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Solar Glint and Glare Study

The British Library

Naked Energy

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ADMINISTRATION PAGE

Job reference:	10635A
Date:	10th June 2021
Author:	Andrea Mariano
Telephone:	01787 319001
Email:	andrea@pagerpower.com

Reviewers:	Waqar Qureshi; Michael Sutton
Date:	10th June 2021
Telephone:	01787 319001
Email:	waqar@pagerpower.com; michael@pagerpower.com;

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1	10th June 2021	Initial issue
2	22nd June 2021	Second issue – minor amendments
3	28th July 2021	Third issue – updated with comments regarding layout change. Completed by Danny Scrivener.
4	17th August 2021	Fourth issue – minor amendments

Unit 2, 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 effects of glint and glare from a proposed solar thermo-photovoltaic development located on the British Library's roof in London. This assessment pertains to the possible effects upon the nearby St. Pancras Renaissance Hotel London and the offices located to the south of the British Library.

Modelling Note

The overall conclusions within this report are based on a previous larger panel layout. The layout has since reduced in size and therefore the modelling results presented within this report represent a worst-case assessment. Based on the results for the larger layout, the modelling and overall conclusions remain valid.

St. Pancras Renaissance Hotel Results

Solar reflections are possible for receptors located within the St. Pancras Renaissance Hotel. However, the impact is expected to be low for all assessed receptor points. This because:

- At the time when solar reflections will occur, an observer with full visibility of the reflective area will also be looking towards the general direction of the sun which is a brighter source of light.
- Solar reflections can only occur when the sky is clear;
- Solar reflections generated by the glass tube are expected to have low significance and therefore will not significantly exacerbate the impact from the aluminium reflector plate.

Therefore, a low impact is predicted for which no mitigation is required (see Section 7.1).

Offices Results

Solar reflections are possible for receptors located within the office south of the proposed development. However, the impact is expected to be low for all assessed receptor points. This because:

- Solar reflections can only occur when the sky is clear;
- Solar reflections generated by the glass tube are expected to have low significance.

Therefore, a low impact is predicted for which no mitigation will be required (see Section 7.2).

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 50 countries within South Africa, Europe, America, Asia and Australasia.

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

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

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

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

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

1 INTRODUCTION

1.1 Overview

Pager Power has been retained to assess the possible effects of glint and glare from a proposed solar thermo-photovoltaic development located on the British Library's roof in London. This assessment pertains to the possible effects upon the nearby St. Pancras Renaissance Hotel London and the offices located south of the British Library. The analysis contains the following:

- Details of the solar development;
- Explanation of glint and glare;
- Overview of relevant guidance;
- Overview of relevant studies;
- Identification of ground-based concerns and receptors;
- Assessment methodology.
- Glint and glare assessment for:
  - St. Pancras Renaissance Hotel London;
  - Offices located south of the proposed development.
- Results discussion.

1.2 Pager Power's Experience

Pager Power has undertaken over 650 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 can vary however, the definition used by Pager Power is as follows:

- Glint – a momentary flash of bright light typically received by moving receptors or from moving reflectors.
- Glare – a continuous source of bright light typically received by static receptors or from large reflective surfaces.

These definitions are aligned with those of the Federal Aviation Administration (FAA) in the United States of America. The term 'solar reflection' is used in this report to refer to both reflection types i.e. glint and glare.

2 PROPOSED DEVELOPMENT LOCATION AND DETAILS

2.1 Proposed Development – Location

The proposed development and its location are shown in Figure 1[1] below and Figure 2[2] on the following page (yellow line boundary considered for the assessment). Information about the development has been provided by Naked Energy[3].

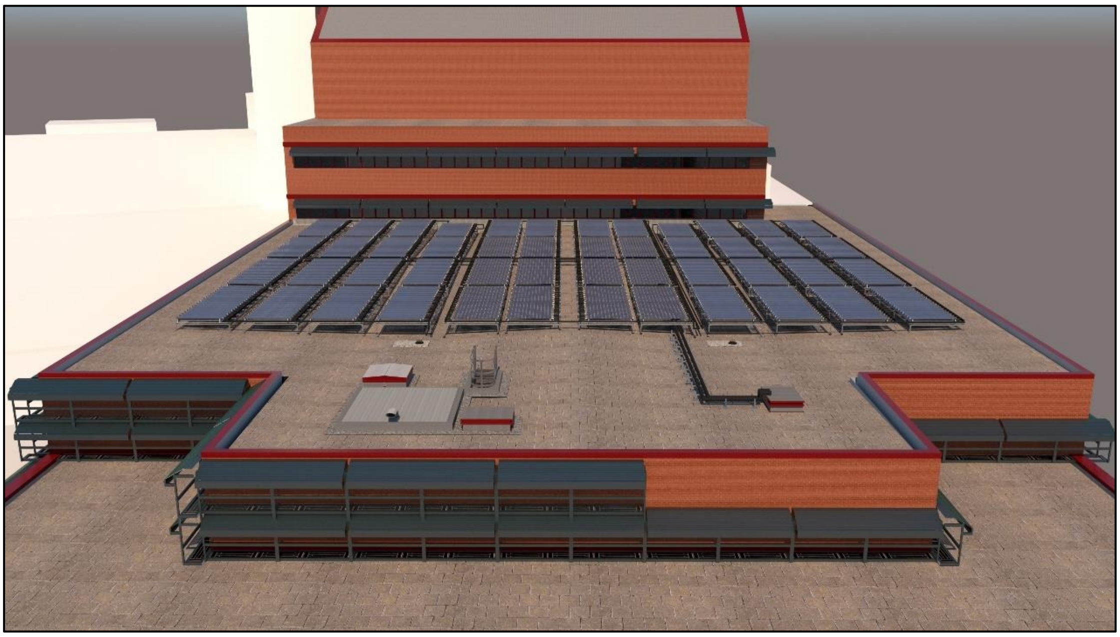

Figure 1 – Proposed development

[1] Source: Virtu glint and glare, Alex Mellor, date: 28/07/2021, cropped.

[2] Source: Copyright © 2021 Google.

[3] Note that the solar collectors have been laid flat on a framework to overcome the level difference on the roof.

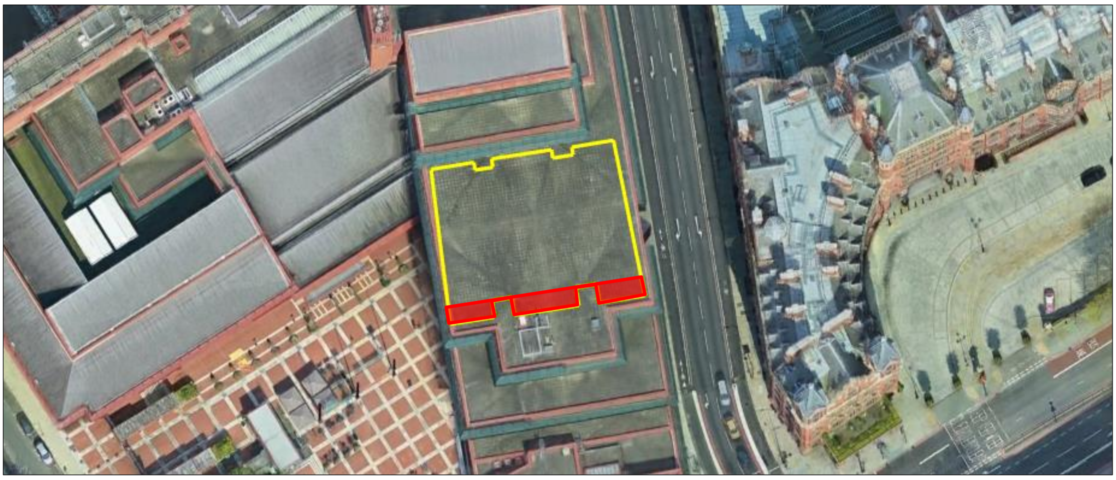

Figure 2 – Proposed development

2.1.1 Modelling Note

Since the modelling produced within this report was completed the layout has reduced in size (removal of the southern rows of panels shown in red in Figure 2). The modelling within this report has not been updated and still considers the larger reflector area. It therefore represents a worst-case assessment. Based on the results for the larger layout, the modelling and overall conclusions remain valid.

2.2 Reflective Surfaces Details

The proposed development will consist of two flat surfaces (the absorber plate and the aluminium reflector plate) and glass tubes (see Figure 3[4] below). One of the surfaces will be located inside the tube. Note that the angled surfaces below are elements within the solar collectors. The solar collectors themselves are laid flat as described before.

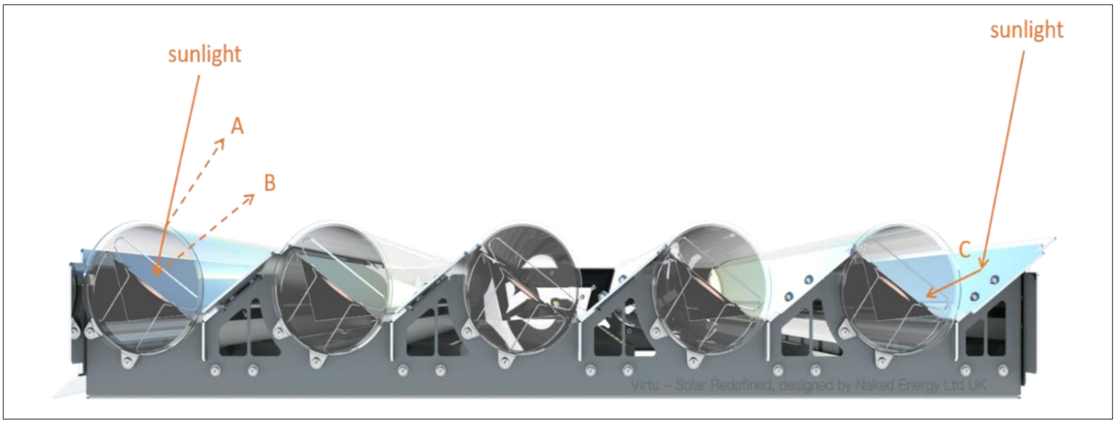

Figure 3 – Thermo-photovoltaic development system

The panel inside the glass tube has not been considered for the analysis since any reflected light will be screened by the glass tube.

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[4] Glare and visual impact of Virtu solar collectors at The British Library, A.Mellor, date: 15/04/2021.

The aluminium reflector plate details used in the assessment are presented in Table 1 and Figure 4 below.

Aluminium Reflector Plate Information	
Azimuth angle[5] (°)	350
Elevation angle (°)	42
Assessed centre height (m agl[6])	0.25

Table 1 – *Solar panel details*

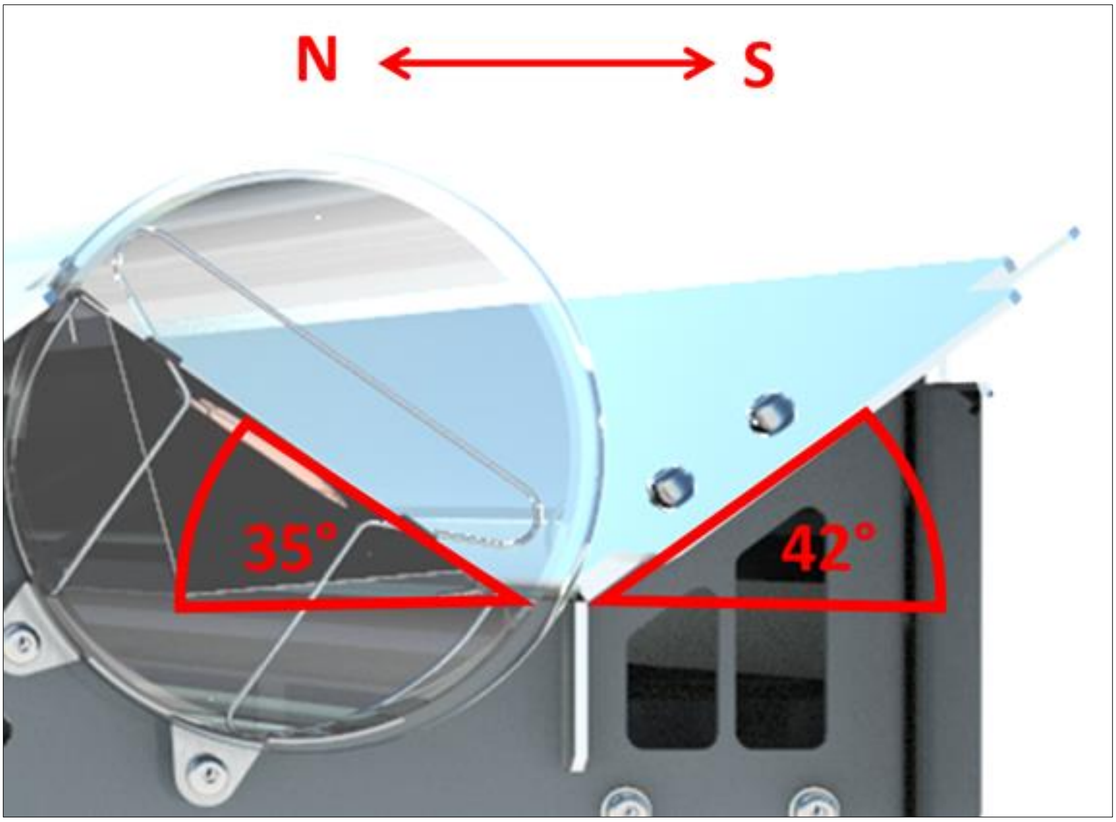

Figure 4 – System specifications

The glass tube has a circular shape. For modelling purposes, the glass tube was assumed to be a polygon of 36 sides. Of these 36 sides only the ones which can potentially reflect sunlight upwards have been considered (19 sides going from 0 to 90 degrees). The glass tubes details used in the assessment are presented in Table 2 on the following page.

