PAGERPOWER
Urban & Renewables

Solar Photovoltaic Glint and Glare Study

RPS

Kirkton Solar PV & Energy Storage Facility

March 2021

ADMINISTRATION PAGE

Job Reference:	10241A
Date:	March 2021
Author:	Waqar Qureshi
Telephone:	01787 319001
Email:	waqar@pagerpower.com

First Reviewer:	Aaron Williams
Second Reviewer:	Kai Frolic
Date:	March 2021
Telephone:	01787 319001
Email:	aaron@pagerpower.com; kai@pagerpower.com

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Stour Valley Business Centre, Brundon Lane, Sudbury, 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 photovoltaic (PV) and energy storage development located approximately 1.2km south-east of St Fergus in Scotland. This glint and glare assessment concerns the possible impact upon surrounding road users and dwellings.

Pager Power

Pager Power has undertaken over 550 glint and glare assessments in the UK, Europe and internationally. The company's own glint and glare guidance is based on industry experience and extensive consultation with industry stakeholders including airports and aviation regulators.

Conclusions

Solar reflections are geometrically possible towards a section of the A90 to the west of the proposed solar development. However, the reflecting solar panels are either significantly screened, or where a moderate impact is predicted, the reflections largely occur outside of a driver's typical field of view in both directions of travel. No mitigation requirement has therefore been identified.

Solar reflections are geometrically possible towards 11 out of the 13 assessed dwellings near the proposed solar development. For eight of these dwellings, the reflecting solar panels are either significantly screened or where a moderate impact is predicted, there are significant mitigating factors such as the separation distance between the dwellings and the nearest reflecting panels, and the time of day that the reflections occur. No mitigation requirement has therefore been identified.

For three dwellings, views of reflecting panels may be possible despite partial screening. A moderate impact is predicted, and since it cannot be reliably concluded that the views are currently obscured, mitigation is recommended (see section 7.3). It is possible that a site survey would reveal that views are already obscured, in which case no further action would be necessary. Further to the implementation of the recommended mitigation, no impact is predicted.

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, however a specific methodology for determining the impact upon road safety or residential amenity has not been produced to date. Therefore, Pager Power has reviewed existing guidelines and the available studies (discussed below) in the process of defining its own glint and glare assessment guidance and methodology[1]. This methodology defines the process for determining the impact upon road safety and residential amenity.

Pager Power's approach is to undertake geometric reflection calculations and, where a solar reflection is predicted, consider the screening (existing and/or proposed) between the receptor and the reflecting solar panels. The scenario in which a solar reflection can occur for all receptors is then identified and discussed, and a comparison is made against the available solar panel reflection studies to determine the overall impact.

The available studies have measured the intensity of reflections from solar panels with respect to other naturally occurring and manmade surfaces. The results show that the reflections produced are of intensity similar to or less than those produced from still water and significantly less than reflections from glass and steel[2].

Assessment Results

Roads

The modelling has shown that solar reflections are geometrically possible towards 24 out of the 30 assessed receptors along the A90. However, after a review of the available imagery, for 19 of these road receptors solar reflections are not predicted to be experienced in practice as the reflecting solar panels are significantly screened by intervening terrain, vegetation and/or buildings. Therefore, no impact is predicted.

For road receptors 14, 15 and 17, views of the reflecting panels may be possible despite partial screening in the form of vegetation. The impact is moderate according to the guidance presented in Appendix D; however, no mitigation is required because the reflections occur outside of a driver's typical field of view in both directions of travel (50 degrees either side).

For road receptors 18 and 19, views of the reflecting panels may be possible despite partial screening in the form of vegetation. The impact is moderate according to the guidance presented in Appendix D; however, no mitigation is required because:

a) the solar reflections will predominantly occur outside of a road user's field of view (only occur on the right edge of the field of view for a driver travelling northbound);
b) the solar reflections will only occur between 05:30 and 06:30 GMT when the level of road traffic on the A90 is likely to be much lower than other times of the day;
c) existing vegetation along the A90 will further reduce potential effects;
d) solar reflections will occur within approximately 3hrs of sunrise when the Sun is low in the sky beyond the reflecting panels. Therefore, an observer will possibly have a view of the sun within the same viewpoint of the reflecting solar panels. The Sun is a far more significant source of light.

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[1] Solar Photovoltaic Development – Glint and Glare Guidance, Third Edition, December 2020. Pager Power.
[2] SunPower, 2009, SunPower Solar Module Glare and Reflectance (appendix to Solargen Energy, 2010).

Dwellings

The modelling has shown that solar reflections are geometrically possible towards 11 out of the 13 assessed dwelling receptors. However, after a review of the available imagery, for five of these dwelling receptors, solar reflections are not predicted to be experienced in practice as the reflecting solar panels are expected to be significantly screened by intervening terrain, vegetation and/or buildings. The impact is low according to the guidance presented in Appendix D and no mitigation requirement has been identified.

For dwelling receptors 5 and 6, views of the reflecting panels may be possible despite partial screening in the form of vegetation. Solar reflections occur for more than 3 months and for less than 60 minutes per day. The impact is moderate according to the guidance presented in Appendix D, and the following is true:

a) solar reflections will occur within approximately 3hrs of sunrise when the Sun is low in the sky beyond the reflecting panels. Therefore, an observer will possibly have a view of the sun within the same viewpoint of the reflecting solar panels. The Sun is a far more significant source of light;
b) existing vegetation along the A90 will further reduce potential effects.

Since it cannot be reliably concluded that the views are currently obscured, mitigation is recommended. It should be ensured that visibility of the reflecting area is obscured from these dwellings. It is possible that a site survey would reveal that views are already obscured, in which case no further action would be necessary. If views remain, it is recommended that mitigation is applied to address the potential impact. A high-level overview of recommended mitigation is presented in section 7.3. Further to the implementation of the recommended mitigation, no impact is predicted.

For dwelling receptor 7, views of the reflecting panels may be possible despite partial screening in the form of vegetation. Solar reflections occur for more than 3 months and for less than 60 minutes per day. The impact is moderate according to the guidance presented in Appendix D, and the following is true:

a) this receptor is significantly screened from the west by vegetation;
b) the receptor is partially screened from the east, it is unclear how significant the screening is but it will further reduce potential effects;
c) solar reflections will occur within approximately 3hrs of sunrise and sunset when the Sun is low in the sky beyond the reflecting panels. Therefore, an observer will possibly have a view of the sun within the same viewpoint of the reflecting solar panels. The Sun is a far more significant source of light.

Since it cannot be reliably concluded that the views are currently obscured, mitigation is recommended. It should be ensured that visibility of the reflecting area is obscured from these dwellings. It is possible that a site survey would reveal that views are already obscured, in which case no further action would be necessary. If views remain, it is recommended that mitigation is applied to address the potential impact. A high-level overview of recommended mitigation is presented in section 7.3. Further to the implementation of the recommended mitigation, no impact is predicted.

For dwelling receptors 10 – 12, views of the reflecting panels may be possible despite partial screening in the form of intervening terrain and/or vegetation. Solar reflections occur for more than 3 months and for less than 60 minutes per day. The impact is moderate according to the guidance presented in Appendix D, however, no mitigation is required because:

a) the separation distance between these dwellings and the nearest reflecting panel is at least 700m;

b) intervening terrain and vegetation will further reduce potential effects;

a) solar reflections will occur within approximately 3hrs of sunrise when the Sun is low in the sky beyond the reflecting panels. Therefore, an observer will possibly have a view of the sun within the same viewpoint of the reflecting solar panels. The Sun is a far more significant source of light.

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 48 countries within Europe, Africa, America, Asia and Australasia.

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

Pager Power was established in 1997. Initially the company focus was on modelling the impact of wind turbines on radar systems.

Over the years, the company has expanded into numerous fields including:

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

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

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

1 INTRODUCTION

1.1 Overview

Pager Power has been retained to assess the possible effects of glint and glare from a proposed solar photovoltaic (PV) and energy storage development located approximately 1.2km south-east of St Fergus in Scotland. This glint and glare assessment concerns the possible impact upon surrounding road users and dwellings.

This report contains the following:

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

Following this, a summary of findings and overall conclusions and recommendations is presented.

1.2 Pager Power's Experience

Pager Power has undertaken over 550 Glint and Glare assessments in the UK and internationally. The studies have included assessment of civil and military aerodromes, railway infrastructure and other ground-based receptors including roads and dwellings.

1.3 Glint and Glare Definition

The definition of glint and glare can vary however, the definition used by Pager Power is as follows[3]:

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

The term 'solar reflection' is used in this report to refer to both reflection types i.e. glint and glare.

[3] These definitions are aligned with those of the Federal Aviation Administration (FAA) in the United States of America.

2 PROPOSED SOLAR DEVELOPMENT LOCATION AND DETAILS

2.1 Proposed Development Site Layout Plan

The layout of the proposed solar development is shown in Figure 1[4] on the following page, received from RPS. The green areas denote the solar panel locations.

[4] JPW1202-002RevN_D210323_(Kirton Site PV Layout Plan)-A0.pdf (cropped)

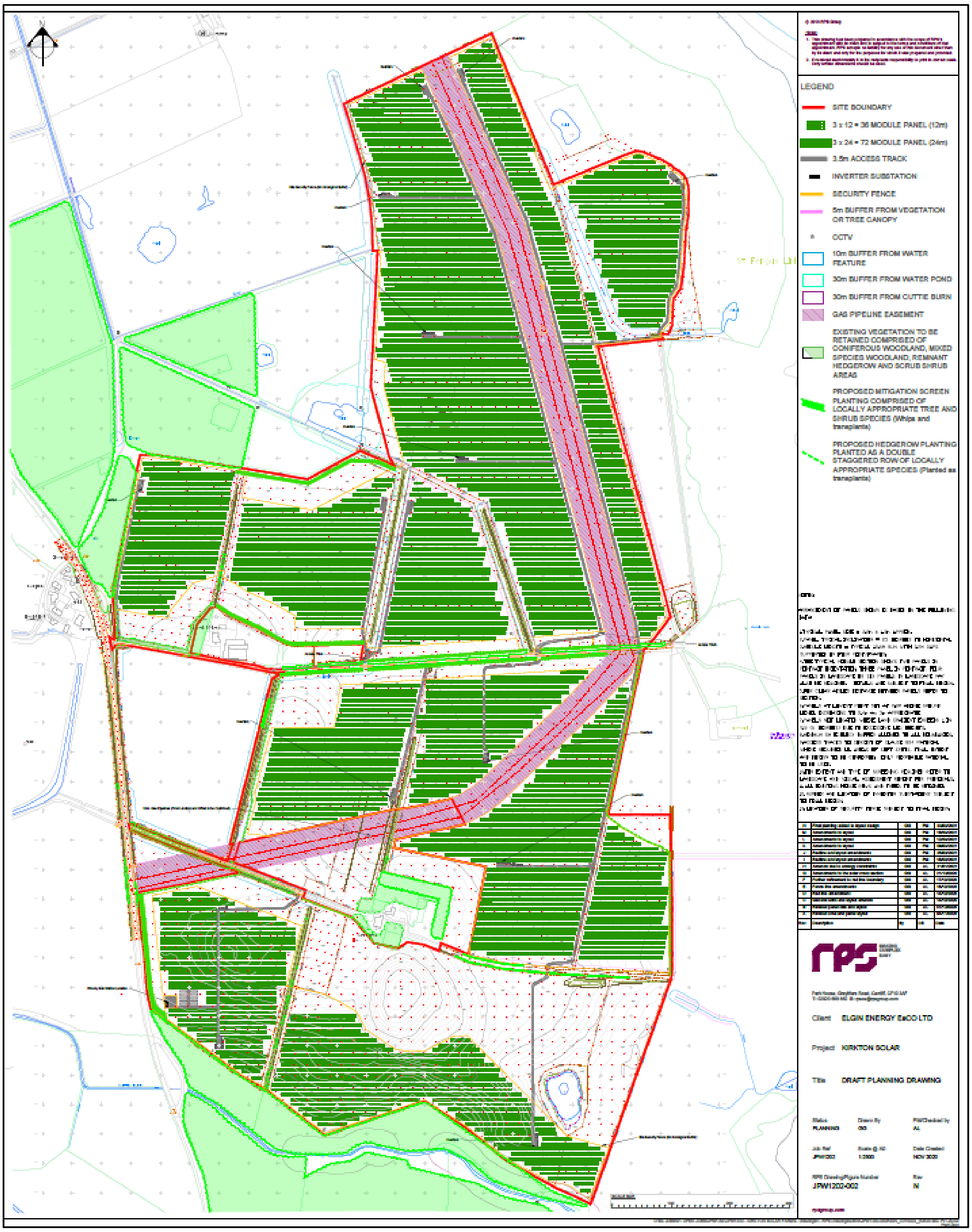

Figure 1 *Solar panel layout*

2.2 Proposed Solar Development Location – Aerial Image

Figure 2[5] below shows the location of the proposed solar development. The red line represents the outer site boundary and the blue shaded area represents a worst-case scenario solar panel area. In reality panels are not located in the entirety of the area and it should be further noted that since the modelling was undertaken, some areas of panels have been removed from the area shaded blue below. This reinforces that the Pager Power assessment is conservative.

Figure 2 *Proposed development location – aerial image*

[5] Copyright © 2021 Google.

2.3 Solar Panel Information

The solar panel characteristics received from RPS are presented in Table 1 below.

Solar Panel Technical Information	
Azimuth angle (°)	180
Elevation angle (°)	25
Assessed centre height (m)	1.9 above ground level (agl)

Table 1 *Solar panel technical information*

3 GLINT AND GLARE ASSESSMENT METHODOLOGY

3.1 Guidance and Studies

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

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

3.2 Background

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

3.3 Pager Power's Methodology

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

- Identify receptors in the area surrounding the solar development. The method for defining the assessment area is explained in section 4.1.
- Consider direct solar reflections from the solar development towards the identified receptors by undertaking geometric calculations.
- Consider the visibility of the panels from the receptor's location. If the panels are not visible from the receptor then no reflection can occur.
- Based on the results of the geometric calculations, determine whether a reflection can occur, and if so, at what time it will occur.
- Consider both the solar reflection from the solar development and the location of the direct sunlight with respect to the receptor's position.
- Consider the solar reflection with respect to the published studies and guidance.
- Determine whether a significant detrimental impact is expected in line with the process presented in Appendix D.

