

Solar Photovoltaic Glint and Glare Study

Bicker Fen

Axis

August 2022

PLANNING SOLUTIONS FOR:

- Solar
- Telecoms
- Railways
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Job reference:	10299A
Date:	31 st May 2022
Author:	Andrea Mariano
Telephone:	01787 319001
Email:	andrea@pagerpower.com

Reviewers:	Michael Sutton; Hannah McNaul
Email:	michael@pagerpower.com; hannahm@pagerpower.com

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Stour Valley Business Centre, Sudbury, Suffolk, CO10 7GB

T: +44 (0)1787 319001 E: info@pagerpower.com W: www.pagerpower.com

EXECUTIVE SUMMARY

Report Purpose

Pager Power has been retained to assess the possible glint and glare effects from a proposed solar photovoltaic (PV) installation to be located north of Spalding, in the South Holland district of Lincolnshire, United Kingdom. This assessment pertains to the possible effects upon road users, dwellings, aviation, railway operations and infrastructure in the surrounding area.

Assessment Results – Aviation Receptors

The analysis has shown that solar reflections are possible towards aircrafts approaching Sempringham Fen Airfield's runway threshold 10 between 1.4 and 2.0 miles. However, it is predicted that the glare intensity will have "low potential for temporary after-image". This level of glare is acceptable in accordance with the associated guidance and industry best practice. Therefore, low impact is predicted, and no mitigation is required.

The high-level assessment of other aviation infrastructure has concluded that solar reflections are unlikely to be possible and if they are possible the impact will be insignificant.

Assessment Results – Dwelling Receptors

The results of the analysis have shown that reflections from the proposed development are geometrically possible towards all 47 identified dwelling receptors. A review of the available imagery has shown that a moderate impact with the requirement for mitigation is predicted for two dwellings if visibility of the reflective area is possible. A site survey can help to determine the level of visibility.

High-level Assessment – Railway

The high-level assessment of the railway infrastructure has concluded that solar reflections are unlikely to be possible or visible.

Assessment Results – Road Receptors

A review of the available imagery has shown that all roads surrounding the proposed development are considered local roads where traffic densities are likely to be relatively low. Therefore, the maximum impact upon these roads is considered to be low.

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 methodology¹. This methodology defines a comprehensive process for determining the impact upon road safety, residential amenity, aviation activity, and railway operations and infrastructure.

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 methodology². The scenario in which a solar reflection can occur for all receptors is then identified and discussed, and a comparison is made against the available solar panel reflection studies to determine the overall impact.

The available studies have measured the intensity of reflections from solar panels with respect to other naturally occurring and manmade surfaces. The results show that the reflections produced are of intensity similar to or less than those produced from still water and significantly less than reflections from glass and steel³.

¹ Pager Power Glint and Glare Guidance, 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).

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 51 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 glint and glare effects from a proposed solar photovoltaic (PV) installation to be located north of Spalding, in the South Holland district of Lincolnshire, United Kingdom. This assessment pertains to the possible effects upon road users, dwellings aviation and railway operations and infrastructure in the surrounding area. A report has therefore been produced that contains the following:

- Details of the proposed solar development;
- Explanation of glint and glare;
- Overview of relevant guidance;
- Overview of relevant studies;
- Identification of aviation concerns and receptors;
- Assessment methodology;
- Glint and glare assessment for:
 - Road receptors;
 - Dwelling receptors;
 - Aviation receptors.
- High-level assessment for aviation and railway infrastructure.
- Results discussion.

The relevant technical analysis is presented in each section. Following the assessment, conclusions and recommendations are made.

Please note that any reference to visual impact made within this report should be read in the context of potential glint and glare. In addition, this report is solely desk based and no site visit has taken place.

1.2 Pager Power's Experience

Pager Power has undertaken over 850 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 follows⁴:

- 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.

⁴ These definitions are aligned with those presented within the Draft National Policy Statement for Renewable Energy Infrastructure (EN-3) – published by the Department for Business, Energy & Industrial Strategy in September 2021 and the Federal Aviation Administration in the USA.

2 PROPOSED DEVELOPMENT LOCATION AND DETAILS

2.1 Proposed Development Location

The proposed development is shown in Figure 1⁵ below and on Figure 2 on the following page. Specific details about the solar panel areas assessed within this report can be seen in Section 5 and Appendix G.



Figure 1 – Proposed development

⁵ Source: General Arrangement Full Layout, Bicker Fen Solar Farm, Axis, date: 02/2022, Drawing No.: 2920-01-03, cropped.



Figure 2 – Proposed development assessed areas – aerial image

2.2 Photovoltaic Panel Mounting Arrangements and Orientation

The proposed development will use fixed panels. The characteristics of the panels are shown in below⁶.

Tilt (°)	Orientation (°)	Height ⁷ (m agl)
20	180 (due south)	1.9m

Table 1 – Panel's characteristics

⁶ Source: Illustrative Pv Frame & Panels, Bicker Fen Solar Farm, Axis, date: 05/2022, Drawing No.: 2920-01-04.

⁷ This is the height used for the assessment and it is the middle height of the panel.

3 GLINT AND GLARE ASSESSMENT METHODOLOGY

3.1 Overview

The following sub-sections provide a general overview with respect to the guidance studies and methodology which informs this report.

3.2 Guidance and Studies

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

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

3.3 Background

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

3.4 Methodology

The assessment methodology is based on guidance, studies, previous discussions with stakeholders and Pager Power's practical experience. Information regarding the methodology of Pager Power's and Sandia National Laboratories' methodology is presented below.

3.4.1 Pager Power's Methodology

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

- Identify receptors in the area surrounding the proposed development;
- Consider direct solar reflections from the proposed development towards the identified receptors by undertaking geometric calculations;
- Consider the visibility of the reflectors from the receptor's location. If the reflectors are not visible from the receptor then no reflection can occur;
- Based on the results of the geometric calculations, determine whether a reflection can occur and if so, at what time it will occur;
- Consider the solar reflection intensity, if appropriate;

- Consider both the solar reflection from the proposed development and the location of the direct sunlight with respect to the receptor's position;
- Consider the solar reflection with respect to the published studies and guidance;
- Determine whether a significant detrimental impact is expected in line with Appendix D.

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

Where a solar reflection is identified for an aviation approach path receptor, intensity calculations are completed in line with the Sandia National Laboratories methodology (discussed in the following section).

3.4.2 Sandia National Laboratories' Methodology

Sandia National Laboratories developed the Solar Glare Hazard Analysis Tool (SGHAT) which is no longer available. Pager Power has since reviewed the Sandia National Laboratories model and is developing its own intensity calculation model in line with Sandia National Laboratories' methodology. Whilst strictly applicable in the USA and to solar photovoltaic developments only, the methodology and associated guidance is widely used by UK aviation stakeholders. 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. Therefore, where the Pager Power geometrical analysis indicates that a solar reflection is geometrically possible, an intensity calculation in line with Sandia National Laboratories' methodology has also been completed⁸.

3.5 Assessment Methodology and Limitations

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

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

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. However, the significance of a solar reflection decreases with distance. This is because the proportion of an observer's field of vision that is taken up by the reflecting area diminishes as the separation distance increases. With regard to ground-based receptors, terrain and shielding by vegetation are also more likely to obstruct an observer's view at longer distances.

4.2 Dwellings Receptors

The analysis has considered dwellings that:

- Are within one kilometre of the proposed development; and
- Have a potential view of the panels.

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 photography⁹ plus local topography).

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, 47 dwelling receptor points¹⁰ have been identified for the assessment. The assessed dwellings are shown in Figure 3 on the following page. 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 dwelling¹¹.

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.

⁹ The aerial and street view imagery may not provide the most up to date information of the surrounding area.

¹⁰ The co-ordinates of the dwelling receptor points are presented in Appendix G.

¹¹ 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.

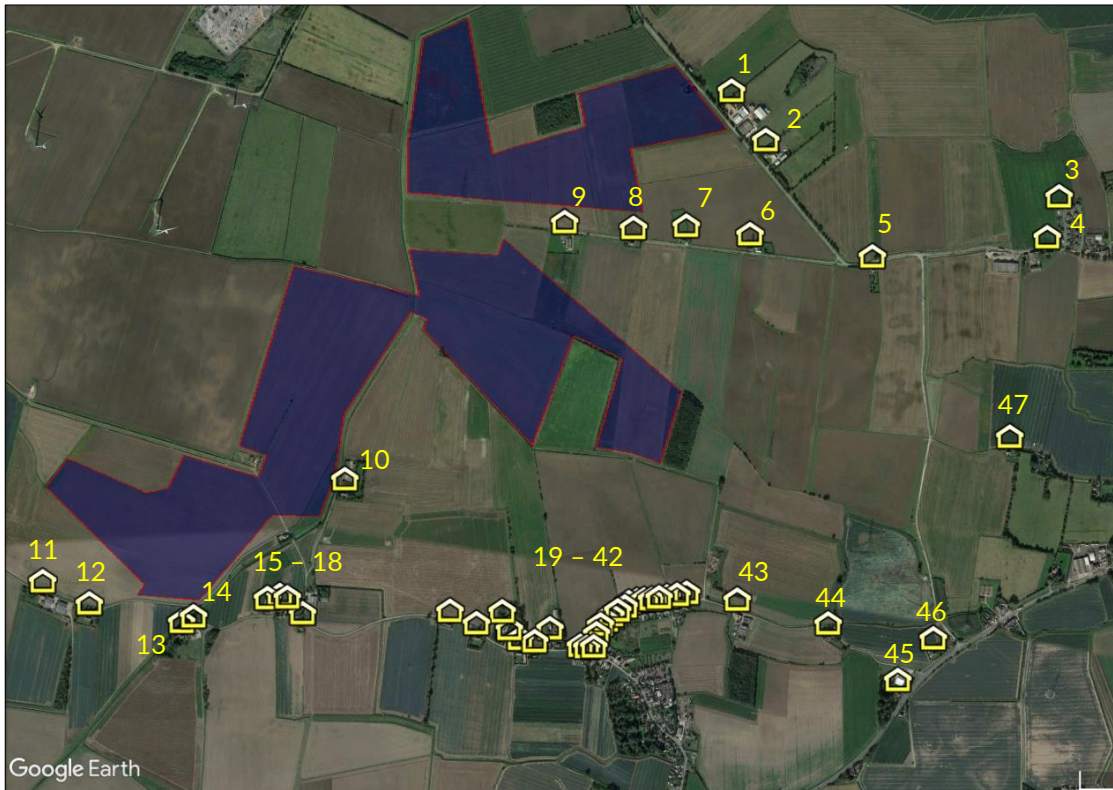


Figure 3 – Dwelling locations 1 to 47

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.

