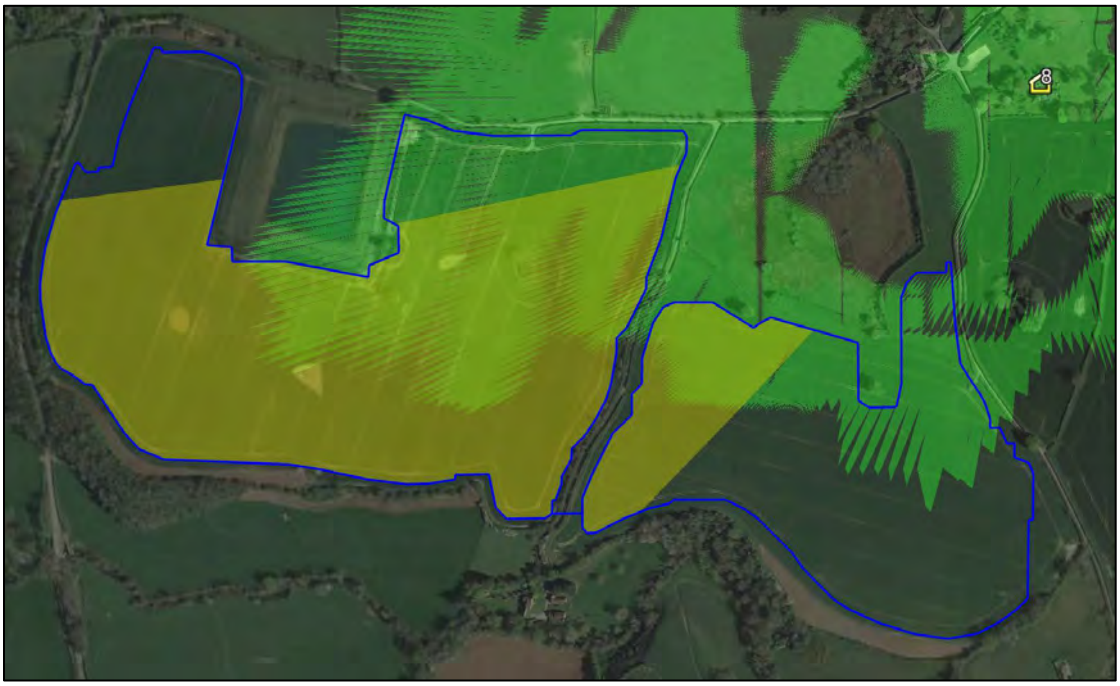

Figure 22 *Visible terrain (green areas) for an observer at 2m[13] above ground level at dwelling 8*

[13] To represent an approximate viewing height for an observer at ground level. Although modelled at 1.8m, 2m is the minimum height (above ground level) usable for terrain analysis within google earth.

Figure 23 *Partial vegetation screening – dwelling 8*

Figure 24 *Vegetation screening – dwellings 9 to 27*

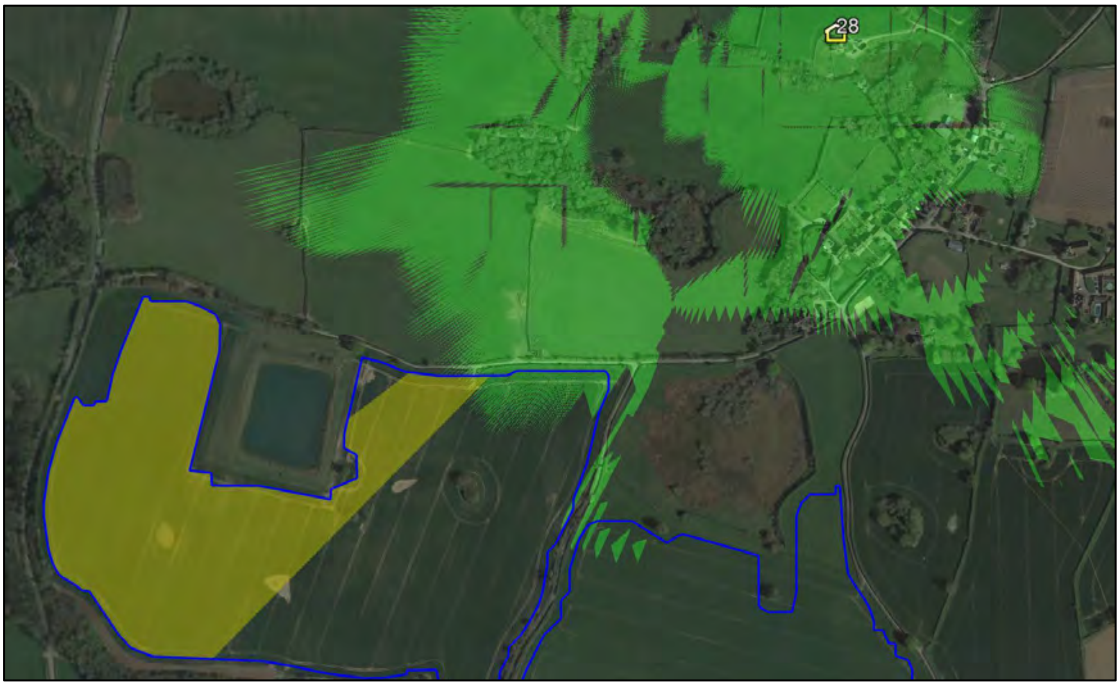

Figure 25 *Visible terrain (green areas) for an observer at 2m above ground level at dwelling 28*

Figure 26 *Vegetation screening – dwellings 29 to 37*

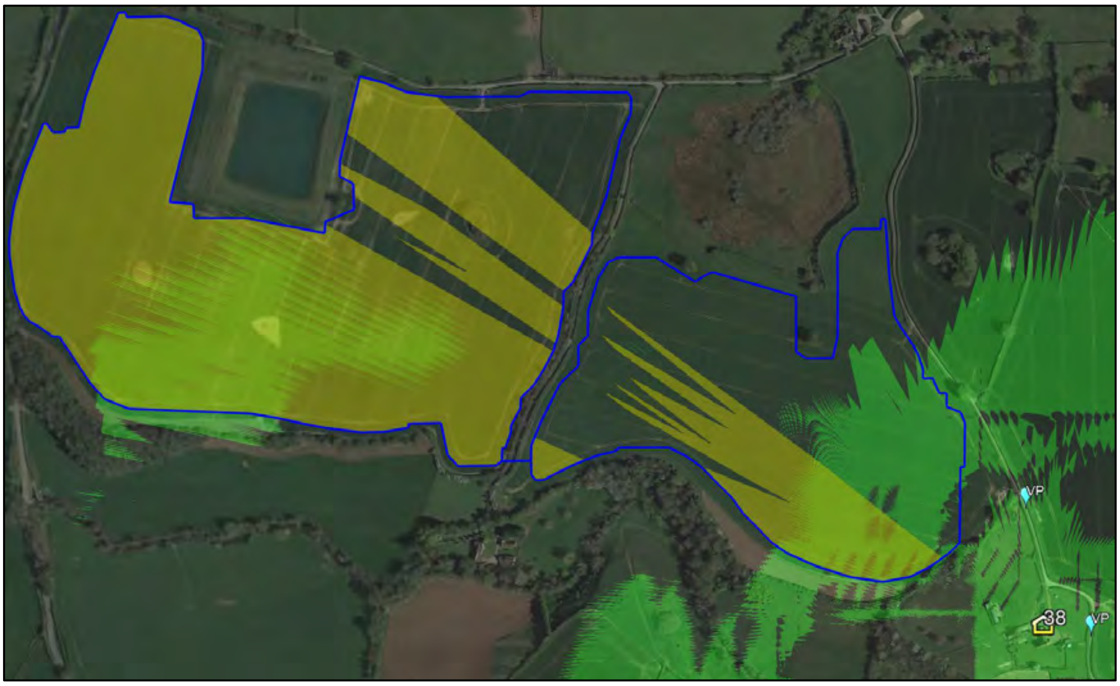

Figure 27 *Visible terrain (green areas) for an observer at 2m above ground level at dwelling 38*

