PAGERPOWER
Urban & Renewables

Solar Photovoltaic Glint and Glare Study

Kilgallioch Windfarm Extension, Dumfries & Galloway

ITPEnergised

October, 2019

PLANNING SOLUTIONS FOR:

- Solar
- Telecoms
- Railways
- Defence
- Buildings
- Wind
- Airports
- Radar
- Mitigation

www.pagerpower.com

ADMINISTRATION PAGE

Job reference:	9698A
Date:	26 September, 2019
Author:	Andrea Mariano
Telephone:	01787 319001
Email:	andrea@pagerpower.com

First reviewer:	Michael Sutton
Second reviewer	Kai Frolic
Date:	26 September, 2019
Telephone:	01787 319001
Email:	michael@pagerpower.com; kai@pagerpower.com

Issue	Date	Detail of Changes
1	26 September, 2019	Initial issue
2	02 October, 2019	Second issue – minor amendments

South Suffolk Business Centre, Alexandra Road, Sudbury, CO10 2ZX

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 the proposed Kilgallioch Windfarm Extension and solar photovoltaic (PV) installation (the proposed Development) located approximately 9.5 km north west of Kirkcowan, in the south west of Scotland. This assessment pertains to the possible effects upon the nearby Southern Upland Way footpath.

Pager Power

Pager Power has undertaken over 400 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.

Findings

Potential solar reflections from the proposed Development upon receptors on the Southern Upland Way footpath have been assessed. The assessment has shown that all potential impacts are acceptable based on the analysis carried out.

Southern Upland Way Footpath

The analysis has shown that a solar reflection from the proposed Development towards the Southern Upland Way footpath is geometrically possible for all receptors assessed.

However, available imagery shows that vegetation will screen any view of the proposed Development.

Therefore, no impact is expected, and no mitigation strategy should be implemented.

Recommendation

The analysis showed that a no impact upon observant walking along the Southern Upland Way footpath is predicted. No mitigation is therefore suggested.

LIST OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 46 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 the proposed Kilgallioch Windfarm Extension and solar photovoltaic (PV) installation (the proposed Development) located approximately 9.5 km north west of Kirkcowan, Dumfries and Galloway, in the south west of Scotland.

This assessment pertains to the possible effects upon the nearby Southern Upland Way footpath. The analysis contains the following:

- Executive summary, contents and introduction;
- Solar development details;
- Explanation of glint and glare;
- Overview of relevant guidance;
- Overview of relevant studies;
- Identification of receptors:
    - Southern Upland Way walkers;
- Assessment methodology;
- Desktop assessment of shielding by vegetation;
- Glint and glare assessment for identified receptors;
- Results discussion;
- High-level overview of mitigation;
- Conclusions and recommendations.

1.2 Pager Power's Experience

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

1.3 Glint and Glare Definition

The definition of glint and glare 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 location of the proposed Development's sites is shown in the aerial image of Figure 1 below[1]. All solar panels are located within the red areas. Information about the proposed Development has been provided by ITPEnergised.

Figure 1 – Location of proposed development

2.2 Proposed Development – Layout

The indicative layout of the solar panels has been provided by ITPEnergised. The details used for the analysis are as follows:

- Panel tilt 25 degrees;
- Panel orientation 180 degrees (south facing);
- Mid-height of the panel above ground 1.75m.

[1] Source: Copyright © 2019 Google.

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

3.3.1 Pager Power's Methodology

The glint and glare assessment methodology has been derived from the information provided to Pager Power through consultation with stakeholders and by reviewing the available guidance. The methodology for the 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[2] 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.

[2] The judgement of the impact is based on Pager Power's professional experience.

4 IDENTIFICATION OF RECEPTORS

4.1 Overview

This assessment has been carried out with specific reference to potential impacts to the nearby footpath.

There is no formal guidance with regard to the maximum distance at which glint and glare should be assessed[3]. From a technical perspective, there is no maximum distance for potential reflections.