[5] The azimuth is calculated from the north, which has azimuth equal to 0°.

[6] metres above ground level

Glass Tube Information	
Azimuth angle[7] (°)	350 / 170
Elevation angle (°)	90/80/70/60/50/40/30/20/10/0/10/20/30/40/50/60/70/80/90
Assessed centre height (m agl[8])	0.25

Table 2 – *Solar panel details*

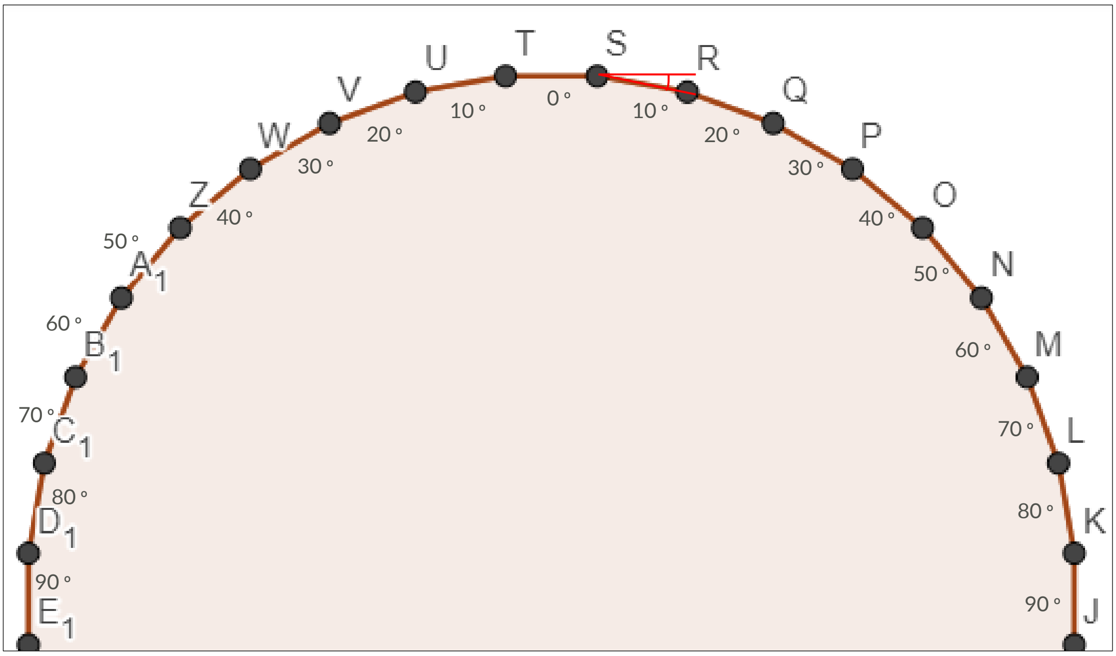

Figure 5 – Reproduction of the glass tube used for modelling purposes

However, it should be considered that since the glass tube is curved, reflected sunlight is scattered over many angles. Therefore, the impact the reflected sunlight on any single viewer will be significantly reduced.

[7] The azimuth is calculated from the north, which has azimuth equal to 0°.

[8] metres above ground level

3 GLINT AND GLARE ASSESSMENT METHODOLOGY

3.1 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. 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.

3.2 Background

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

3.3 Methodology

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

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

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

3.4 Assessment Methodology and Limitations

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

4 IDENTIFICATION OF RECEPTORS

4.1 Overview

The applicant has requested to carry out a glint and glare assessment considering receptors located within the nearby St. Pancras Renaissance Hotel London (located to the east) and the offices located south of the British Library. Pager Power guidance pertains solely to the impact upon amenity at residential dwellings and does not include hotels and offices.

The receptor details are presented in Appendix G and the terrain elevations have been interpolated based on OSGB36 data.

4.2 St. Pancras Renaissance Hotel London

There is no formal guidance for the selection and the assessment of receptors within hotels. The analysis has therefore considered all windows that can have a view of the proposed development, therefore:

- Are facing the roof of the British Library;
- Located at an equal or higher altitude compared to the proposed development; and
- Have potential views of the proposed development.

In total 29 receptor points have been identified for the St. Pancras Renaissance Hotel (see Figure 6[9] below). The co-ordinates and the height considered for the assessment of the receptor points are presented in Appendix G.

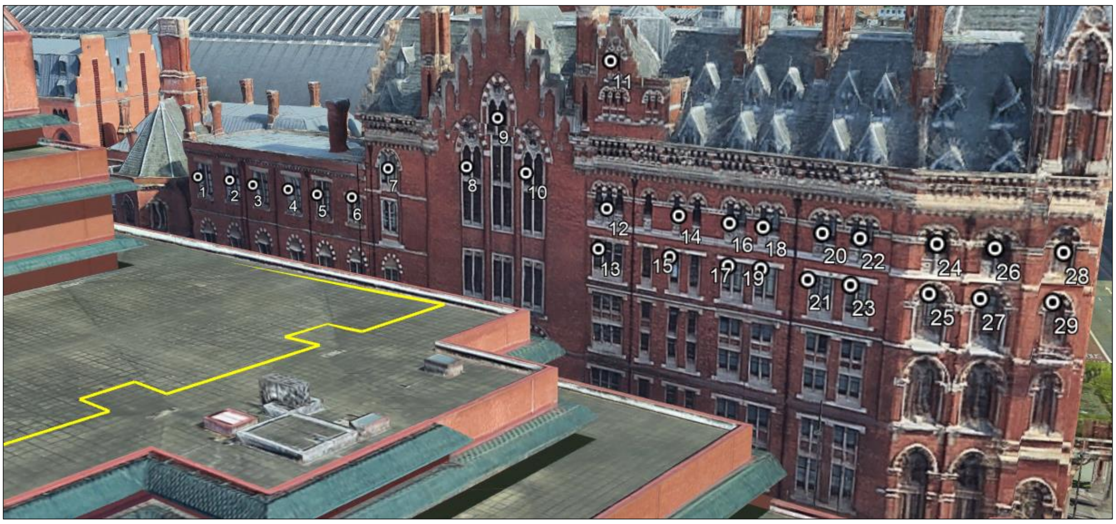

Figure 6 – St. Pancras Renaissance Hotel London receptor locations

[9] Source: Copyright © 2021 Google.

4.3 Offices

There is no formal guidance for the selection and the assessment of receptors within offices. The analysis has therefore considered windows that can have a view of the proposed development, therefore:

- Are facing the roof of the British Library;
- Located at an equal or higher altitude compared to the proposed development; and
- Have potential views of the proposed development.

In total 24 receptor points have been identified for the office located south of the proposed development (see Figure 7[10] below). The co-ordinates and the height considered for the assessment of the receptor points are presented in Appendix G.

Figure 7 – Offices receptor locations

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[10] Source: Copyright © 2021 Google.

5 ASSESSED REFLECTOR AREA

5.1 Reflector Area

A number of representative panel locations are selected within the proposed reflector area. The number of modelled reflector points being determined by the size of the reflector area and the assessment resolution. The bounding co-ordinates for the proposed solar development have been extrapolated from the site maps. All ground heights are based on interpolated OSGB data and panel data has been provided by the developer. The data can be found in Appendix G.

A resolution of 1m has been chosen for this assessment. This means that a geometric calculation is undertaken for each identified receptor every 1m from within the defined area. 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 area assessed is shown in Figure 8 below (area defined by red line).

Figure 8 – Assessed reflector area

5.1.1 Modelling Note

As stated within Section 2.1.1, the modelling results presented within this report represent a worst-case assessment. This is because the layout has since reduced in size (removal of the southern rows of panels). Based on the results for the larger layout, the modelling and overall conclusions remain valid.

6 GLINT AND GLARE ASSESSMENT RESULTS

6.1 Overview

The following section presents an overview of the solar reflection modelling for the identified receptors.

The Pager Power model has been used to determine whether reflections are possible.

6.2 Summary of Results

The tables in the following subsections summarise the months and times during which a solar reflection could be experienced by a receptor.

<u>This does not mean that reflections would occur continuously between the times shown</u>.

The range of times at which reflections are geometrically possible is generally greater than the length of time for any particular day. This is because the times of day at which reflections could start and stop vary throughout the days/months.

The results of the analysis are presented in the following sections. Appendix H presents the results charts.

6.3 Geometric Calculation Results Overview – Aluminium Reflector Plate Reflective Surface

6.3.1 St. Pancras Renaissance Hotel London

The results of the geometric calculations for hotel's receptor points are presented in Table 3 below.

Receptor	Predicted reflection times towards the identified receptors (GMT)		Comment
	am	pm	
1	None.	Between 15:26 and 16:24 from mid- April to late August.	Solar reflections are geometrically possible. Great part of the reflective surface will be screened. No impact predicted. Discussed in section 7.1.1.
2	None.	Between 15:25 and 16:35 from mid- April to the end of August.	Solar reflections are geometrically possible. Great part of the reflective surface will be screened. No impact predicted. Discussed in section 7.1.1.
3	None.	Between 15:26 and 16:42 from mid- April to mid-September.	Solar reflections are geometrically possible. Part of the reflective surface will be screened. No to low impact predicted. Discussed in section 7.1.1.
4	None.	Between 15:26 and 17:07 from late March to mid-September.	Solar reflections are geometrically possible. Part of the reflective surface will be screened. No to low impact predicted. Discussed in section 7.1.1.

Receptor	Predicted reflection times towards the identified receptors (GMT)		Comment
	am	pm	
5	None.	Between 15:26 and 17:22 from mid- March to the end of September.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. Discussed in section 7.1.1.
6	None.	Between 15:27 and 17:31 from mid- March to early October.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. Discussed in section 7.1.1.
7	None.	Between 16:00 and 18:04 from mid- March to early October.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. Discussed in section 7.1.1.
8	None.	Between 16:26 and 18:14 from mid- March to the end of May. Between 16:28 and 18:00 from late June to early October.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. Discussed in section 7.1.1.
9	None.	Between 17:14 and 18:29 from mid- March to late May. At circa 17:18 during late June. Between 17:24 and 18:31 from mid- July to late September.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. Discussed in section 7.1.1.

Receptor	Predicted reflection times towards the identified receptors (GMT)		Comment
	am	pm	
10	None.	Between 17:06 and 18:15 from mid- March to late April. Between 17:12 and 18:01 from mid- August to the beginning of October.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. Discussed in section 7.1.1.
11	None.	Between 18:19 and 19:15 from late March to the end of April. Between 18:08 and 19:24 from mid- August to mid- September.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. Discussed in section 7.1.1.
12	None.	Between 17:53 and 18:01 during mid- March. Between 17:27 and 17:35 during early October.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. Discussed in section 7.1.1.
13 – 29	None.	None.	None.

Table 3 – Geometric analysis results for the St. Pancras Renaissance Hotel London's receptor points

6.3.2 Offices

The results of the geometric calculations for office's receptor points are presented in Table 4 below.

Receptor	Predicted reflection times towards the identified receptors (GMT)		Comment
	am	pm	
30 – 53	None.	None.	None.

Table 4 – Geometric analysis results for the Office's receptor points

6.4 Geometric Calculation Results Overview – Aluminium Reflector Plate and Glass Tube Reflective Surfaces

6.4.1 St. Pancras Renaissance Hotel London

The results of the geometric calculations for hotel's receptor points are presented in Table 5 below.

Receptor	Predicted reflection times towards nearby hotel receptors (GMT)		Comment
	am	pm	
1	None.	Between 13:04 and 16:09 from late January to mid- February. Between 13:02 and 20:21 from mid- March to early October. Between 14:17 and 15:15 during early November.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.
2	None.	Between 13:15 and 16:25 from late January to mid- February. Between 13:01 and 20:20 from mid- March to early October. Between 14:17 and 15:16 during early November.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.
3	None.	Between 13:02 and 20:20 from late January to early October. Between 14:18 and 15:16 during early November.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.
4	None.	Between 13:23 and 20:20 from mid- January to early October. Between 14:17 and 16:31 during early November. Between 15:49 and 15:53 during early December.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.

Receptor	Predicted reflection times towards nearby hotel receptors (GMT)		Comment
	am	pm	
5	None.	Between 13:25 and 20:21 from mid- January to early October. Between 14:17 and 16:32 during early November. Between 15:48 and 15:53 during early December.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.
6	None.	Between 13:41 and 20:20 from mid- January to early October. Between 14:18 and 16:31 during early November. Between 15:48 and 15:53 during early December.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.
7	None.	Between 14:09 and 19:19 from mid- January to early October. Between 15:17 and 16:35 during early November. Between 14:51 and 15:04 during early December.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.
8	None.	Between 14:49 and 19:21 from mid- January to early October. Between 15:01 and 16:40 during early November. Between 15:49 and 15:51 during early December.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.
9	None.	Between 14:58 and 19:22 from mid- January to early October. Between 14:58 and 16:34 during early November. Between 14:52 and 16:01 during early December.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.