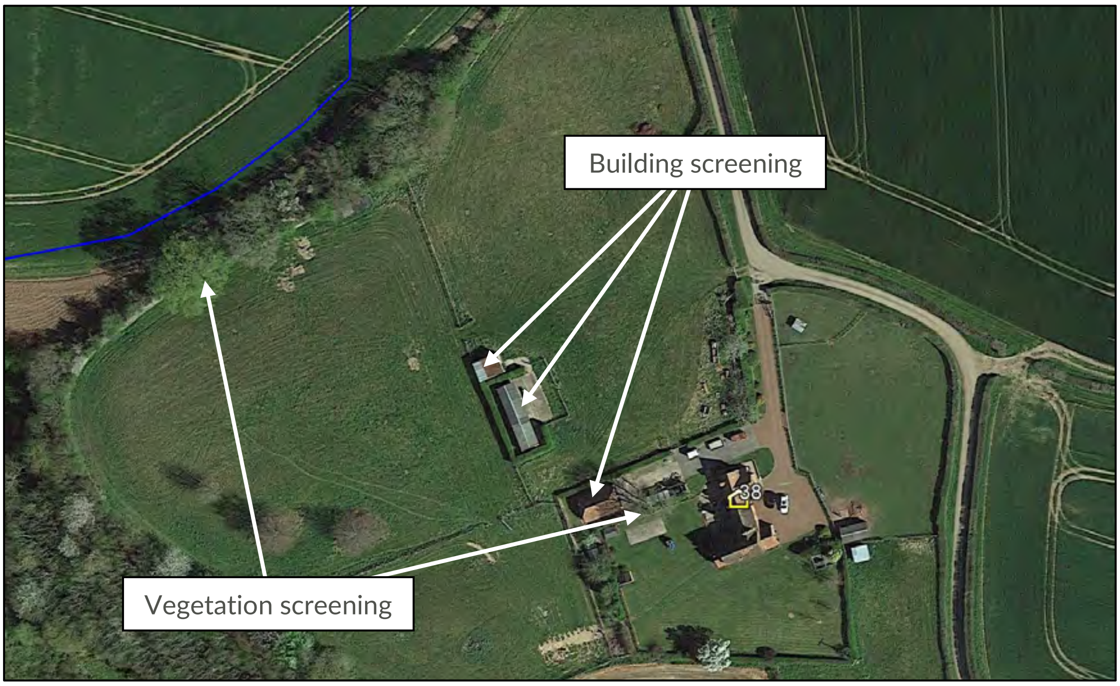

Figure 28 *Partial vegetation and building screening – dwelling 38*

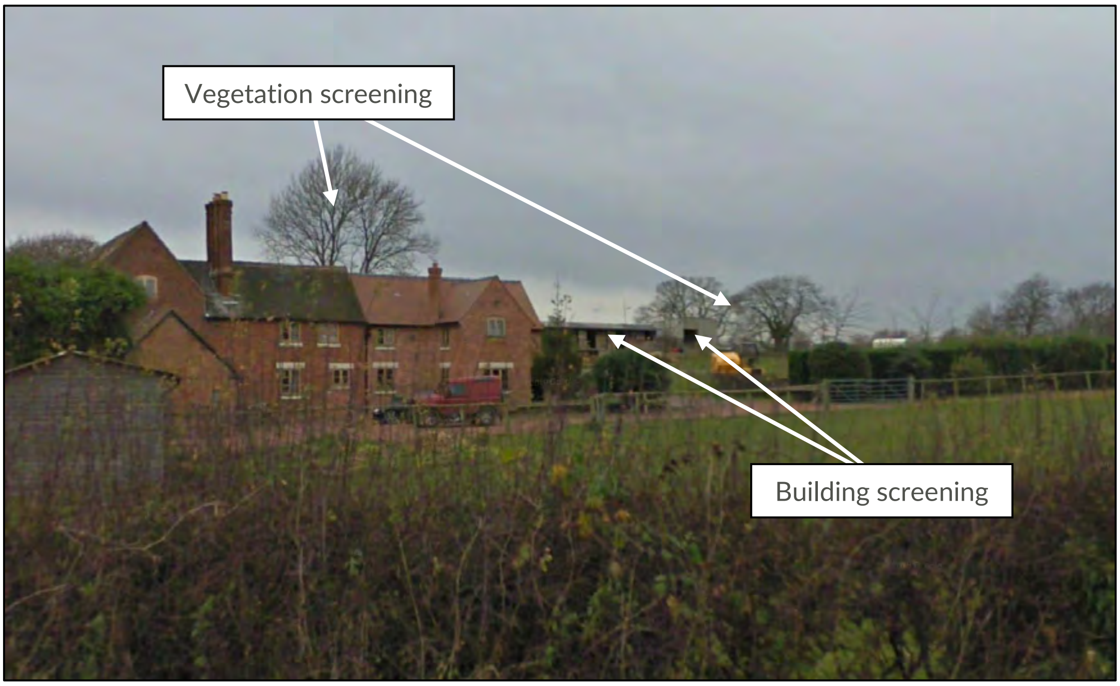

Figure 29 *Partial vegetation and building screening – dwelling 38*

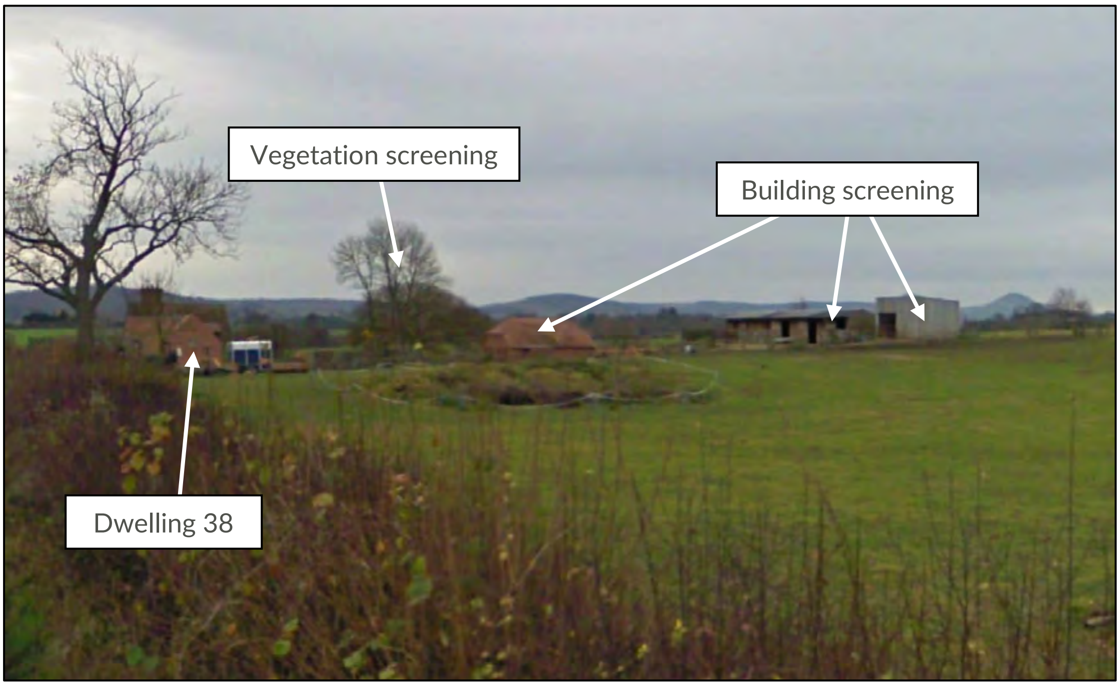

Figure 30 *Partial vegetation and building screening – dwelling 38*

Figure 31 *Terrain screening view towards the reflecting panels for dwellings 39 and 40*

Figure 32 *Building screening – dwellings 41 to 45*

Figure 33 *Vegetation screening – dwelling 46*

Figure 34 *Building/vegetation screening and visible terrain (green areas) for an observer at 2m above ground level at dwelling 47*

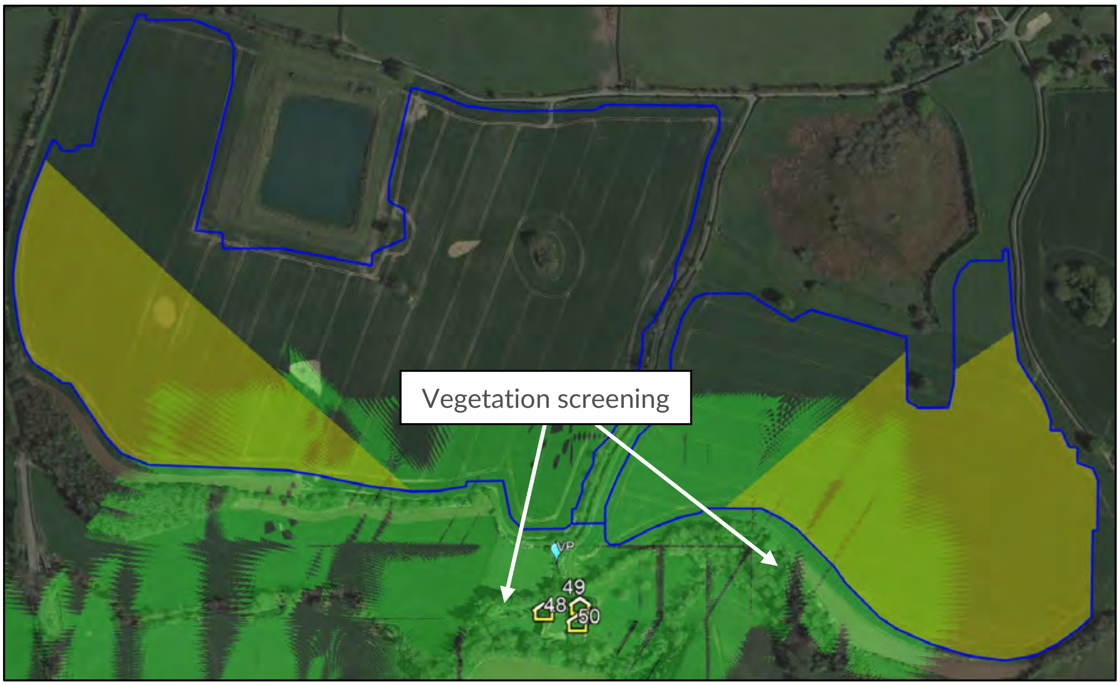

Figure 35 *Vegetation screening and visible terrain (green areas) for an observer at 2m above ground level at dwellings 48 to 50*[14]

Figure 36 *Vegetation screening – dwellings 48 to 50*

[14] Visible terrain shown is for a ground floor observer at dwelling 50.