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

3.4 Assessment Limitations

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

4 IDENTIFICATION OF RECEPTORS

4.1 Ground-Based Receptors

There is no formal guidance with regard to the maximum distance at which glint and glare should be assessed. From a technical perspective, there is no maximum distance for potential reflections. The significance of a reflection however decreases with distance because the proportion of an observer's field of vision that is taken up by the reflecting area diminishes as the separation distance increases. Terrain and shielding by vegetation are also more likely to obstruct an observer's view at longer distances.

A 1km buffer is considered appropriate for glint and glare effects on ground-based receptors. The panels are fixed south facing and therefore solar reflections at ground level towards the north are not geometrically possible at this latitude. The receptor zone has been designed accordingly as a 1km boundary from the site, cutting away the area to the north of the site which is of no relevance to this assessment. This leaves the yellow area on Figure 3[5] on the next page. Receptors within this distance are identified based on mapping and aerial photography of the region. The blue lines on the figure show the boundaries of the solar panel areas.

Terrain elevation heights have been interpolated based on OSGB36 data. Receptor details can be found in Appendix G.

Figure 3 *Assessed receptor area – aerial image*

4.2 Road Receptors

Road types can generally be categorised as:

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

Assessment is not recommended for local roads, where traffic volumes and/or speeds are likely to be relatively low, as any solar reflections from the proposed development that are experienced by a road user would be considered 'low' impact in the worst case. The analysis has therefore considered any major national, national, and regional roads that:

- Are within, or close to one kilometre of the proposed development.
- Have a potential view of the panels.

The assessed road receptor points are on the A90 to the west of the site (receptors 1 – 30), as shown in Figure 4[5] below. A height of 1.5 metres above ground level has been taken as typical eye level for a road user. The distance between road receptors is circa 100m.

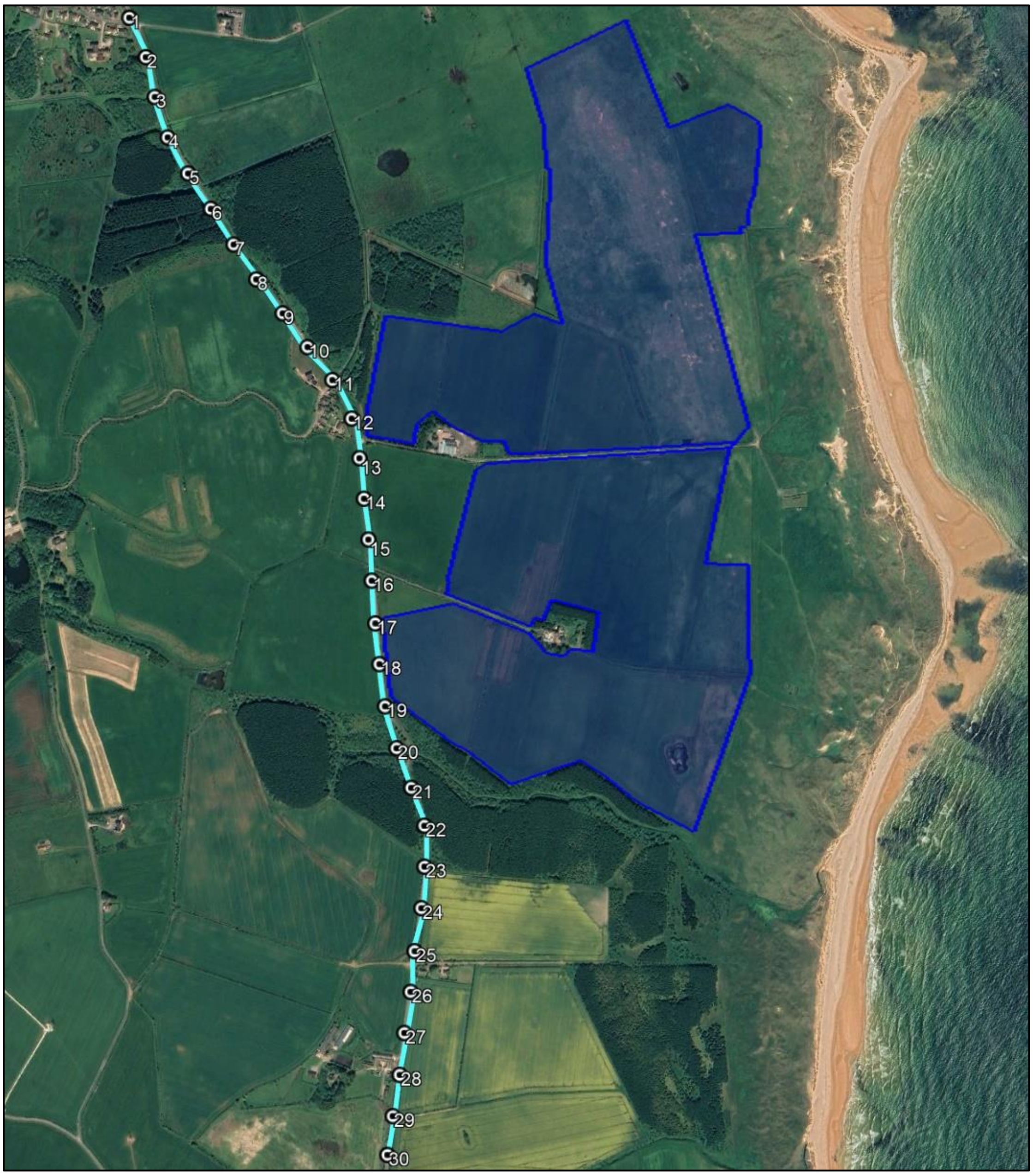

Figure 4 *Assessed road receptors – aerial image*

4.3 Dwelling Receptors

The analysis has considered dwellings that:

- Are within, or close to one kilometre of the proposed development.
- Have a potential view of the panels.

The individual assessed dwelling receptors are shown in Figures 5 to 7[5] on the following pages. An overview of all dwelling receptors is shown in Figure 7[5] on page 21. A height of 1.8 metres above ground level has been taken as typical eye level for an observer on the ground floor of the dwelling. Consideration of views from a first floor (if appropriate) are discussed further in section 7.

Figure 5 *Assessed dwelling receptors – 1 to 7 – aerial image*

Figure 6 *Assessed dwelling receptors – 8 to 12 – aerial image*

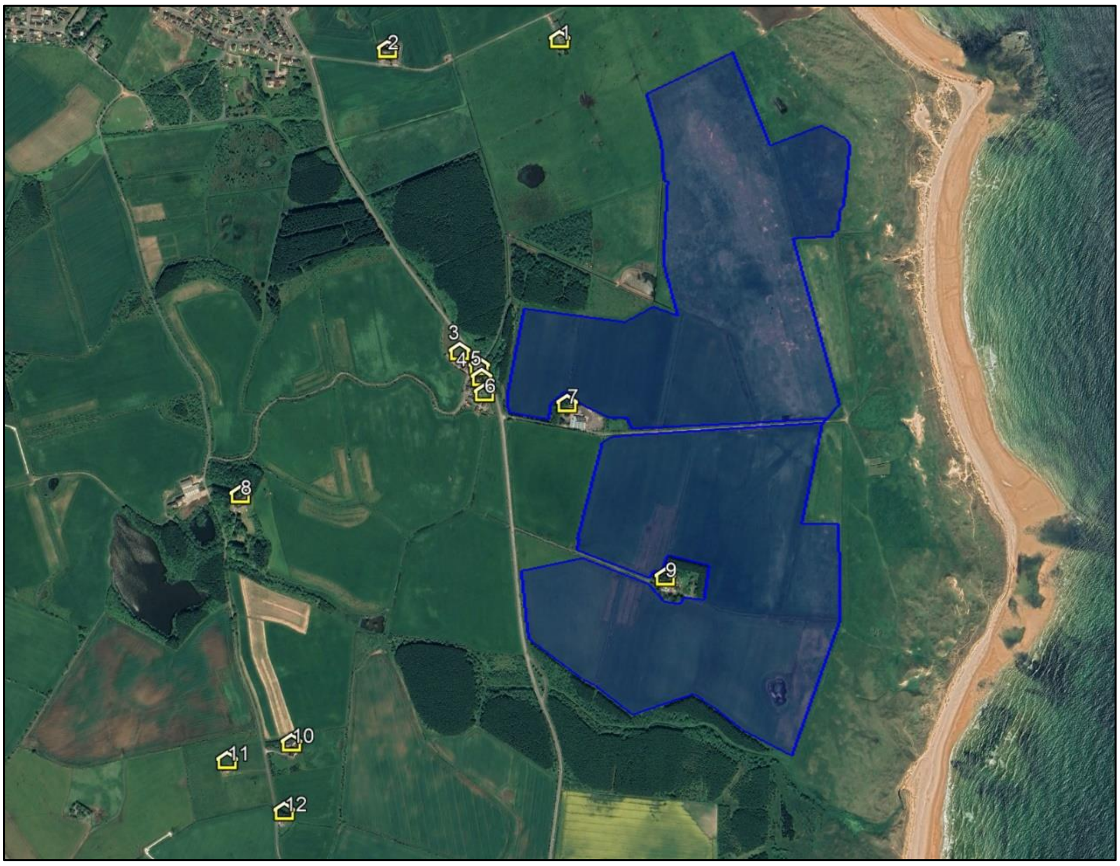

Figure 7 *Assessed dwelling receptors overview – aerial image*

5 ASSESSED REFLECTOR AREA

5.1 Reflector Area

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

A resolution of 10m has been chosen for this assessment. This means that a geometric calculation is undertaken for each identified receptor every 10m from within the defined 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 farm development.

Figure 8 below shows the assessed reflector area that has been used for modelling purposes. The assessed reflector area represents a worst-case scenario as panels are not located in the entirety of the area. This is consistent with the conservative assessment approach.

Figure 8 *Assessed reflector area – aerial image*

6 GLINT AND GLARE ASSESSMENT – TECHNICAL RESULTS

6.1 Summary of Results

The tables in the following subsections summarise the results of the assessment. The predicted glare times are based solely on bare-earth terrain i.e. without consideration of screening from buildings and vegetation. The final column summarises the predicted impact considering the level of predicted screening based on a desk-based review of the available imagery. The significance of any predicted impact is discussed in the subsequent report sections. The modelling output showing the precise predicted times and the reflecting panel area is shown in Appendix H.

6.2 Geometric Calculation Results Overview – Road Receptors

Table 2 below presents the results of the roads analysis.

Receptor	Results – Reflection possible towards the receptor? (GMT)		Comments
	am	pm	
1; 26 – 30.	No.	No.	No solar reflections are geometrically possible. No impact predicted.
2 – 13; 16; 20 – 25.	Yes.	No.	Solar reflections are not predicted to be experienced in practice as the reflecting solar panels are significantly screened by intervening terrain, vegetation and/or buildings. No impact predicted.
14 – 15; 17 – 19.	Yes.	No.	Solar reflections are geometrically possible and views of the reflecting panels may be possible. Moderate impact predicted. Discussed further in section 7.1.

Table 2 *Geometric analysis results – road receptors*

6.3 Geometric Calculation Results Overview – Dwelling Receptors

Table 3 below presents the results of the dwellings analysis.

Receptor	Results		Comments
	Reflection possible towards the receptor? (GMT)		
	am	pm	
1; 13.	No.	No.	No solar reflections are geometrically possible. No impact predicted.
2 – 4; 8.	Yes.	No.	Solar reflections are not predicted to be experienced in practice as the reflecting solar panels are significantly screened by intervening terrain, vegetation and/or buildings. A low impact is predicted.
9.	Yes.	Yes.	Solar reflections are not predicted to be experienced in practice as the reflecting solar panels are significantly screened by intervening terrain, vegetation and/or buildings. A low impact is predicted.
5 – 6; 10 – 12.	Yes.	No.	Solar reflections are geometrically possible and views of the reflecting panels may be possible. A moderate impact is predicted. Discussed further in section 7.2.
7.	Yes.	Yes.	Solar reflections are geometrically possible and views of the reflecting panels may be possible. A moderate impact is predicted. Discussed further in section 7.2.

Table 3 *Geometric analysis results – dwelling receptors*

7 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

7.1 Road Receptors

The process for quantifying impact significance is defined in the report appendices. For road users, the key considerations are:

- Whether a reflection is predicted in practice.
- The type of road (and associated likely traffic levels/speeds).
- The location of the reflecting panels relative to a road user's direction of travel (a reflection directly in front of a driver is more hazardous than a reflection from a location off to one side).

The modelling has shown that solar reflections are geometrically possible towards 24 out of the 30 assessed receptors along the A90 (2 – 25). The section of road where solar reflections are geometrically possible towards is highlighted in red in Figure 9[5] on the following page.

Following a conservative review of the available imagery, however, for 19 of these road receptors (2 – 13, 16 and 20 – 25), solar reflections are not predicted to be experienced in practice as the reflecting solar panels are significantly screened by intervening terrain, vegetation and/or buildings. Therefore, no impact is predicted.

For five road receptors (14 – 15 and 17 – 19), views of reflecting panels may be possible based on a conservative review of the available imagery of the area. The impact is moderate according to the guidance presented in Appendix D. The results for these receptors are further discussed in 7.1.1.