Receptor	Predicted reflection times towards nearby hotel receptors (GMT)		Comment
	am	pm	
10	None.	Between 14:41 and 19:10 from mid- January to early October. Between 15:16 and 16:36 during early November. Between 15:08 and 15:48 during early December.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.
11	None.	Between 13:59 and 20:03 from mid- January to early October. Between 14:03 and 16:23 during early November. Between 14:15 and 15:52 during early December.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.
12	None.	Between 13:47 and 19:44 from mid- January to early October. Between 15:12 and 16:22 during early November.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.
13	None.	Between 13:46 and 19:01 from mid- January to early October. Between 13:36 and 16:21 during early November. Between 15:28 and 15:42 during early December.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.
14	None.	Between 13:26 and 19:54 from mid- January to early October. Between 15:07 and 16:25 during early November. Between 13:25 and 14:16 during the beginning of December.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.
15	None.	Between 13:28 and 18:59 from mid- January to early October. Between 13:30 and 16:23 during early November. Between 15:31 and 15:42 during early December.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.

Receptor	Predicted reflection times towards nearby hotel receptors (GMT)		Comment
	am	pm	
16	None.	Between 13:10 and 19:57 from mid- January to early October. Between 15:11 and 16:10 during early November. Between 13:10 and 14:03 during the beginning of December.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.
17	None.	Between 13:13 and 18:57 from mid- January to early October. Between 13:30 and 16:21 during early November. Between 15:30 and 15:44 during early December.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.
18	None.	Between 13:03 and 19:58 from mid- January to early October. Between 15:10 and 16:02 during early November. Between 13:03 and 14:02 during the beginning of December.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.
19	None.	Between 13:09 and 19:00 from mid- January to early October. Between 13:40 and 16:20 during early November. Between 15:34 and 15:44 during early December.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.
20	None.	Between 13:05 and 20:01 from mid- January to early October. Between 15:09 and 15:49 during early November. Between 13:04 and 13:57 during the beginning of December.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.

Receptor	Predicted reflection times towards nearby hotel receptors (GMT)		Comment
	am	pm	
21	None.	Between 13:07 and 18:57 from mid- January to the beginning of October. Between 13:32 and 15:00 during early November. Between 15:33 and 15:44 during early December.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.
22	None.	Between 13:10 and 15:43 from mid- January to the end of January. Between 13:02 and 20:01 from mid- March to early October. Between 15:08 and 15:48 during early November. Between 13:17 and 13:57 during the beginning of December.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.
23	None.	Between 13:08 and 16:24 from mid- January to mid-February. Between 13:06 and 18:55 from mid- March to the beginning of October. Between 13:30 and 14:58 during early November. Between 15:37 and 15:43 during early December.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.
24	None.	Between 13:02 and 15:34 from mid- January to the end of January. Between 13:00 and 20:02 from mid- March to early October. Between 15:11 and 15:21 during early November. Between 13:11 and 13:52 during the beginning of December.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.

Receptor	Predicted reflection times towards nearby hotel receptors (GMT)		Comment
	am	pm	
25	None.	Between 13:02 and 16:04 from mid- January to mid-February. Between 13:01 and 15:50 from mid- March to late March. Between 13:04 and 18:55 from mid- April to the end of August. Between 13:01 and 15:28 during late September. Between 13:34 and 15:01 during early November. Between 15:39 and 15:44 during early December.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.
26	None.	Between 13:02 and 15:29 from mid- January to the end of January. Between 13:00 and 20:04 from mid- March to early October. Between 15:06 and 15:21 during early November. At circa 13:35 during the beginning of December	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.
27	None.	Between 13:01 and 15:47 from late January to mid- February. Between 13:00 and 15:41 from mid- March to late March. Between 13:02 and 18:56 from mid- April to the end of August. Between 13:02 and 15:20 during late September. Between 13:35 and 15:00 during early November.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.
28	None.	Between 13:02 and 15:27 from mid- January to the end of January. Between 13:01 and 20:05 from mid- March to early October. At circa 15:10 during early November	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.

Receptor	Predicted reflection times towards nearby hotel receptors (GMT)		Comment
	am	pm	
29	None.	Between 13:02 and 15:37 from late January to mid- February. Between 13:00 and 15:32 from mid- March to late March. Between 13:03 and 18:53 from mid- April to the end of August. Between 13:01 and 15:11 during late September. Between 13:47 and 14:58 during early November.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.1.2.

Table 5 – Geometric analysis results for the St. Pancras Renaissance Hotel London's receptor points

6.4.2 Offices

The results of the geometric calculations for office's receptor points are presented in Table 5 below.

Receptor	Predicted reflection times towards nearby office receptors (GMT)		Comment
	am	pm	
30	Between 10:42 and 10:58 during the beginning of February. Between 10:42 and 10:58 during the end of March. Between 10:42 and 11:08 during the beginning of June. Between 10:55 and 11:15 during the end of July. Between 10:42 and 10:58 during the end of September. Between 10:22 and 10:50 during the end of November.	None.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.3.2.

Receptor	Predicted reflection times towards nearby office receptors (GMT)		Comment
	am	pm	
31	Between 10:42 and 10:58 during the beginning of February. Between 10:42 and 10:58 during the end of March. Between 10:42 and 11:08 during the beginning of June. Between 10:55 and 11:15 during the end of July. Between 10:42 and 10:58 during the end of September. Between 10:22 and 10:50 during the end of November.	None.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.3.2.
32	Between 10:42 and 10:58 during the beginning of February. Between 10:42 and 10:58 during the end of March. Between 10:42 and 11:08 during the beginning of June. Between 10:55 and 11:15 during the end of July. Between 10:42 and 10:58 during the end of September. Between 10:22 and 10:50 during the end of November.	None.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.3.2.
33	Between 10:42 and 10:58 during the beginning of February. Between 10:42 and 10:58 during the end of March. Between 10:42 and 11:08 during the beginning of June. Between 10:55 and 11:15 during the end of July. Between 10:42 and 10:58 during the end of September. Between 10:22 and 10:50 during the end of November.	None.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.3.2.

Receptor	Predicted reflection times towards nearby office receptors (GMT)		Comment
	am	pm	
34	Between 10:42 and 10:58 during the beginning of February. Between 10:42 and 10:58 during the end of March. Between 10:42 and 11:08 during the beginning of June. Between 10:55 and 11:15 during the end of July. Between 10:42 and 10:58 during the end of September. Between 10:22 and 10:50 during the end of November.	None.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.3.2.
35	Between 10:42 and 10:58 during the beginning of February. Between 10:42 and 10:58 during the end of March. Between 10:42 and 11:08 during the beginning of June. Between 10:55 and 11:15 during the end of July. Between 10:42 and 10:58 during the end of September. Between 10:22 and 10:50 during the end of November.	None.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.3.2.
36	Between 10:06 and 10:58 during early February. Between 10:42 and 10:58 during the end of March. Between 09:57 and 11:08 during the beginning of June. Between 10:20 and 10:54 during early July. Between 09:54 and 09:59 during mid-September. Between 09:29 and 09:59 during early November.	None.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.3.2.

Receptor	Predicted reflection times towards nearby office receptors (GMT)		Comment
	am	pm	
37	Between 10:04 and 10:27 during the beginning of February. Between 10:42 and 10:58 during the end of March. Between 09:56 and 09:59 during late May. At circa 09:55 during mid-September. Between 09:28 and 09:50 during early November.	None.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.3.2.
38	Between 09:50 and 10:59 from the beginning of February to mid- February. At circa 09:55 during the end of March. Between 09:48 and 11:04 during the beginning of June. Between 09:55 and 10:52 during mid- July. Between 09:44 and 09:59 during mid- September. Between 09:25 and 09:59 during early November.	None.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.3.2.
39	Between 10:00 and 10:28 during the beginning of February. At circa 09:57 during late March. Between 09:46 and 09:59 during late May. Between 09:56 and 09:59 during late July. At circa 09:50 during mid- September. Between 09:18 and 09:56 during early November.	None.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.3.2.

Receptor	Predicted reflection times towards nearby office receptors (GMT)		Comment
	am	pm	
40	Between 09:41 and 10:52 from the beginning of February to mid- February. Between 09:45 and 09:59 during the end of March. Between 09:37 and 10:53 during the beginning of June. Between 09:45 and 10:56 during mid- July. Between 09:37 and 09:59 during mid- September. Between 09:26 and 09:59 during the beginning of November.	None.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.3.2.
41	Between 10:00 and 10:26 during the beginning of February. Between 09:44 and 09:59 during late March. Between 09:37 and 09:59 during late May. Between 09:47 and 09:59 during late July. Between 09:34 and 09:59 during mid- September. Between 09:09 and 09:56 during early November.	None.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.3.2.
42	Between 09:34 and 10:42 from the beginning of February to mid- February. Between 09:37 and 09:59 during the end of March. Between 09:29 and 10:43 during the beginning of June. Between 09:37 and 10:50 during mid- July. Between 09:28 and 09:59 during mid- September. Between 09:26 and 09:59 during the beginning of November.	None.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.3.2.

Receptor	Predicted reflection times towards nearby office receptors (GMT)		Comment
	am	pm	
43	Between 09:32 and 10:29 during early February. Between 09:36 and 09:59 during late March. Between 09:28 and 09:59 during late May. Between 09:38 and 09:59 during late July. Between 09:26 and 09:59 during mid- September. Between 09:01 and 09:54 during early November.	None.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.3.2.
44	Between 09:25 and 10:33 from early February to mid-February. Between 09:29 and 09:59 during the end of March. Between 09:20 and 10:33 during the end of May. Between 09:28 and 10:36 during mid- July. Between 09:20 and 09:59 during mid- September. Between 09:27 and 09:59 during the beginning of November.	None.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.3.2.
45	Between 09:25 and 10:28 from the beginning of February to mid- February. Between 09:29 and 09:59 during late March. Between 09:22 and 09:59 during late May. Between 09:30 and 09:59 during late July. Between 09:22 and 09:59 during mid- September. Between 09:02 and 09:55 during early November.	None.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.3.2.

Receptor	Predicted reflection times towards nearby office receptors (GMT)		Comment
	am	pm	
46	Between 09:19 and 10:24 from early February to mid-February. Between 09:28 and 09:59 during the end of March. Between 09:12 and 10:23 during the end of May. Between 09:21 and 10:30 during mid- July. Between 09:13 and 09:59 during mid- September. Between 09:26 and 09:50 during the beginning of November.	None.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.3.2.
47	Between 09:18 and 10:23 from the beginning of February to mid- February. Between 09:22 and 09:59 during the end of March. Between 09:13 and 09:59 during late May. Between 09:23 and 09:59 during late July. Between 09:12 and 09:59 during mid- September. Between 09:04 and 09:53 during early November.	None.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.3.2.
48	Between 09:07 and 10:10 from early February to late February. Between 09:28 and 09:59 during the end of March. Between 09:00 and 10:08 during the end of May. Between 09:09 and 10:15 from early July to mid- July. Between 09:02 and 09:59 during mid- September. Between 09:28 and 09:39 during the beginning of November.	None.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.3.2.

Receptor	Predicted reflection times towards nearby office receptors (GMT)		Comment
	am	pm	
49	Between 09:07 and 10:09 from early February to mid-February. Between 09:10 and 09:59 during the end of March. Between 09:01 and 09:59 during late May. Between 09:11 and 09:59 during late July. Between 09:01 and 09:56 during mid- September. Between 09:06 and 09:39 during the beginning of November.	None.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.3.2.
50	Between 09:05 and 10:06 from early February to late February. Between 09:29 and 09:59 during the end of March. Between 08:57 and 10:04 from late May to early June. Between 09:07 and 10:11 from early July to late July. Between 09:00 and 09:56 during mid- September. At circa 09:31 during the beginning of November	None.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.3.2.
51	Between 09:05 and 10:05 from early February to mid-February. Between 09:08 and 09:59 during the end of March. Between 08:58 and 09:59 during late May. Between 09:08 and 09:59 during late July. Between 08:59 and 09:59 during mid- September. Between 09:05 and 09:35 during the beginning of November.	None.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.3.2.

Receptor	Predicted reflection times towards nearby office receptors (GMT)		Comment
	am	pm	
52	Between 09:02 and 09:59 from mid- February to late February. Between 09:28 and 09:59 during the end of March. Between 08:54 and 10:00 during the end of May. Between 09:04 and 10:07 from early July to late July. Between 08:59 and 09:56 during mid- September. At circa 09:30 during the beginning of November	None.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.3.2.
53	Between 09:02 and 09:43 during mid- February. Between 09:05 and 09:59 during the end of March. Between 08:56 and 09:57 during late May. Between 09:06 and 09:59 during late July. Between 09:00 and 09:52 during mid- September. Between 09:05 and 09:28 during the beginning of November.	None.	Solar reflections are geometrically possible. No screening has been identified. Low impact predicted. See section 7.3.2.