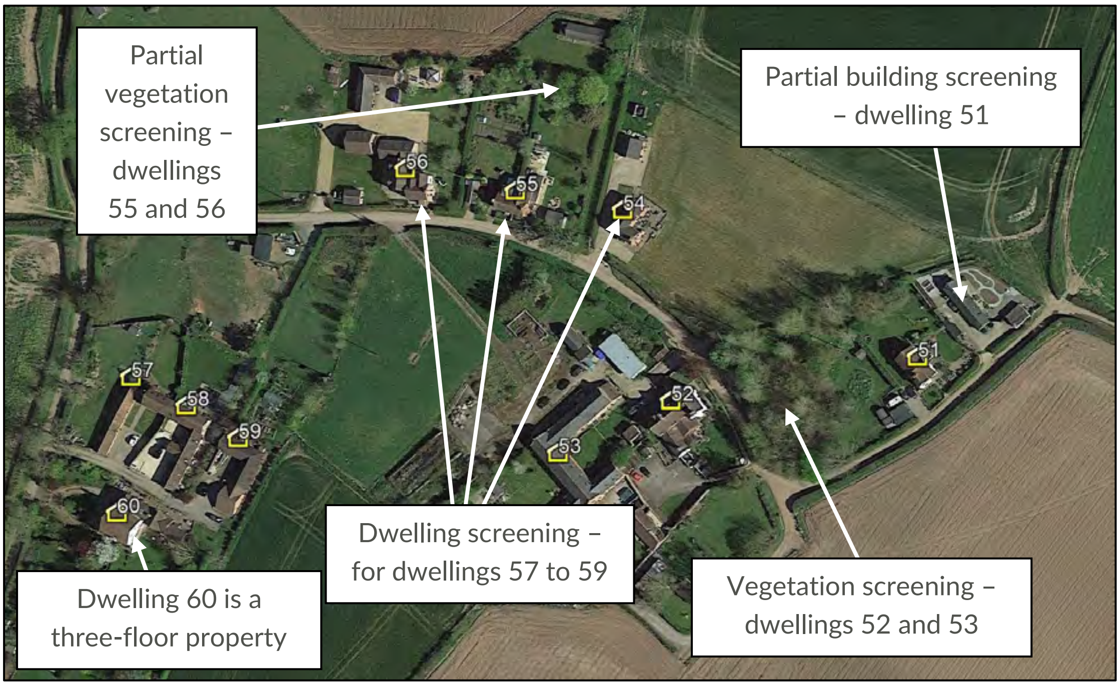

Figure 37 *Screening overview – dwellings 51 to 60*

Figure 38 *Building screening – dwelling 62*

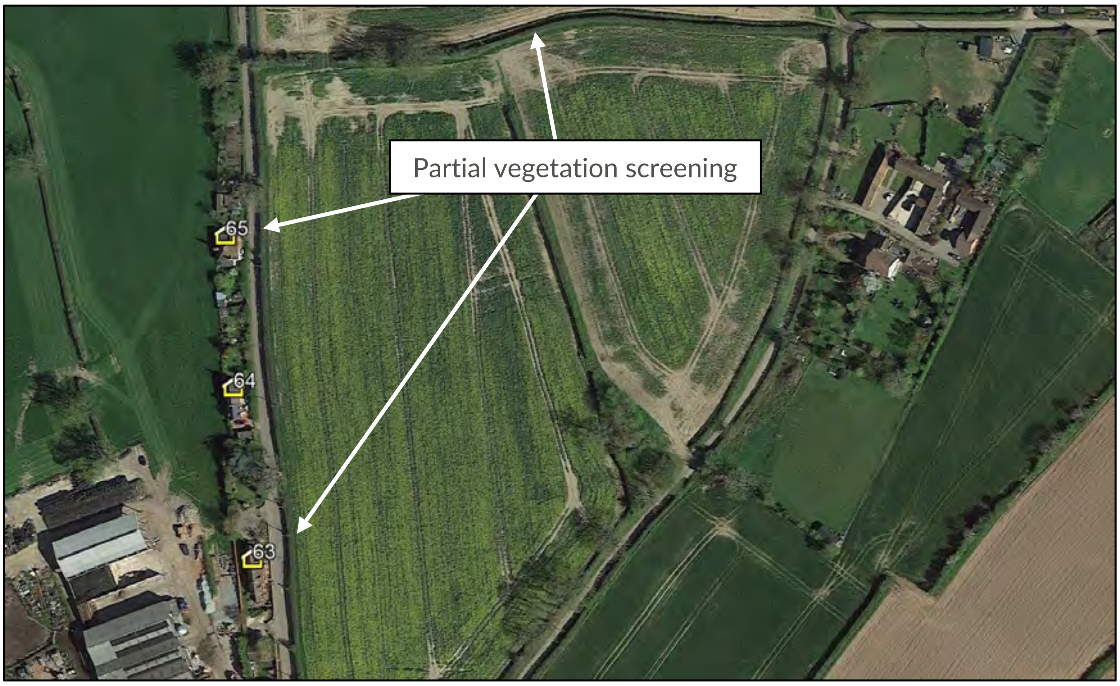

Figure 39 *Partial vegetation screening – dwellings 63 to 65*

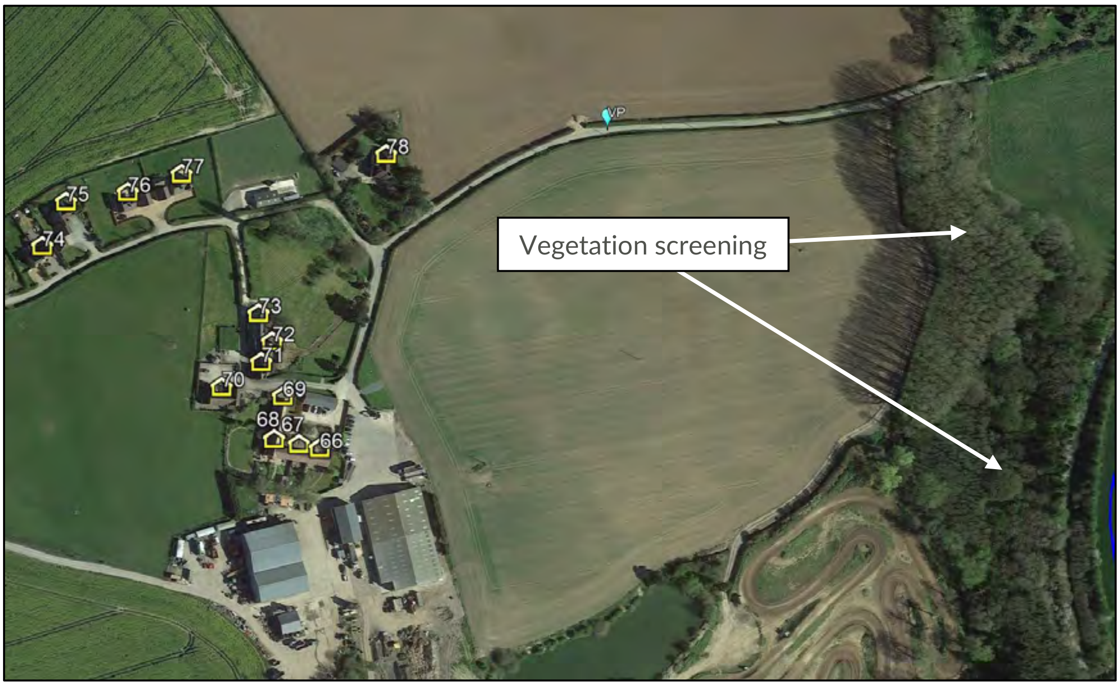

Figure 40 *Vegetation screening – dwellings 66 to 78*

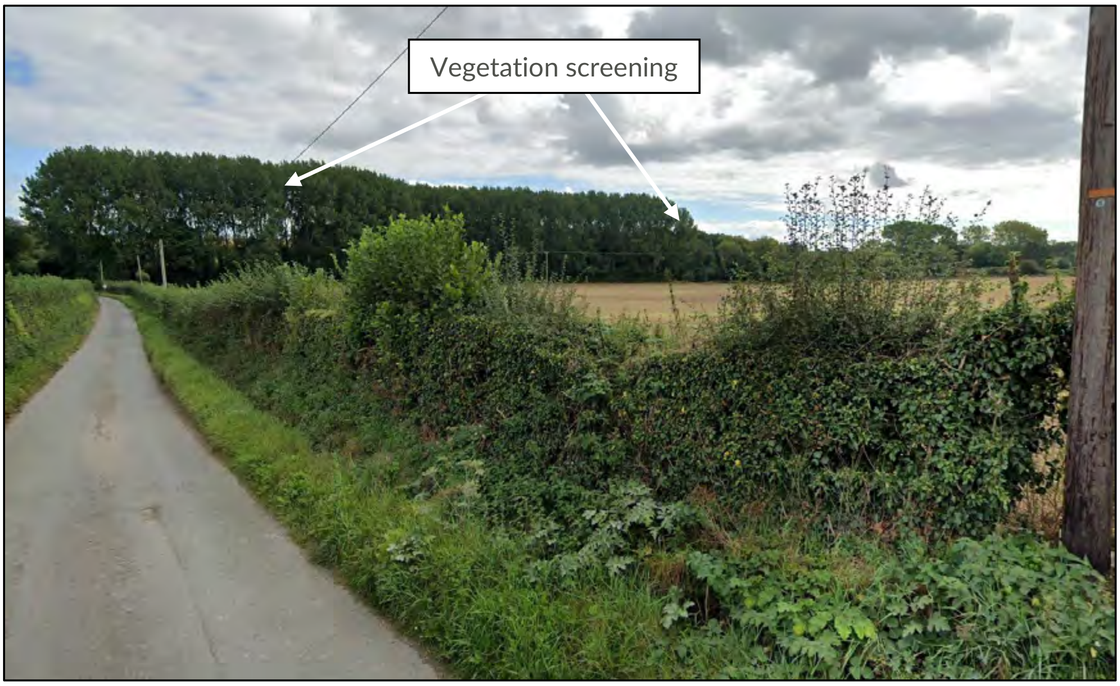

Figure 41 *Vegetation screening – dwellings 66 to 78*

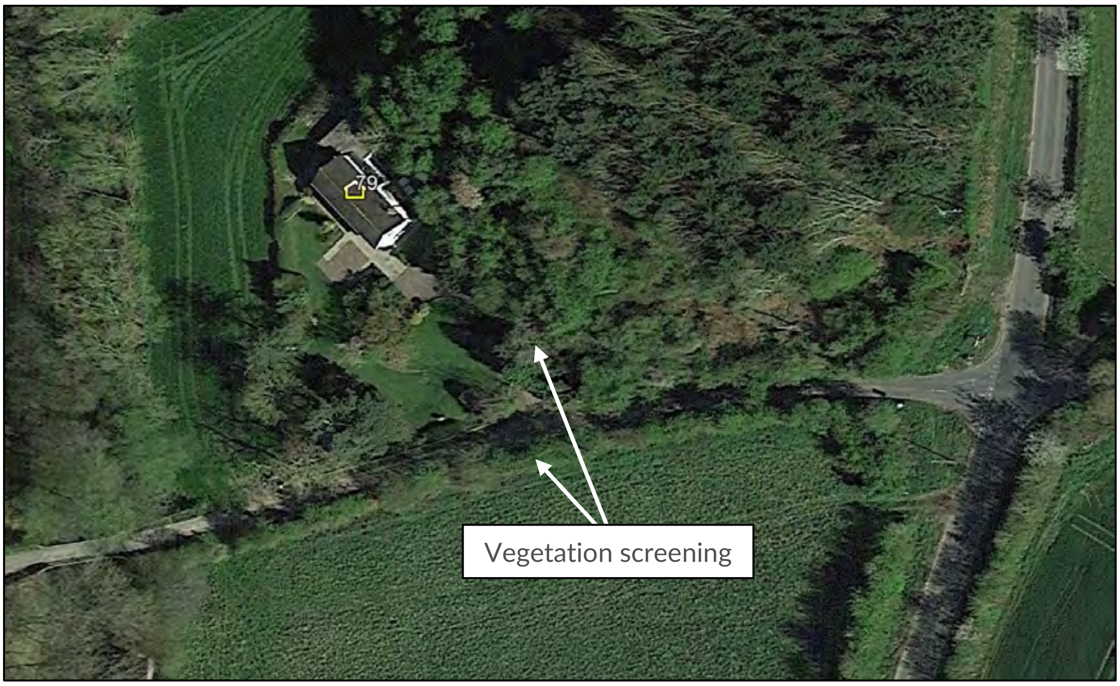

Figure 42 *Vegetation screening – dwelling 79*

8 OVERALL CONCLUSIONS

8.1 Assessment Results – Roads

All roads within the 1km assessment area for consideration of glint and glare effects are local roads. 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.

Overall, no significant impacts upon road users are predicted and no mitigation is required.