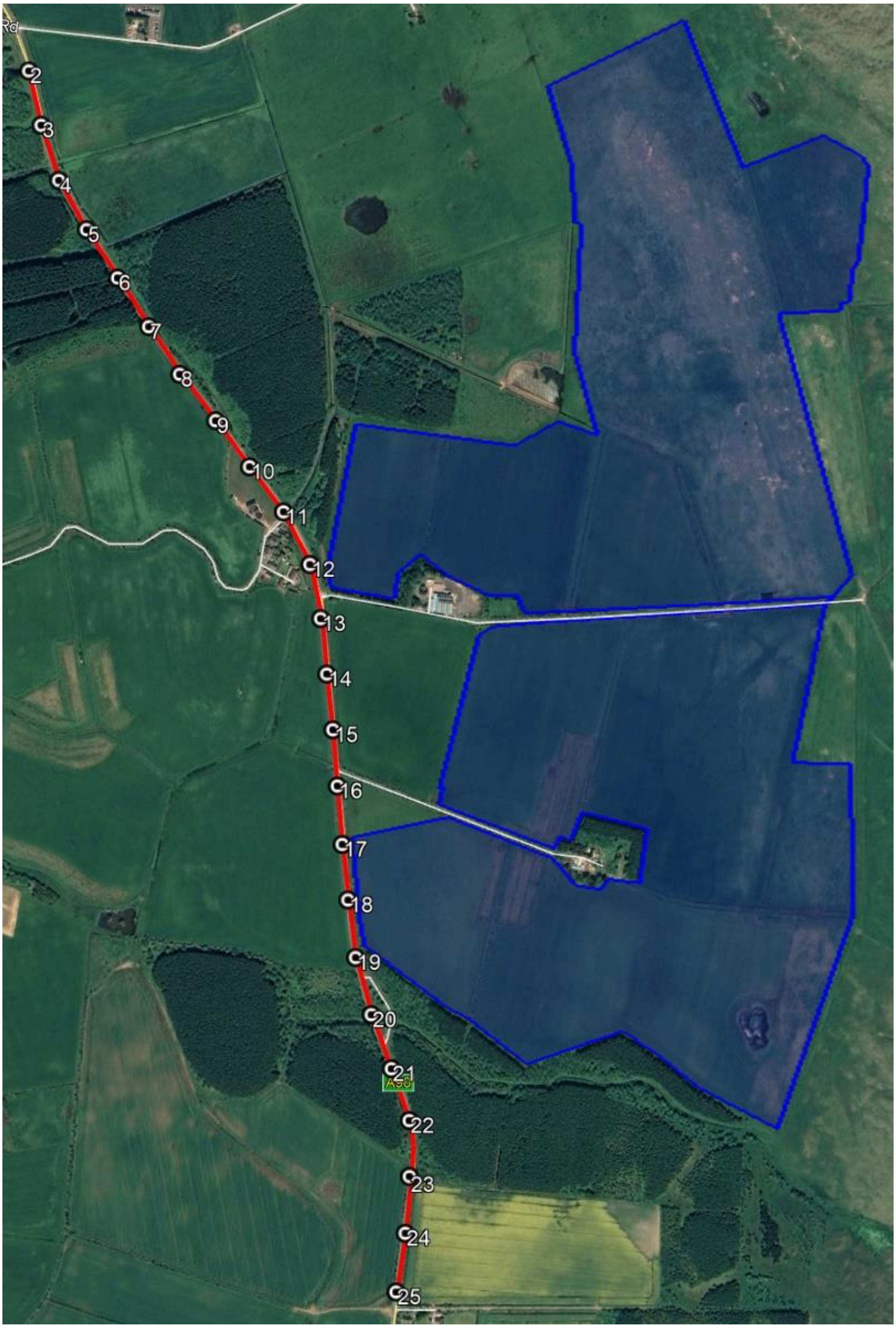

Figure 9 *Section of the A90 where solar reflections are geometrically possible– aerial image*

7.1.1 Further Discussion

Road receptors 2 – 13 are significantly screened by roadside vegetation, as shown in Figure 10[5] on the following page.

For road receptors 14 and 15, views of the reflecting panels may be possible despite partial screening in the form of vegetation, as shown in Figures 11 to 12[5]. The impact is moderate according to the guidance presented in Appendix D, however, no mitigation is required because the reflections occur outside of a driver's typical field of view in both directions of travel (50 degrees either side).

Road receptor 16 is significantly screened by roadside vegetation, as shown in Figure 13[5].

For road receptor 17, views of the reflecting panels may be possible despite partial screening in the form of vegetation, as shown in Figure 14[5]. The impact is moderate according to the guidance presented in Appendix D, however, no mitigation is required because the reflections occur outside of a driver's typical field of view in both directions of travel (50 degrees either side).

For road receptors 18 and 19, views of the reflecting panels may be possible despite partial screening in the form of vegetation, as shown in Figures 15 to 16[5]. The impact is moderate according to the guidance presented in Appendix D, however, no mitigation is required because:

a) the solar reflections will predominantly occur outside of a road user's field of view (only occur on the right edge of the field of view for a driver travelling northbound)
b) the solar reflections will only occur between 05:30 and 06:30 GMT when the level of road traffic on the A90 is likely to be much lower than other times of the day;
c) existing vegetation along the A90 will further reduce potential effects;
d) solar reflections will occur within approximately 3hrs of sunrise when the Sun is low in the sky beyond the reflecting panels. Therefore, an observer will possibly have a view of the sun within the same viewpoint of the reflecting solar panels. The Sun is a far more significant source of light.

Road receptors 20 – 25 are significantly screened by roadside vegetation, as shown in Figure 17[5].

Figure 10 *Significant vegetation screening (green highlighted area) for road receptors 2-13 – aerial image*

Figure 11 *View towards reflecting panels from road receptor 14 – street view image*

Figure 12 *View towards reflecting panels from road receptor 15 – street view image*

Figure 13 *Significant screening (green highlighted area) for road receptor 16 – aerial image*

Figure 14 *View towards reflecting panels from road receptor 17 – street view image*

Figure 15 *View towards reflecting panels from road receptor 18 – street view image*

Figure 16 *View towards reflecting panels from road receptor 19 – street view image*

Figure 17 *Significant screening (green highlighted area) for road receptors 20-25 – aerial image*

7.2 Dwelling Receptors

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

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

The modelling has shown that solar reflections are geometrically possible towards 11 (2 – 12) out of the 13 assessed dwelling receptors. The dwelling receptors towards which solar reflections are geometrically possible are highlighted in red in Figure 18[5] on the next page.

Following a conservative review of the available imagery, however, for five of these dwelling receptors, solar reflections are not predicted to be experienced in practice as the reflecting solar panels are expected to be significantly screened by intervening terrain, vegetation and/or buildings. The impact is low according to the guidance presented in Appendix D and no mitigation requirement has been identified.

For six dwellings receptors (5 – 7 and 10 – 12), views of reflecting panels may be possible based despite partial screening in the form of intervening terrain and/or vegetation. Solar reflections occur for more than 3 months and for less than 60 minutes per day. The impact is moderate according to the guidance presented in Appendix D. The results for these receptors are further discussed in 7.2.1.

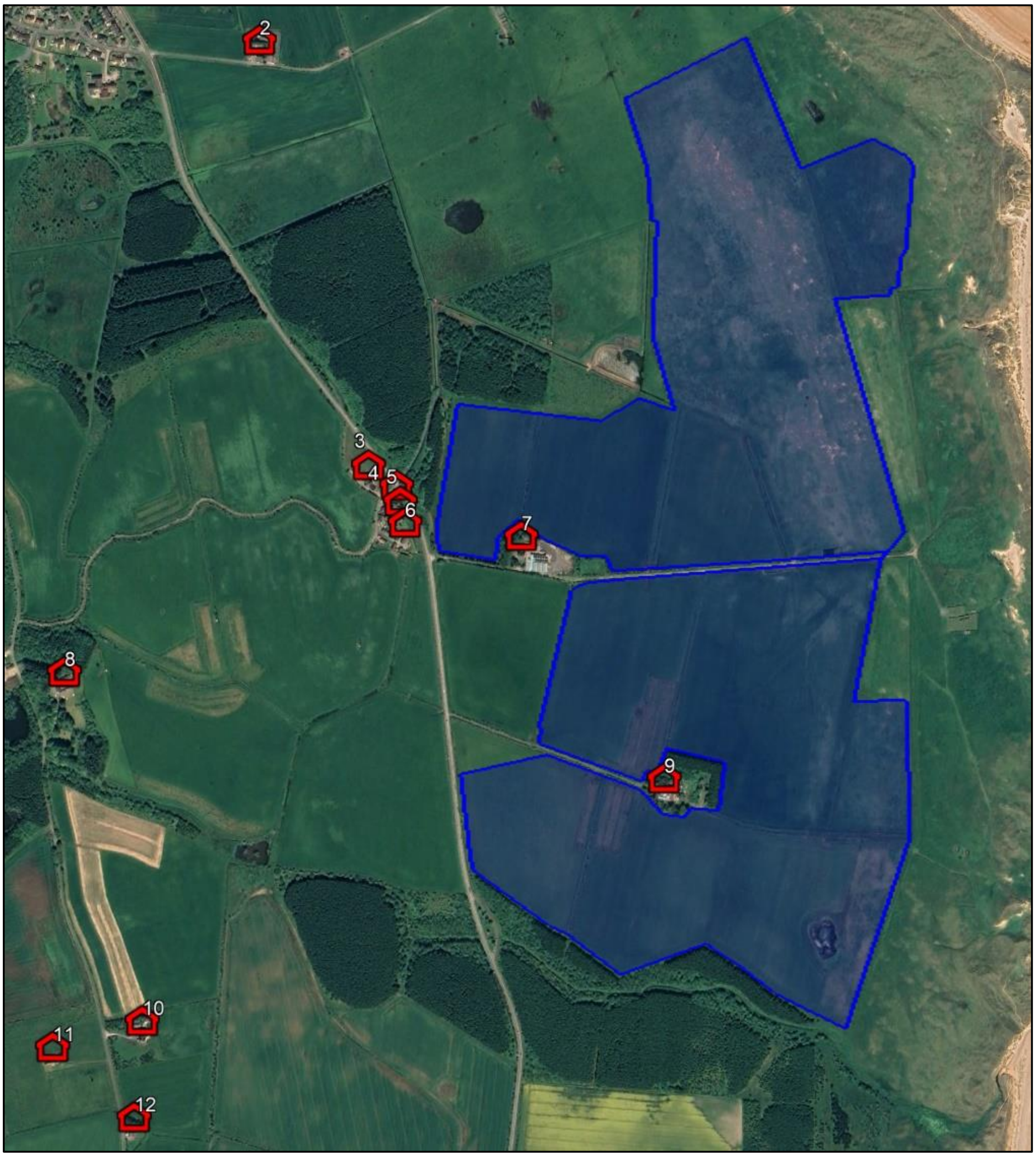

Figure 18 *Dwelling receptors towards which solar reflections are geometrically possible– aerial image*

7.2.1 Further Discussion

Dwelling receptor 2 is significantly screened by vegetation immediately to the east, as shown in Figures 19 to 20[5]. The impact is low according to the guidance presented in Appendix D and no mitigation requirement has been identified.

Dwelling receptors 3 and 4 are significantly screened by vegetation alongside the A90, as shown in Figure 21[5]. The impact is low according to the guidance presented in Appendix D and no mitigation requirement has been identified.

For dwelling receptors 5 and 6, views of the reflecting panels may be possible despite partial screening in the form of vegetation, as shown in Figures 22 to 23[5]. Solar reflections occur for more than 3 months and for less than 60 minutes per day. The impact is moderate according to the guidance presented in Appendix D, and the following is true:

a) solar reflections will occur within approximately 3hrs of sunrise when the Sun is low in the sky beyond the reflecting panels. Therefore, an observer will possibly have a view of the sun within the same viewpoint of the reflecting solar panels. The Sun is a far more significant source of light;
b) existing vegetation along the A90 will further reduce potential effects.

Since it cannot be reliably concluded that the views are currently obscured, mitigation is recommended. It should be ensured that visibility of the reflecting area is obscured from these dwellings. It is possible that a site survey would reveal that views are already obscured, in which case no further action would be necessary. If views remain, it is recommended that mitigation is applied to address the potential impact. A high-level overview of recommended mitigation is presented in section 7.3. Further to the implementation of the recommended mitigation, no impact is predicted. The reflecting areas of concern are shown in Figures 24 to 25 respectively.

For dwelling receptor 7, views of the reflecting panels may be possible despite partial screening in the form of vegetation, as shown in Figure 26[5]. Solar reflections occur for more than 3 months and for less than 60 minutes per day. The impact is moderate according to the guidance presented in Appendix D, and the following is true:

a) this receptor is significantly screened from the west by trees;
b) the receptor is screened from the east, it is unclear from available imagery how significant the screening is but it will further reduce potential effects;
c) solar reflections will occur within approximately 3hrs of sunrise and sunset when the Sun is low in the sky beyond the reflecting panels. Therefore, an observer will possibly have a view of the sun within the same viewpoint of the reflecting solar panels. The Sun is a far more significant source of light;

Since it cannot be reliably concluded that the views are currently obscured, mitigation is recommended. It should be ensured that visibility of the reflecting area is obscured from these dwellings. It is possible that a site survey would reveal that views are already obscured, in which case no further action would be necessary. If views remain, it is recommended that mitigation is applied to address the potential impact. A high-level overview of recommended mitigation is presented in section 7.3. Further to the implementation of the recommended mitigation, no impact is predicted. The reflecting area of concern is shown in Figure 27.

Dwelling receptor 8 is significantly screened by intervening terrain to the east. The impact is low according to the guidance presented in Appendix D and no mitigation requirement has been identified.

Dwelling receptor 9 is significantly screened by vegetation, as shown in Figure 28[5]. The impact is low according to the guidance presented in Appendix D and no mitigation requirement has been identified.

For dwelling receptors 10 – 12, views of the reflecting panels may be possible despite partial screening in the form of intervening terrain and vegetation. Solar reflections occur for more than

3 months and for less than 60 minutes per day. The impact is moderate according to the guidance presented in Appendix D, however, no mitigation is required because:

a) the separation distance between these dwellings and the nearest reflecting panel is at least 700m;

b) intervening terrain and vegetation will further reduce potential effects.

c) solar reflections will occur within approximately 3hrs of sunrise when the Sun is low in the sky beyond the reflecting panels. Therefore, an observer will possibly have a view of the sun within the same viewpoint of the reflecting solar panels. The Sun is a far more significant source of light.