However, the significance of a solar reflection decreases with distance. This is because the proportion of an observer's field of vision that is taken up by the reflecting area diminishes as the separation distance increases.

Terrain and shielding by vegetation are also more likely to obstruct an observer's view at longer distances for ground-based receptors.

[3] Usually reflections do not create significant annoyance beyond 1km.

4.2 Southern Upland Way Footpath

The analysis has considered location of the footpath that: are close to the proposed Development[4] and have a potential view of the panels.

The assessed receptors are shown in Figure 2[5] below. The receptors are located west of the proposed Development. The receptor height is of 1.8m. The height represents the typical eye level for an observer. The co-ordinates of the receptor points are presented in Appendix G. The red areas represent the panel area.

Figure 2 – Southern Upland Way receptors locations

[4] Receptors located beyond 1km have been assessed, as requested by the developer

[5] Source: Copyright © 2019 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 Development have been extrapolated from the site maps. All ground heights are based on interpolated OSGB36 (Ordinance Survey Great Britain 1936) data and panel data has been provided by ITPEnergised. 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 development.

The reflector areas assessed are shown in Figure 3 below[6] (areas defined by red lines).

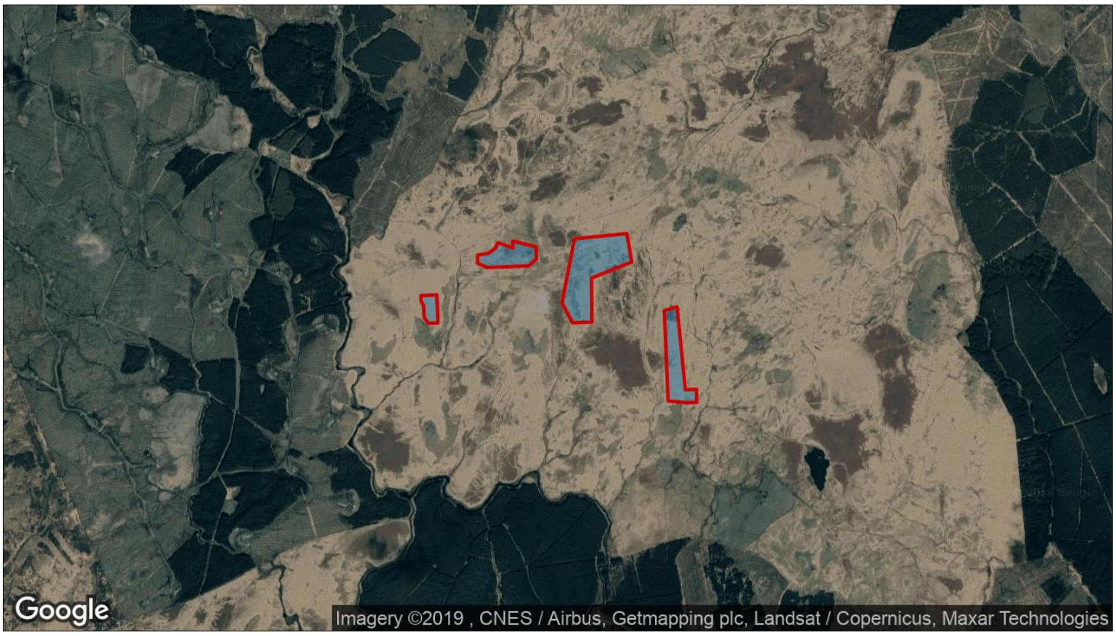


Figure 3 – Assessed reflector areas

[6] Source: Copyright © 2019 Google.

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.

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.

6.2 Geometric Calculation Results Overview – Southern Upland Way Footpath

The results of the geometric calculations for people walking along the Southern Upland Way footpath are presented in Table 1 below.