A review of the available imagery showed that all roads surrounding the proposed development are considered local roads where traffic densities are likely to be relatively low. The closest major road is the A52 located southeast of the proposed development. This road is not within the 1km study area considered for the identification of receptors. 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. Therefore, no road receptors have been identified and no modelling has been carried out.

4.1 Approaching Aircraft

Sempringham Fen Airfield has one operational runways (10/28) with two associated approach paths, one for each bearing. It is Pager Power's methodology to assess whether a solar reflection can be experienced on the approach paths for the associated runways. This is considered to be the most critical stage of the flight.

A geometric glint and glare assessment has been undertaken for both aircraft approach paths for the runway. The Pager Power approach for determining receptor (aircraft) locations on the approach path is to select locations along the extended runway centre line from 50ft above the runway threshold out to a distance of 2 miles. The height of the aircraft is determined by using a 3-degree descent path relative to the runway threshold height. The receptor details for each runway approach are presented in Appendix G. Figure 4 below shows the assessed aircraft approach paths as well as their location relative to the proposed development.



Figure 4 – Runway approach and location relative to the proposed development

5 ASSESSED REFLECTOR AREAS

5.1 Overview

The following section presents the modelled reflector areas.

5.2 Reflector Areas

A number of representative panel locations are selected within the proposed reflector areas. The number of modelled points is determined by the size of the reflector areas and the assessment resolution. The bounding coordinates for the proposed solar development were extrapolated from the site plans and can be found in Appendix F.

For the Pager Power model, a resolution of 20m has been chosen for this assessment. This means that a geometric calculation is undertaken for each identified receptor every 20m from within the defined areas. This resolution is sufficiently high to maximise the accuracy of the results – increasing the resolution further would not significantly change the modelling output. If a reflection is experienced from an assessed panel location, then it is likely that a reflection will be viewable from similarly located panels within the proposed solar development.

The reflector areas assessed is shown in Figure 5 below. The area has been overlaid on aerial imagery.



Figure 5 – Assessed reflector area

6 GLINT AND GLARE ASSESSMENT RESULTS

6.1 Overview

The following section presents an overview of the glare for the identified receptors. The Pager Power model has been used initially. Where solar reflections have been predicted, intensity calculations in line with Sandia National Laboratories' methodology have been undertaken. The intensity calculations determine the potential for an after-image (or worse) occurring. The designation used by the model is presented in Table 2 below along with the associated colour coding.

Coding Used	Intensity Key
Glare beyond 50°	 Glare beyond 50 deg from pilot line-of-sight
Low potential	 Low potential for temporary after-image
Potential	 Potential for temporary after-image
Potential for permanent eye damage	 Potential for permanent eye damage

Table 2 – Glare intensity designation

This coding has been used in the table where a reflection has been calculated and is in accordance with Sandia National Laboratories' methodology.

In addition, the intensity model allows for assessment of a variety of solar panel surface materials. In the first instance, a surface material of 'smooth glass without an anti-reflective coating' is assessed. This is the most reflective surface and allows for a 'worst case' assessment. Other surfaces that could be modelled include:

- Smooth glass with an anti-reflective coating;
- Light textured glass without an anti-reflective coating;
- Light textured glass with an anti-reflective coating; or
- Deeply textured glass.

If significant glare is predicted, modelling of less reflective surfaces could be undertaken.

The tables in the following subsections summarise the time (am or pm) and intensity for a solar reflection be experienced by a receptor. Appendix H presents the results charts.

6.2 Geometric Calculation Results Overview – Runway 10 Approach

The results of the geometric calculation for the aviation receptors associated with runway 10 approach path are presented in Table 3 below. Discussed in Section 7.1.

Receptor	Reflection possible toward the identified aviation receptors? (GMT)		Glare Type	Reflection Predicted
	am	pm		
Threshold – 1.3 miles	None.	None.	None.	Solar reflections are not geometrically possible. No impact is predicted.
1.4 miles	Between 05:42 and 05:44 during late June.	None.	“Green-glare” with low potential for temporary after-image.	Solar reflections are geometrically possible. However, the level of intensity is acceptable in accordance with the associated guidance and industry best practice. Therefore, a low impact is predicted, and no mitigation is required.
1.5 miles	Between 05:41 and 05:46 from early June to early July.	None.	“Green-glare” with low potential for temporary after-image.	Solar reflections are geometrically possible. However, the level of intensity is acceptable in accordance with the associated guidance and industry best practice. Therefore, a low impact is predicted, and no mitigation is required.

Receptor	Reflection possible toward the identified aviation receptors? (GMT)		Glare Type	Reflection Predicted
	am	pm		
1.6 miles	Between 05:40 and 05:47 from early June to early July.	None.	"Green-glare" with low potential for temporary after-image.	Solar reflections are geometrically possible. However, the level of intensity is acceptable in accordance with the associated guidance and industry best practice. Therefore, a low impact is predicted, and no mitigation is required.
1.7 miles	Between 05:40 and 05:48 from the end of May to mid- July.	None.	"Green-glare" with low potential for temporary after-image.	Solar reflections are geometrically possible. However, the level of intensity is acceptable in accordance with the associated guidance and industry best practice. Therefore, a low impact is predicted, and no mitigation is required.
1.8 miles	Between 05:41 and 05:49 from the end of May to mid- July.	None.	"Green-glare" with low potential for temporary after-image.	Solar reflections are geometrically possible. However, the level of intensity is acceptable in accordance with the associated guidance and industry best practice. Therefore, a low impact is predicted, and no mitigation is required.

Receptor	Reflection possible toward the identified aviation receptors? (GMT)		Glare Type	Reflection Predicted
	am	pm		
1.9 miles	Between 05:41 and 05:50 from late May to mid- July.	None.	"Green-glare" with low potential for temporary after-image.	Solar reflections are geometrically possible. However, the level of intensity is acceptable in accordance with the associated guidance and industry best practice. Therefore, a low impact is predicted, and no mitigation is required.
2.0 miles	Between 05:41 and 05:52 from late May to late July.	None.	"Green-glare" with low potential for temporary after-image.	Solar reflections are geometrically possible. However, the level of intensity is acceptable in accordance with the associated guidance and industry best practice. Therefore, a low impact is predicted, and no mitigation is required.

Table 3 – Geometric analysis results for the aviation receptors – Runway 10 Approach

6.3 Geometric Calculation Results Overview – Runway 28 Approach

The results of the geometric calculation for the aviation receptors associated with runway 28 approach path are presented in Table 4 below. Discussed in Section 7.1.

Receptor	Reflection possible toward the identified aviation receptors? (GMT)		Glare Type	Reflection Predicted
	am	pm		
Threshold – 2.0 miles	None.	None.	None.	Solar reflections are not geometrically possible. No impact is predicted.

Table 4 – Geometric analysis results for the aviation receptors – Runway 28 Approach

6.4 Geometric Calculation Results Overview – Dwelling Receptors

The results of the geometric calculations for the identified dwelling receptors are presented in Table 5 below. Discussed in Section 7.2.

Receptor	Reflection possible toward the identified dwelling receptors? (GMT)		Reflection Predicted
	am	pm	
1	None.	Between 17:55 and 18:28 from late March to late September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
2	None.	Between 17:54 and 18:28 from late March to late September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
3	None.	Between 18:09 and 18:16 from late March to late May. Between 17:55 and 18:26 from late July to late September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.

Receptor	Reflection possible toward the identified dwelling receptors? (GMT)		Reflection Predicted
	am	pm	
4	None.	Between 17:54 and 18:28 from mid- March to late September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
5	None.	Between 17:54 and 18:28 from mid- March to late September.	Solar reflections are geometrically possible. However, mitigating circumstances have been identified. A moderate impact is predicted but no mitigation is recommended.
6	None.	At circa 18:09 during late March. Between 18:10 and 18:28 from mid- April to the end of August.	Solar reflections are geometrically possible. However, mitigating circumstances have been identified. A moderate impact is predicted but no mitigation is recommended.

Receptor	Reflection possible toward the identified dwelling receptors? (GMT)		Reflection Predicted
	am	pm	
7	None.	At circa 18:09 during late March. Between 18:10 and 18:28 from mid- April to the end of August. At circa 17:55 during late September.	Solar reflections are geometrically possible. However, existing and proposed screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
8	None.	At circa 18:09 during late March. Between 18:11 and 18:28 from late April to late August. Between 17:54 and 17:56 during late September.	Solar reflections are geometrically possible. However, existing and proposed screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
9	At circa 05:40 during early May. At circa 05:37 during mid- June. At circa 05:41 during the end of June. At circa 05:50 during early August.	Between 18:12 and 18:28 from the beginning of May to mid- August.	Solar reflections are geometrically possible. However, existing and proposed screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.