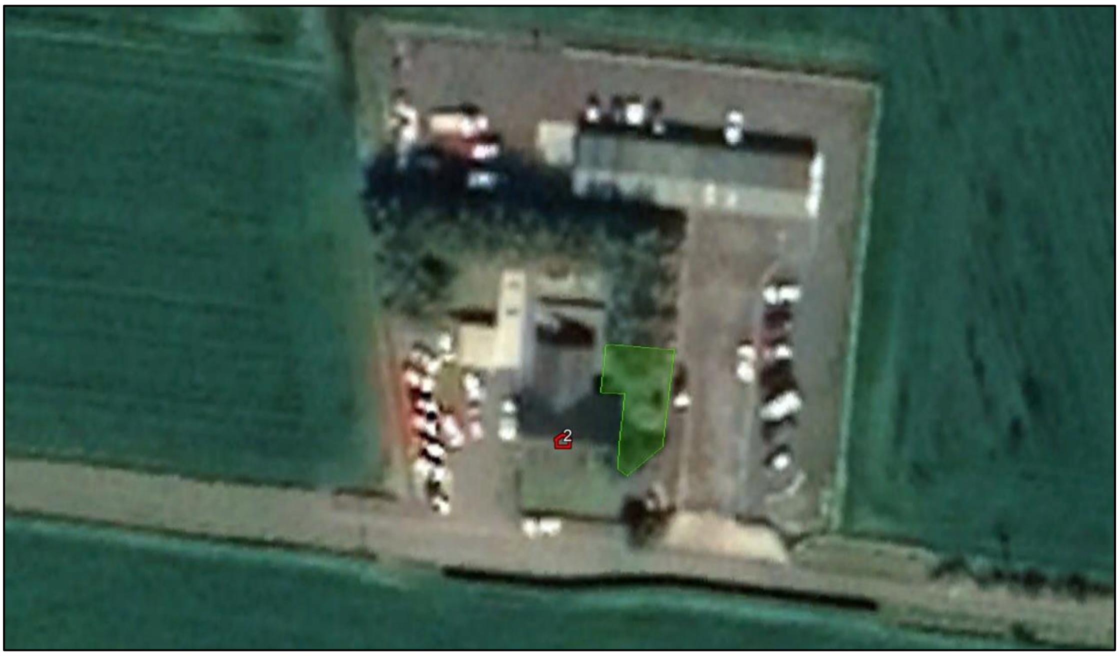

Figure 19 *Significant vegetation screening (green highlighted area) for dwelling receptor 2 – aerial image*

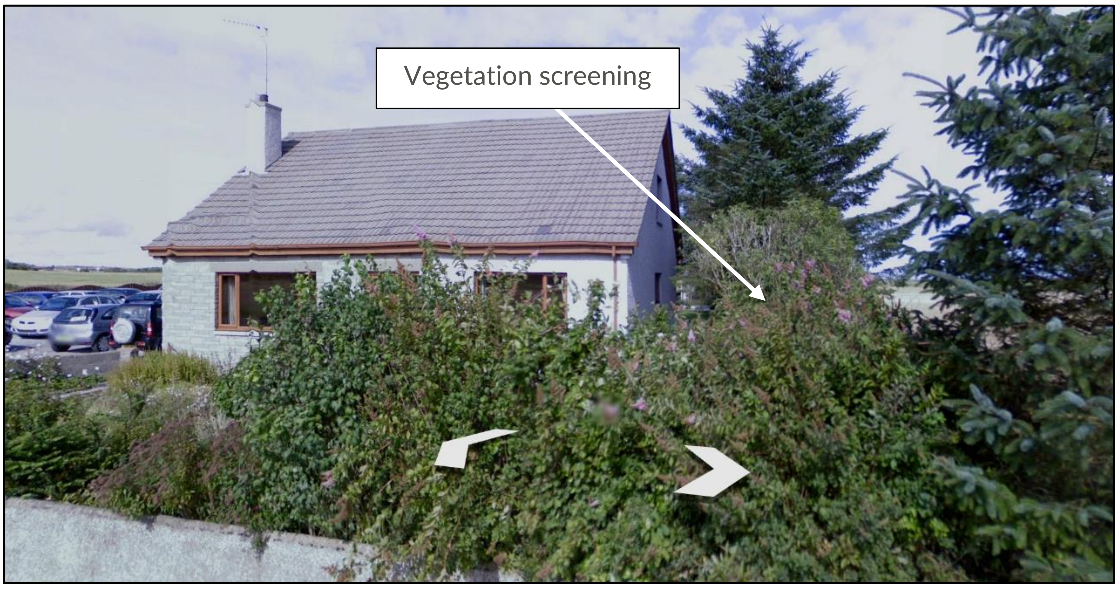

Figure 20 *Significant vegetation screening (green highlighted area) for dwelling receptor 2 – street view image*

Figure 21 *Significant vegetation screening (green highlighted area) for dwelling receptors 3-4 – aerial image*

Figure 22 *Partial vegetation screening between reflecting panels and dwelling receptors 5-6 – street view image*

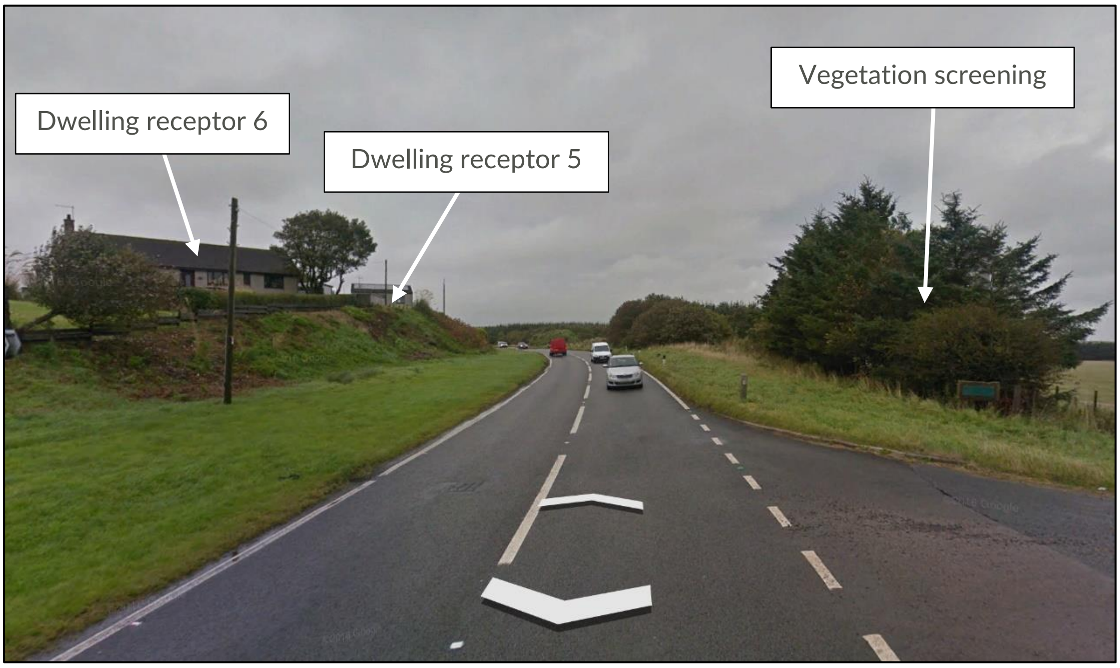

Figure 23 *Partial vegetation screening between reflecting panels and dwelling receptors 5-6 – street view image*

Figure 24 *Reflecting panel area for dwelling receptor 5 – aerial image*

Figure 25 *Reflecting panel area for dwelling receptor 6 – aerial image*

Figure 26 *Significant vegetation screening (green highlighted area) and partial screening (red area) for dwelling receptor 7 – aerial image*

Figure 27 *Reflecting panel areas for dwelling receptor 7 – aerial image*

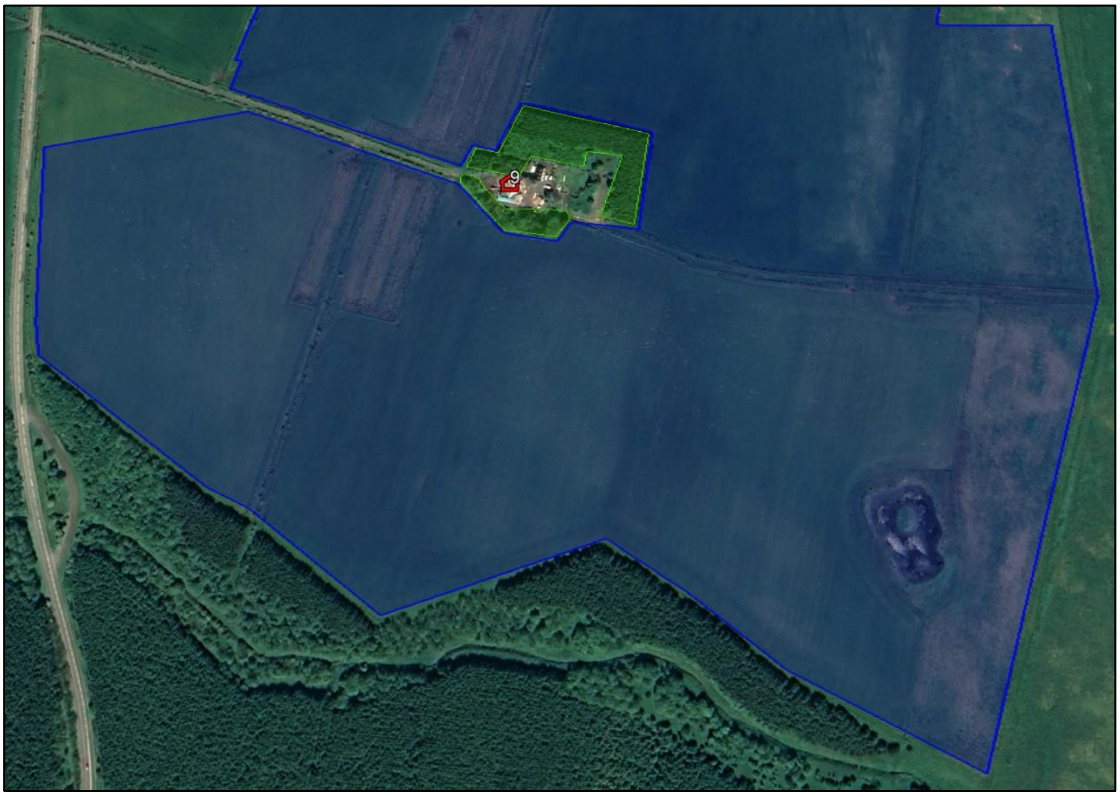

Figure 28 *Significant vegetation screening (green highlighted area) for dwelling receptor 9 – aerial image*

7.3 High-Level Mitigation Recommendation

Figure 29[5] below presents the overall mitigation recommendation (pink lines) located near the site boundary. This relates to dwelling receptors 5, 6 and 7, where mitigation has been recommended in the form of new planting.

The height of this planting should be managed such that views of the reflecting panels are sufficiently obstructed. The required height will depend on the relative elevation of the receptors, the base of the planting itself, and the reflecting panels. Consideration of this should inform the landscaping / LVIA aspect of the proposal.

Further to the implementation of the recommended mitigation, no impact is predicted.

Figure 29 *Mitigation recommendation (pink lines), proposed development (blue area) and site boundary (red line)*

8 OVERALL CONCLUSIONS

8.1 Conclusions

Solar reflections are geometrically possible towards a section of the A90 to the west of the proposed solar development. However, the reflecting solar panels are either significantly screened, or where a moderate impact is predicted, the reflections largely occur outside of a driver's typical field of view in both directions of travel. No mitigation requirement has therefore been identified.

Solar reflections are geometrically possible towards 11 out of the 13 assessed dwellings near the proposed solar development. For eight of these dwellings, the reflecting solar panels are either significantly screened or where a moderate impact is predicted, there are significant mitigating factors such as the separation distance between the dwellings and the nearest reflecting panels, and the time of day that the reflections occur. No mitigation requirement has therefore been identified.

For three dwellings, views of reflecting panels may be possible despite partial screening. A moderate impact is predicted, and since it cannot be reliably concluded that the views are currently obscured, mitigation is recommended (see section 7.3). It is possible that a site survey would reveal that views are already obscured, in which case no further action would be necessary. Further to the implementation of the recommended mitigation, no impact is predicted.

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[6] (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 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

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

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

[7] Solar Photovoltaic Development – Glint and Glare Guidance, Third Edition, December 2020. Pager Power.