Receptor	Pager Power Results Predicted reflection times towards Southern Upland Way Footpath (GMT)		Comment
	am	pm	
Receptor 1	Between 06:20 and 06:25 during late March. Between 06:08 and 06:11 during mid-September.	None.	Reflection generating from the northern portion of Site 2 and 3. Sufficient screening in from of vegetation has been identified. No impact expected. No mitigation required.
Receptor 2	Between 06:17 and 06:25 from late March to early April. Between 06:08 and 06:14 from early September to late September.	None.	Reflection generating from the entire portion of Site 2 and the northern portion of Site 3. Sufficient screening in from of vegetation has been identified. No impact expected. No mitigation required.

Receptor	Pager Power Results		Comment
	Predicted reflection times towards Southern Upland Way Footpath (GMT)		
	am	pm	
Receptor 3	Between 06:13 and 06:24 from late March to mid-April. Between 06:08 and 06:17 from late August to late September.	None.	Reflection generating from the entire portion of Site 2 and the northern portion of Site 3. Sufficient screening in from of vegetation has been identified. No impact expected. No mitigation required.
Receptor 4	Between 06:09 and 06:24 from late March to early May. Between 06:08 and 06:19 from early August to late September.	None.	Reflection generating from the entire portion of Site 1, 2 and 4. Sufficient screening in from of vegetation has been identified. No impact expected. No mitigation required.
Receptor 5	Between 06:07 and 06:26 from mid-March to late September.	None.	Reflection generating from the entire portion of Site 1, 2, 3 and northern portion of Site 4. Sufficient screening in from of vegetation has been identified. No impact expected. No mitigation required.

Receptor	Pager Power Results		Comment
	Predicted reflection times towards Southern Upland Way Footpath (GMT)		
	am	pm	
Receptor 6	Between 06:05 and 06:26 from mid-March to late September.	None.	Reflection generating from the southern portion of Site 1 the entire portion of Site 3 and 4. Sufficient screening in from of vegetation has been identified. No impact expected. No mitigation required.
Receptor 7	Between 06:06 and 06:24 from late March to mid-September.	None.	Reflection generating from the southern portion of Site 3 and the entire portion of Site 4. Sufficient screening in from of vegetation has been identified. No impact expected. No mitigation required.
Receptor 8	Between 06:07 and 06:19 from early April to early September.	None.	Reflection generating from the southern portion of Site 3 and the entire portion of Site 4. Sufficient screening in from of vegetation has been identified. No impact expected. No mitigation required.

Receptor	Pager Power Results		Comment
	Predicted reflection times towards Southern Upland Way Footpath (GMT)		
	am	pm	
Receptor 9	Between 06:07 and 06:16 from mid-April to late May. At circa 06:11 during late June. Between 06:17 and 06:19 from mid-July to late August.	None.	Reflection generating from the entire portion of Site 4. Sufficient screening in from of vegetation has been identified. No impact expected. No mitigation required.
Receptor 10	Between 06:06 and 06:19 from late April to mid-August.	None.	Reflection generating from the entire portion of Site 4. Sufficient screening in from of vegetation has been identified. No impact expected. No mitigation required.

Table 1 – Geometric analysis results for the Southern Upland Way Footpath

7 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

7.1 Southern Upland Way Footpath

The analysis has shown that a solar reflection from the proposed Development towards the Southern Upland Way footpath is geometrically possible for all receptors assessed.

However, available imagery (Figure 4[7] below) shows that vegetation will screen the view of the entire panel area.

Therefore, no impact is expected, and no mitigation is required.