Table 6 – Geometric analysis results for the Office's receptor points

7 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

7.1 St. Pancras Renaissance Hotel London

7.1.1 Aluminium Reflector Plate Reflective Surface

The analysis has shown that solar reflections from the proposed solar development are geometrically possible towards 12 out of the 29 identified receptors at St. Pancras Renaissance Hotel (see Figure 9[11] below).

Figure 9 – Views from the proposed development towards the affected receptors

For two of these 12 receptor points (receptors 1 and 2) the reflective area will be fully screened by the section of the building located north (see Figure 10[12] on the following page). For observers located at receptor 3 and 4, this screening will partially block views of the proposed development. It is also likely that observers located within hotel rooms 1 to 6 will have scarce visibility of the proposed development because they will be located at a similar elevation (see Figure 9 above) and they will be only able to see the first visible row of panels.

[11] Source: Copyright © 2021 Google.
[12] Source: Copyright © 2021 Google.

Figure 10 – Affected receptor points for the assessment of aluminium reflector plates only

Therefore, entirely unscreened solar reflections will occur only for six reflectors (7 to 12). The worst-case scenario is predicted for receptor location 9. Solar reflections can be experienced for more than one hour per day (see Figure 11[13] on the following page).

[13] Source: Copyright © 2021 Google.

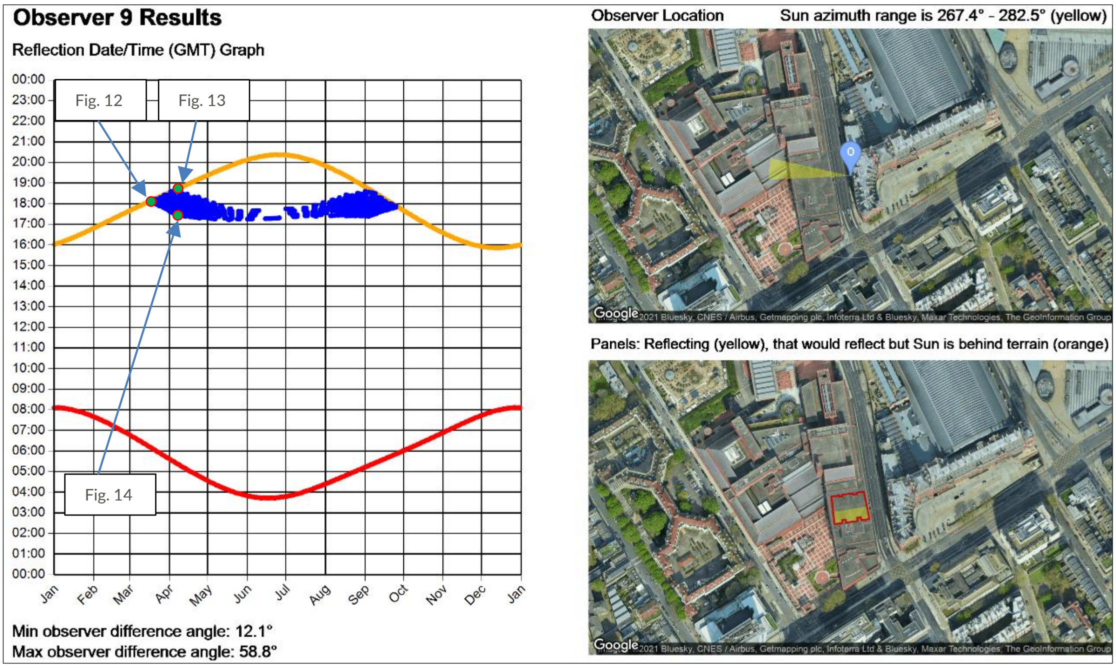


Figure 11 – Solar reflections at receptor 9

However, it should be considered that at the time of solar reflections, an observer located within receptor 9 looking towards the proposed development will mostly be looking towards the Sun (see Figure 12[14] below, Figure 13 and Figure 14 on the following page). Furthermore, solar reflections can only occur when the sky is clear.

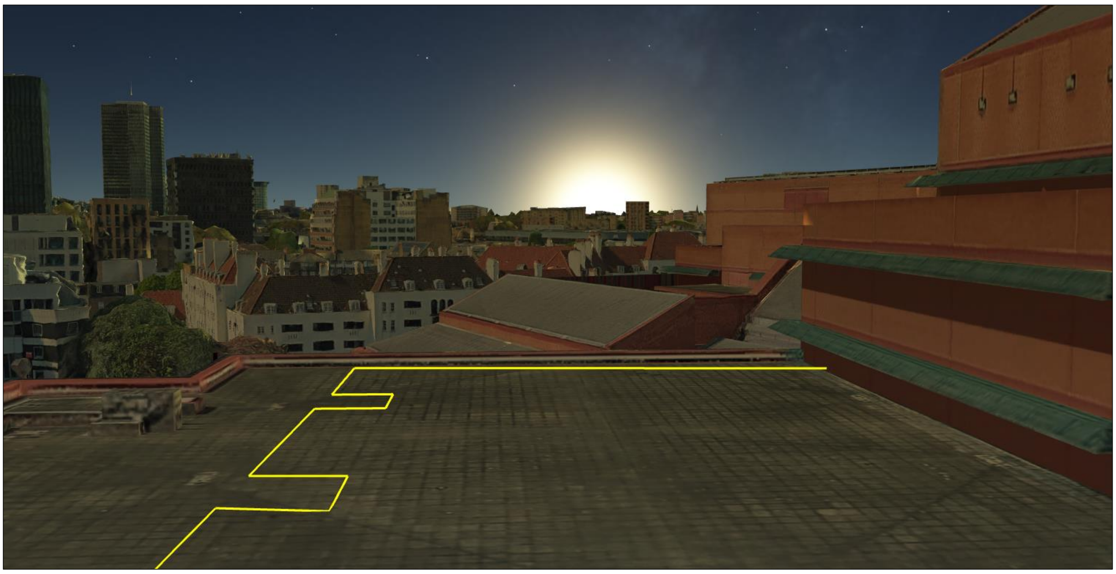


Figure 12 – Sun location at the time of reflection on the 15th of March at 18:00

[14] Source: Copyright © 2021 Google.

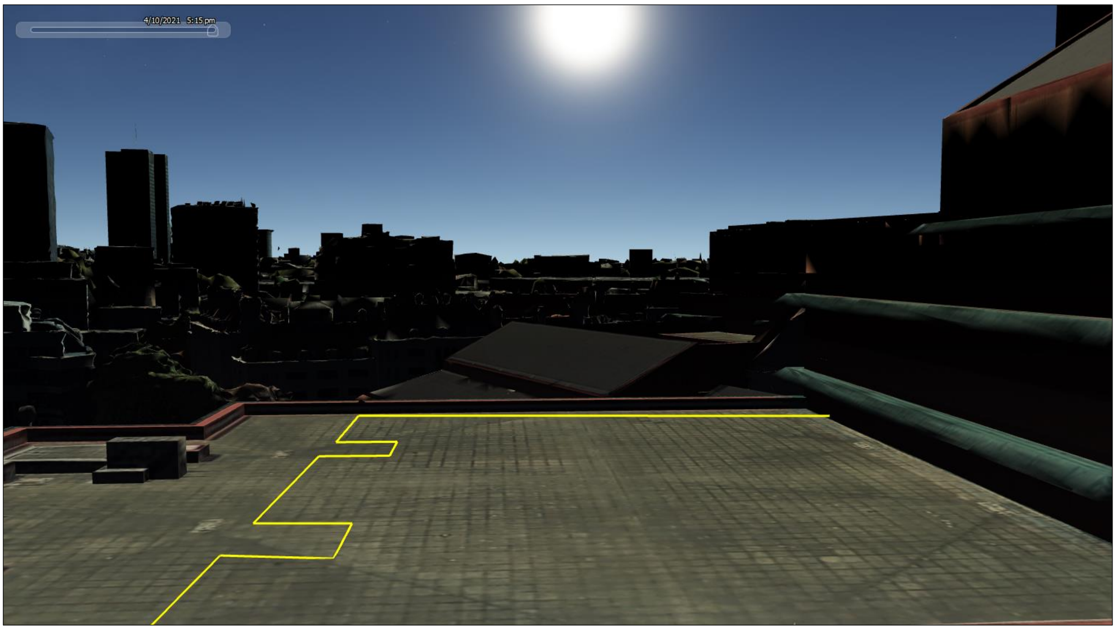


Figure 13 – Sun location at the time of reflection on the 10th of April at 17:15

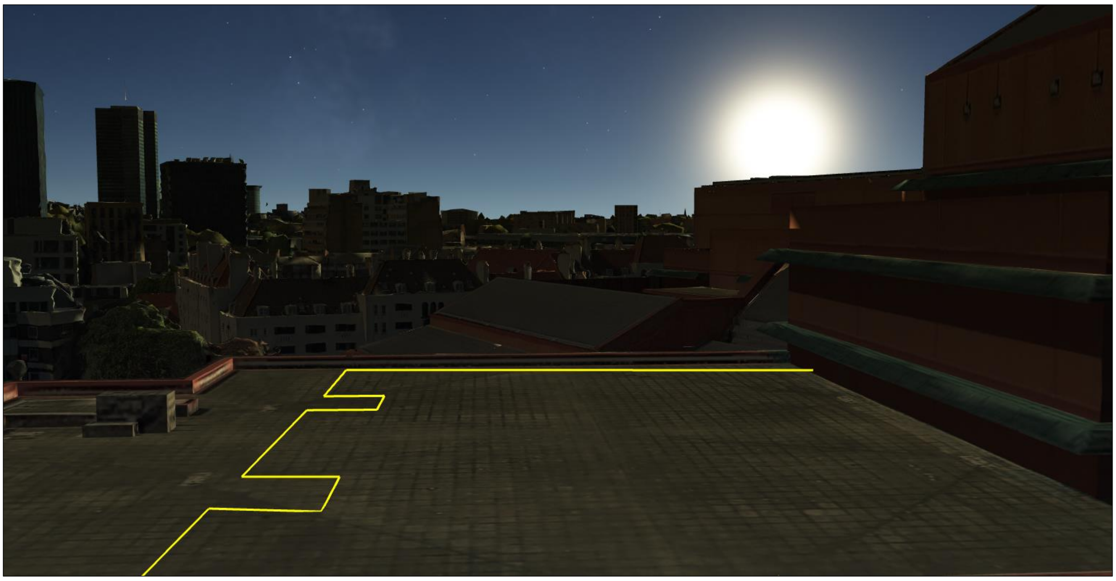


Figure 14 – Sun location at the time of reflection on the 10th of April at 18:15

7.1.2 All reflective surfaces (Glass tube and aluminium plate)

The assessment of all identified reflective surfaces (see Section 2.2) showed that solar reflections are predicted for all identified receptors associated with the St. Pancras Renaissance Hotel.

A low impact is predicted for observers that are expected to experience solar reflections from the glass tubes, since the glare generated by the glass tube will have low significance. This is because solar reflections generated by the glass tube will be scattered at different angles and only a small amount of the tube surface will reflect sunlight towards a specific receptor point at a specific time (as explained in Section 2.2). It should also be considered that a large number of reflective surfaces are already present in the local environment, and the glass tubes from the proposed development will not significantly exacerbate the current baseline conditions. Furthermore, some screening has been identified for some of the receptor points (13, 15, 17, 19, 21, 23, 25 and 27) which will partially screen solar reflection and therefore reduce the impact further. Ultimately, observers located within receptors locations 28 and 29 are not expected to directly look towards the reflective surface. The impact is not expected to be significantly worse for those receptor points which are predicted to experience glare from both the aluminium plate and the glass tube (1 to 12 see section 7.1.1). This because, despite solar reflections are expected to increase in duration per day and year, the solar reflections generated by glass tubes are expected to have low significance and therefore they will not significantly exacerbate the impact upon those receptors.

7.1.3 Conclusions: St. Pancras Renaissance Hotel London

Solar reflections are possible for receptors located within the St. Pancras Renaissance Hotel. However, the impact is expected to be low for all assessed receptor points. This because:

- At the time when solar reflections will occur an observer with full visibility of the reflective area will also be looking towards the general direction of the sun which is a brighter source of light.
- Solar reflections can only occur when the sky is clear;
- Solar reflections generated by the glass tube are expected to have low significance and therefore will not significantly exacerbate the impact from the aluminium reflector plate.

Therefore, a low impact is predicted for which no mitigation is required.

7.3 Offices

7.3.1 Aluminium Reflector Plate Reflective Surface

The glint and glare assessment has shown that no reflection is geometrically possible towards the receptors associated with the office building located south of the proposed development.

7.3.2 All reflective surfaces (Glass tube and aluminium plate)

The assessment of all identified reflective surfaces (see Section 2.2) showed that solar reflections are predicted for all identified receptors associated with the office building. For these receptors a low impact is predicted because the glare generated by the glass tube will have low significance. This is because solar reflections generated by the glass tube will be scattered at different angles and only a small amount of the tube surface will reflect sunlight towards a specific receptor point at a specific time (as explained in Section 2.2)

7.3.3 Conclusions: Offices

Solar reflections are possible for receptors located within the office south of the proposed development. However, the impact is expected to be low for all assessed receptor points. This because:

- Solar reflections can only occur when the sky is clear;
- Solar reflections generated by the glass tube are expected to have low significance.