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

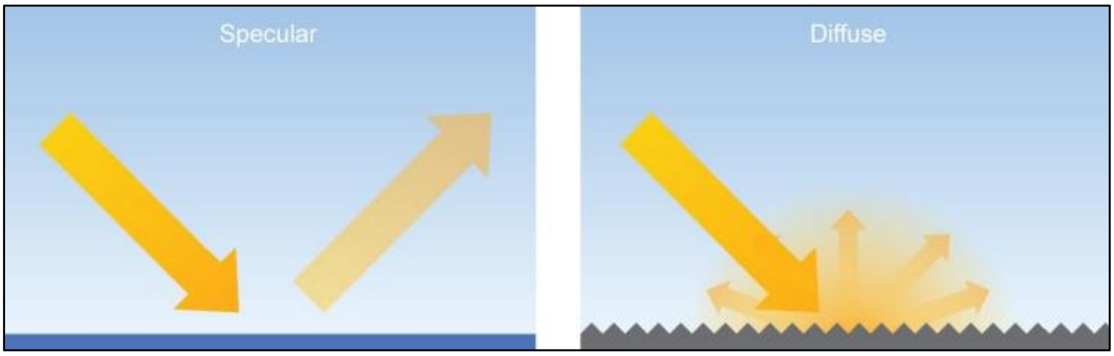
Overview

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

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

Reflection Type from Solar Panels

Based on the surface conditions reflections from light can be specular and diffuse. A specular reflection has a reflection characteristic similar to that of a mirror; a diffuse will reflect the incoming light and scatter it in many directions. The figure below, taken from the FAA guidance[8], 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

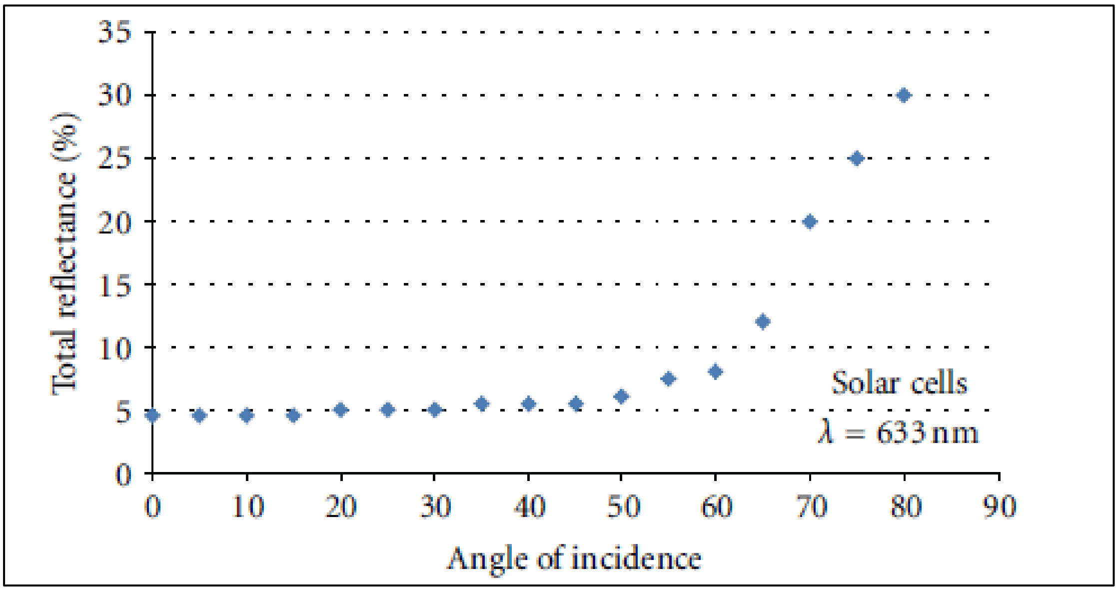
[8] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.

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*[9]". 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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[9] 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"[10]

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[11]
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.

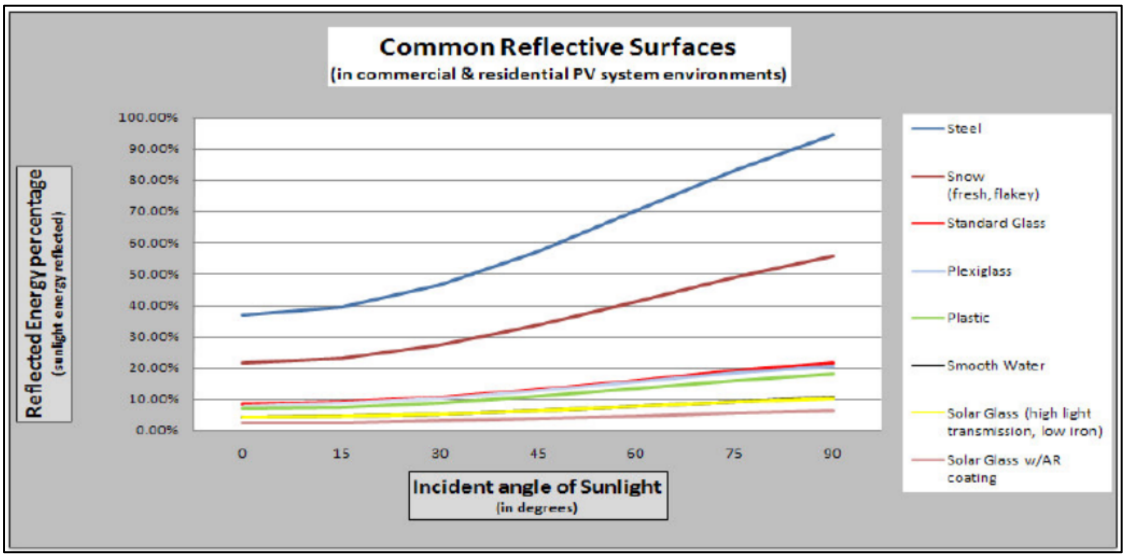
The study by Riley and Olsen study (2011) also concludes that still water has a very similar reflectivity to solar panels.

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

SunPower Technical Notification (2009)

SunPower published a technical notification[12] 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.

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

APPENDIX C – OVERVIEW OF SUN MOVEMENTS AND RELATIVE REFLECTIONS

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

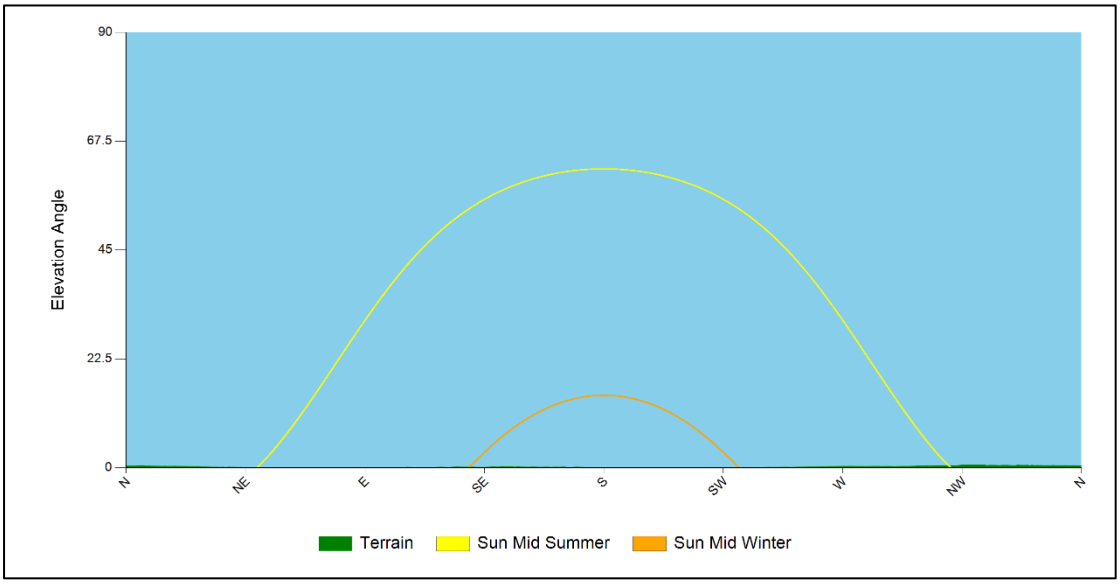
The Sun's position can be accurately calculated for a specific location. The following data being used for the calculation:

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

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

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

The combination of the Sun's azimuth angle and vertical elevation will affect the direction and angle of the reflection from a reflector. The figure below shows terrain at the horizon as well as the sunrise and sunset curves throughout the year from lon: -2.030903 lat: 51.660144.



Terrain elevation at the horizon

APPENDIX D – GLINT AND GLARE IMPACT SIGNIFICANCE

Overview

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

Impact Significance Definition

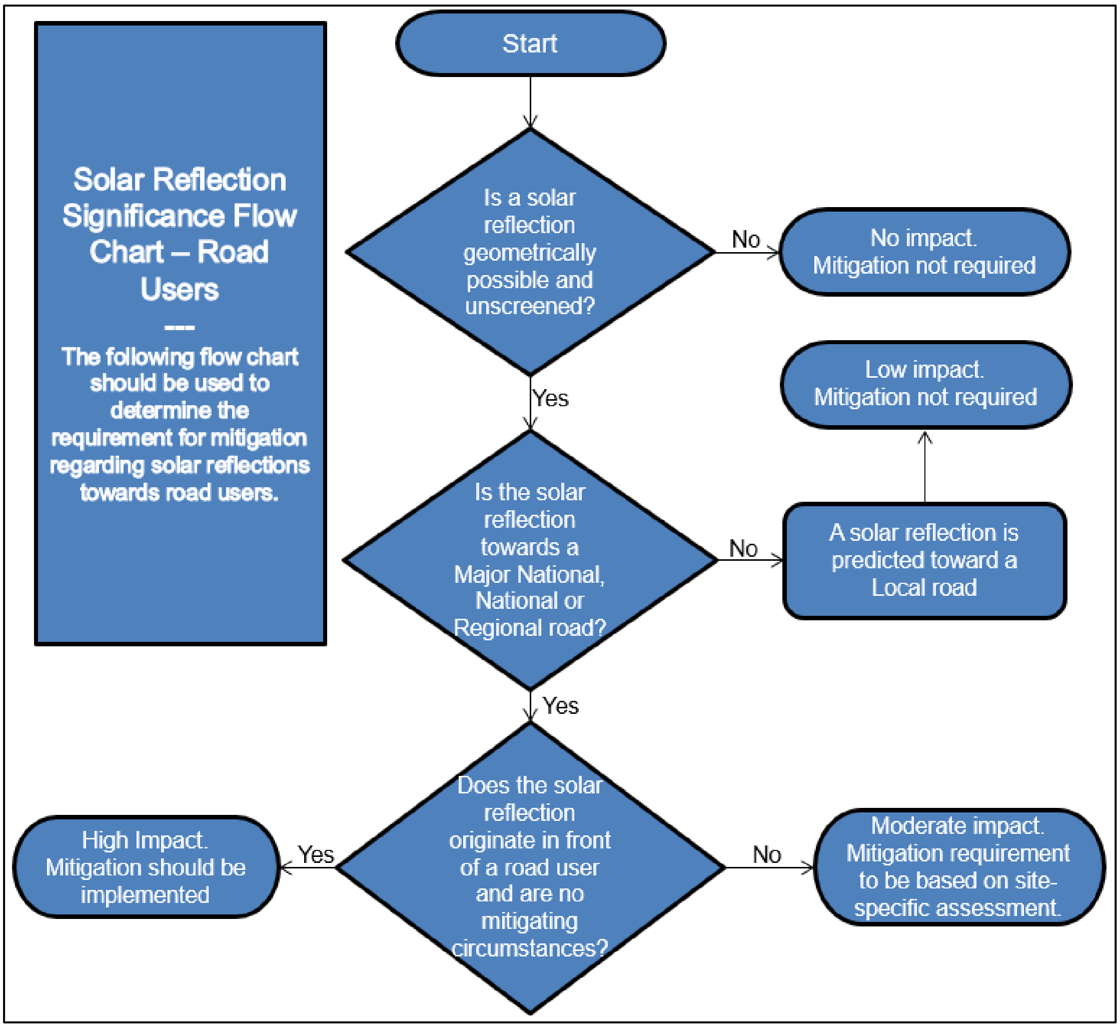
The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

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

Impact significance definition

Assessment Process for Road Receptors

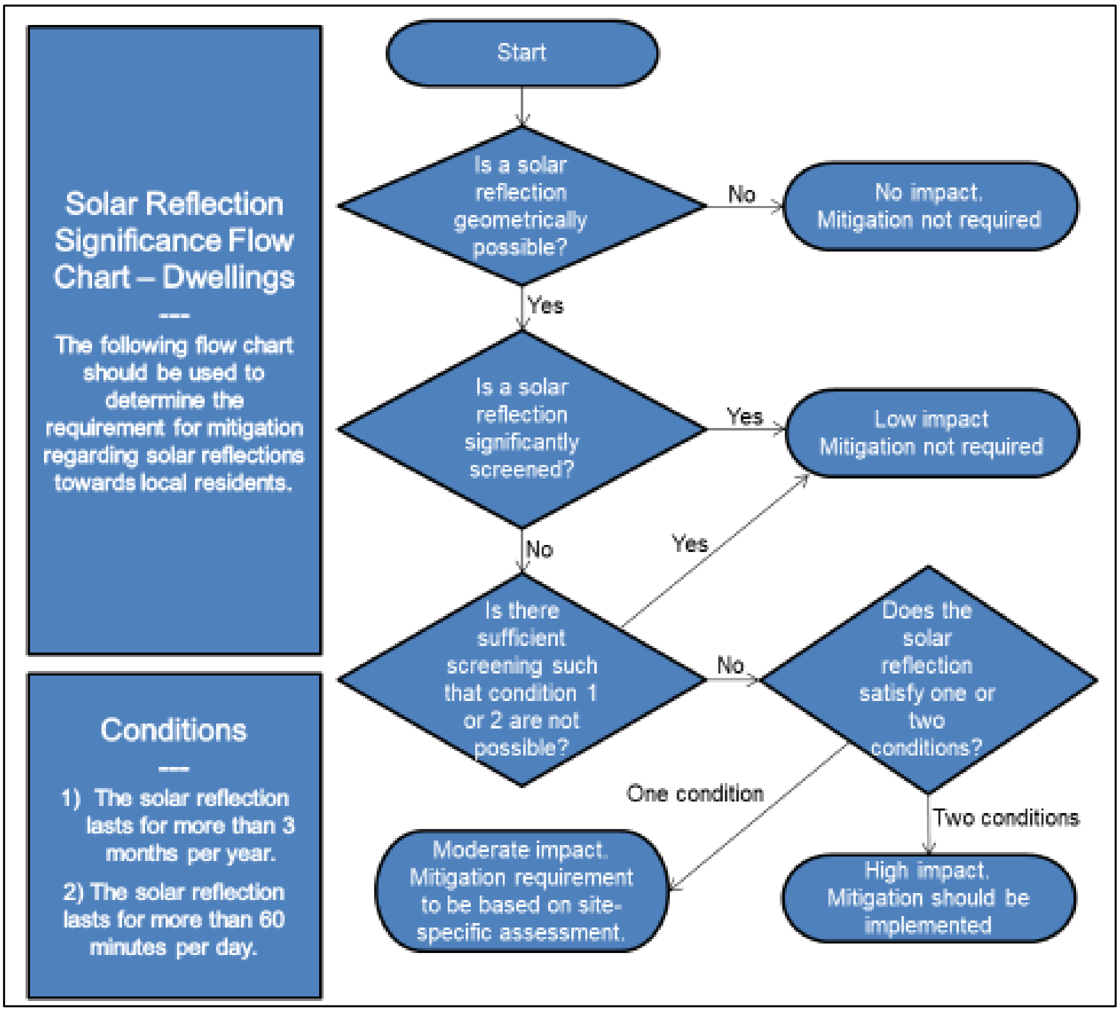
The flow chart presented below has been followed when determining the mitigation requirement for road receptors.