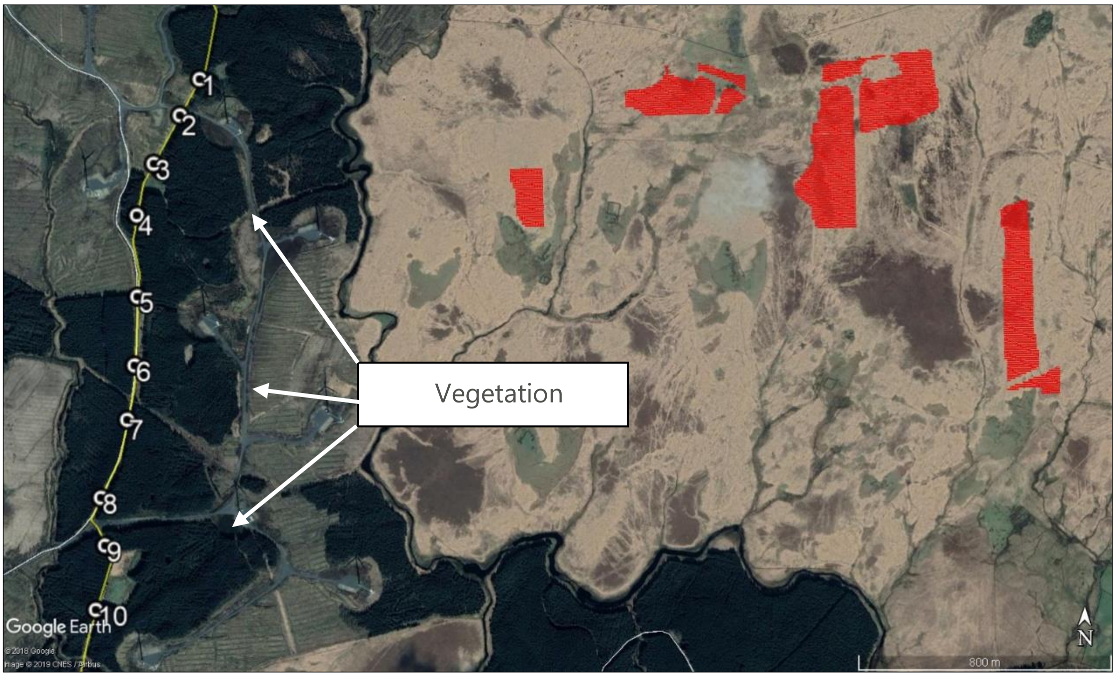


Figure 4 – Southern Upland Way pathside screening

If vegetation is removed,, the impact would be categorised as "low" (due to the great distance between the observer and the reflecting area) and it will sill be acceptable.

[7] Source: Copyright © 2019 Google.

8 OVERALL CONCLUSIONS

8.1 Overall Conclusion

Potential solar reflections from the proposed Development upon receptors on the Southern Upland Way footpath have been assessed. The assessment has shown that all potential impacts are acceptable[8] based on the analysis carried out which has considered the current scenario with vegetation and the scenario without.

8.2 Southern Upland Way Footpath

The analysis has shown that a solar reflection from the proposed Development towards the Southern Upland Way footpath is geometrically possible for all receptors assessed.

However, available imagery shows that vegetation will screen any view of the proposed development. If vegetation will be removed the impact will be considered low, and therefore, still acceptable.

Therefore, no impact is expected, and no mitigation strategy should be implemented.

8.3 Recommendation

The analysis showed that a no impact upon people walking along the Southern Upland Way footpath is predicted. No mitigation is therefore suggested.

[8] Usually reflections do not create significant annoyance beyond 1km.

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

UK National Planning Practice Guidance dictates that in some instances a glint and glare assessment is required however, there is no specific guidance with respect to the methodology for assessing the impact of glint and glare.

The planning policy from the Department for Communities and Local Government (paragraph 27[9]) states:

'Particular factors a local planning authority will need to consider include… the effect on landscape of glint and glare and on ***neighbouring uses and aircraft safety**.'*

The National Planning Policy Framework for Renewable and Low Carbon Energy[10] (specifically regarding the consideration of solar farms, paragraph 26 and 27) 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;*

[9] Source: Planning practice guidance for renewable and low carbon energy, Department for Communities and Local Government, date: 06/2013, accessed on: 20/03/2019

[10] Source: Planning practice guidance for renewable and low carbon energy, Department for Communities and Local Government, date: 06/2013, accessed on: 20/03/2019

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.'