8.2 Assessment Results – Dwellings

Views of the reflecting panels are considered possible for 10 dwellings; however, a mitigation recommendation has not been identified because:

- The duration of effects is not significant; and/or
- The separation distance between the dwelling and the closest reflecting panel is sufficiently large; and/or
- Due to existing screening views are likely to be possible for observers above the ground floor only, i.e. the first floor or above[15]; and/or
- Solar reflections would occur within approximately 2 hours of sunrise/sunset; therefore, effects would mostly coincide with direct sunlight.

8.3 Overall Conclusions

No impacts requiring mitigation are predicted for the surrounding road users or dwellings.

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[15] The ground floor is typically considered the main living space and therefore has a greater significance with respect to residential amenity.

APPENDIX A – OVERVIEW OF GLINT AND GLARE GUIDANCE

Overview

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

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

UK Planning Policy

Renewable and Low Carbon Energy

The National Planning Policy Framework under the planning practice guidance for Renewable and Low Carbon Energy[16] (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.'

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

Draft National Policy Statement for Renewable Energy Infrastructure

The Draft 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. Section 2.52 states:

'2.52.1 Solar panels may reflect the sun's rays, 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.

2.52.2 In some instances, it may be necessary to seek a glint and glare assessment as part of the application. This may need to account for 'tracking' panels if they are proposed as these may cause differential diurnal and/or seasonal impacts. The potential for solar PV panels, frames and supports to have a combined reflective quality should be assessed. This assessment needs to consider the likely reflective capacity of all of the materials used[18] in the construction of the solar PV farm.

2.52.3 Applicants should consider using, and in some cases the Secretary of State may require, solar panels to be of a non-glare/ non-reflective type and the front face of the panels to comprise of (or be covered) with a non-reflective coating for the lifetime of the permission.

2.52.4 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 and motorists.

2.52.5 There is no evidence that glint and glare from solar farms interferes in any way with aviation navigation or pilot and aircraft visibility or safety. Therefore, the Secretary of State is unlikely to have to give any weight to claims of aviation interference as a result of glint and glare from solar farms.'

Consultation to determine whether EN-3 provides a suitable framework to support decision making for nationally significant energy infrastructure ended in November 2021. Pager Power is aware that aviation stakeholders were not consulted prior to the publication of the draft policy and understands that they will still request a glint and glare assessment on the basis that glare may lead to impact upon aviation safety. It is possible that the draft policy will change in light of the consultation responses from aviation stakeholders.

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

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[17] Draft National Policy Statement for Renewable Energy Infrastructure (EN-3), Department for Business, Energy & Industrial Strategy, date: September 2021, accessed on: 01/11/2021.

[18] In Pager Power's experience, the solar panels themselves are the overriding source of specular reflections which have the potential to cause significant impacts upon safety or amenity.

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

[19] Solar Photovoltaic Development Glint and Glare Guidance, Third Edition V3.1, May 2021. Pager Power.

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

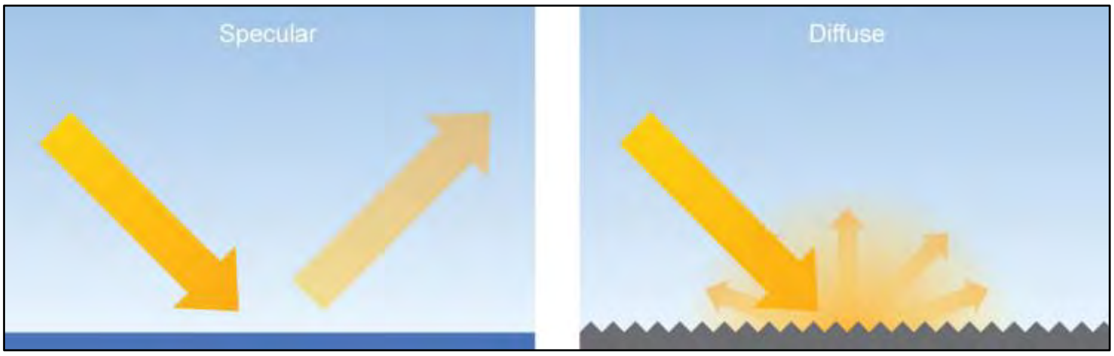
Overview

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

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

Reflection Type from Solar Panels

Based on the surface conditions reflections from light can be specular and diffuse. A specular reflection has a reflection characteristic similar to that of a mirror; a diffuse will reflect the incoming light and scatter it in many directions. The figure below, taken from the FAA guidance[20], 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

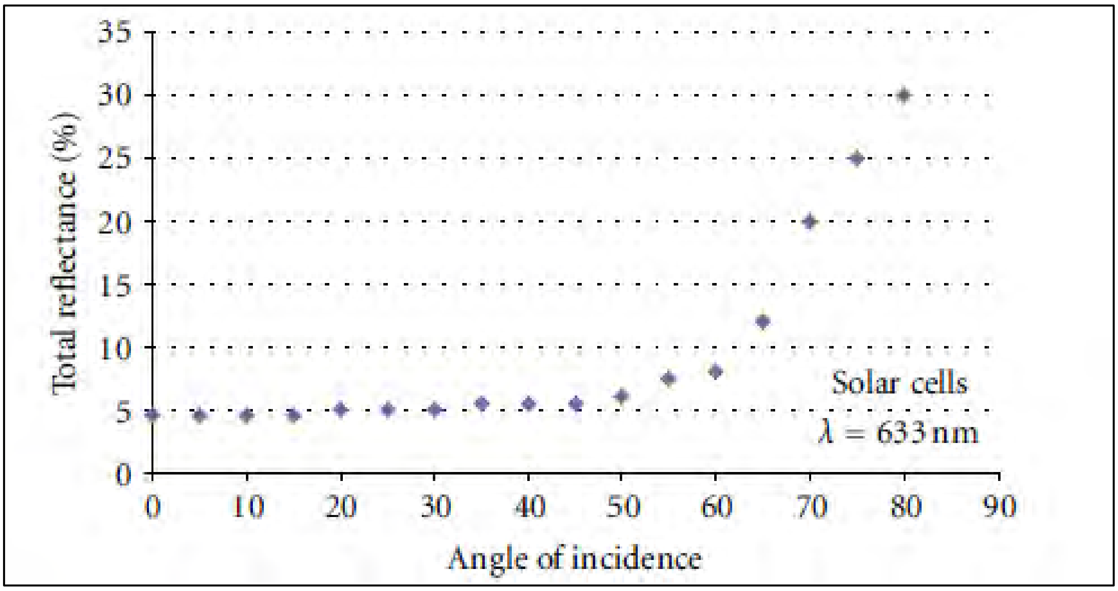
[20] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.

Solar Reflection Studies

An overview of content from identified solar panel reflectivity studies is presented in the subsections below.

Evan Riley and Scott Olson, "A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems"

Evan Riley and Scott Olson published in 2011 their study titled: *A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems*[21]". 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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[21] 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"[22]

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[23]
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).

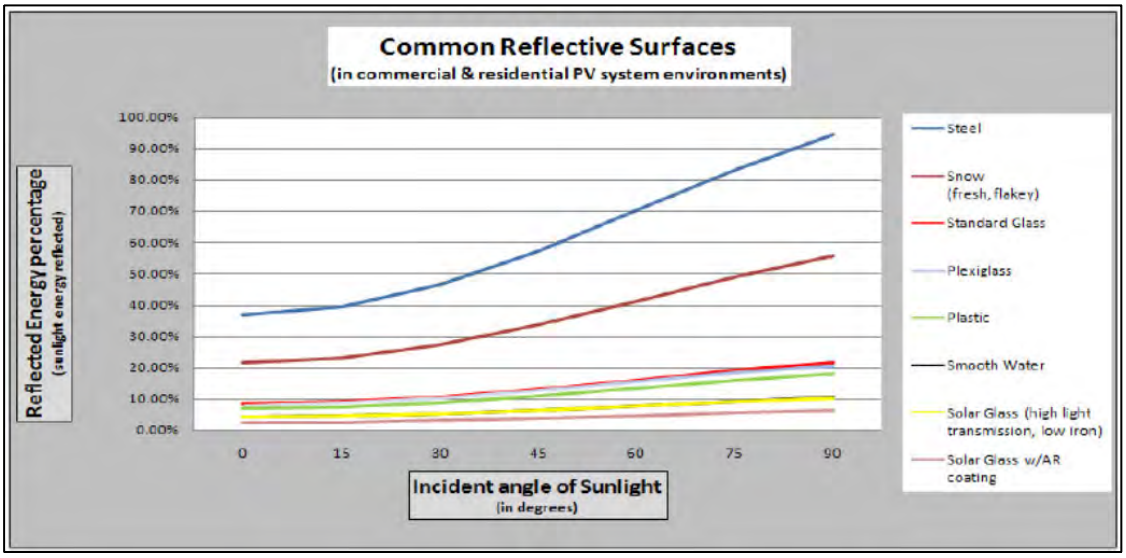
An important comparison in this table is the reflectivity compared to water which will produce a reflection of very similar intensity when compared to that from a solar panel. The study by Riley and Olsen study (2011) also concludes that still water has a very similar reflectivity to solar panels.

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

SunPower Technical Notification (2009)

SunPower published a technical notification[24] 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.

[24] 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.