Therefore, a low impact is predicted for which no mitigation is required.

8 OVERALL CONCLUSIONS

8.1 Overview

A glint and glare assessment has been made to evaluate the impact of the proposed solar development on nearby building occupants. The nearby St. Pancras Renaissance Hotel and the offices located south of the British Library have been identified as the locations most likely to be affected. Whilst there is no specific guidance for the assessment of the impact of glint and glare on hotels and offices, the study has been carried out for completeness to ensure it won't impact on these nearby receptors.

8.2 St. Pancras Renaissance Hotel Results

Solar reflections are possible for receptors located within the St. Pancras Renaissance Hotel. However, the impact is expected to be low for all assessed receptor points. This because:

- At the time when solar reflections will occur, an observer with full visibility of the reflective area will also be looking towards the general direction of the sun which is a brighter source of light.
- Solar reflections can only occur when the sky is clear;
- Solar reflections generated by the glass tube are expected to have low significance and therefore will not significantly exacerbate the impact from the aluminium reflector plate.

Therefore, a low impact is predicted for which no mitigation is required (see Section 7.1).

8.3 Offices Results

Solar reflections are possible for receptors located within the office south of the proposed development. However, the impact is expected to be low for all assessed receptor points. This because:

- Solar reflections can only occur when the sky is clear;
- Solar reflections generated by the glass tube are expected to have low significance.

Therefore, a low impact is predicted for which no mitigation will be required (see Section 7.2).

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

The National Planning Policy Framework under the planning practice guidance for Renewable and Low Carbon Energy[15] (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.'

Assessment Process – Ground-Based Receptors

No process for determining and contextualising the effects of glint and glare are, however, provided for assessing the impact of solar reflections upon surrounding roads and dwellings. Therefore, the Pager Power approach is to determine whether a reflection from the proposed

[15] Renewable and low carbon energy, Ministry of Housing, Communities & Local Government, date: 18 June 2015, accessed on: 17/06/2020

solar development is geometrically possible and then to compare the results against the relevant guidance/studies to determine whether the reflection is significant.

The Pager Power approach has been informed by the policy presented above, current studies (presented in Appendix B) and stakeholder consultation. Further information can be found in Pager Power's Glint and Glare Guidance document[16] which was produced due to the absence of existing guidance and a specific standardised assessment methodology.

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

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

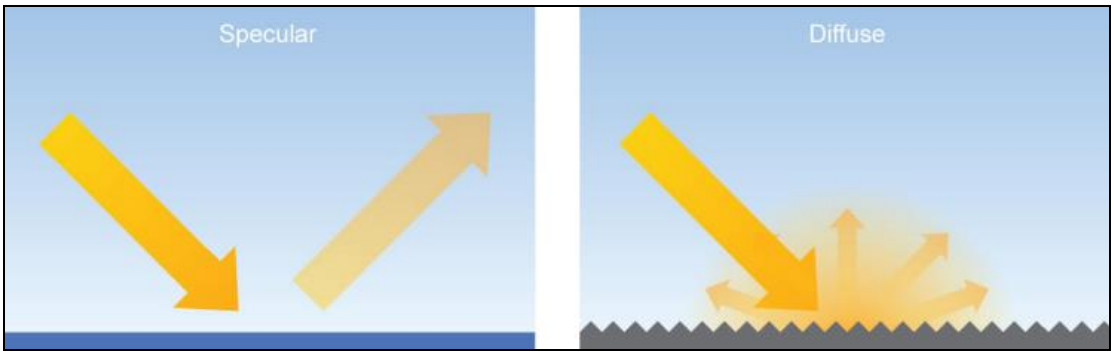
Overview

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

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

Reflection Type from Solar Panels

Based on the surface conditions reflections from light can be specular and diffuse. A specular reflection has a reflection characteristic similar to that of a mirror; a diffuse will reflect the incoming light and scatter it in many directions. The figure below, taken from the FAA guidance[17], 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

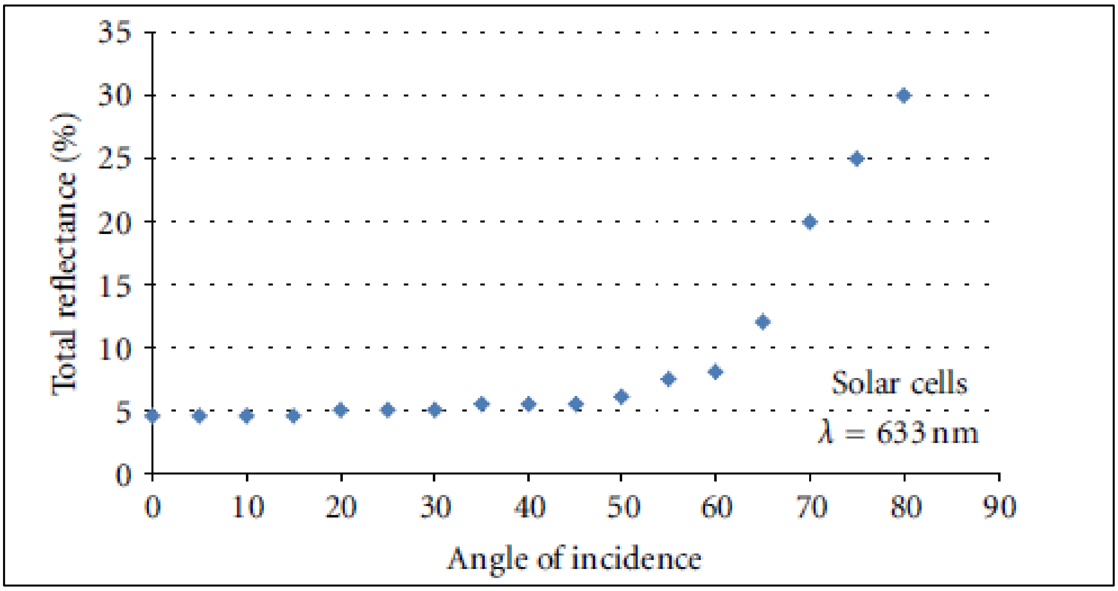
[17] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.

Solar Reflection Studies

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

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

Evan Riley and Scott Olson published in 2011 their study titled: *A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems*[18]". They researched the potential glare that a pilot could experience from a 25 degree fixed tilt PV system located outside of Las Vegas, Nevada. The theoretical glare was estimated using published ocular safety metrics which quantify the potential for a postflash glare after-image. This was then compared to the postflash glare after-image caused by smooth water. The study demonstrated that the reflectance of the solar cell varied with angle of incidence, with maximum values occurring at angles close to 90 degrees. The reflectance values varied from approximately 5% to 30%. This is shown on the figure below.



Total reflectance % when compared to angle of incidence

The conclusions of the research study were:

- The potential for hazardous glare from flat-plate PV systems is similar to that of smooth water;
- Portland white cement concrete (which is a common concrete for runways), snow, and structural glass all have a reflectivity greater than water and flat plate PV modules.

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[18] 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"[19]
The 2010 FAA Guidance included a diagram which illustrates the relative reflectance of solar panels compared to other surfaces. The figure shows the relative reflectance of solar panels compared to other surfaces. Surfaces in this figure produce reflections which are specular and diffuse. A specular reflection (those made by most solar panels) has a reflection characteristic similar to that of a mirror. A diffuse reflection will reflect the incoming light and scatter it in many directions. A table of reflectivity values, sourced from the figure within the FAA guidance, is presented below.

Surface	Approximate Percentage of Light Reflected[20]
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).

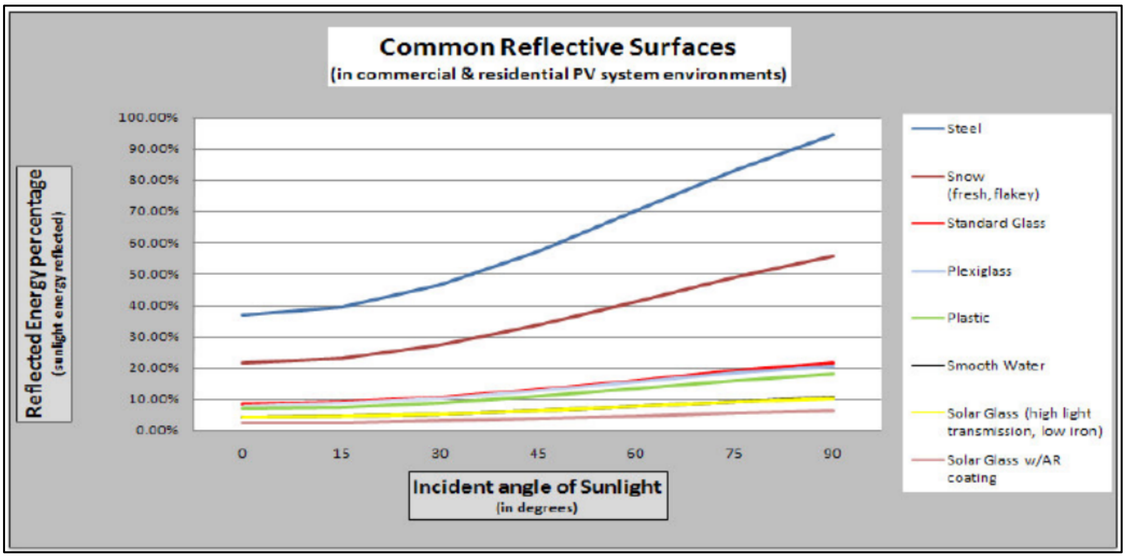
An important comparison in this table is the reflectivity compared to water which will produce a reflection of very similar intensity when compared to that from a solar panel. The study by Riley and Olsen study (2011) also concludes that still water has a very similar reflectivity to solar panels.

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

SunPower Technical Notification (2009)

SunPower published a technical notification[21] 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.

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

APPENDIX C – OVERVIEW OF SUN MOVEMENTS AND RELATIVE REFLECTIONS

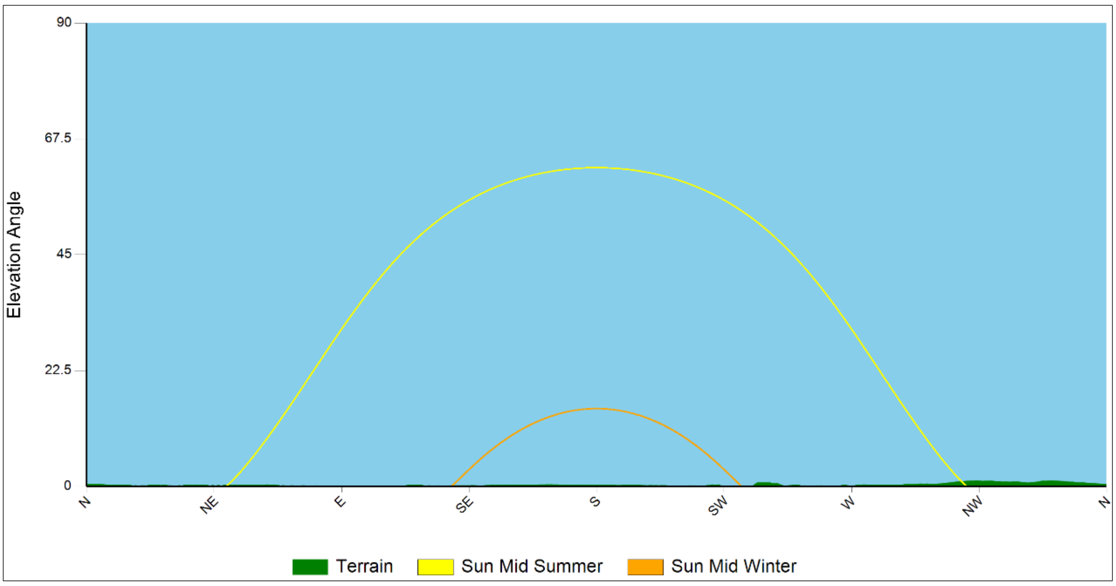
Overview

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 combination of the Sun's azimuth angle and vertical elevation will affect the direction and angle of the reflection from a reflector. The terrain Sun curve is shown in the image below. The coordinates are the following: lon:-0.126882 lat:51.529672