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

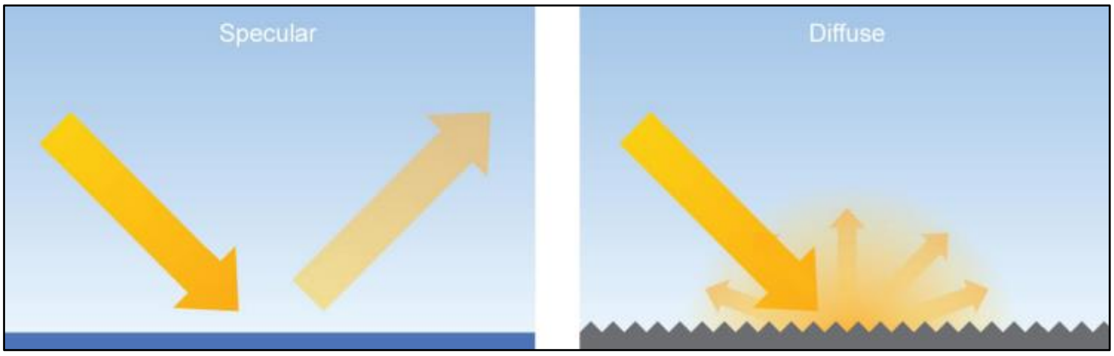
Overview

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[11], 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

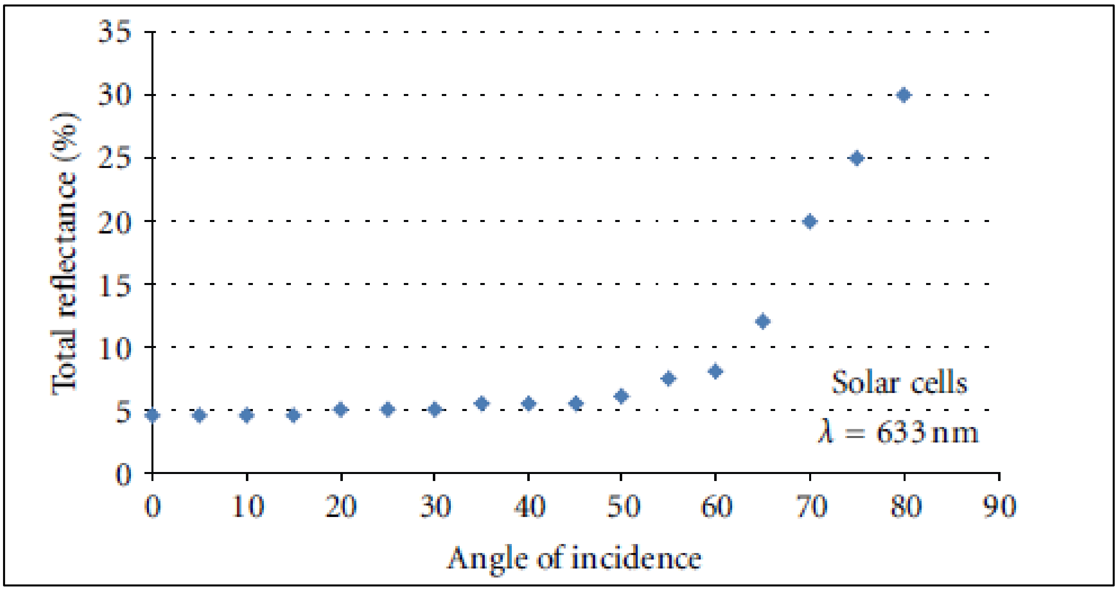
[11] Source: Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.

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*[12]". 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:

[12] Source: 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

- 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.

FAA Guidance – "Technical Guidance for Evaluating Selected Solar Technologies on Airports"[13]

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[14]
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

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

[14] Extrapolated data, baseline of 1,000 W/m^2 for incoming sunlight.