APPENDIX D – GLINT AND GLARE IMPACT SIGNIFICANCE

Overview

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

Impact Significance Definition

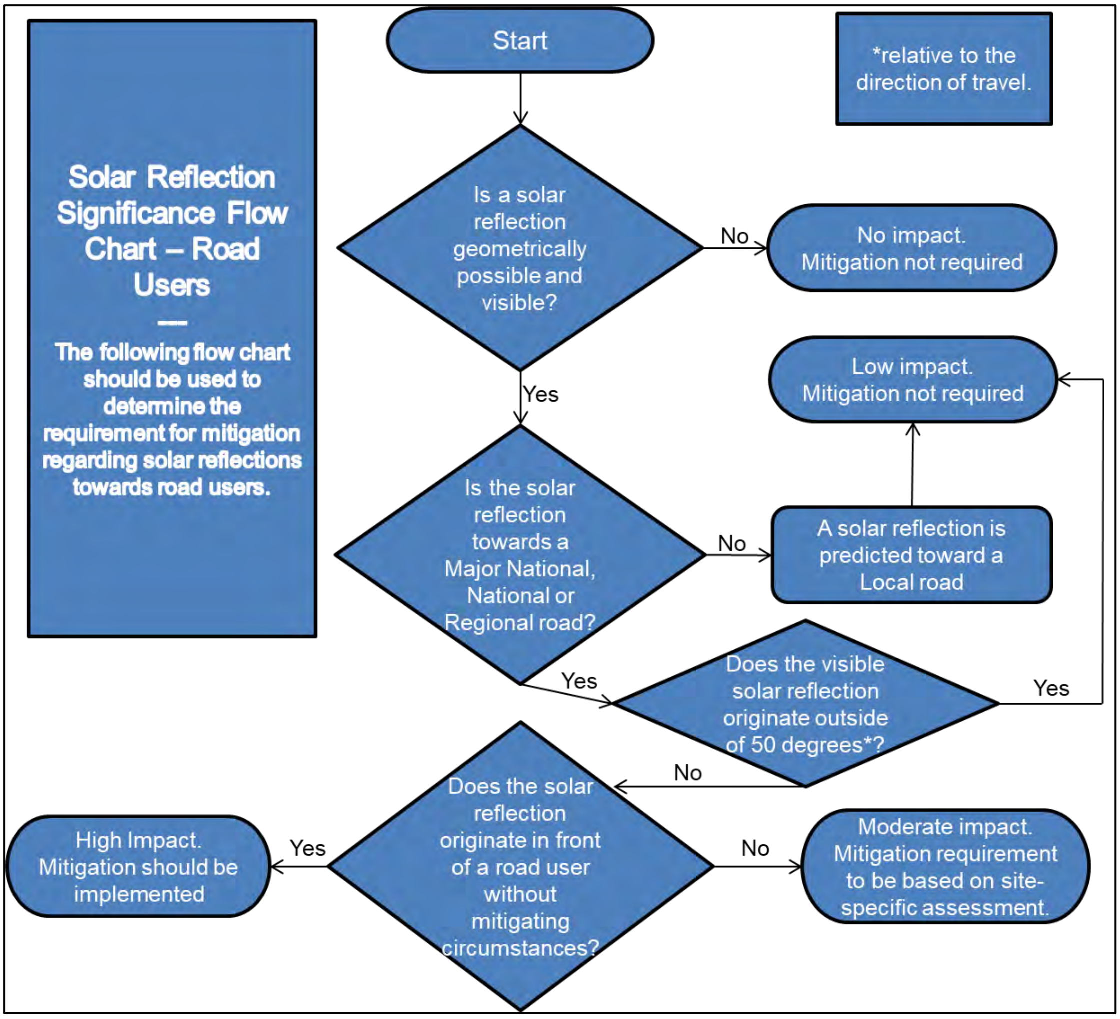
The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

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

Impact significance definition

Assessment Process for Road Receptors

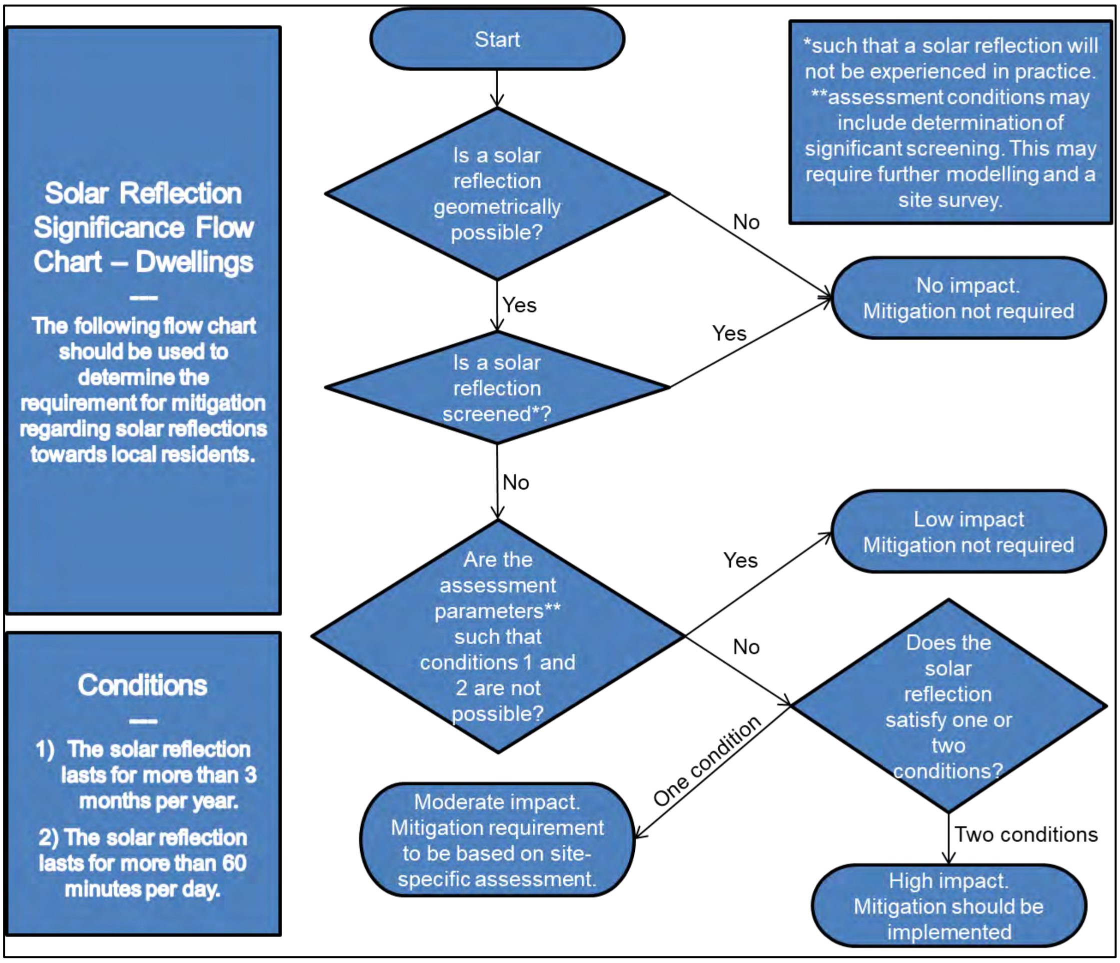
The flow chart presented below has been followed when determining the mitigation requirement for road receptors.



Road user impact significance flow chart

Assessment Process for Dwelling Receptors

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



Dwelling impact significance flow chart

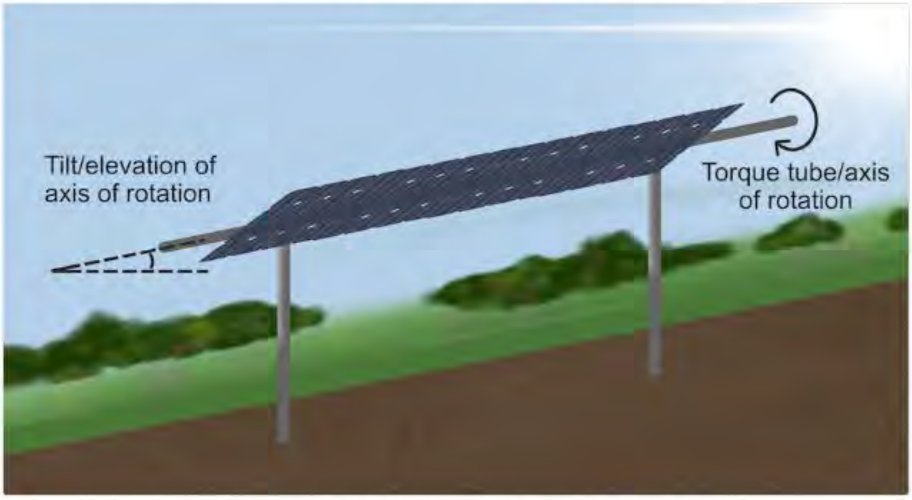
APPENDIX E – REFLECTION CALCULATIONS METHODOLOGY

Forge Reflection Calculations Methodology

Extracts taken from the Forge Solar Model.

Tracking System Parameters

Single-axis module tracking systems are described by a unique set of parameters. These angular inputs model the tracking axis, rotation range and backtracking behavior. Dual-axis module tracking systems are assumed to track the sun at all times.



Single-axis tracking system with torque tube tilted due to geography

Tilt of tracking axis (°)
Tilt above flat ground of axis over which panels rotate (e.g. torque tube). System on flat, level ground would have axis tilt of 0°.

Orientation of tracking axis (°)
Azimuthal angle of axis over which panels rotate. Angle represents the facing of the axis and system. For example, typical tracking system in northern hemisphere has tracking axis oriented north-south with an orientation of 180°, allowing panels to rotate east-west with potential south-facing tilt. Typical tracking system in southern hemisphere runs south-north with axis orientation of 0°, yielding east-west rotation with potential north-facing tilt.

Offset angle of module (°)
Additional tilt angle of PV module elevated above tracking axis/torque tube. Offset angle is measured from the torque tube.

Maximum tracking angle (°)
Maximum angle of rotation of tracking system in one direction. For example, a typical system with a 120° range of rotation has a *max tracking angle* of 60° (east/west).

Resting angle (°)
Angle of rotation of panels when sun is outside tracking range. Used to model backtracking. Panels will revert to the position described by this rotation angle at all times when the sun is outside the rotation range. Setting this equal to the *maximum tracking angle* implies the panels do not backtrack.

ForgeSolar utilizes a simplified model of backtracking which assumes panels instantaneously revert to the *resting angle* whenever the sun is outside the rotation range. For example, panels with *max tracking angle* of 60° and *resting angle* of 0° would lie flat from sunrise until the sun enters the rotation range, and immediately after the sun leaves the rotation range until sunset daily.

Tracking System Parameters

APPENDIX F – ASSESSMENT LIMITATIONS AND ASSUMPTIONS

Forge's Sandia National Laboratories' (SGHAT) Model

The following text is taken from Forge[25] and is presented for reference.