Receptor	Reflection possible toward the identified dwelling receptors? (GMT)		Reflection Predicted
	am	pm	
10	Between 05:36 and 05:58 from the beginning of April to early September.	Between 17:54 and 18:28 from mid- March to late September.	Solar reflections are geometrically possible. However, existing and proposed screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
11	Between 05:36 and 06:05 from late March to late September.	None.	Solar reflections are geometrically possible. It was not possible to determine the level of screening from the available imagery. A moderate impact is predicted.
12	Between 05:36 and 05:53 from mid- April to the end of August.	None.	Solar reflections are geometrically possible. It was not possible to determine the level of screening from the available imagery. A moderate impact is predicted.

Receptor	Reflection possible toward the identified dwelling receptors? (GMT)		Reflection Predicted
	am	pm	
13	Between 05:36 and 05:48 from mid- May to the end of July.	None.	Solar reflections are geometrically possible. However, existing and proposed screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
14	Between 05:36 and 05:48 from mid- May to the end of July.	None.	Solar reflections are geometrically possible. However, existing and proposed screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.

Receptor	Reflection possible toward the identified dwelling receptors? (GMT)		Reflection Predicted
	am	pm	
15	Between 05:36 and 05:47 from late May to late July.	Between 18:07 and 18:28 from early April to the beginning of September.	Solar reflections are geometrically possible. However, existing screening is expected to block all views of the reflective area that generates reflections in the afternoon. It was not possible to determine the level of screening for the reflective area generating reflections in the morning which however will last less than 3 months per year and less than 60 minutes per day. A low impact is predicted.
16	Between 05:36 and 05:47 from late May to late July.	Between 18:04 and 18:28 from early April to early September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.

Receptor	Reflection possible toward the identified dwelling receptors? (GMT)		Reflection Predicted
	am	pm	
17	Between 05:36 and 05:46 from late May to mid- July.	Between 18:07 and 18:28 from early April to the beginning of September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
18	None.	Between 18:10 and 18:28 from late April to late August.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
19	None.	Between 18:03 and 18:27 from the beginning of April to early September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.

Receptor	Reflection possible toward the identified dwelling receptors? (GMT)		Reflection Predicted
	am	pm	
20	None.	Between 18:06 and 18:28 from early April to early September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
21	None.	Between 18:02 and 18:27 from the end of March to mid-September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
22	None.	Between 18:07 and 18:27 from early April to the beginning of September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.

Receptor	Reflection possible toward the identified dwelling receptors? (GMT)		Reflection Predicted
	am	pm	
23	None.	Between 18:09 and 18:27 from mid- April to the end of August.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
24	None.	Between 18:09 and 18:27 from mid- April to the end of August.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
25	None.	Between 18:05 and 18:27 from early April to early September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.

Receptor	Reflection possible toward the identified dwelling receptors? (GMT)		Reflection Predicted
	am	pm	
26	None.	Between 18:08 and 18:27 from mid- April to the beginning of September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
27	None.	Between 18:08 and 18:27 from mid- April to the beginning of September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
28	None.	Between 18:08 and 18:27 from mid- April to the beginning of September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.

Receptor	Reflection possible toward the identified dwelling receptors? (GMT)		Reflection Predicted
	am	pm	
29	None.	Between 18:05 and 18:28 from early April to early September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
30	None.	Between 18:03 and 18:27 from the beginning of April to early September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
31	None.	Between 18:02 and 18:28 from the beginning of April to mid-September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.

Receptor	Reflection possible toward the identified dwelling receptors? (GMT)		Reflection Predicted
	am	pm	
32	None.	Between 18:01 and 18:27 from the end of March to mid-September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
33	None.	Between 17:59 and 18:27 from the end of March to mid-September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
34	None.	Between 17:58 and 18:27 from late March to mid-September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.

Receptor	Reflection possible toward the identified dwelling receptors? (GMT)		Reflection Predicted
	am	pm	
35	None.	Between 17:58 and 18:27 from late March to mid- September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
36	None.	Between 17:57 and 18:27 from late March to mid- September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
37	None.	Between 17:57 and 18:27 from late March to mid- September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.

Receptor	Reflection possible toward the identified dwelling receptors? (GMT)		Reflection Predicted
	am	pm	
38	None.	Between 17:56 and 18:27 from late March to mid- September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
39	None.	Between 17:56 and 18:28 from late March to late September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
40	None.	Between 17:56 and 18:27 from late March to late September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.

Receptor	Reflection possible toward the identified dwelling receptors? (GMT)		Reflection Predicted
	am	pm	
41	None.	Between 17:56 and 18:27 from late March to late September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
42	None.	Between 17:55 and 18:27 from late March to late September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
43	None.	Between 17:56 and 18:28 from late March to late September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.

Receptor	Reflection possible toward the identified dwelling receptors? (GMT)		Reflection Predicted
	am	pm	
44	None.	Between 17:59 and 18:28 from the end of March to mid-September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
45	None.	Between 18:06 and 18:28 from early April to early September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.
46	None.	Between 18:00 and 18:28 from the end of March to mid-September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.

Receptor	Reflection possible toward the identified dwelling receptors? (GMT)		Reflection Predicted
	am	pm	
47	None.	Between 17:54 and 18:28 from mid- March to late September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation will block views of the reflective area. No impact predicted and no mitigation is recommended.

Table 5 – Geometric analysis results for the identified dwelling receptors

7 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

7.1 Aviation Receptors

The analysis has shown that solar reflections are possible towards planes approaching threshold 10 between 1.4 and 2.0 miles. However, it is predicted that the glare intensity will have “low potential for after-image”. This level of glare is acceptable in accordance with the associated guidance and industry best practice. Therefore, low impact is predicted, and no mitigation is required.

7.2 Dwelling Receptors

The key considerations for quantifying impact significance for dwelling receptors are:

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

Where no effects are predicted to be experienced by residents in practice, no impacts are possible, and mitigation is not required. Where effects are predicted to be experienced for less than 3 months per year and less than 60 minutes per day, 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.
- Whether visibility is likely from all storeys – the ground floor is typically considered the main living space and has a greater significance with respect to residential amenity.
- Whether the dwelling appears to have windows facing the reflecting area – factors that restrict potential views of a reflecting area reduce the level of impact.

The results of the analysis have shown that reflections from the proposed development are geometrically possible towards all 47 identified dwelling receptors. After a review of the available imagery a moderate impact is predicted for four out of the 47 dwelling receptors (see Figure 6 on the following page). For the remaining 43 receptors no or low impact is predicted.

For two (5 and 6) out of these four dwelling receptors no mitigation is recommended once mitigating factors (such as: distance from the reflective area and Sun light and solar reflections originating from the same point in space) are taken into consideration. For the remaining two receptors (11 and 12) it was not possible to determine the level of existing screening and no

mitigating circumstances have been identified. If a site survey will confirm the visibility of the reflective area, mitigation is recommended. The location of the proposed screening is shown in Figure 7 below.



Figure 6 – Dwellings where a moderate impact is predicted



Figure 7 – Reflective area for dwelling 11 and 12 and relative proposed screening

8 HIGH-LEVEL ASSESSMENT OF RAILWAY AND AVIATION RECEPTORS

8.1 Railway Receptors

8.1.1 Overview

There is no formal buffer distance within which railway effects must be modelled. However, in practice, concerns are most often raised for developments within 200m of a railway line. A high-level railway assessment has been undertaken considering the nearby railway line. No engagement with Network Rail has been undertaken since, in Pager Power experience, it is not required for development located more than 200m from a railway receptor.

8.1.2 High-Level Assessment

The railway line is located circa 760m¹² (at its closest point) southwest of the proposed development (see Figure 8 below).



Figure 8 – Railway line location relative to the proposed development

It is also likely that terrain or other ground-based obstruction such as existing vegetation or buildings will screen views of the proposed development for train drivers travelling in both directions. Therefore, no significant impact is possible for train drivers travelling on both directions of the identified stretch of railway.

¹² At this distance it is unlikely that Network Rail will raise a concern.

8.2 Aviation Receptors

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

A high-level aviation assessment has been undertaken considering the nearest aerodromes to the proposed development.

8.2.1 High-Level Assessment

The locations of the aerodromes listed above relative to the proposed development are shown in Figure 9 below. The red lines represent the 2-mile runway approach paths associated with each aerodrome.



Figure 9 – Aerodromes relative to panel area

8.2.1.1 Boston Airfield

Boston is an unlicensed aerodrome located approximately 11 km east-northeast of the panel area centre. The airfield has one grass runway that runs approximately east-west.

Any reflections towards pilots on the final two miles of approach at this airstrip are not predicted since solar reflections for receptors located north of the most northern panel are not possible for fixed systems. Significant impacts on pilots are not predicted and technical modelling is not recommended.

8.2.1.2 RAF Cranwell

RAF Cranwell is a military aerodrome located approximately 22 km northwest of the proposed development. The aerodrome has two asphalt runways, one running west-southwest to east-northeast and another running south-southwest to north-northeast. There is also a grass strip running parallel to the main runway. The Air Traffic Control tower is located north of runway 08/26 and west of runway 01/19.

Any reflections towards pilots on the final two miles of approach at this airstrip or towards the ATC tower personnel are not predicted since solar reflections for receptors located north of the most northern panel are not possible for fixed systems. Significant impacts on pilots are not predicted and technical modelling is not recommended.