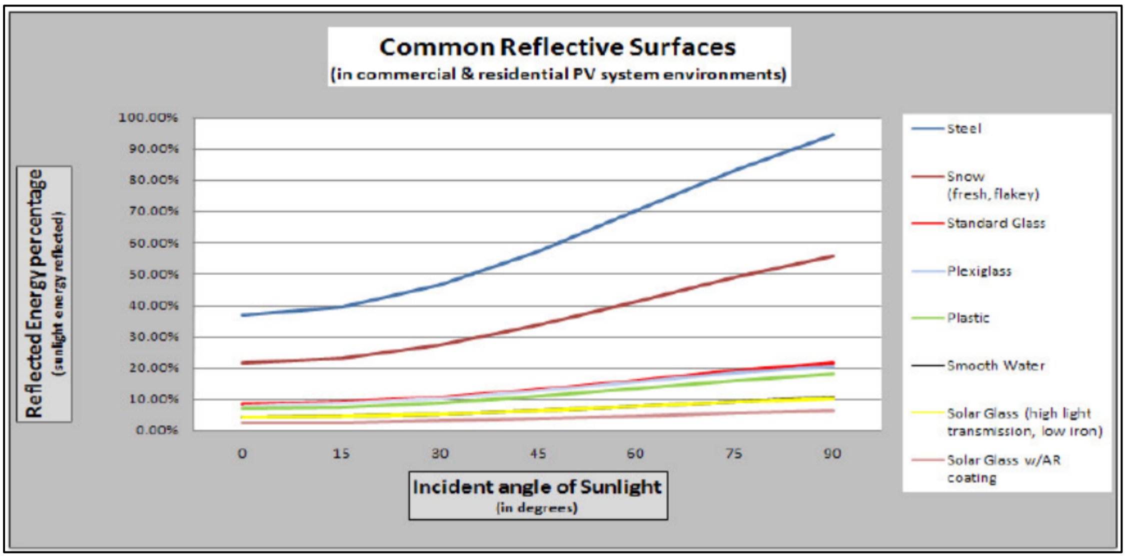
Note that the data above does not appear to consider the reflection type (specular or diffuse).

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.

SunPower Technical Notification (2009)

SunPower published a technical notification[15] 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.