Summary of assumptions and abstractions required by the SGHAT/ForgeSolar analysis methodology

1. Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
2. Result data files and plots are now retained for two years after analysis completion. Files should be downloaded and saved if additional persistence is required.
3. The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. However, we have validated our models against several systems, including a PV array causing glare to the air-traffic control tower at Manchester-Boston Regional Airport and several sites in Albuquerque, and the tool accurately predicted the occurrence and intensity of glare at different times and days of the year.
4. Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare. This primarily affects analyses of path receptors.
5. Random number computations are utilized by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result. This limitation primarily affects analyses of Observation Point receptors, including ATCTs. Note that the SGHAT/ForgeSolar methodology has always relied on an analytical, qualitative approach to accurately determine the overall hazard (i.e. green vs. yellow) of expected glare on an annual basis.
6. The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
7. The algorithm assumes that the PV array is aligned with a plane defined by the total heights of the coordinates outlined in the Google map. For more accuracy, the user should perform runs using minimum and maximum values for the vertex heights to bound the height of the plane containing the solar array. Doing so will expand the range of observed solar glare when compared to results using a single height value.
8. The algorithm does not consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc.
9. The variable direct normal irradiance (DNI) feature (if selected) scales the user-prescribed peak DNI using a typical clear-day irradiance profile. This profile has a lower DNI in the mornings and evenings and a maximum at solar noon. The scaling uses a clear-day irradiance profile based on a normalized time relative to sunrise, solar noon, and sunset, which are prescribed by a sun-position algorithm and the latitude and longitude obtained from Google maps. The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors.
10. The ocular hazard predicted by the tool depends on a number of environmental, optical, and human factors, which can be uncertain. We provide input fields and typical ranges of values for these factors so that the user can vary these parameters to see if they have an impact on the results. The speed of SGHAT allows expedited sensitivity and parametric analyses.
11. The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
12. Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
13. Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
14. Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
15. PV array tracking assumes the modules move instantly when tracking the sun, and when reverting to the rest position.

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[25] Source: https://www.forgesolar.com/help/#assumptions

APPENDIX G – RECEPTOR AND REFLECTOR AREA DETAILS

Dwelling Receptor Data

An additional height of 1.8m has been added to the ground height, this has been taken as typical eye level for an observer on the ground floor.

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-2.70968	52.66330	41	-2.68609	52.64809
2	-2.70405	52.66287	42	-2.68570	52.64800
3	-2.70350	52.66310	43	-2.68585	52.64790
4	-2.70278	52.66331	44	-2.68644	52.64787
5	-2.70234	52.66329	45	-2.68664	52.64784
6	-2.70084	52.65664	46	-2.69109	52.64604
7	-2.70053	52.65661	47	-2.69489	52.64290
8	-2.69872	52.65638	48	-2.70718	52.65125
9	-2.70017	52.65743	49	-2.70663	52.65130
10	-2.70039	52.65762	50	-2.70667	52.65115
11	-2.69991	52.65741	51	-2.70582	52.64765
12	-2.69980	52.65748	52	-2.70702	52.64752
13	-2.69965	52.65755	53	-2.70756	52.64736
14	-2.69944	52.65765	54	-2.70725	52.64808
15	-2.69920	52.65775	55	-2.70777	52.64814
16	-2.69904	52.65790	56	-2.70831	52.64821
17	-2.69848	52.65786	57	-2.70964	52.64759
18	-2.69839	52.65800	58	-2.70937	52.64750
19	-2.69832	52.65811	59	-2.70911	52.64741
20	-2.69783	52.65789	60	-2.70969	52.64719
21	-2.69818	52.65826	61	-2.71188	52.64369

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
22	-2.69791	52.65846	62	-2.71416	52.64509
23	-2.69776	52.65862	63	-2.71354	52.64604
24	-2.69712	52.65832	64	-2.71368	52.64667
25	-2.69732	52.65863	65	-2.71374	52.64725
26	-2.69724	52.65888	66	-2.72236	52.65470
27	-2.69733	52.65940	67	-2.72255	52.65473
28	-2.70023	52.65978	68	-2.72277	52.65475
29	-2.69575	52.65706	69	-2.72270	52.65499
30	-2.69568	52.65684	70	-2.72325	52.65504
31	-2.69526	52.65685	71	-2.72289	52.65517
32	-2.69512	52.65673	72	-2.72280	52.65529
33	-2.69521	52.65701	73	-2.72292	52.65544
34	-2.69537	52.65716	74	-2.72487	52.65581
35	-2.69506	52.65720	75	-2.72466	52.65605
36	-2.69478	52.65700	76	-2.72411	52.65611
37	-2.69477	52.65712	77	-2.72362	52.65621
38	-2.69740	52.65035	78	-2.72178	52.65632
39	-2.68889	52.64900	79	-2.71592	52.65733
40	-2.68640	52.64858			

Dwelling Receptor Data

Modelled Reflector Data

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
1	-2.71467	52.65573	73	-2.70099	52.65351
2	-2.71461	52.65573	74	-2.70099	52.65437
3	-2.71449	52.65564	75	-2.70089	52.65452
4	-2.71428	52.65564	76	-2.70073	52.65462

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
5	-2.71426	52.65568	77	-2.70025	52.65462
6	-2.71404	52.65569	78	-2.70024	52.65472
7	-2.71393	52.65599	79	-2.70017	52.65472
8	-2.71376	52.65629	80	-2.70010	52.65411
9	-2.71335	52.65689	81	-2.70001	52.65371
10	-2.71323	52.65689	82	-2.69986	52.65356
11	-2.71320	52.65684	83	-2.69969	52.65341
12	-2.71251	52.65684	84	-2.69960	52.65331
13	-2.71229	52.65679	85	-2.69952	52.65316
14	-2.71194	52.65669	86	-2.69952	52.65306
15	-2.71185	52.65658	87	-2.69935	52.65306
16	-2.71187	52.65627	88	-2.69924	52.65291
17	-2.71243	52.65490	89	-2.69911	52.65291
18	-2.71201	52.65487	90	-2.69911	52.65277
19	-2.71200	52.65473	91	-2.69886	52.65271
20	-2.71112	52.65473	92	-2.69878	52.65260
21	-2.70976	52.65457	93	-2.69878	52.65214
22	-2.70975	52.65469	94	-2.69885	52.65214
23	-2.70926	52.65482	95	-2.69886	52.65134
24	-2.70927	52.65508	96	-2.69904	52.65123
25	-2.70951	52.65516	97	-2.69936	52.65109
26	-2.70950	52.65533	98	-2.69970	52.65098
27	-2.70916	52.65619	99	-2.70017	52.65093
28	-2.70877	52.65613	100	-2.70073	52.65098
29	-2.70836	52.65603	101	-2.70130	52.65109
30	-2.70771	52.65598	102	-2.70184	52.65123

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
31	-2.70644	52.65599	103	-2.70208	52.65133
32	-2.70626	52.65604	104	-2.70259	52.65164
33	-2.70459	52.65603	105	-2.70276	52.65180
34	-2.70453	52.65598	106	-2.70333	52.65214
35	-2.70453	52.65582	107	-2.70357	52.65225
36	-2.70471	52.65557	108	-2.70387	52.65234
37	-2.70495	52.65496	109	-2.70472	52.65233
38	-2.70519	52.65457	110	-2.70479	52.65230
39	-2.70520	52.65446	111	-2.70513	52.65225
40	-2.70553	52.65406	112	-2.70554	52.65214
41	-2.70568	52.65397	113	-2.70602	52.65199
42	-2.70569	52.65381	114	-2.70617	52.65199
43	-2.70578	52.65351	115	-2.70624	52.65204
44	-2.70586	52.65335	116	-2.70624	52.65219
45	-2.70603	52.65315	117	-2.70675	52.65219
46	-2.70619	52.65300	118	-2.70686	52.65214
47	-2.70642	52.65286	119	-2.70751	52.65214
48	-2.70643	52.65275	120	-2.70769	52.65226
49	-2.70659	52.65257	121	-2.70780	52.65259
50	-2.70659	52.65250	122	-2.70835	52.65259
51	-2.70669	52.65233	123	-2.70836	52.65254
52	-2.70675	52.65233	124	-2.70878	52.65250
53	-2.70675	52.65219	125	-2.70916	52.65249
54	-2.70625	52.65219	126	-2.70981	52.65254
55	-2.70624	52.65235	127	-2.71027	52.65260
56	-2.70608	52.65260	128	-2.71060	52.65264

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
57	-2.70575	52.65301	129	-2.71109	52.65269
58	-2.70543	52.65320	130	-2.71320	52.65274
59	-2.70543	52.65340	131	-2.71360	52.65284
60	-2.70527	52.65351	132	-2.71385	52.65301
61	-2.70527	52.65376	133	-2.71418	52.65331
62	-2.70508	52.65412	134	-2.71439	52.65349
63	-2.70491	52.65428	135	-2.71451	52.65350
64	-2.70474	52.65432	136	-2.71475	52.65360
65	-2.70410	52.65432	137	-2.71492	52.65366
66	-2.70343	52.65407	138	-2.71500	52.65371
67	-2.70331	52.65412	139	-2.71509	52.65381
68	-2.70314	52.65417	140	-2.71517	52.65397
69	-2.70170	52.65392	141	-2.71525	52.65436
70	-2.70170	52.65334	142	-2.71525	52.65452
71	-2.70152	52.65327	143	-2.71516	52.65487
72	-2.70107	52.65327	144	-2.71499	52.65523