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

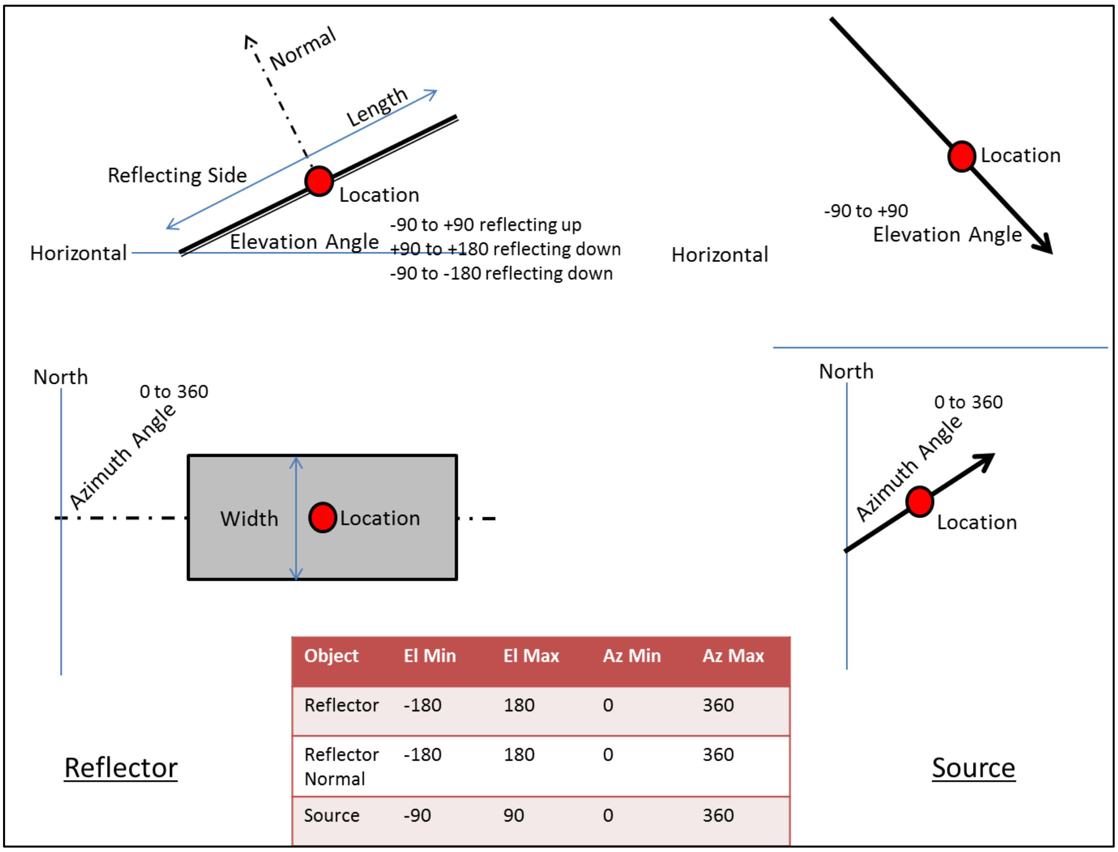
The flow charts presented in the following sub-sections have been followed when determining the mitigation requirement for receptors.

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. Note that the angles drawn below are to aid understanding of the model, and do not represent the angles of the collectors in the roof in this project.



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

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

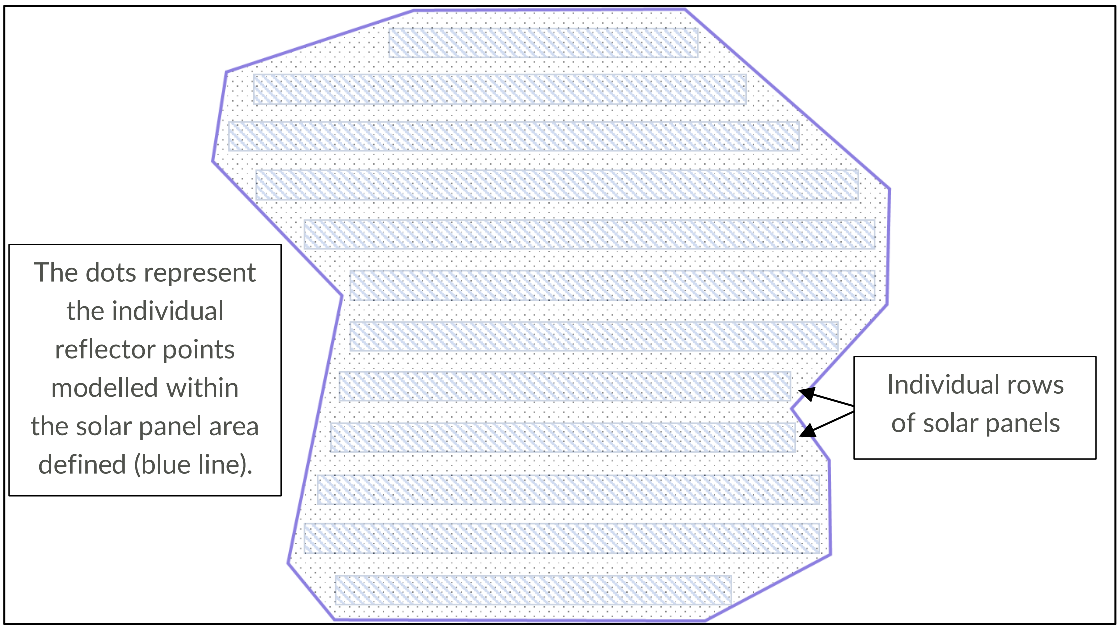
It is assumed that the panel elevation angle provided by the developer represents the elevation angle for all of the panels within each solar panel area defined.

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

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

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

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



Solar panel area modelling overview

A single reflection point is chosen for the geometric calculations. This suitably determines whether a solar reflection can be experienced at a receptor location and the time of year and duration of the solar reflection. Increased accuracy could be achieved by increasing the number of heights assessed however this would only marginally change the results and is not considered significant.

The available street view imagery, satellite mapping, terrain and any site imagery provided by the developer has been used to assess line of sight from the assessed receptors to the modelled solar panel area, unless stated otherwise. In some cases, this imagery may not be up to date and may not give the full perspective of the installation from the location of the assessed receptor.

Any screening in the form of trees, buildings etc. that may obstruct the Sun from view of the solar panels is not within the modelling unless stated otherwise. The terrain profile at the horizon is considered if stated.

APPENDIX G – RECEPTOR AND REFLECTOR AREA DETAILS

St. Pancras Renaissance Hotel London Receptor Details

No.	Longitude (°)	Latitude (°)	Height (m agl)	No.	Longitude (°)	Latitude (°)	Height (m agl)
1	-0.12647	51.53003	19	16	-0.12633	51.52951	21
2	-0.12645	51.53000	19	17	-0.12633	51.52951	18
3	-0.12645	51.52996	19	18	-0.12633	51.52949	21
4	-0.12644	51.52992	19	19	-0.12632	51.52949	18
5	-0.12643	51.52988	19	20	-0.12631	51.52945	21
6	-0.12642	51.52985	19	21	-0.12633	51.52946	18
7	-0.12640	51.52981	22	22	-0.12630	51.52943	21
8	-0.12639	51.52973	23	23	-0.12632	51.52943	18
9	-0.12638	51.52970	27	24	-0.12628	51.52939	21
10	-0.12638	51.52967	23	25	-0.12629	51.52939	18
11	-0.12635	51.52961	32	26	-0.12626	51.52936	21
12	-0.12635	51.52961	21	27	-0.12628	51.52936	18
13	-0.12637	51.52960	18	28	-0.12623	51.52933	21
14	-0.12634	51.52955	21	29	-0.12624	51.52933	18
15	-0.12635	51.52955	18				

Assessed receptor locations for St. Pancras Renaissance Hotel

Offices

No.	Longitude (°)	Latitude (°)	Height (m agl)	No.	Longitude (°)	Latitude (°)	Height (m agl)
30	-0.12668	51.52878	19	42	-0.12721	51.52855	19
31	-0.12666	51.52878	22	43	-0.12721	51.52856	22
32	-0.12675	51.52874	19	44	-0.12729	51.52853	19
33	-0.12674	51.52874	22	45	-0.12729	51.52852	22

No.	Longitude (°)	Latitude (°)	Height (m agl)	No.	Longitude (°)	Latitude (°)	Height (m agl)
34	-0.12683	51.52871	19	46	-0.12737	51.52849	19
35	-0.12682	51.52871	22	47	-0.12737	51.52849	22
36	-0.12697	51.52865	19	48	-0.12752	51.52844	19
37	-0.12697	51.52865	22	49	-0.12752	51.52844	22
38	-0.12705	51.52862	19	50	-0.12756	51.52842	19
39	-0.12705	51.52862	22	51	-0.12755	51.52842	22
40	-0.12713	51.52859	19	52	-0.12760	51.52841	19
41	-0.12713	51.52859	22	53	-0.12759	51.52840	22

Assessed receptor locations for the offices

Modelled Reflector Area

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.12712	51.52976	11	-0.12662	51.52958
2	-0.12702	51.52977	12	-0.12673	51.52957
3	-0.12702	51.52976	13	-0.12674	51.52959
4	-0.12698	51.52977	14	-0.12679	51.52959
5	-0.12698	51.52978	15	-0.12678	51.52956
6	-0.12684	51.52979	16	-0.12693	51.52955
7	-0.12684	51.52978	17	-0.12693	51.52957
8	-0.12679	51.52978	18	-0.12698	51.52957
9	-0.12679	51.52979	19	-0.12698	51.52955
10	-0.12670	51.52980	20	-0.12708	51.52954

Modelled reflector area coordinates

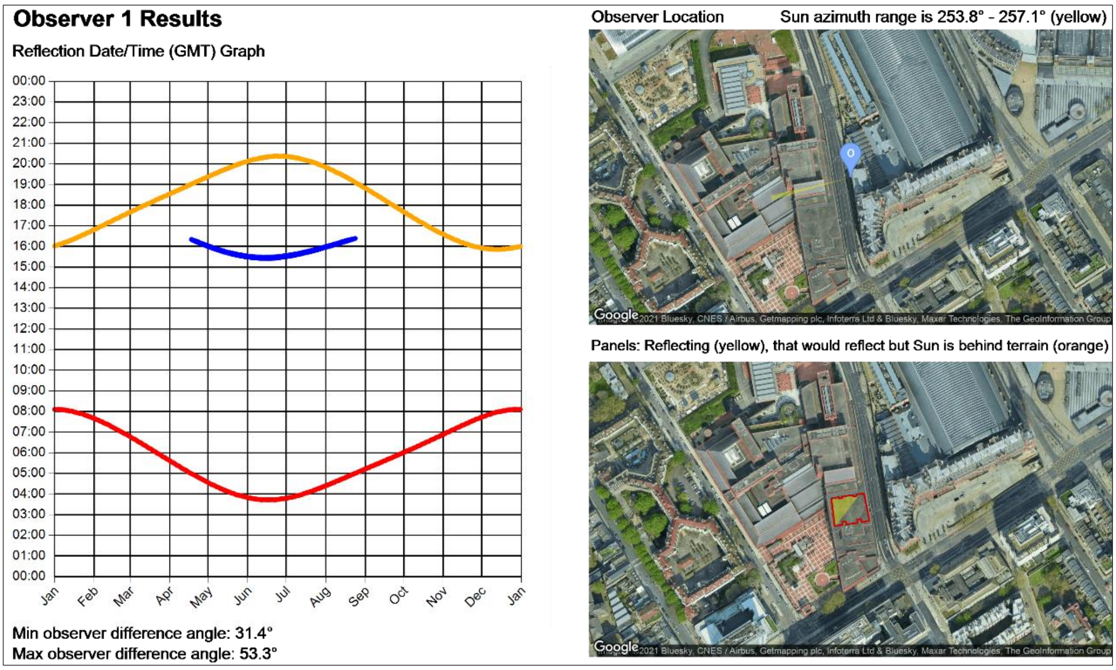
APPENDIX H – GEOMETRIC CALCULATION RESULTS – PAGER POWER RESULTS

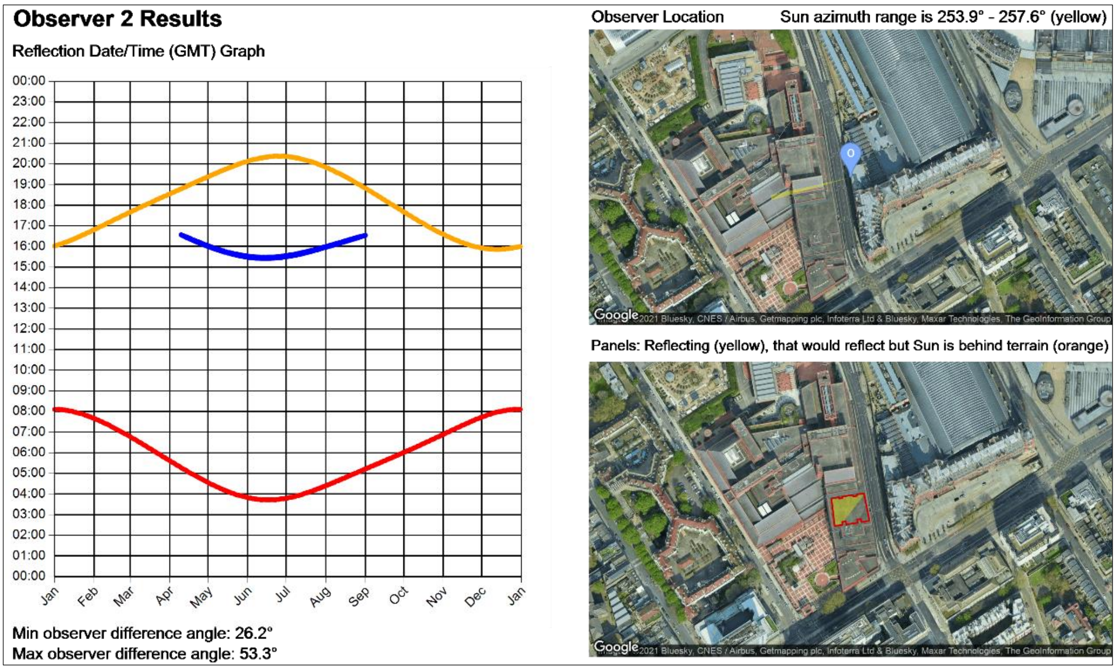
The charts for the receptors are shown below and on the following pages. Each chart shows:

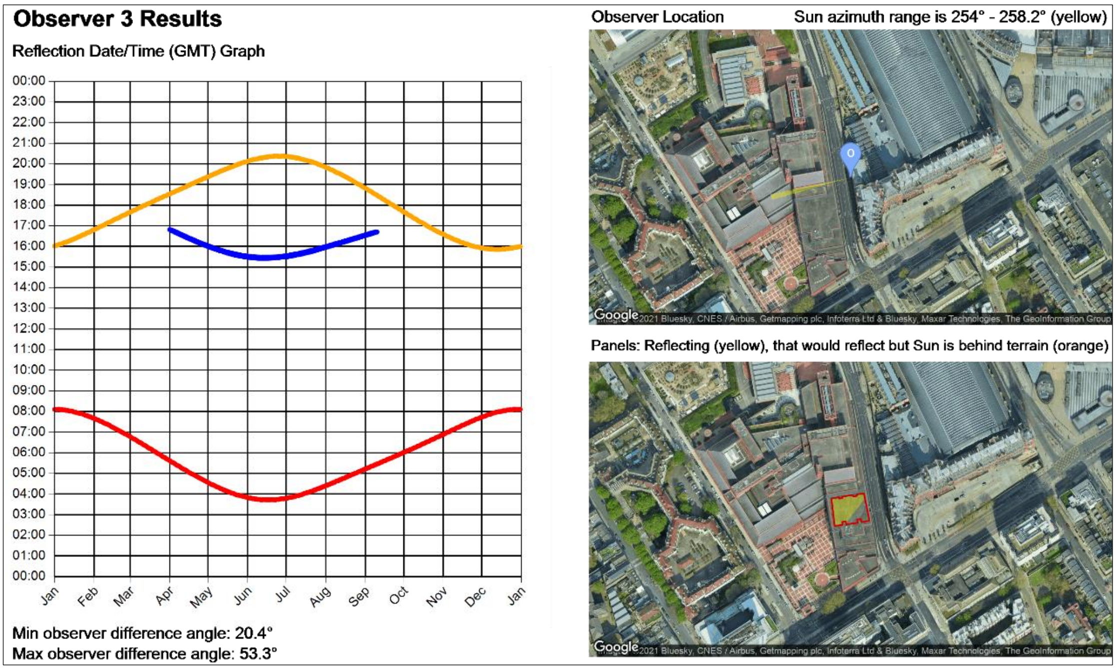
- The receptor (observer) location – top right image. This also shows the azimuth range of the Sun itself at times when reflections are possible. If sunlight is experienced from the same direction as the reflecting panels, the overall impact of the reflection is reduced as discussed within the body of the report;
- The reflecting areas – 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 reflector area from view are considered separately within the analysis;
- The reflection date/time graph – left hand side of the page. The blue line indicates the dates and times at which geometric reflections are possible. This relates to reflections from the yellow areas only;
- In the same graph the red line shows the time at which the sun is rising while the yellow line shows when the sun is setting for each specific month.

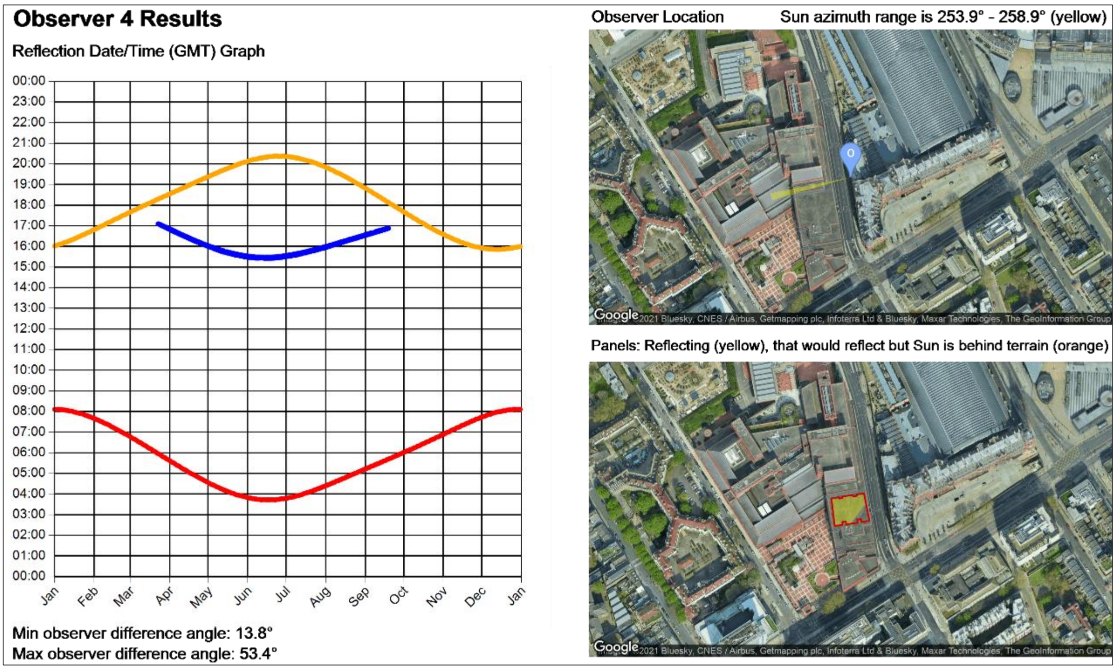
The charts below show only the solar reflection generated by the aluminium plates.

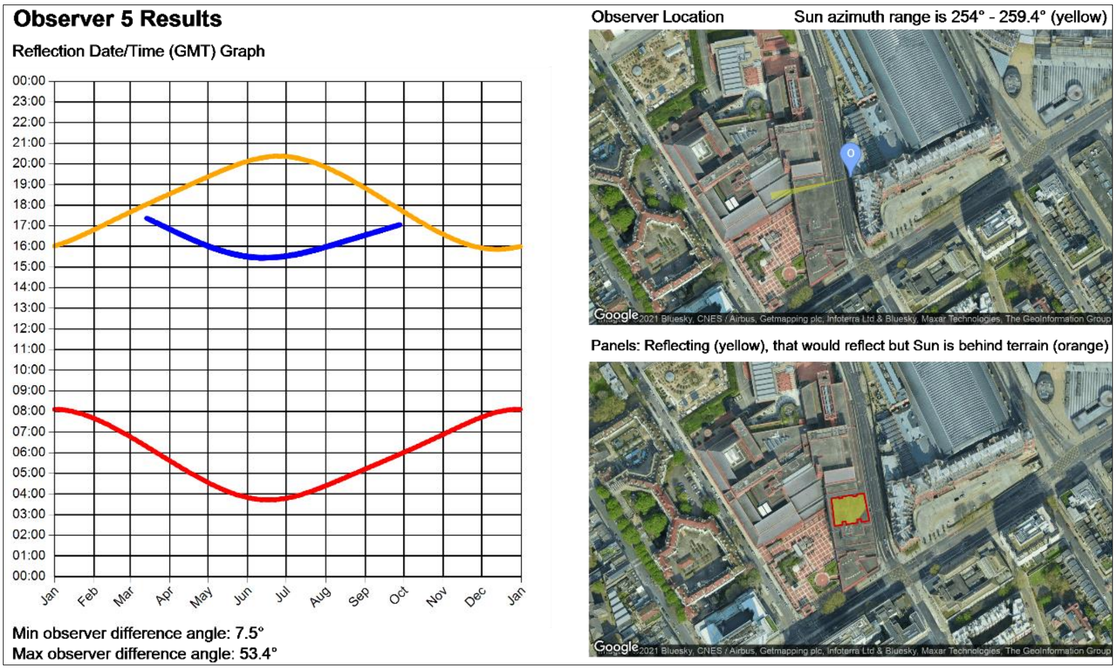
St. Pancras Renaissance Hotel London

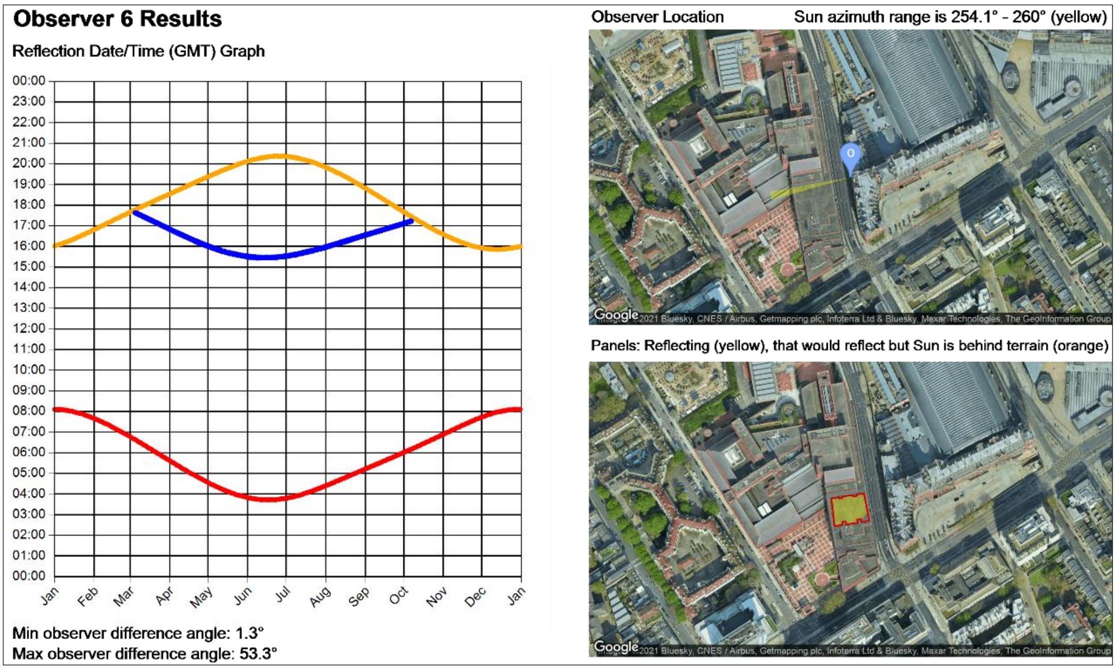


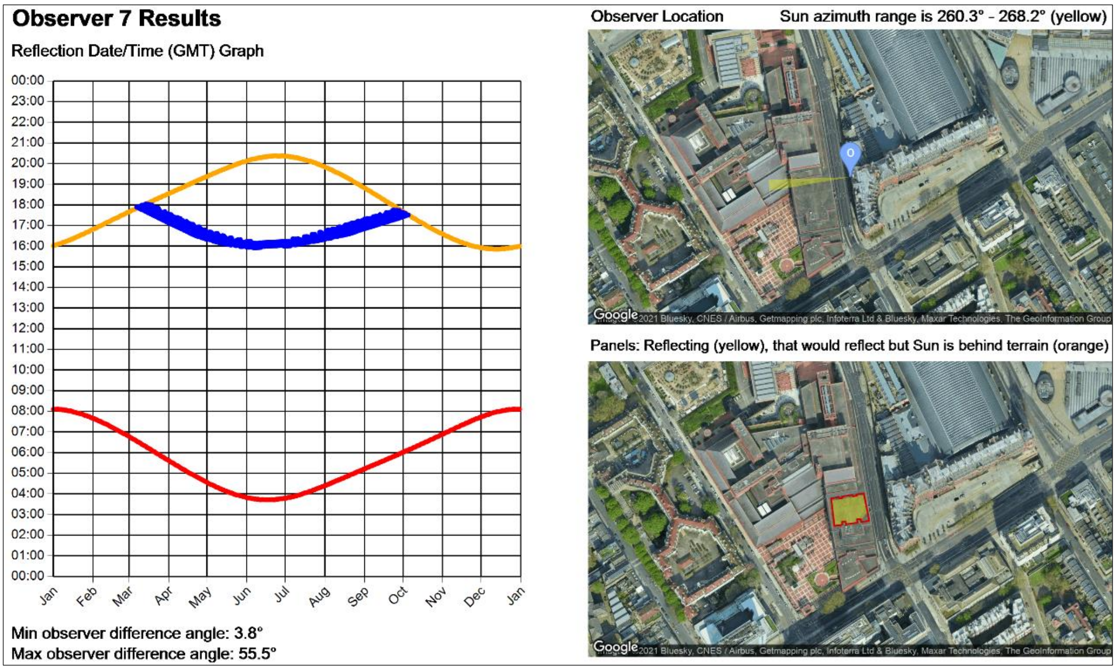

Observer 2 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 26.2°
Max observer difference angle: 53.3°
Observer Location
Sun azimuth range is 253.9° - 257.6° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