8.2.1.3 RAF Coningsby

RAF Coningsby is a military aerodrome located approximately 18 km northeast of the proposed development. The aerodrome has one asphalt runway, running west-southwest to east-northeast. The Air Traffic Control tower is located north of the runway.

Any reflections towards pilots on the final two miles of approach at this airstrip or towards the ATC tower personnel are not predicted since solar reflections for receptors located north of the most northern panel are not possible for fixed systems. Significant impacts on pilots are not predicted and technical modelling is not recommended.

9 OVERALL CONCLUSIONS

9.1 Assessment Results – Aviation Receptors

The analysis has shown that solar reflections are possible towards aircrafts approaching Sempringham Fen Airfield's runway threshold 10 between 1.4 and 2.0 miles. However, it is predicted that the glare intensity will have "low potential for temporary after-image". This level of glare is acceptable in accordance with the associated guidance and industry best practice. Therefore, low impact is predicted, and no mitigation is required.

The high-level assessment of other aviation infrastructure has concluded that solar reflections are unlikely to be possible and if they are possible the impact will be insignificant.

9.2 Assessment Results – Dwelling Receptors

The results of the analysis have shown that reflections from the proposed development are geometrically possible towards all 47 identified dwelling receptors. A review of the available imagery has shown that a moderate impact with the requirement for mitigation is predicted for two dwellings if visibility of the reflective area is possible. A site survey can help to determine the level of visibility.

9.3 High-level Assessment – Railway

The high-level assessment of the railway infrastructure has concluded that solar reflections are unlikely to be possible or visible.

9.4 Assessment Results – Road Receptors

A review of the available imagery has shown that all roads surrounding the proposed development are considered local roads where traffic densities are likely to be relatively low. Therefore, the maximum impact upon these roads is considered to be low.

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 Energy¹³ (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.’

Draft National Policy Statement for Renewable Energy Infrastructure

¹³ Renewable and low carbon energy, Ministry of Housing, Communities & Local Government, date: 18 June 2015, accessed on: 01/11/2021

The Draft National Policy Statement for Renewable Energy Infrastructure (EN-3)¹⁴ 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 used¹⁵ 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.

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.

¹⁴ Draft National Policy Statement for Renewable Energy Infrastructure (EN-3), Department for Business, Energy & Industrial Strategy, date: September 2021, accessed on: 01/11/2021.

¹⁵ 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.

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 document¹⁶ which was produced due to the absence of existing guidance and a specific standardised assessment methodology.

Aviation Assessment Guidance

The UK Civil Aviation Authority (CAA) issued interim guidance relating to Solar Photovoltaic Systems (SPV) on 17 December 2010 and was subject to a CAA information alert 2010/53. The formal policy was cancelled on September 7th, 2012¹⁷ however the advice is still applicable¹⁸ until a formal policy is developed. The relevant aviation guidance from the CAA is presented in the section below.

CAA Interim Guidance

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

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

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

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

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

12. If an installation of SPV systems is planned on-aerodrome (i.e. within its licensed boundary) then it is recommended that data on the reflectivity of the solar panel material should be included in any assessment before installation approval can be granted. Although approval for installation is the responsibility of the ALH¹⁹, as part of a condition of a CAA Aerodrome Licence, the ALH is required to

¹⁶ Solar Photovoltaic Development Glint and Glare Guidance, Third Edition V3.1, May 2021. Pager Power.

¹⁷ Archived at Pager Power

¹⁸ Reference email from the CAA dated 19/05/2014.

¹⁹ Aerodrome Licence Holder.

obtain prior consent from CAA Aerodrome Standards Department before any work is begun or approval to the developer or LPA is granted, in accordance with the procedures set out in CAP 791 Procedures for Changes to Aerodrome Infrastructure.

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

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

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

FAA Guidance

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

The 2010 document is entitled 'Technical Guidance for Evaluating Selected Solar Technologies on Airports'²⁰, the 2013 update is entitled 'Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports'²¹, and the 2021 final policy is entitled 'Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports'²².

Key excerpts from the final policy are presented below:

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

The policy in this document updates and replaces the previous policy by encouraging airport sponsors to conduct an ocular analysis of potential impacts to ATCT cabs prior to submittal of a Notice of Proposed Construction or Alteration Form 7460-1 (hereinafter Form 7460-1). Airport sponsors are no longer required to submit the results of an ocular analysis to FAA. Instead, to demonstrate compliance with 14 CFR 77.5(c), FAA will rely on the submittal of Form 7460-1 in which the sponsor confirms

²⁰ Archived at Pager Power

²¹ [Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports](#), Department of Transportation, Federal Aviation Administration (FAA), date: 10/2013, accessed on: 08/12/2021.

²² [Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports](#), Federal Aviation Administration, date: May 2021, accessed on: 08/12/2021.

that it has analyzed the potential for glint and glare and determined there is no potential for ocular impact to the airport's ATCT cab. This process will enable FAA to evaluate the solar energy system project, with assurance that the system will not impact the ATCT cab.

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

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

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

In 2018, the FAA released the latest version (Version 1.1) of the 'Technical Guidance for Evaluating Selected Solar Technologies on Airports'²³. Whilst the 2021 final policy also supersedes this guidance, many of the points are still relevant because aerodromes are still safeguarding against glint and glare irrespective of the FAA guidance. The key points are presented below for reference:

- *Reflectivity refers to light that is reflected off surfaces. The potential effects of reflectivity are glint (a momentary flash of bright light) and glare (a continuous source of bright light). These two effects are referred to hereinafter as "glare," which can cause a brief loss of vision, also known as flash blindness²⁴.*
- *The amount of light reflected off a solar panel surface depends on the amount of sunlight hitting the surface, its surface reflectivity, geographic location, time of year, cloud cover, and solar panel orientation.*
- *As illustrated on Figure 16²⁵, flat, smooth surfaces reflect a more concentrated amount of sunlight back to the receiver, which is referred to as specular reflection. The more a surface*

²³ Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 08/12/2021.

²⁴ Flash Blindness, as described in the FAA guidelines, can be described as a temporary visual interference effect that persists after the source of illumination has ceased. This occurs from many reflective materials in the ambient environment.

²⁵ First figure in Appendix B.

is polished, the more it shines. Rough or uneven surfaces reflect light in a diffused or scattered manner and, therefore, the light will not be received as bright.

- Because the FAA has no specific standards for airport solar facilities and potential glare, the type of glare analysis may vary. Depending on site specifics (e.g., existing land uses, location and size of the project) an acceptable evaluation could involve one or more of the following levels of assessment:
 - A qualitative analysis of potential impact in consultation with the Control Tower, pilots and airport officials;
 - A demonstration field test with solar panels at the proposed site in coordination with FAA Tower personnel;
 - A geometric analysis to determine days and times when an impact is predicted.
- The extent of reflectivity analysis required to assess potential impacts will depend on the specific project site and system design.
- **1. Assessing Baseline Reflectivity Conditions** – Reflection in the form of glare is present in current aviation operations. The existing sources of glare come from glass windows, auto surface parking, rooftops, and water bodies. At airports, existing reflecting surfaces may include hangar roofs, surface parking, and glassy office buildings. To minimize unexpected glare, windows of air traffic control towers and airplane cockpits are coated with anti-reflective glazing. Operators also wear polarized eye wear. Potential glare from solar panels should be viewed in this context. Any airport considering a solar PV project should first review existing sources of glare at the airport and the effectiveness of measures used to mitigate that glare.
- **2. Tests in the Field** – Potential glare from solar panels can easily be viewed at the airport through a field test. A few airports have coordinated these tests with FAA Air Traffic Controllers to assess the significance of glare impacts. To conduct such a test, a sponsor can take a solar panel out to proposed location of the solar project, and tilt the panel in different directions to evaluate the potential for glare onto the air traffic control tower. For the two known cases where a field test was conducted, tower personnel determined the glare was not significant. If there is a significant glare impact, the project can be modified by ensuring panels are not directed in that direction.
- **3. Geometric Analysis** – Geometric studies are the most technical approach for reflectivity issues. They are conducted when glare is difficult to assess through other methods. Studies of glare can employ geometry and the known path of the sun to predict when sunlight will reflect off of a fixed surface (like a solar panel) and contact a fixed receptor (e.g., control tower). At any given site, the sun moves across the sky every day and its path in the sky changes throughout year. This in turn alters the destination of the resultant reflections since the angle of reflection for the solar panels will be the same as the angle at which the sun hits the panels. The larger the reflective surface, the greater the likelihood of glare impacts.
- Facilities placed in remote locations, like the desert, will be far from receptors and therefore potential impacts are limited to passing aircraft. Because the intensity of the light reflected from the solar panel decreases with increasing distance, an appropriate question is how far

you need to be from a solar reflected surface to avoid flash blindness. It is known that this distance is directly proportional to the size of the array in question²⁶ but still requires further research to definitively answer.

- **Experiences of Existing Airport Solar Projects** – Solar installations are presently operating at a number of airports, including megawatt-sized solar facilities covering multiple acres. Air traffic control towers have expressed concern about glint and glare from a small number of solar installations. These were often instances when solar installations were sited between the tower and airfield, or for installations with inadequate or no reflectivity analysis. Adequate reflectivity analysis and alternative siting addressed initial issues at those installations.

Air Navigation Order (ANO) 2016

In some instances, an aviation stakeholder can refer to the ANO 2016²⁷ with regard to safeguarding. Key points from the document are presented below.

Lights liable to endanger

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

(a) by reason of its glare is liable to endanger aircraft taking off from or landing at an aerodrome; or

(b) by reason of its liability to be mistaken for an aeronautical ground light is liable to endanger aircraft.

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

(a) to extinguish or screen the light; and

(b) to prevent in the future the exhibition of any other light which may similarly endanger aircraft.