Road receptor mitigation requirement flow chart

Assessment Process for Dwelling Receptors

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



Dwelling receptor mitigation requirement flow chart

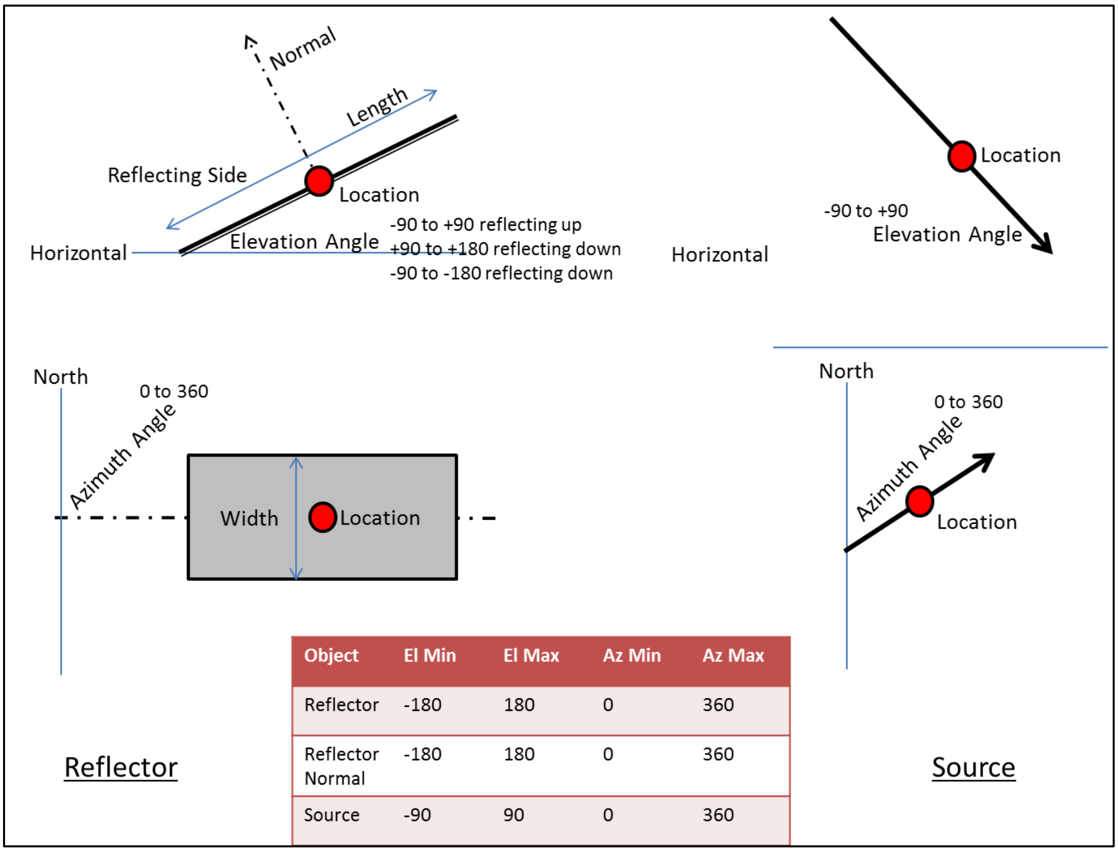
APPENDIX E – REFLECTION CALCULATIONS METHODOLOGY

Pager Power'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.



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

The model considers 100% sunlight during daylight hours which is highly conservative.

The model does not account for terrain between the reflecting solar panels and the assessed receptor where a solar reflection is geometrically possible.

The model considers terrain between the reflecting solar panels and the visible horizon (where the sun may be obstructed from view of the panels)[13].

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

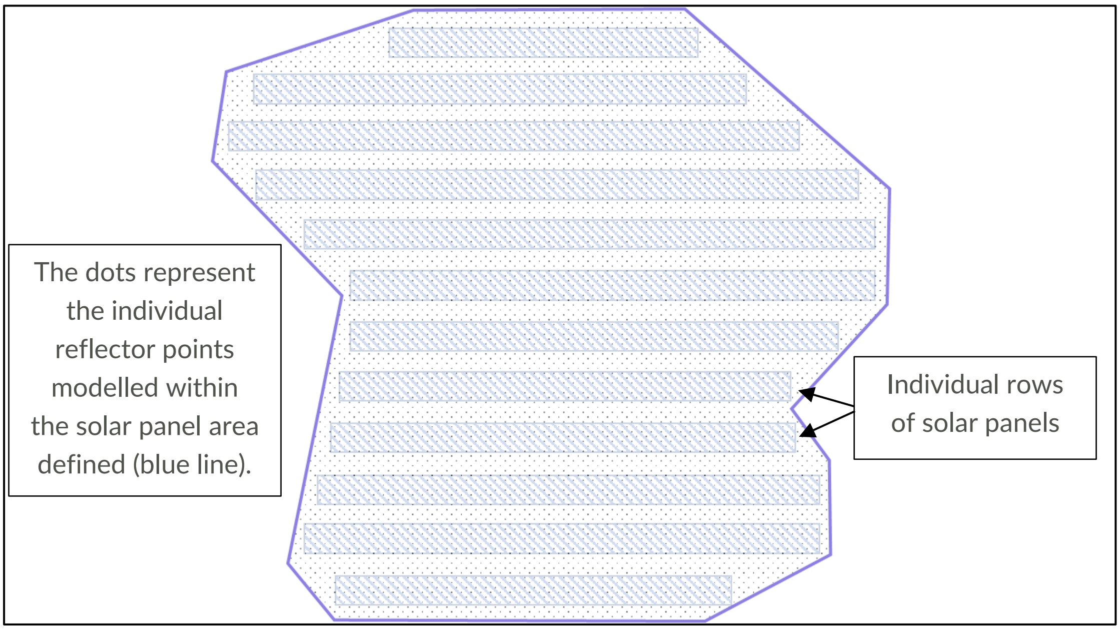
It is assumed that the panel azimuth angle assessed represents the azimuth angle for all of the panels within each solar panel area defined.

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

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

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

[13] UK only.



Solar panel area modelling overview

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

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

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

APPENDIX G – RECEPTOR AND REFLECTOR AREA DETAILS

Terrain Height

Terrain Height was calculated from Pager Power's database (established on OS Panorama 50m DTM) based on the coordinates of the point of interest.

Road Receptor Data

The table below presents the coordinates for the assessed road receptors.

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
1	-1.83542	57.55728	16	-1.82551	57.54495
2	-1.83475	57.55642	17	-1.82536	57.54401
3	-1.83439	57.55555	18	-1.82519	57.54312
4	-1.83386	57.55467	19	-1.82497	57.54220
5	-1.83303	57.55387	20	-1.82450	57.54128
6	-1.83209	57.55310	21	-1.82390	57.54042
7	-1.83116	57.55231	22	-1.82337	57.53959
8	-1.83023	57.55154	23	-1.82336	57.53870
9	-1.82915	57.55080	24	-1.82349	57.53779
10	-1.82814	57.55006	25	-1.82376	57.53685
11	-1.82712	57.54934	26	-1.82392	57.53596
12	-1.82633	57.54849	27	-1.82418	57.53506
13	-1.82601	57.54763	28	-1.82437	57.53414
14	-1.82582	57.54674	29	-1.82465	57.53323
15	-1.82564	57.54585	30	-1.82487	57.53238

Road Receptor Data

Dwelling Receptor Data

The table below presents the coordinates for the assessed dwelling receptors.

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
1	-2.498160	52.688616	8	-2.497891	52.683040
2	-2.497753	52.687953	9	-2.498649	52.682112
3	-2.497309	52.687809	10	-2.499817	52.681578
4	-2.497638	52.687151	11	-2.500064	52.677424
5	-2.497553	52.686477	12	-2.499811	52.674131
6	-2.497980	52.685178	13	-2.499711	52.672556
7	-2.497542	52.684016			

Dwelling Receptor Data

Panel Boundary Data

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
1	-1.81934	57.55618	32	-1.81860	57.54406
2	-1.81864	57.55489	33	-1.81821	57.54446
3	-1.81849	57.55392	34	-1.81628	57.54421
4	-1.81832	57.55389	35	-1.81655	57.54337
5	-1.81853	57.55183	36	-1.81746	57.54341
6	-1.81790	57.55059	37	-1.81771	57.54327
7	-1.81896	57.55081	38	-1.81843	57.54333
8	-1.82032	57.55040	39	-1.81910	57.54376
9	-1.82507	57.55074	40	-1.82225	57.54441
10	-1.82583	57.54863	41	-1.82516	57.54411
11	-1.82574	57.54809	42	-1.82475	57.54237

12	-1.82380	57.54790	43	-1.81988	57.54045
13	-1.82367	57.54834	44	-1.81704	57.54096
14	-1.82335	57.54843	45	-1.81239	57.53941
15	-1.82307	57.54860	46	-1.81012	57.54285
16	-1.82261	57.54840	47	-1.81014	57.54528
17	-1.82238	57.54836	48	-1.81192	57.54529
18	-1.82231	57.54829	49	-1.81091	57.54780
19	-1.82113	57.54797	50	-1.81012	57.54830
20	-1.82014	57.54793	51	-1.81228	57.55250
21	-1.82013	57.54768	52	-1.81037	57.55262
22	-1.81079	57.54795	53	-1.81035	57.55269
23	-1.81097	57.54784	54	-1.81017	57.55269
24	-1.81999	57.54751	55	-1.81007	57.55316
25	-1.82096	57.54744	56	-1.80987	57.55331
26	-1.82128	57.54735	57	-1.80962	57.55477
27	-1.82252	57.54489	58	-1.80983	57.55506
28	-1.82240	57.54490	59	-1.81014	57.55518
29	-1.82249	57.54462	60	-1.81105	57.55538
30	-1.81910	57.54387	61	-1.81334	57.55490
31	-1.81895	57.54408	62	-1.81513	57.55724