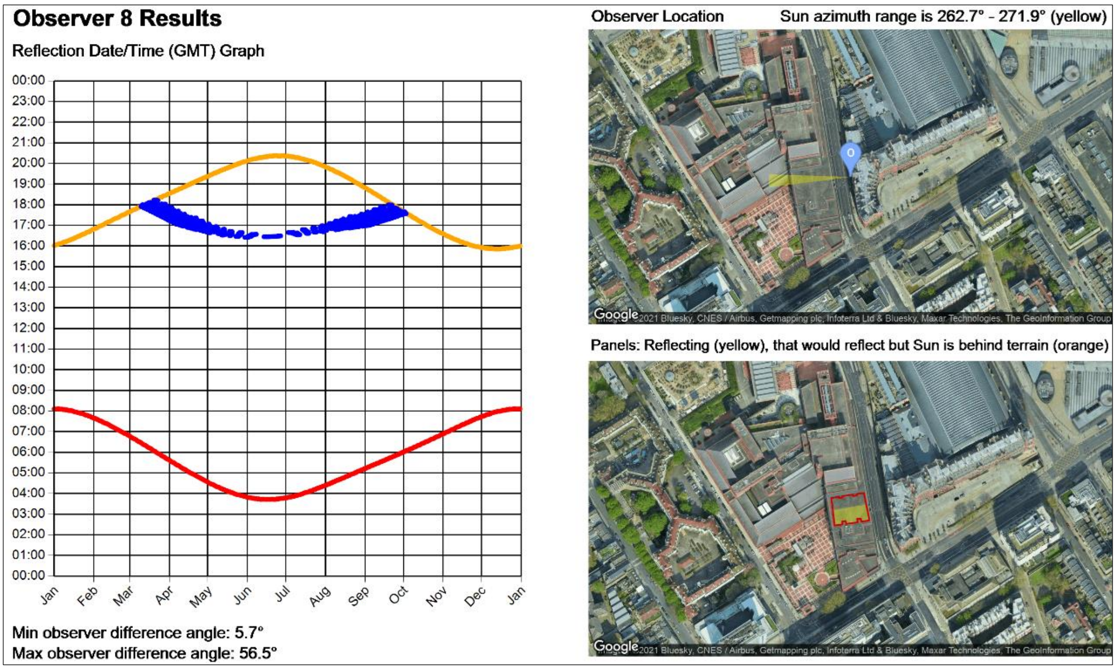

Observer 3 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 20.4°
Max observer difference angle: 53.3°
Observer Location
Sun azimuth range is 254° - 258.2° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

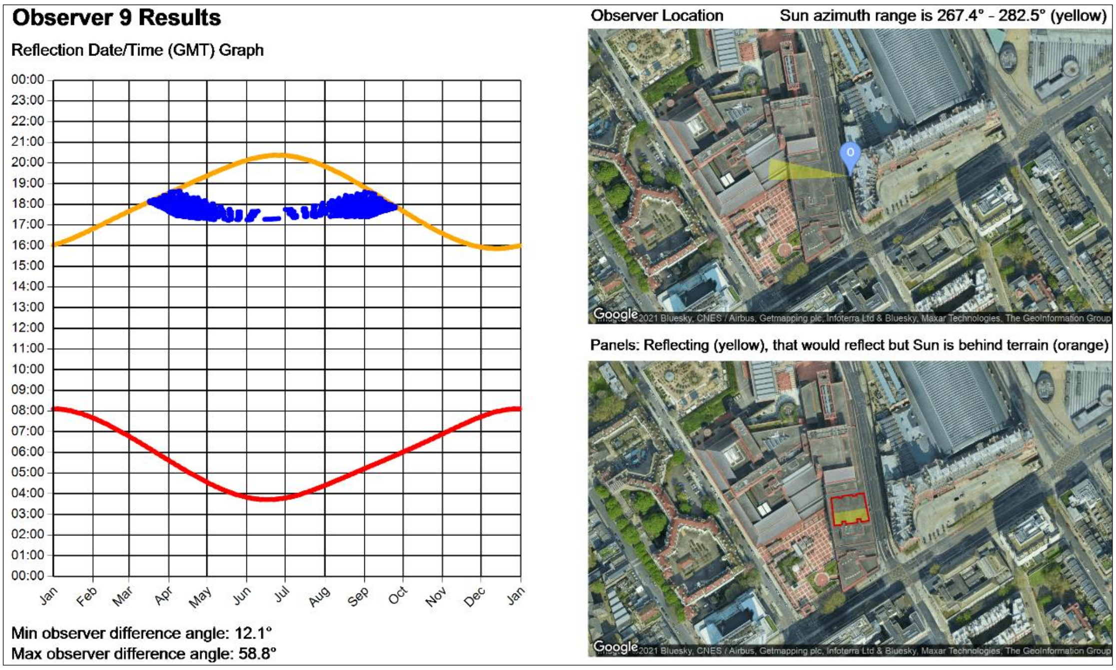

Observer 4 Results
Reflection Date/Time (GMT) Graph
00:00 23:00 22:00 21:00 20:00 19:00 18:00 17:00 16:00 15:00 14:00 13:00 12:00 11:00 10:00 09:00 08:00 07:00 06:00 05:00 04:00 03:00 02:00 01:00 00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 13.8°
Max observer difference angle: 53.4°
Observer Location
Sun azimuth range is 253.9° - 258.9° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer 5 Results
Reflection Date/Time (GMT) Graph
00:00 23:00 22:00 21:00 20:00 19:00 18:00 17:00 16:00 15:00 14:00 13:00 12:00 11:00 10:00 09:00 08:00 07:00 06:00 05:00 04:00 03:00 02:00 01:00 00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 7.5°
Max observer difference angle: 53.4°
Observer Location
Sun azimuth range is 254° - 259.4° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer 6 Results
Reflection Date/Time (GMT) Graph
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 1.3°
Max observer difference angle: 53.3°
Observer Location
Sun azimuth range is 254.1° - 260° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 7 Results
Reflection Date/Time (GMT) Graph
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 3.8°
Max observer difference angle: 55.5°
Observer Location
Sun azimuth range is 260.3° - 268.2° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 8 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth range is 262.7° - 271.9° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Min observer difference angle: 5.7°
Max observer difference angle: 56.5°


Observer 9 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth range is 267.4° - 282.5° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Min observer difference angle: 12.1°
Max observer difference angle: 58.8°

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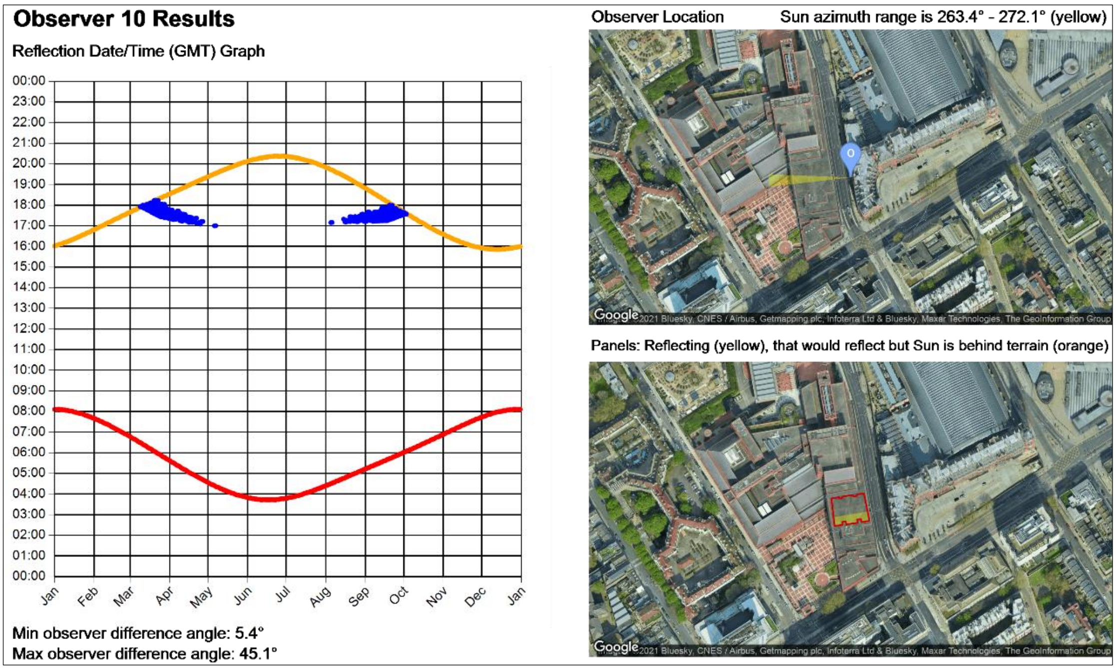

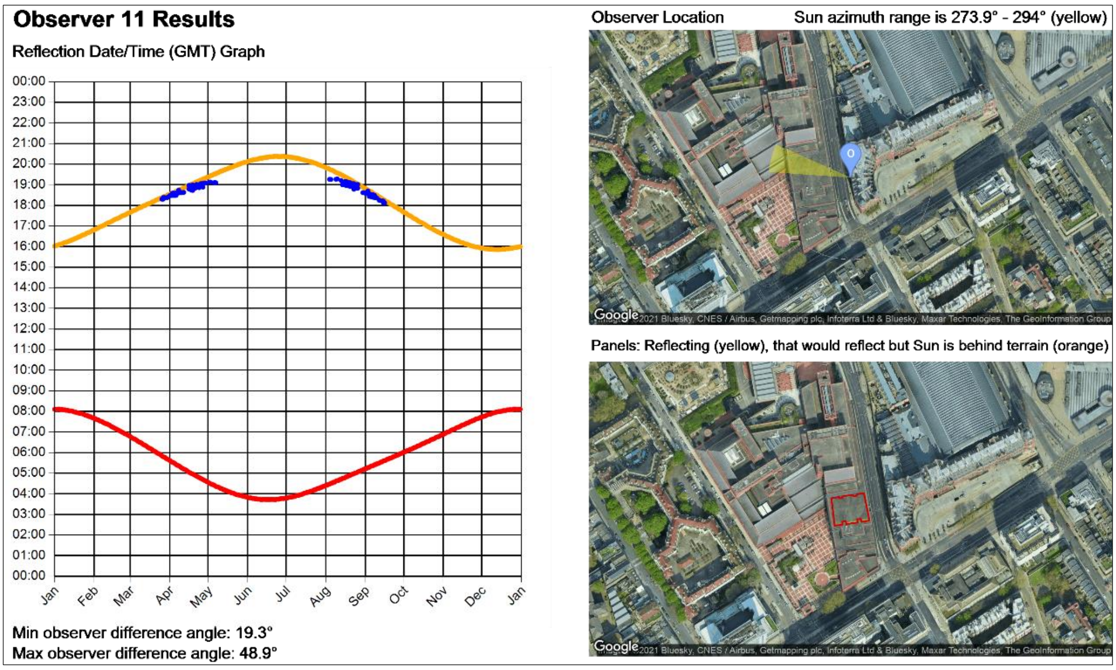

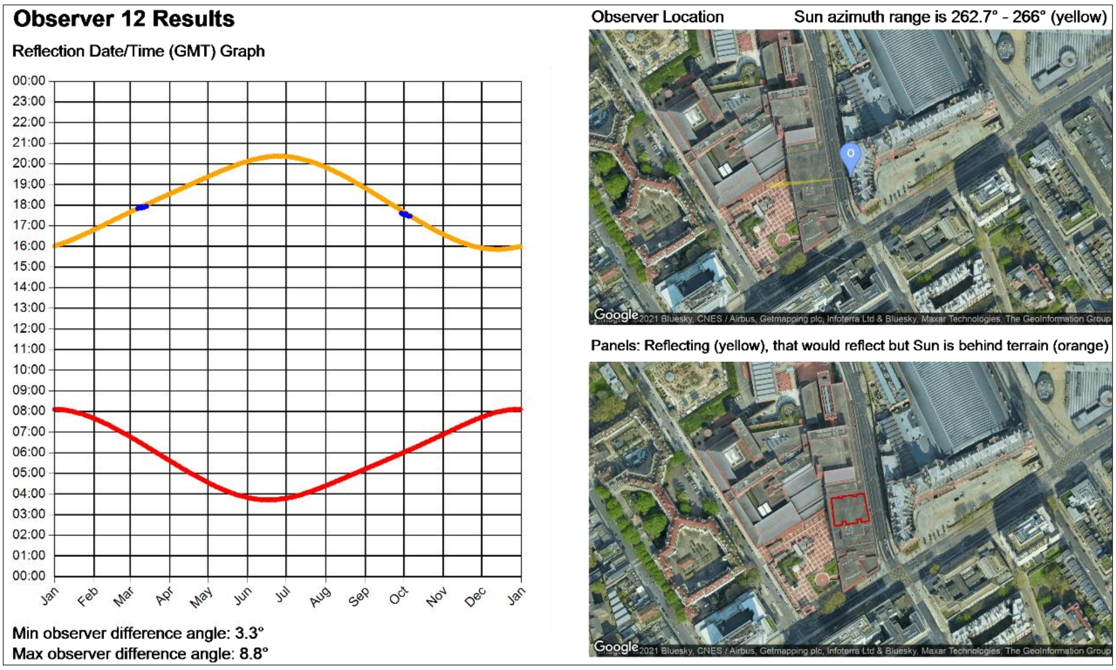
Observer 12 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 3.3°
Max observer difference angle: 8.8°
Observer Location
Sun azimuth range is 262.7° - 266° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

PAGERPOWER
Urban & Renewables

Pager Power Limited
South Suffolk Business Centre
Alexandra Road
Sudbury
Suffolk
CO10 2ZX

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