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

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

Lights which dazzle or distract

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

²⁶ Ho, Clifford, Cheryl Ghanbari, and Richard Diver. 2009. Hazard Analysis of Glint and Glare From Concentrating Solar Power Plants. SolarPACES 2009, Berlin Germany. Sandia National Laboratories.

²⁷ The Air Navigation Order 2016. [online] Available at: <<https://www.legislation.gov.uk/uksi/2016/765/contents/made>> [Accessed 4 February 2022].

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

Endangering safety of an aircraft

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

Endangering safety of any person or property

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

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

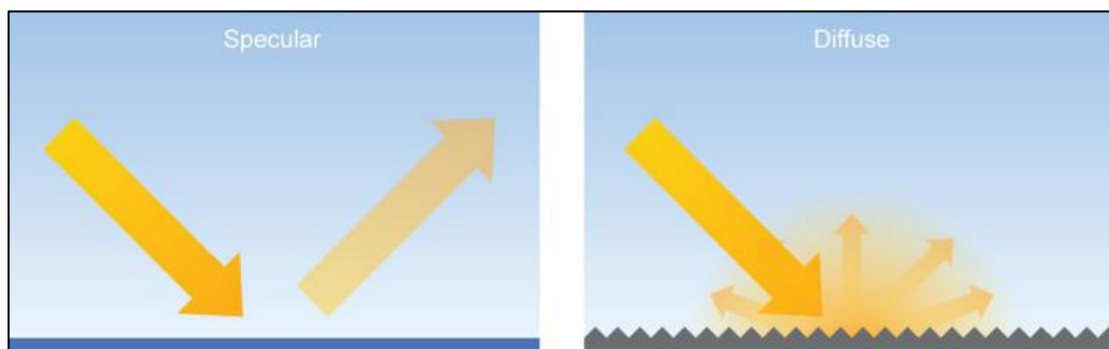
Overview

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 guidance²⁸, 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

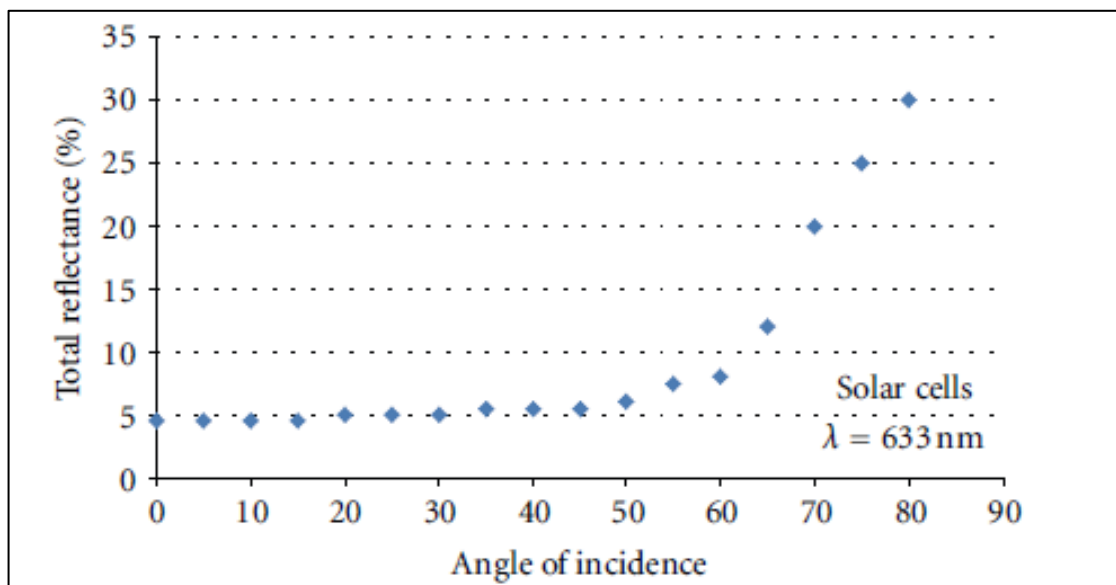
²⁸ [Technical Guidance for Evaluating Selected Solar Technologies on Airports](#), Federal Aviation Administration (FAA), date: 04/2018, accessed on: 08/12/2021.

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*²⁹. 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.

²⁹ 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”³⁰

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 ³¹
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.

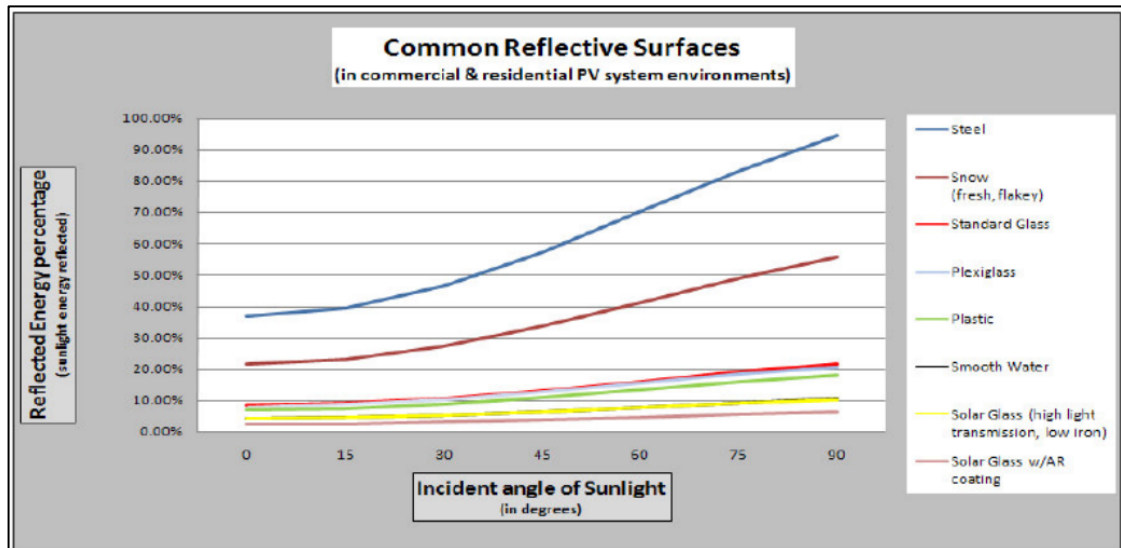
³⁰ Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 08/12/2021.

³¹ Extrapolated data, baseline of 1,000 W/m² for incoming sunlight.

SunPower Technical Notification (2009)

SunPower published a technical notification³² 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.

³² Source: Technical Support, 2009. SunPower Technical Notification – Solar Module Glare and Reflectance.

APPENDIX C – OVERVIEW OF SUN MOVEMENTS AND RELATIVE REFLECTIONS

Overview

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

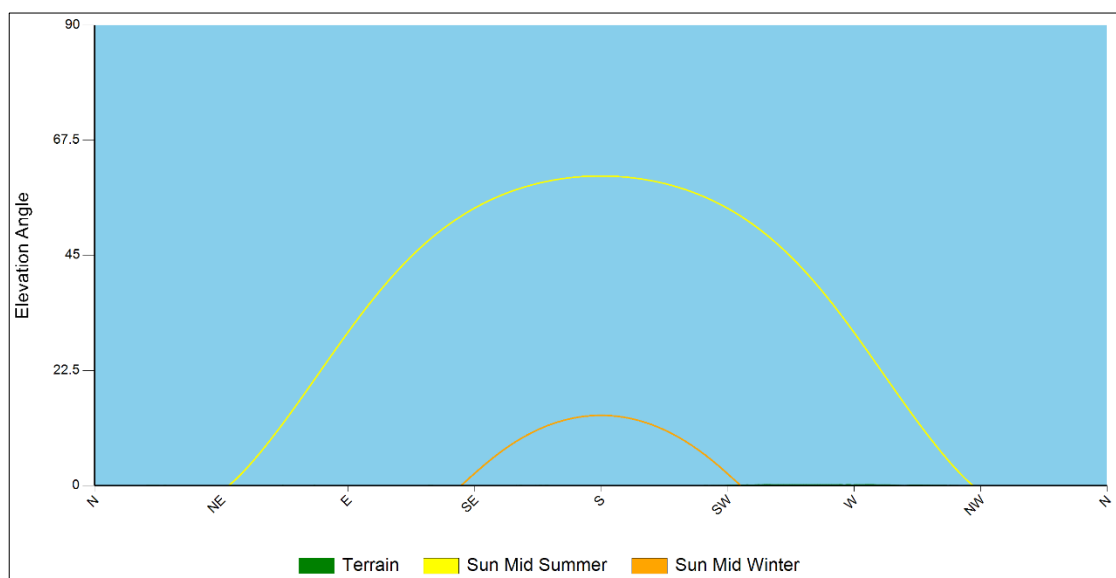
The Sun's position can be accurately calculated for a specific location. The following data being used for the calculation:

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

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

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

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



Terrain at the visible horizon and Sun paths

APPENDIX D – GLINT AND GLARE IMPACT SIGNIFICANCE

Overview

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

Impact significance definition

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

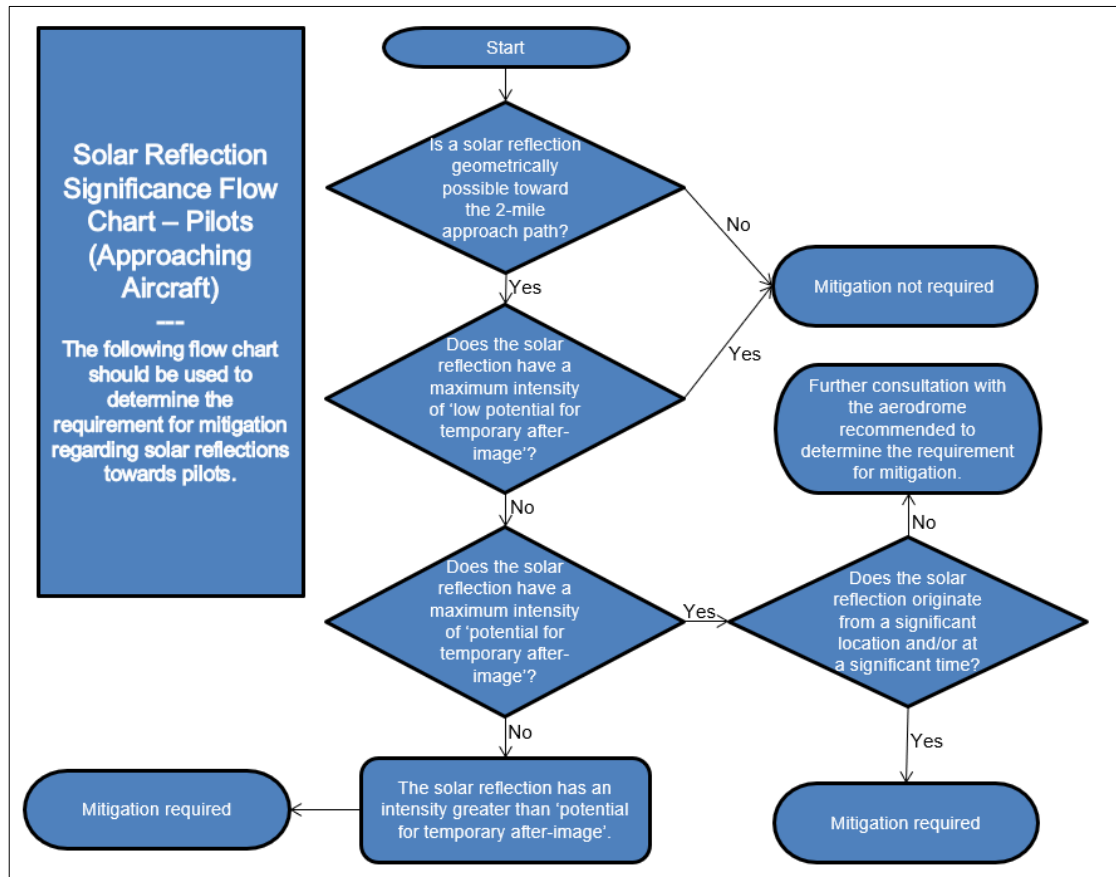
Impact Significance	Definition	Mitigation Requirement
No Impact	A solar reflection is not geometrically possible or will not be visible from the assessed receptor.	No mitigation required.
Low	A solar reflection is geometrically possible however any impact is considered to be small such that mitigation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

Impact significance definition

The flow charts presented in the following sub-sections have been followed when determining the mitigation requirement for aviation receptors.

Assessment Process for Approaching Aircraft

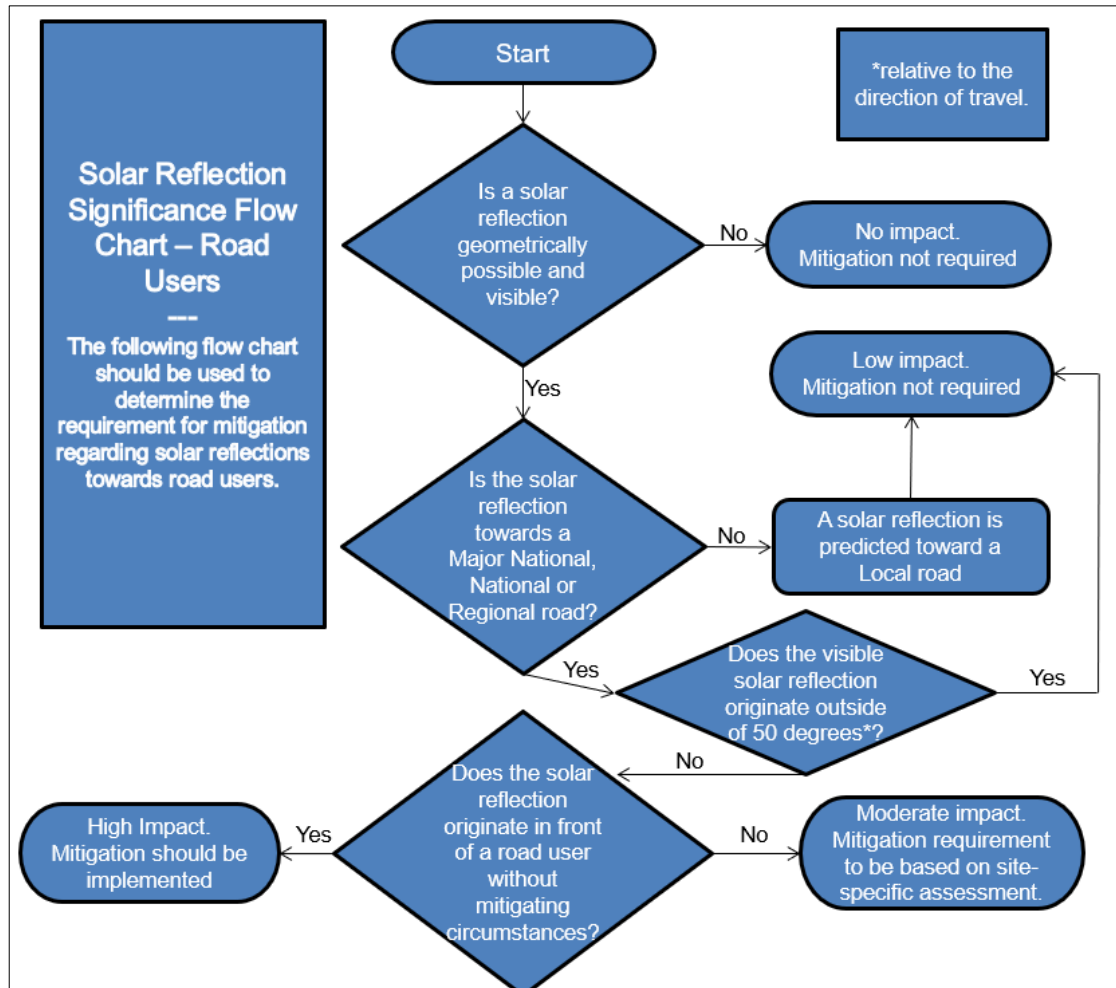
The charts relate to the determining the potential impact upon approaching aircraft.



Approaching aircraft receptor mitigation requirement flow chart

Assessment Process for Road Receptors

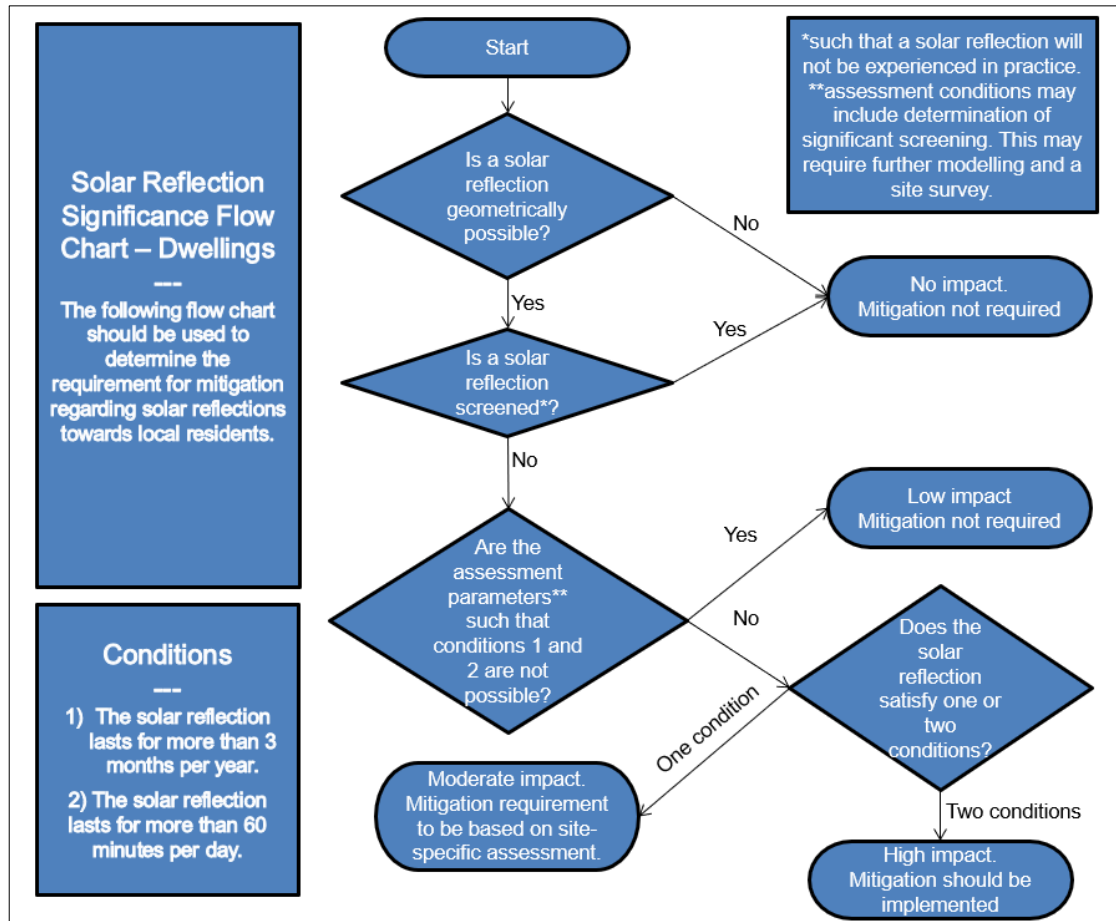
The flow chart presented below has been followed when determining the mitigation requirement for road receptors.