Panel Boundary Data

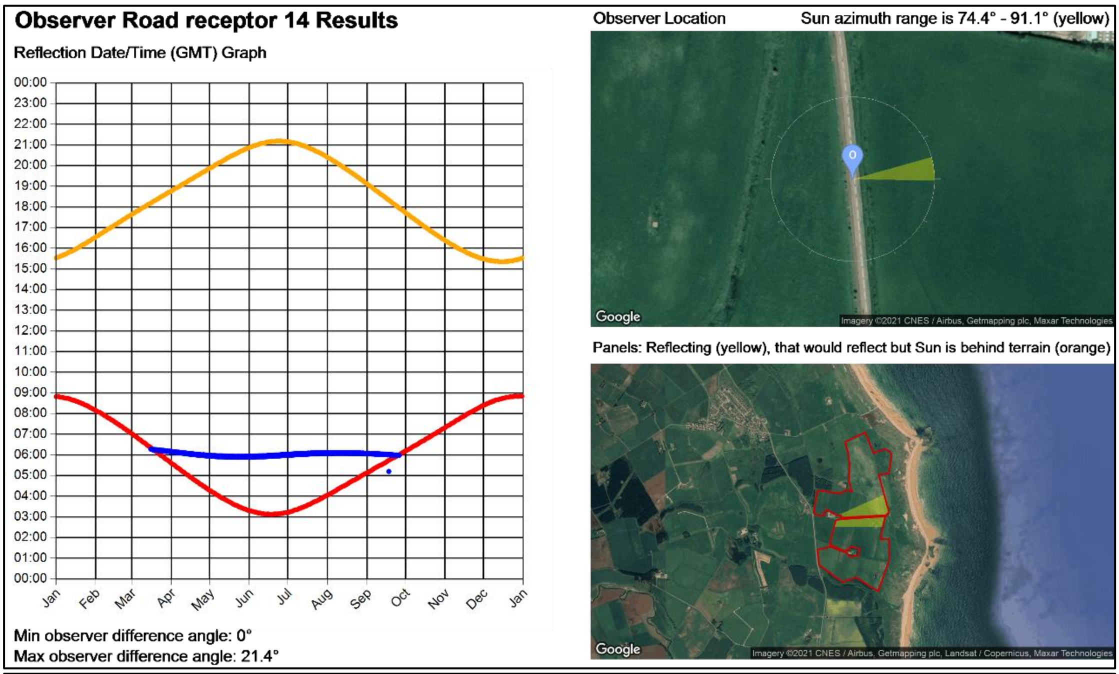
APPENDIX H – DETAILED MODELLING RESULTS

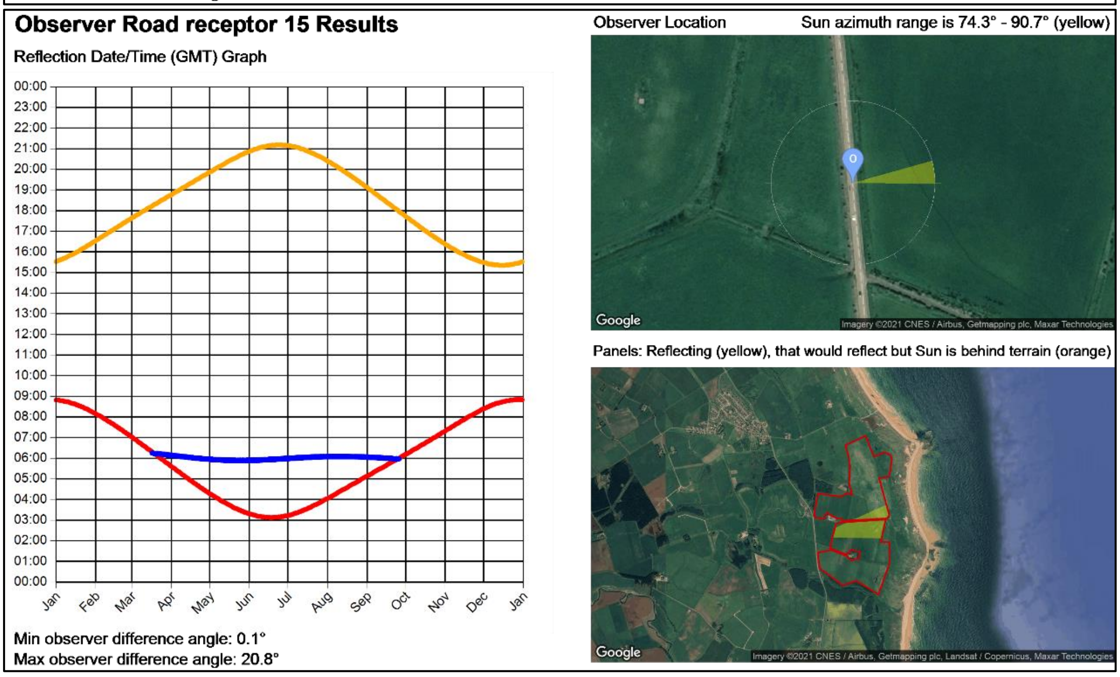
Overview

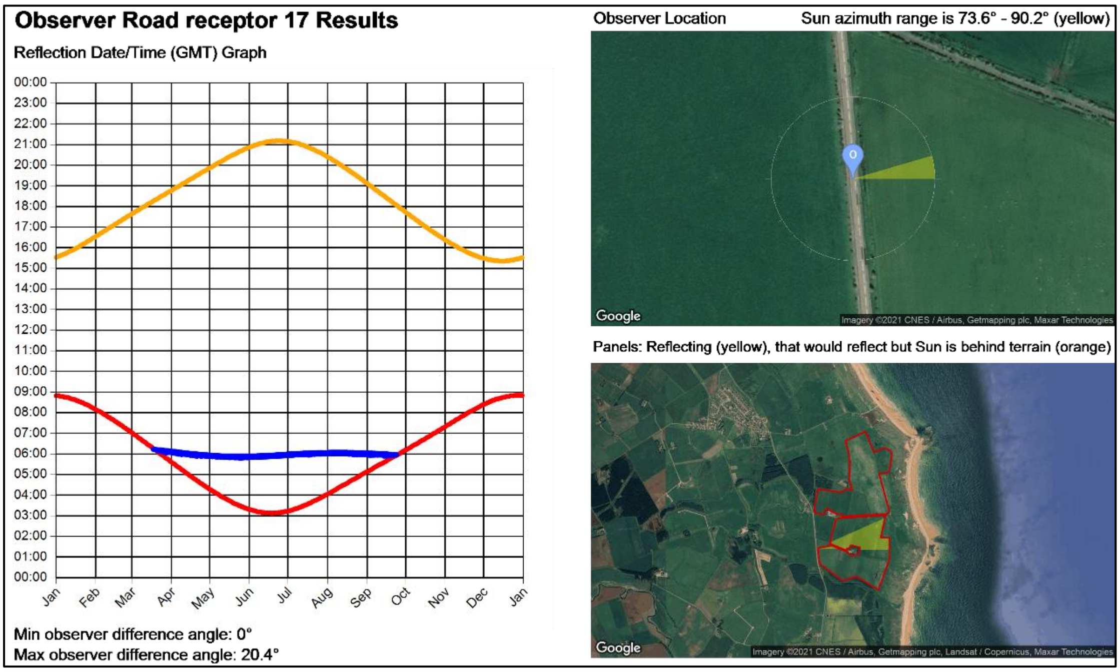
The charts for the potentially affected receptors are shown on the following pages for completeness. Each chart shows:

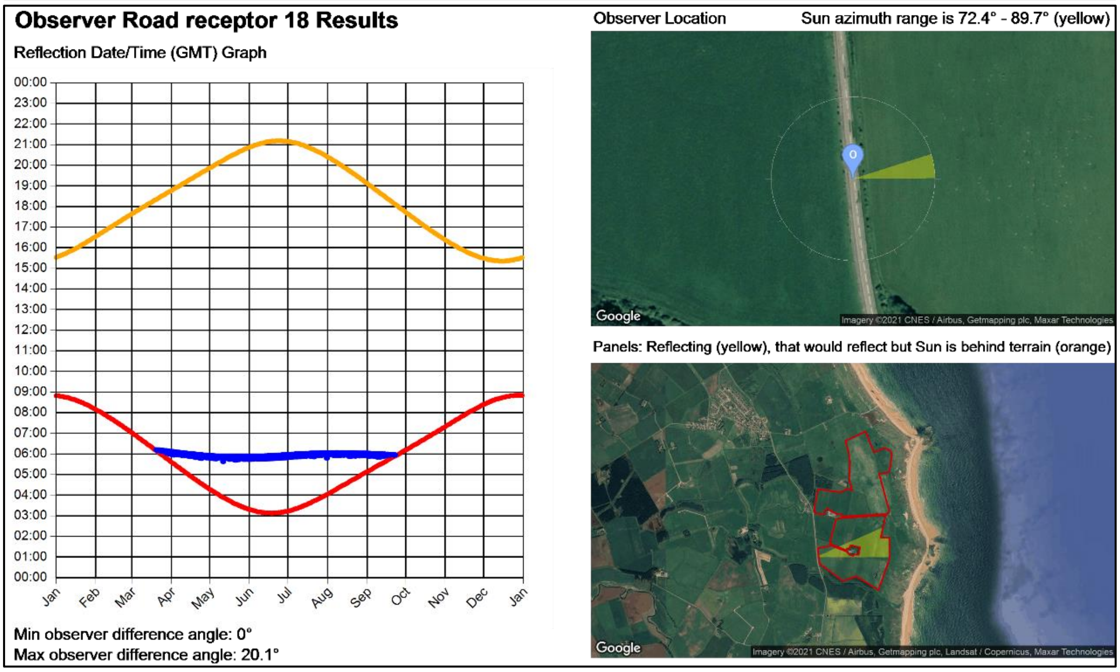
- The receptor (observer) location – top right image. This also shows the azimuth range of the Sun itself at times when reflections are possible. If sunlight is experienced from the same direction as the reflecting panels, the overall impact of the reflection is reduced as discussed within the body of 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).

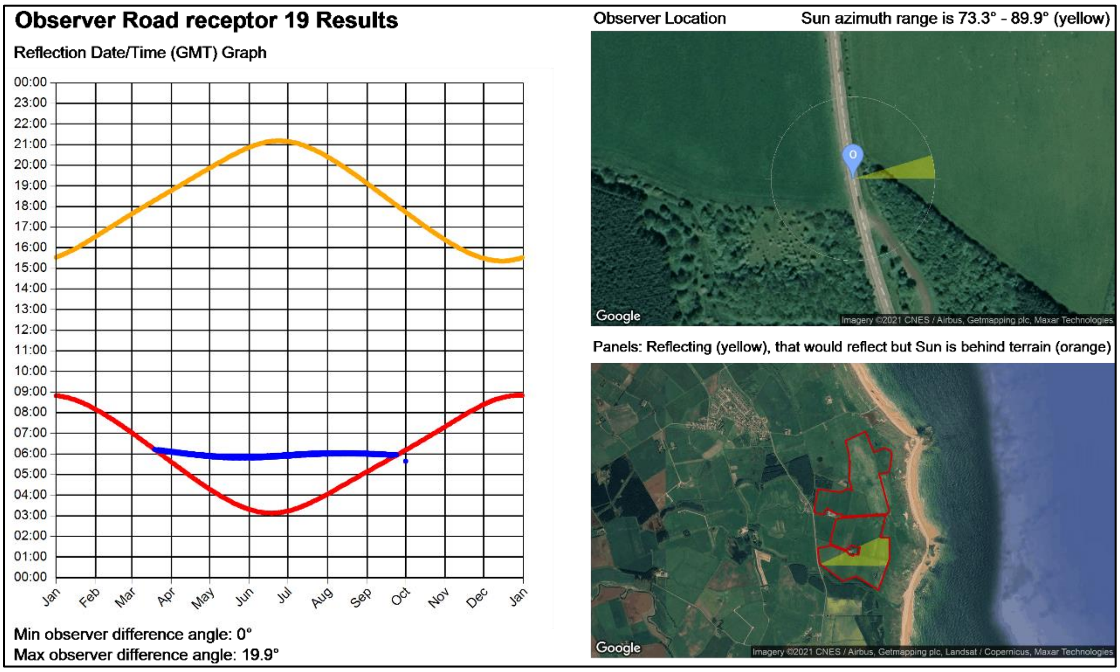
Road Receptors



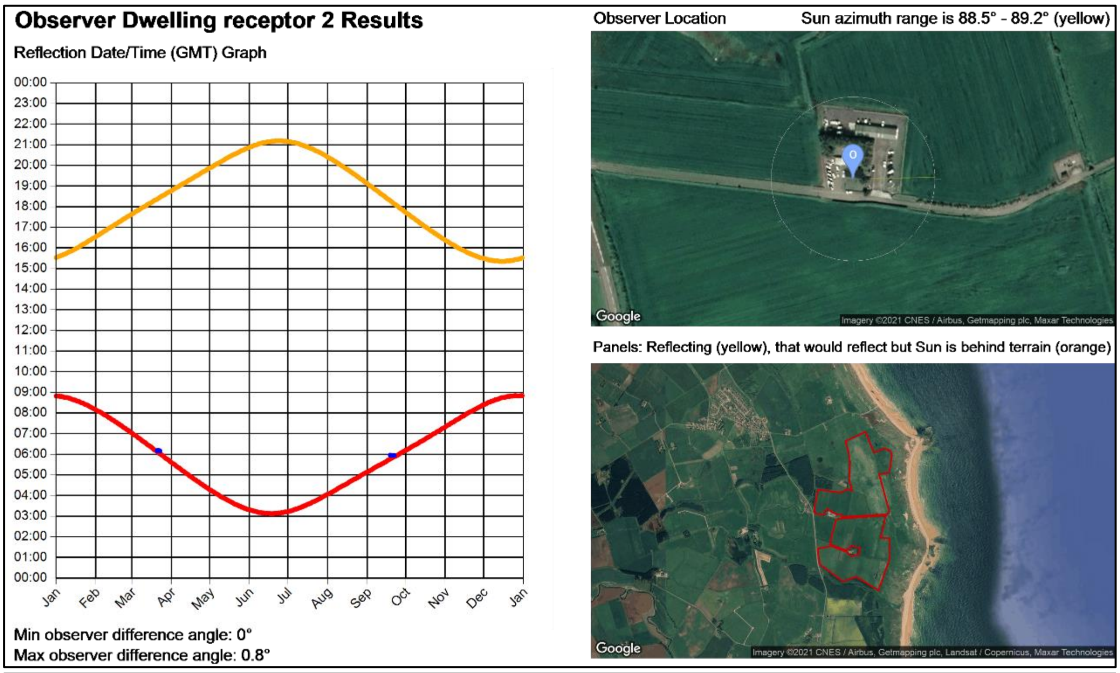


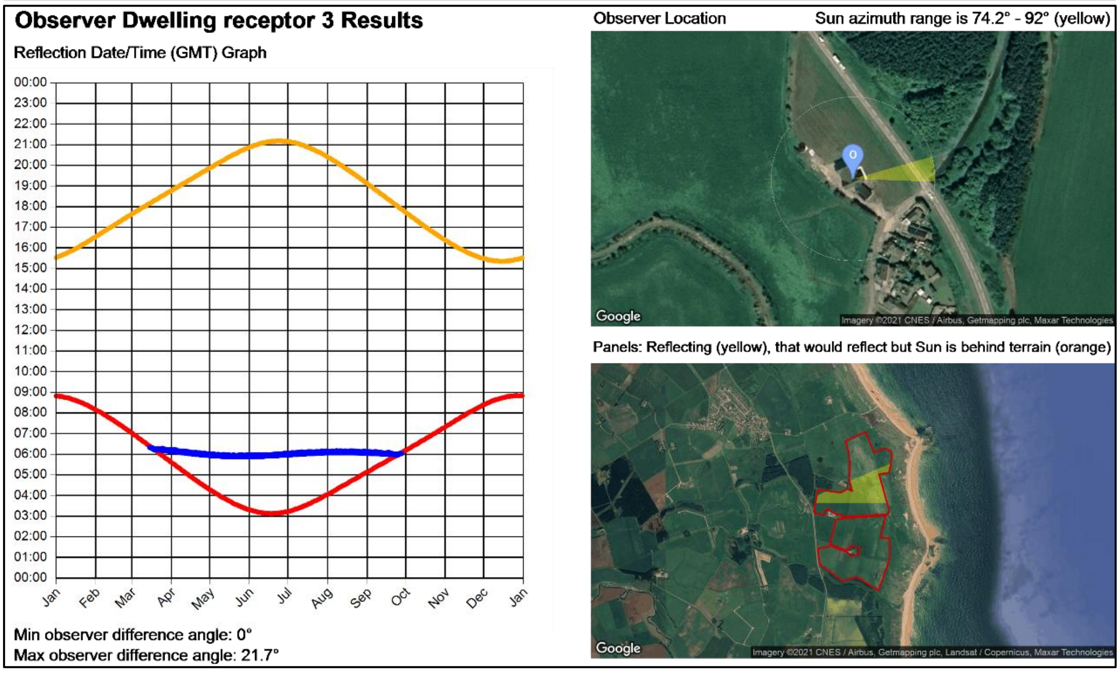

Observer Road receptor 17 Results
Reflection Date/Time (GMT) Graph
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0°
Max observer difference angle: 20.4°
Observer Location
Sun azimuth range is 73.6° - 90.2° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer Road receptor 18 Results
Reflection Date/Time (GMT) Graph
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0°
Max observer difference angle: 20.1°
Observer Location
Sun azimuth range is 72.4° - 89.7° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer Road receptor 19 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 0°
Max observer difference angle: 19.9°
Observer Location
Sun azimuth range is 73.3° - 89.9° (yellow)
Google
Imagery ©2021 CNES / Airbus, Getmapping plc, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2021 CNES / Airbus, Getmapping plc, Landsat / Copernicus, Maxar Technologies