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

APPENDIX C – OVERVIEW OF SUN MOVEMENTS AND RELATIVE REFLECTIONS

Overview

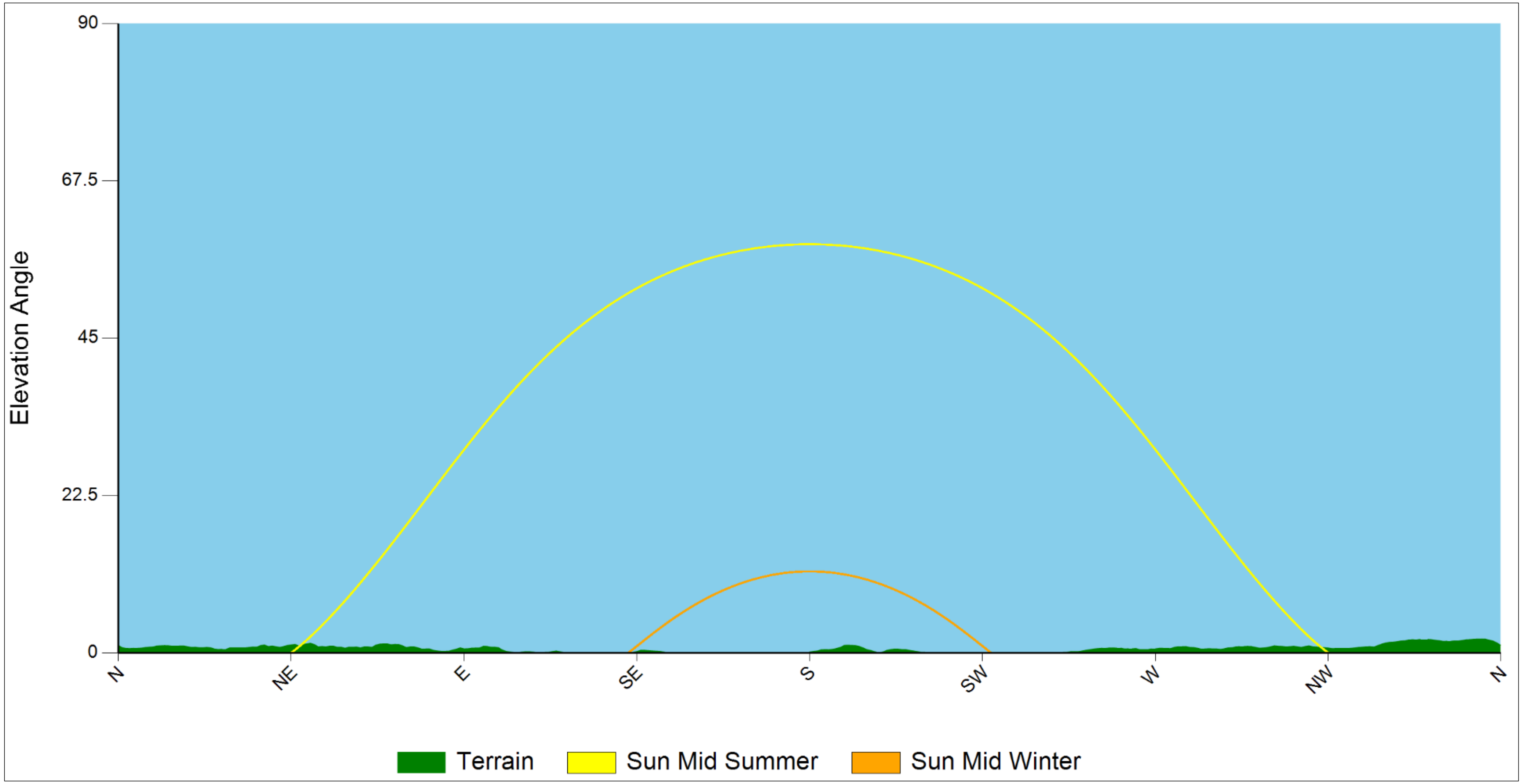
The Sun's position in the sky can be accurately described by its azimuth and elevation. Azimuth is a direction relative to true north (horizontal angle i.e. from left to right) and elevation describes the Sun's angle relative to the horizon (vertical angle i.e. up and down).

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.

Terrain Sun Curve - From lon: -4.758119 lat: 54.997911



Terrain profile at horizon and sunrise/sunset curve at proposed development location

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.