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.



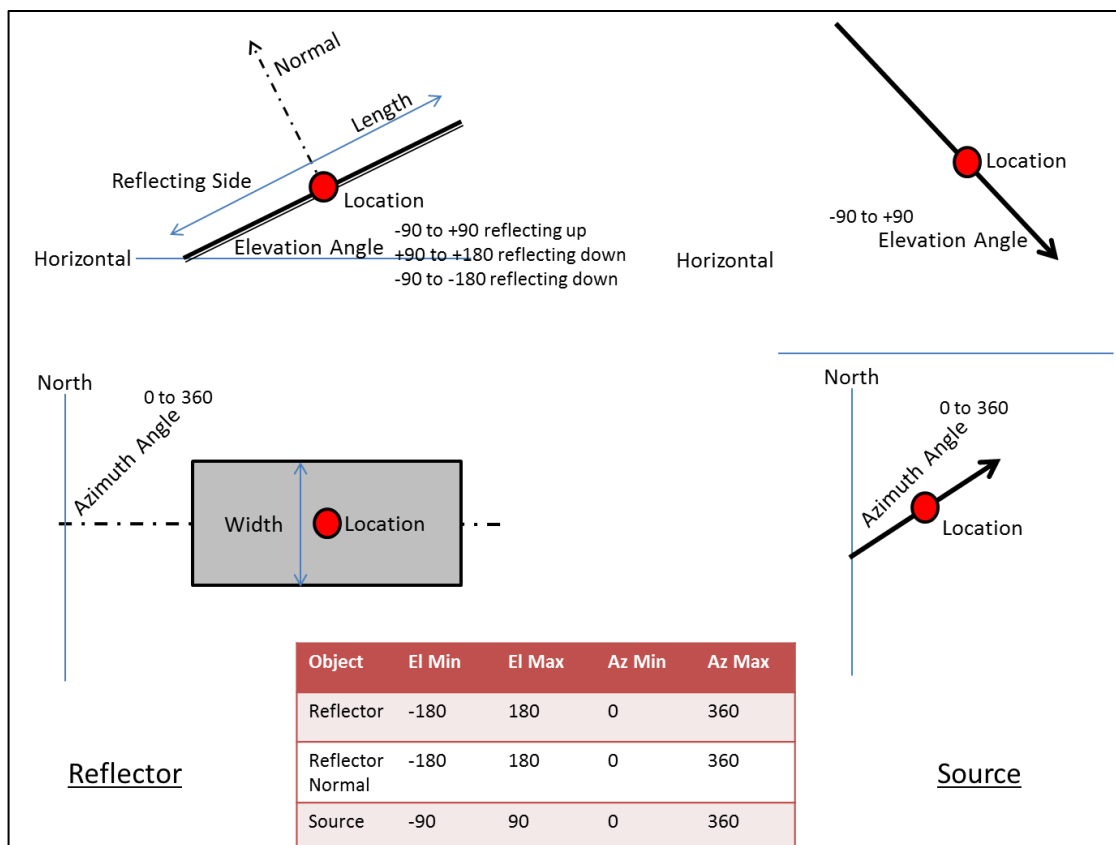
Dwelling receptor mitigation requirement flow chart

APPENDIX E – PAGER POWER’S REFLECTION CALCULATIONS METHODOLOGY

The calculations are three dimensional and complex, accounting for:

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

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



The following process is used to determine the 3D azimuth and elevation of a reflection:

- Use the Latitude and Longitude of reflector as the reference for calculation purposes;
- Calculate the Azimuth and Elevation of the normal to the reflector;
- Calculate the 3D angle between the source and the normal;

- If this angle is less than 90 degrees a reflection will occur. If it is greater than 90 degrees no reflection will occur because the source is behind the reflector;
- Calculate the Azimuth and Elevation of the reflection in accordance with the following:
 - The angle between source and normal is equal to angle between normal and reflection;
 - Source, Normal and Reflection are in the same plane.

APPENDIX F – ASSESSMENT LIMITATIONS AND ASSUMPTIONS

Pager Power's Model

It is assumed that the panel elevation angle provided by the developer represents the elevation angle for all of the panels within the solar development.

It is assumed that the panel azimuth angle provided by the developer represents the azimuth angle for all of the panels within the solar development.

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 within the proposed development area whilst in reality this, in the majority of cases, will not occur. Therefore any predicted reflection from the face of a solar panel that is not visible to a receptor will not occur. A finite number of points within the proposed development are chosen based on an assessment resolution so we can build a comprehensive understanding of the entire development. This will determine whether a reflection could ever occur at a chosen receptor. The calculations do not incorporate all of the possible panel locations within the development outline.

A single reflection point on the panel has been chosen for the geometric calculations. This will suitably determine whether a reflection can be experienced at a location and the general time of year and duration of this 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.

Whilst line of sight to the development from receptors has been considered, only available street view imagery and satellite mapping has been used. 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 considered unless stated.

Forge's Sandia National Laboratories' (SGHAT) Model

The following text is taken from Forge³³ 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.

³³ Source: <https://www.forgesolar.com/help/#assumptions>

APPENDIX G – RECEPTOR AND REFLECTOR AREA DETAILS

Receptor Locations for Aircraft Landing on Runway 10

The table below presents the data for the assessed locations for aircraft on approach to runway 10. The altitude of the aircraft is based on a 3-degree descent path referenced to 50 feet (15.2m) above the runway threshold.

No.	Longitude (°)	Latitude (°)	Assessed Altitude (m amsl)
Approach 10 - Threshold	-0.29964	52.88104	18.24
Approach 10 - 0.1 miles	-0.30200	52.88126	26.66
Approach 10 - 0.2 miles	-0.30436	52.88148	35.09
Approach 10 - 0.3 miles	-0.30672	52.88170	43.51
Approach 10 - 0.4 miles	-0.30909	52.88192	51.93
Approach 10 - 0.5 miles	-0.31145	52.88214	60.35
Approach 10 - 0.6 miles	-0.31381	52.88236	68.78
Approach 10 - 0.7 miles	-0.31617	52.88258	77.20
Approach 10 - 0.8 miles	-0.31854	52.88280	85.62
Approach 10 - 0.9 miles	-0.32090	52.88302	94.04
Approach 10 - 1.0 mile	-0.32326	52.88324	102.47
Approach 10 - 1.1 miles	-0.32562	52.88346	110.89
Approach 10 - 1.2 miles	-0.32799	52.88368	119.31
Approach 10 - 1.3 miles	-0.33035	52.88390	127.73
Approach 10 - 1.4 miles	-0.33271	52.88413	136.16
Approach 10 - 1.5 miles	-0.33507	52.88435	144.58
Approach 10 - 1.6 miles	-0.33744	52.88457	153.00
Approach 10 - 1.7 miles	-0.33980	52.88479	161.43
Approach 10 - 1.8 miles	-0.34216	52.88501	169.85

No.	Longitude (°)	Latitude (°)	Assessed Altitude (m amsl)
Approach 10 - 1.9 miles	-0.34453	52.88523	178.27
Approach 10 - 2.0 miles	-0.34689	52.88545	186.69

Assessed receptor (aircraft) locations on the approach path for runway 10

Receptor Locations for Aircraft Landing on Runway 28

The table below presents the data for the assessed locations for aircraft on approach to runway 28. The altitude of the aircraft is based on a 3-degree descent path referenced to 50 feet (15.2m) above the runway threshold.

No.	Longitude (°)	Latitude (°)	Assessed Altitude (m amsl)
Approach 28 - Threshold	-0.29236	52.88035	18.24
Approach 28 - 0.1 miles	-0.29000	52.88013	26.66
Approach 28 - 0.2 miles	-0.28764	52.87991	35.09
Approach 28 - 0.3 miles	-0.28527	52.87969	43.51
Approach 28 - 0.4 miles	-0.28291	52.87947	51.93
Approach 28 - 0.5 miles	-0.28055	52.87925	60.35
Approach 28 - 0.6 miles	-0.27819	52.87902	68.78
Approach 28 - 0.7 miles	-0.27582	52.87880	77.20
Approach 28 - 0.8 miles	-0.27346	52.87858	85.62
Approach 28 - 0.9 miles	-0.27110	52.87836	94.04
Approach 28 - 1.0 mile	-0.26874	52.87814	102.47
Approach 28 - 1.1 miles	-0.26638	52.87792	110.89
Approach 28 - 1.2 miles	-0.26401	52.87770	119.31
Approach 28 - 1.3 miles	-0.26165	52.87747	127.73
Approach 28 - 1.4 miles	-0.25929	52.87725	136.16
Approach 28 - 1.5 miles	-0.25693	52.87703	144.58
Approach 28 - 1.6 miles	-0.25457	52.87681	153.00

No.	Longitude (°)	Latitude (°)	Assessed Altitude (m amsl)
Approach 28 - 1.7 miles	-0.25220	52.87659	161.43
Approach 28 - 1.8 miles	-0.24984	52.87637	169.85
Approach 28 - 1.9 miles	-0.24748	52.87614	178.27
Approach 28 - 2.0 miles	-0.24512	52.87592	186.69

Assessed receptor (aircraft) locations on the approach path for runway 28

Dwelling Receptor Details

The dwelling receptors details are presented in the table below.