Modelled Reflector Data

APPENDIX H – DETAILLED MODELLING RESULTS

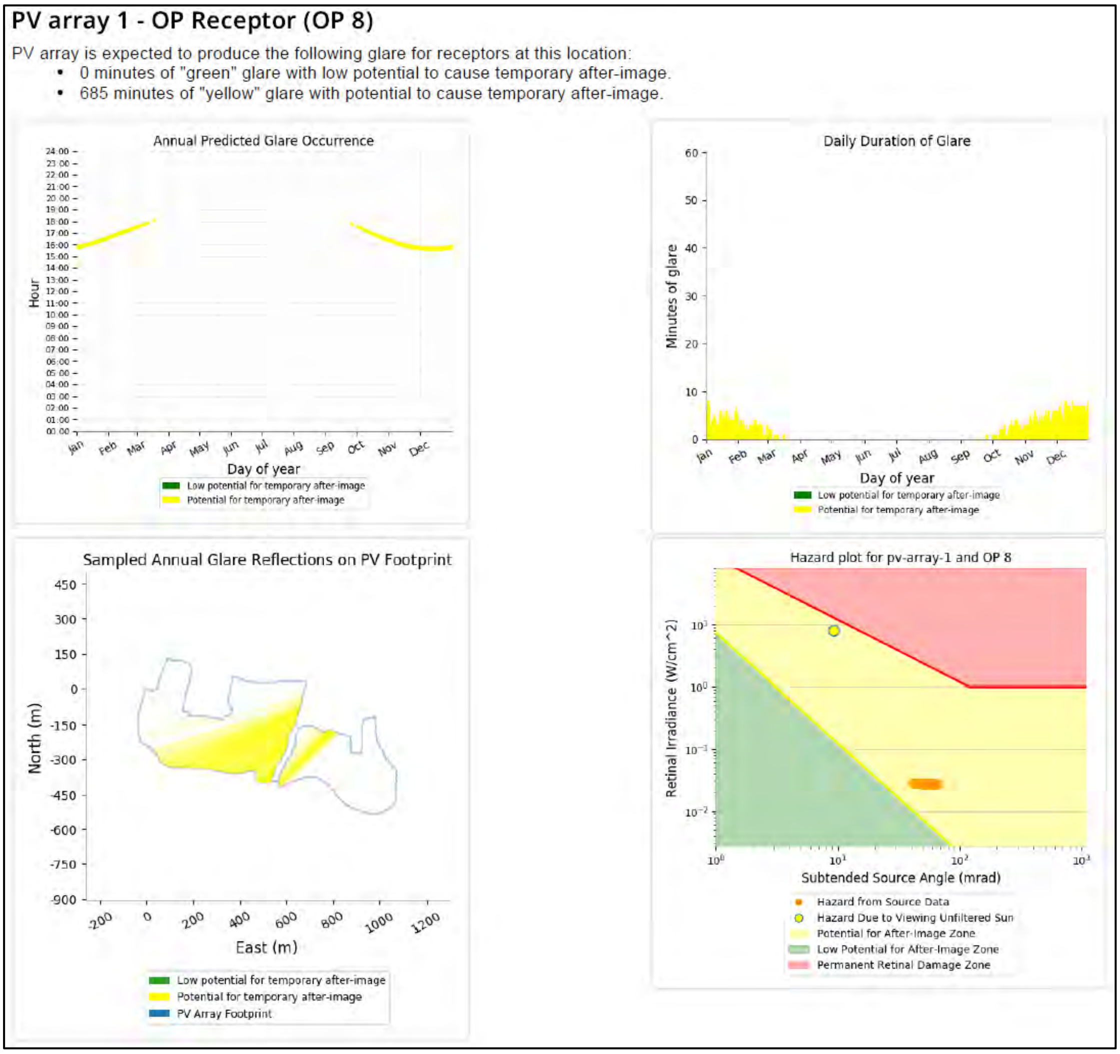
Overview

The Forge charts for the receptors, where a moderate impact is predicted, are shown below and on the following pages. Each chart shows:

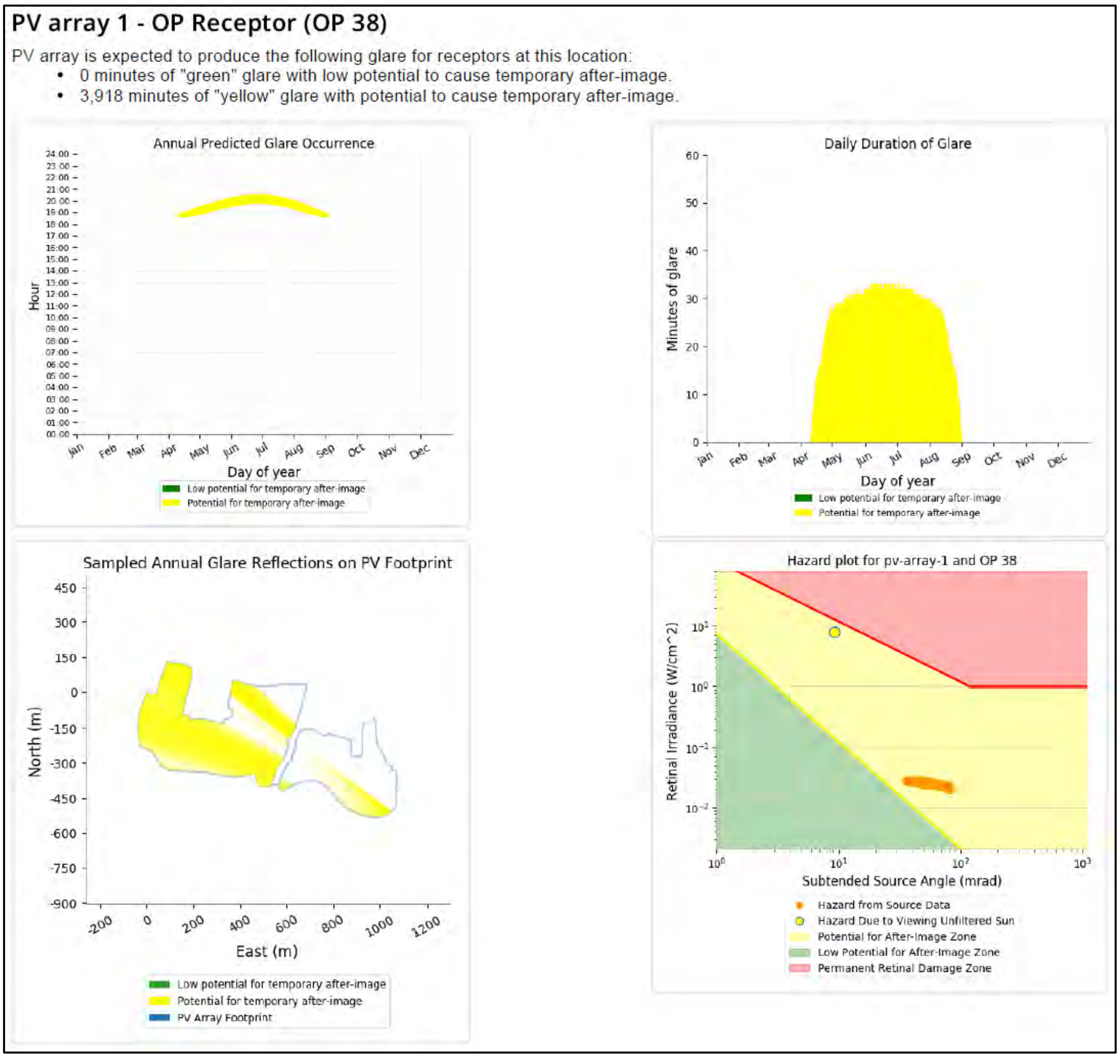
- The annual predicted solar reflections and their intensities – top left;
- The daily duration of the solar reflections – top right;
- The location of the proposed development where glare will originate – bottom left;
- The calculated intensity of the predicted solar reflections – bottom right.

Dwelling Receptors

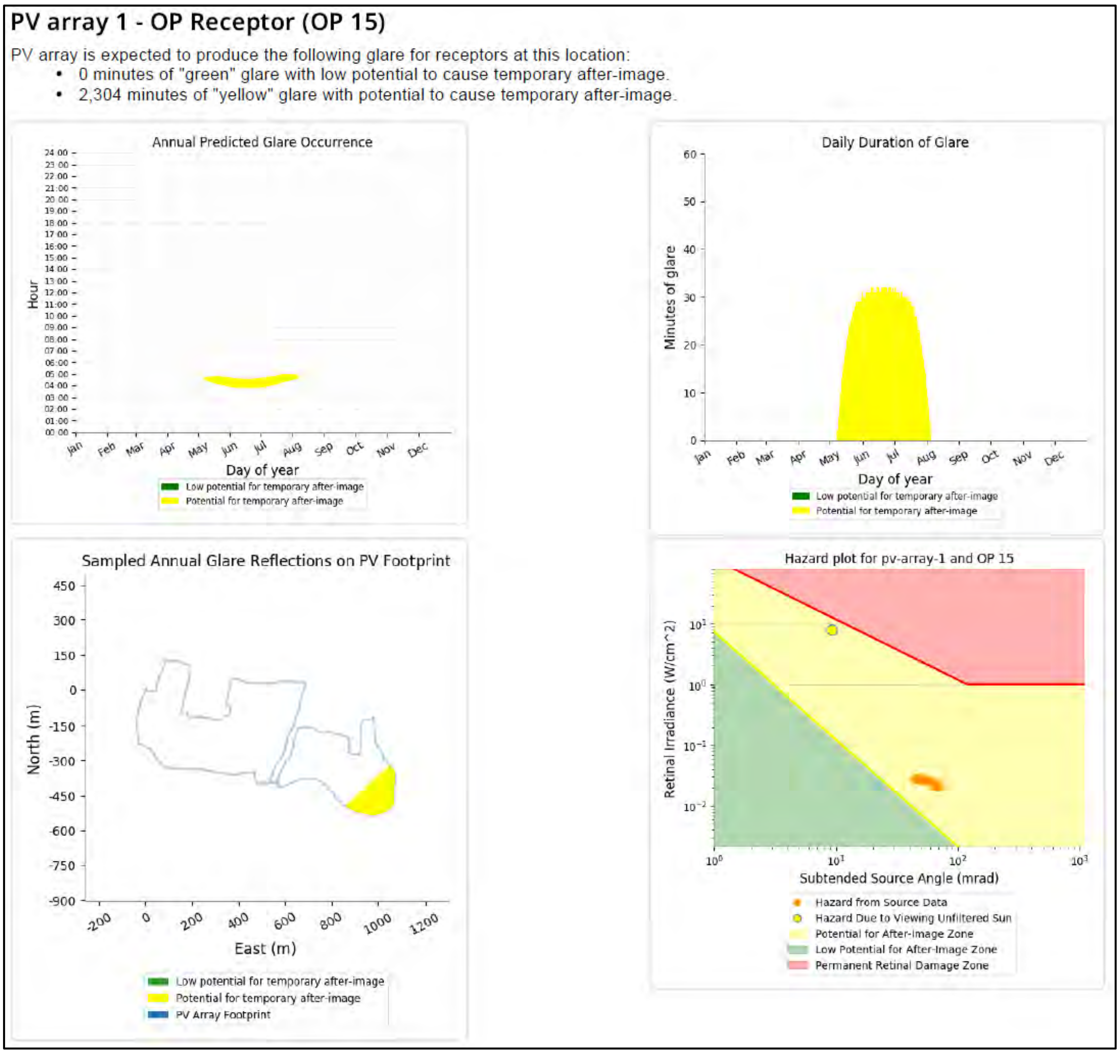
Dwelling 8



Dwelling 38


PV array 1 - OP Receptor (OP 38)
PV array is expected to produce the following glare for receptors at this location:
• 0 minutes of "green" glare with low potential to cause temporary after-image.
• 3,918 minutes of "yellow" glare with potential to cause temporary after-image.
Annual Predicted Glare Occurrence
Hour
Day of year
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Low potential for temporary after-image
Potential for temporary after-image
Daily Duration of Glare
Minutes of glare
Day of year
Low potential for temporary after-image
Potential for temporary after-image
Sampled Annual Glare Reflections on PV Footprint
North (m)
East (m)
Low potential for temporary after-image
Potential for temporary after-image
PV Array Footprint
Hazard plot for pv-array-1 and OP 38
Retinal Irradiance (W/cm^2)
Subtended Source Angle (mrad)
Hazard from Source Data
Hazard Due to Viewing Unfiltered Sun
Potential for After-Image Zone
Low Potential for After-Image Zone
Permanent Retinal Damage Zone