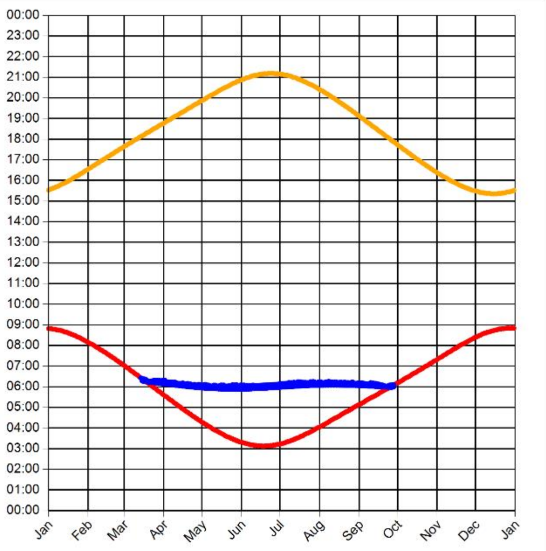
Dwelling Receptors





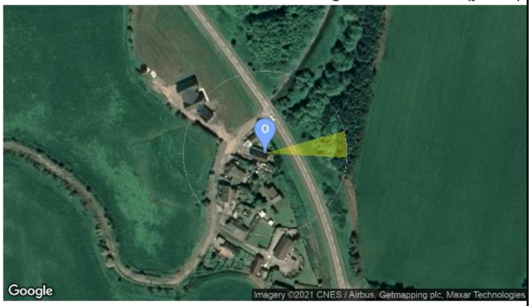
Observer Dwelling receptor 4 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.1°
Max observer difference angle: 23.9°

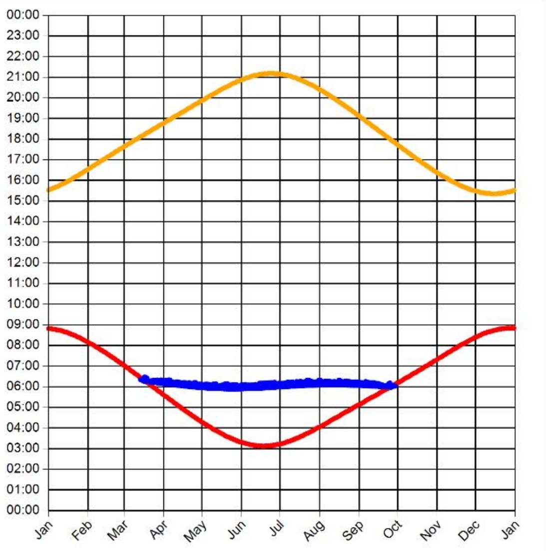
Observer Location Sun azimuth range is 74.4° - 93.3° (yellow)



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

Observer Dwelling receptor 5 Results

Reflection Date/Time (GMT) Graph



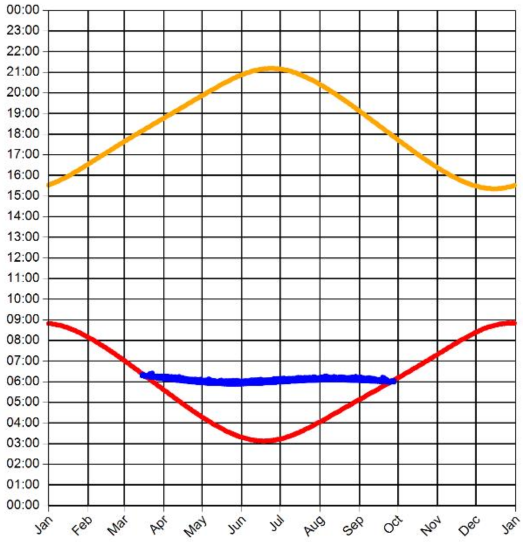
Min observer difference angle: 0.1°
Max observer difference angle: 26.1°

Observer Location Sun azimuth range is 74.5° - 93.4° (yellow)

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

Observer Dwelling receptor 6 Results

Reflection Date/Time (GMT) Graph



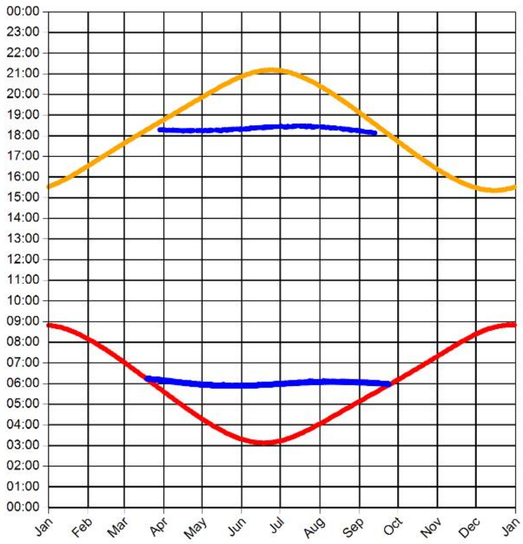
Min observer difference angle: 0.2°
Max observer difference angle: 24.4°

Observer Location — Sun azimuth range is 74.5° - 92.2° (yellow)

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

Observer Dwelling receptor 7 Results

Reflection Date/Time (GMT) Graph



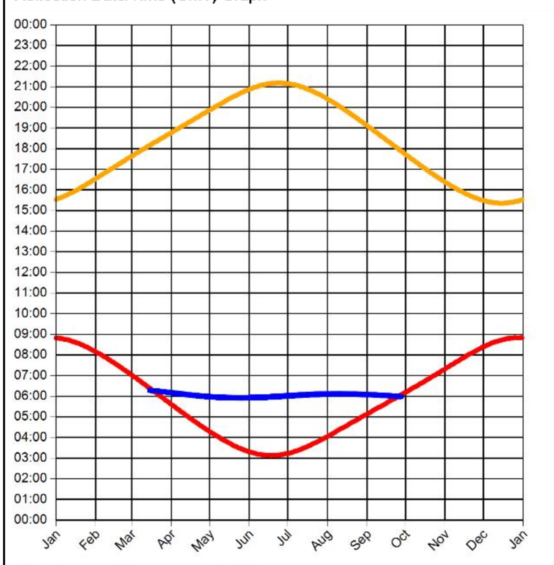
Min observer difference angle: 0.1°
Max observer difference angle: 21.1°

Observer Location — Sun azimuth ranges (yellow)

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

Observer Dwelling receptor 8 Results

Reflection Date/Time (GMT) Graph



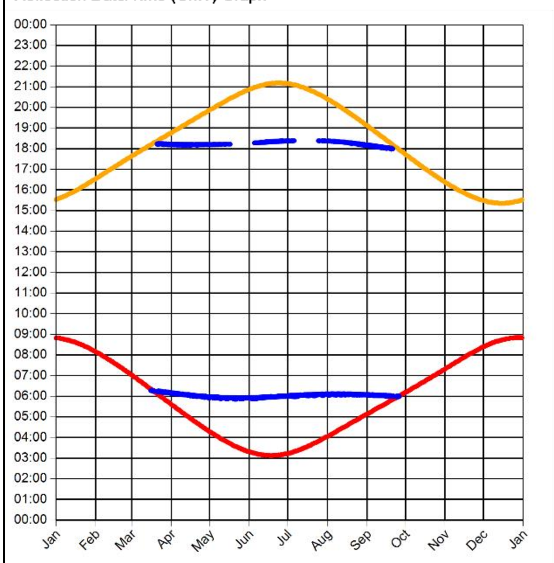
Min observer difference angle: 0°
Max observer difference angle: 21.6°

Observer Location — Sun azimuth range is 74.6° - 91.5° (yellow)

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

Observer Dwelling receptor 9 Results

Reflection Date/Time (GMT) Graph



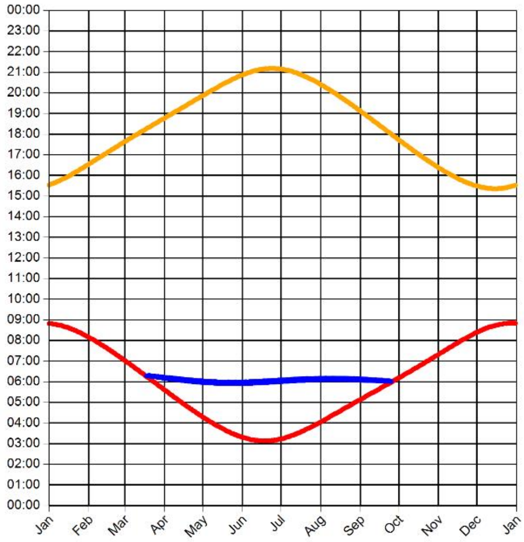
Min observer difference angle: 0.1°
Max observer difference angle: 21.4°

Observer Location — Sun azimuth ranges (yellow)

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

Observer Dwelling receptor 10 Results

Reflection Date/Time (GMT) Graph



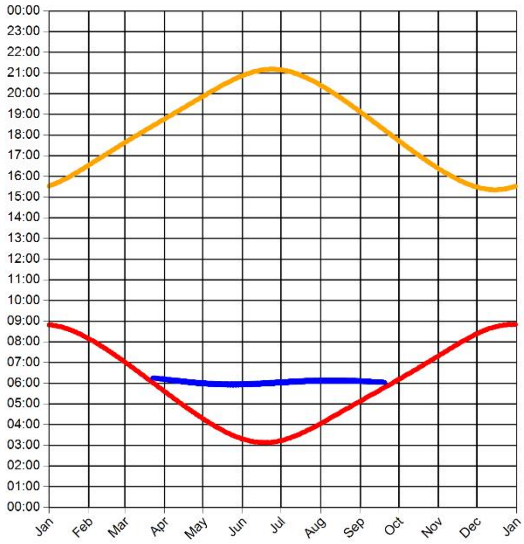
Min observer difference angle: 1.1°
Max observer difference angle: 22.5°

Observer Location | Sun azimuth range is 74.8° - 90.9° (yellow)

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

Observer Dwelling receptor 11 Results

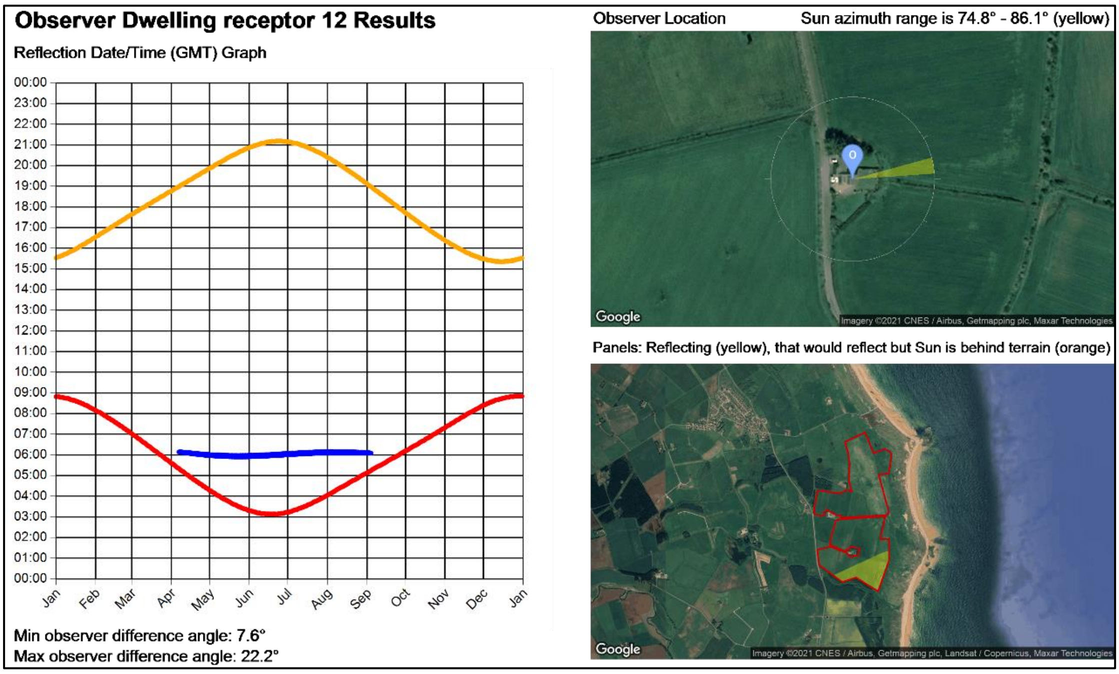
Reflection Date/Time (GMT) Graph



Min observer difference angle: 2.6°
Max observer difference angle: 22.2°

Observer Location | Sun azimuth range is 74.9° - 89.8° (yellow)

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


Observer Dwelling receptor 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: 7.6°
Max observer difference angle: 22.2°
Observer Location
Sun azimuth range is 74.8° - 86.1° (yellow)
Google
Imagery ©2021 CNES / Airbus, Getmapping plc, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2021 CNES / Airbus, Getmapping plc, Landsat / Copernicus, Maxar Technologies

PAGERPOWER

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