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.20008	52.92824	25	-0.20796	52.91419
2	-0.19859	52.92695	26	-0.20664	52.91373
3	-0.18586	52.92548	27	-0.20636	52.91370
4	-0.18637	52.92441	28	-0.20606	52.91372
5	-0.19397	52.92391	29	-0.20594	52.91406
6	-0.19928	52.92449	30	-0.20577	52.91429
7	-0.20204	52.92471	31	-0.20553	52.91439
8	-0.20434	52.92466	32	-0.20530	52.91454
9	-0.20732	52.92481	33	-0.20502	52.91465
10	-0.21686	52.91809	34	-0.20471	52.91476
11	-0.22997	52.91542	35	-0.20454	52.91487
12	-0.22794	52.91484	36	-0.20419	52.91492
13	-0.22393	52.91436	37	-0.20388	52.91494
14	-0.22342	52.91450	38	-0.20355	52.91495
15	-0.22022	52.91498	39	-0.20323	52.91499
16	-0.21968	52.91506	40	-0.20288	52.91502

17	-0.21936	52.91500	41	-0.20245	52.91506
18	-0.21870	52.91458	42	-0.20204	52.91512
19	-0.21230	52.91465	43	-0.19984	52.91494
20	-0.21115	52.91432	44	-0.19589	52.91431
21	-0.21003	52.91463	45	-0.19287	52.91284
22	-0.20972	52.91417	46	-0.19133	52.91392
23	-0.20926	52.91391	47	-0.18801	52.91919
24	-0.20862	52.91385			

Assessed receptor (dwellings) locations

Road Receptor Details

Drovers Lane

The road receptor details are presented in the table below.

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.21408	52.92594	7	-0.20668	52.92857
2	-0.21411	52.92740	8	-0.20256	52.92929
3	-0.21345	52.92996	9	-0.20026	52.92761
4	-0.21156	52.93048	10	-0.20443	52.92713
5	-0.21046	52.92700	11	-0.20394	52.92546
6	-0.20643	52.92771			

Assessed road receptor locations (Drovers Lane)

Modelled Reflector Area Details

The modelled reflector area details are presented in the tables below.

Site 1

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.21408	52.92594	7	-0.20668	52.92857
2	-0.21411	52.92740	8	-0.20256	52.92929
3	-0.21345	52.92996	9	-0.20026	52.92761

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
4	-0.21156	52.93048	10	-0.20443	52.92713
5	-0.21046	52.92700	11	-0.20394	52.92546
6	-0.20643	52.92771			

Modelled reflector area (Site 1)

Site 2

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.21906	52.92405	16	-0.21688	52.92019
2	-0.21362	52.92326	17	-0.21728	52.91859
3	-0.21405	52.92445	18	-0.21793	52.91750
4	-0.21020	52.92433	19	-0.21999	52.91753
5	-0.20996	52.92475	20	-0.22320	52.91531
6	-0.20222	52.92076	21	-0.22584	52.91545
7	-0.20317	52.91893	22	-0.22557	52.91570
8	-0.20434	52.91916	23	-0.22980	52.91826
9	-0.20592	52.91930	24	-0.22891	52.91901
10	-0.20484	52.92159	25	-0.22549	52.91811
11	-0.20688	52.92222	26	-0.22455	52.91822
12	-0.20869	52.91935	27	-0.22384	52.91909
13	-0.21340	52.92240	28	-0.22062	52.91852
14	-0.21330	52.92266	29	-0.22028	52.91906
15	-0.21400	52.92285	30	-0.22146	52.91934

Modelled reflector area (Site 2)

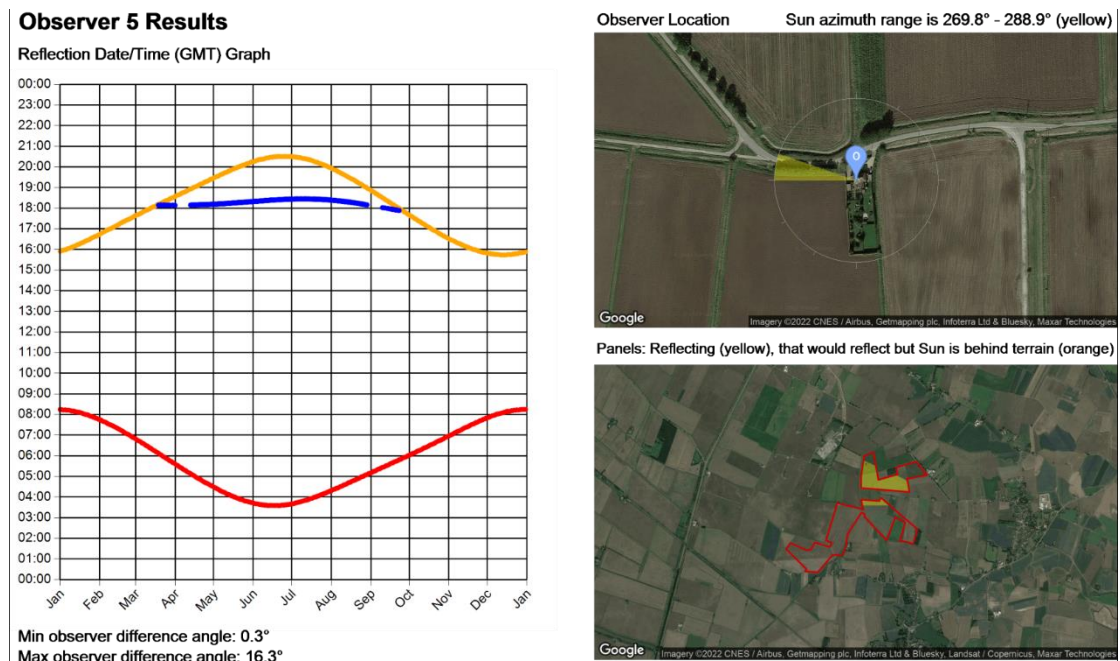
APPENDIX H – GEOMETRIC CALCULATION RESULTS

Overview

The charts from the Pager Power modelling for the receptors where mitigation has been recommended are shown on the following pages for completeness³⁴. Each chart shows:

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

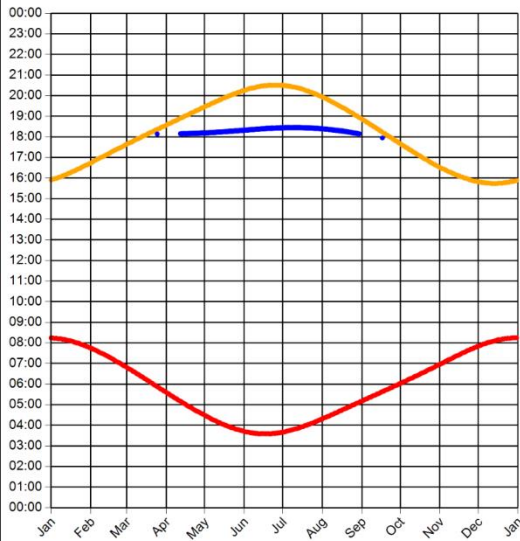
Dwellings



³⁴ Forge modelling results can be made available upon request.

Observer 6 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 1.8°
Max observer difference angle: 16.3°

Observer Location

Sun azimuth ranges (yellow)

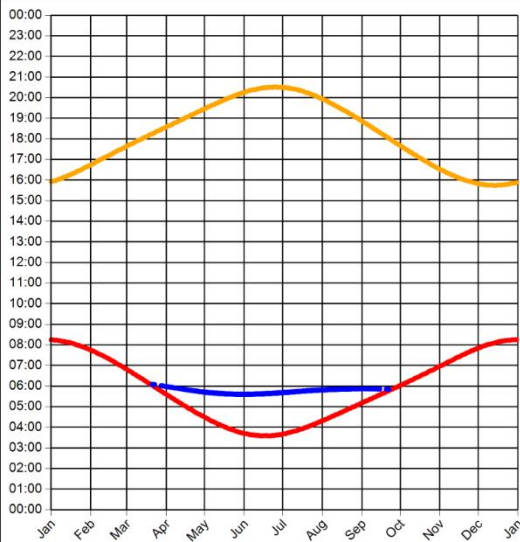


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 11 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.3°
Max observer difference angle: 16°

Observer Location

Sun azimuth range is 70.8° - 89.3° (yellow)

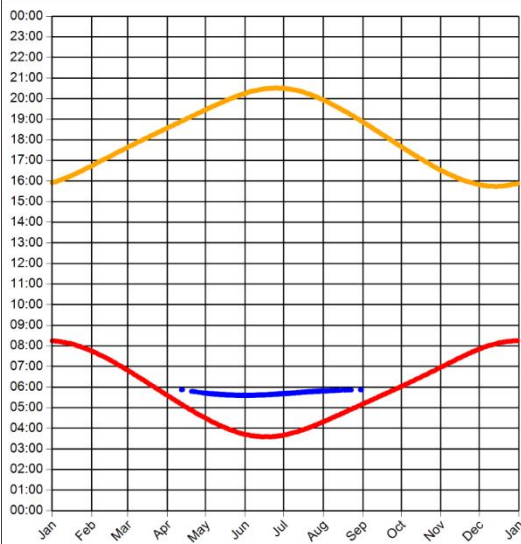


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 12 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 5.9°
Max observer difference angle: 16°

Observer Location

Sun azimuth range is 70.8° - 82.9° (yellow)



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





Urban & Renewables

Pager Power Limited
Stour Valley Business Centre
Sudbury
Suffolk
CO10 7GB

Tel: +44 1787 319001 **Email:** info@pagerpower.com **Web:** www.pagerpower.com