Dwelling 55[26]



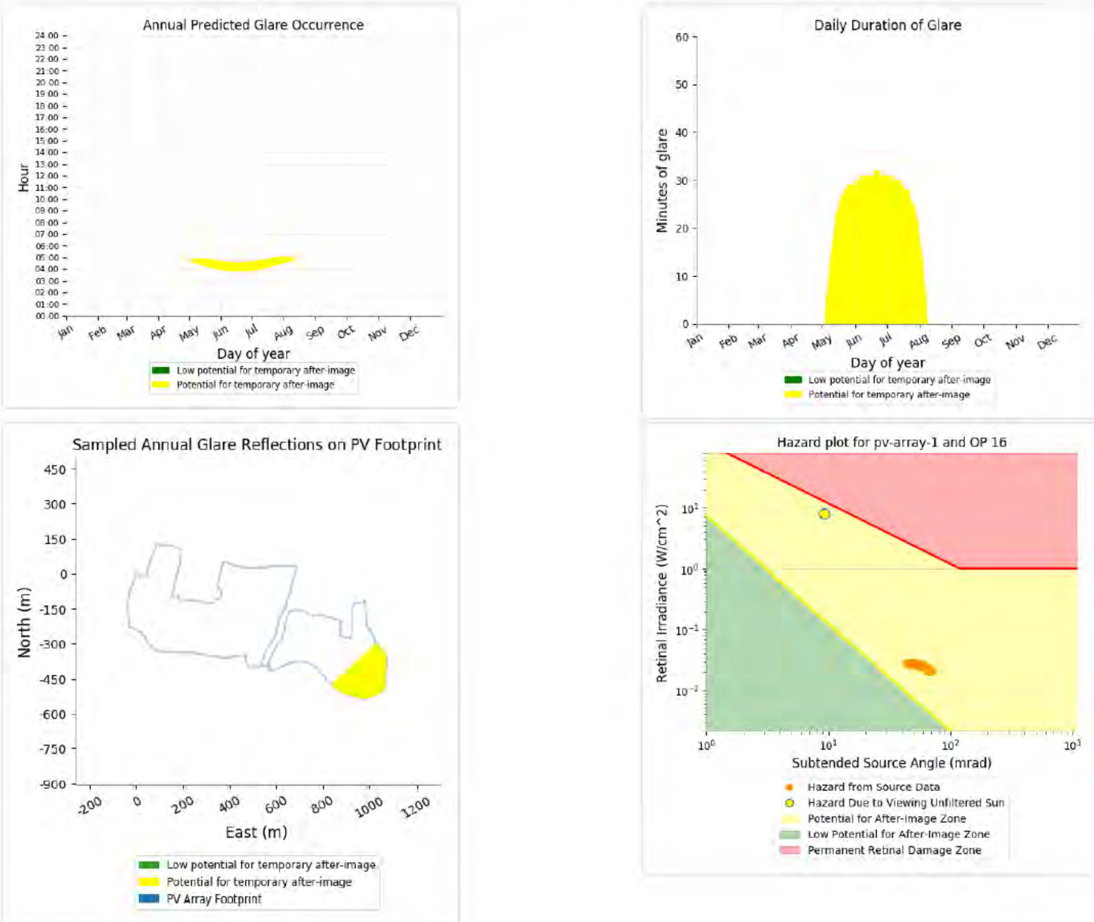
[26] Note: Forge modelling has a limit of 40 receptors; therefore, receptors 41 to 79 are named OP 1 to 39, respectively.

Dwelling 56

PV array 1 - OP Receptor (OP 16)

PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,525 minutes of "yellow" glare with potential to cause temporary after-image.

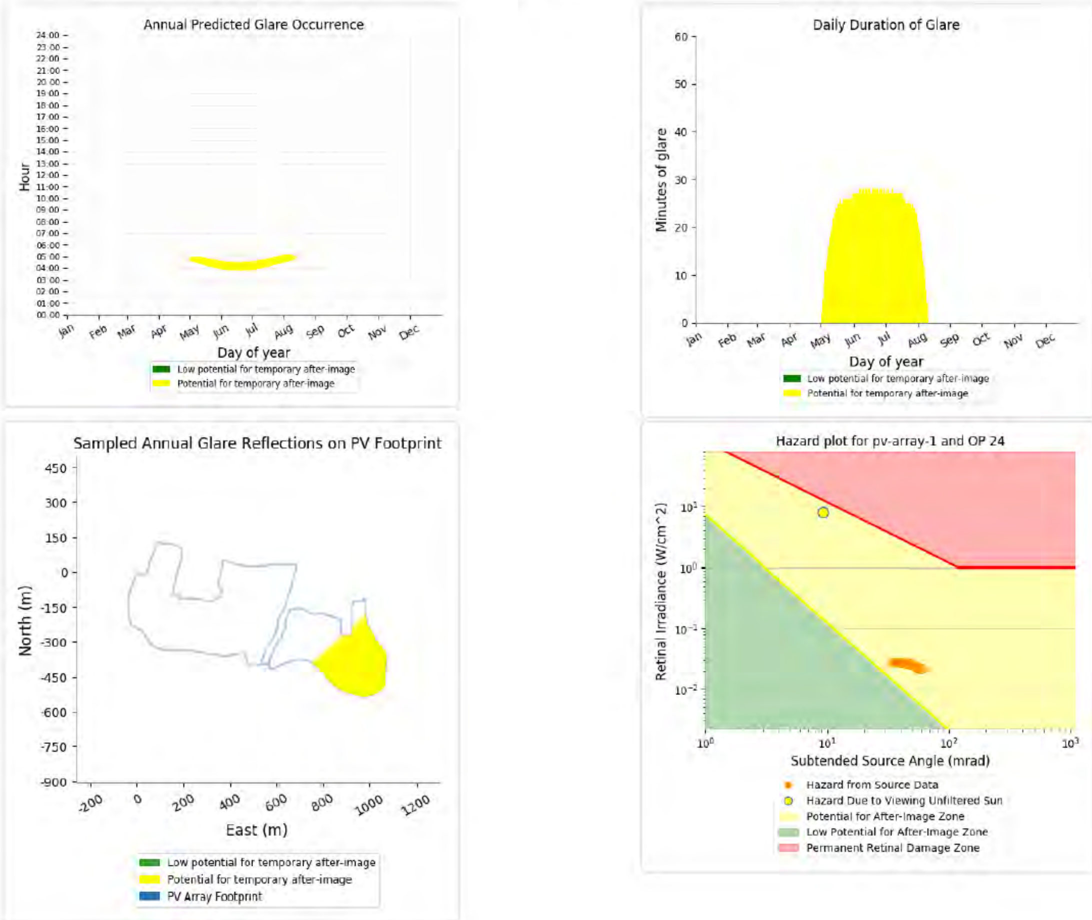


Dwelling 64

PV array 1 - OP Receptor (OP 24)

PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,402 minutes of "yellow" glare with potential to cause temporary after-image.

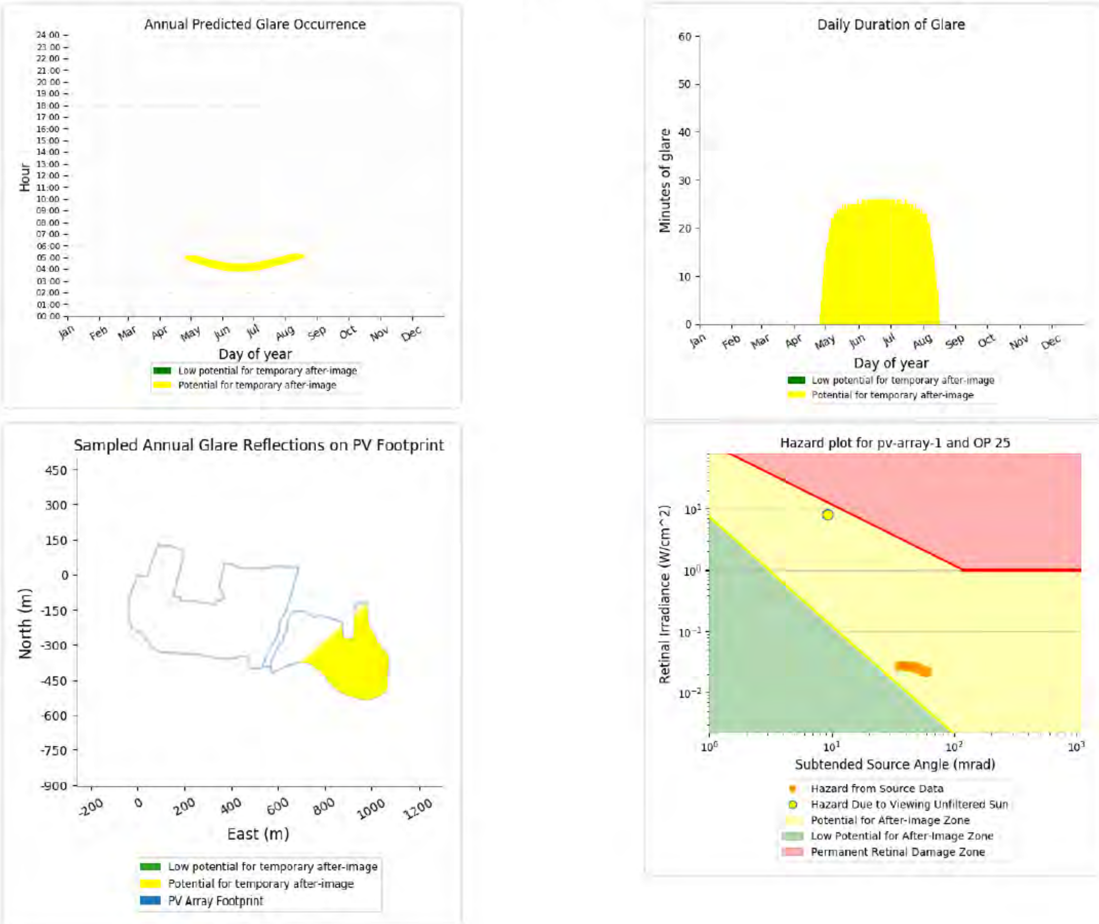


Dwelling 65

PV array 1 - OP Receptor (OP 25)

PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,578 minutes of "yellow" glare with potential to cause temporary after-image.



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