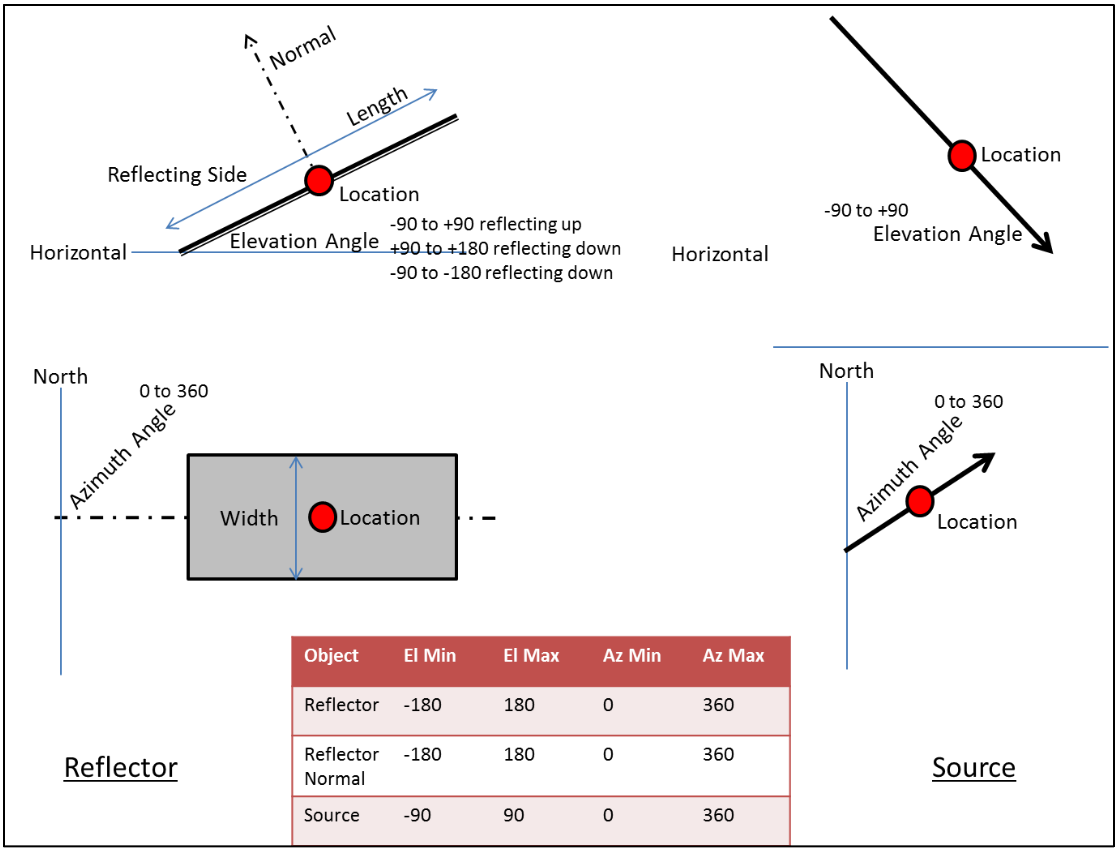
Impact significance definition

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.



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 the solar development.

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

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

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

A finite number of points within the proposed development are chosen based on an assessment resolution so we can build a comprehensive understanding of the entire development. This will determine whether a reflection could ever occur at a chosen receptor. The calculations do not incorporate all of the possible panel locations within the development outline.

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

Whilst line of sight to the development from receptors has been considered, only available street view imagery and satellite mapping has been used. In some cases this imagery may not be up to date and may not give the full perspective of the installation from the location of the assessed receptor.

Any screening in the form of trees, buildings etc. that may obstruct the Sun from view of the solar panels is not considered unless stated.

APPENDIX G – RECEPTOR AND REFLECTOR AREA DETAILS

Southern Upland Way Footpath

ID	Longitude (°)	Latitude (°)	Observer height (agl)	Overall height (amsl)
1	-4.785591	55.000361	1.8m	182.51
2	-4.78653	54.999335		184.73
3	-4.787784	54.997967		182.15
4	-4.788572	54.996509		181.36
5	-4.788463	54.994225		189.63
6	-4.788559	54.992293		184.77
7	-4.788887	54.990763		183.80
8	-4.790093	54.988568		191.21
9	-4.789854	54.987229		189.77
10	-4.790298	54.985409		182.39

Assessed receptor (road) locations for Southern Upland Way Footpath

Modelled Reflector Area

Site 1

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
1	-4.770369	54.997917	5	-4.770033	54.996657
2	-4.768784	54.997960	6	-4.770096	54.997366
3	-4.768681	54.996368	7	-4.770347	54.997590
4	-4.769606	54.996345			

Site 1: modelled reflector area details

Site 2

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
1	-4.764734	55.000207	7	-4.761240	55.001007
2	-4.763711	55.000304	8	-4.758947	55.000668
3	-4.762931	55.000618	9	-4.758910	54.999994
4	-4.762795	55.000895	10	-4.759686	54.999597
5	-4.762675	55.000899	11	-4.763786	54.999510
6	-4.761239	55.000608	12	-4.764745	54.999748

Site 2: modelled reflector area details

Site 3

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
1	-4.755147	55.001133	5	-4.753419	54.996427
2	-4.749954	55.001428	6	-4.755338	54.996371
3	-4.749484	54.999813	7	-4.756382	54.997511
4	-4.753464	54.998907			

Site 3: modelled reflector area details

Site 4

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
1	-4.746255	54.997066	5	-4.743046	54.991871
2	-4.744989	54.997284	6	-4.744053	54.991853
3	-4.744166	54.992583	7	-4.745863	54.991947
4	-4.743067	54.992602			

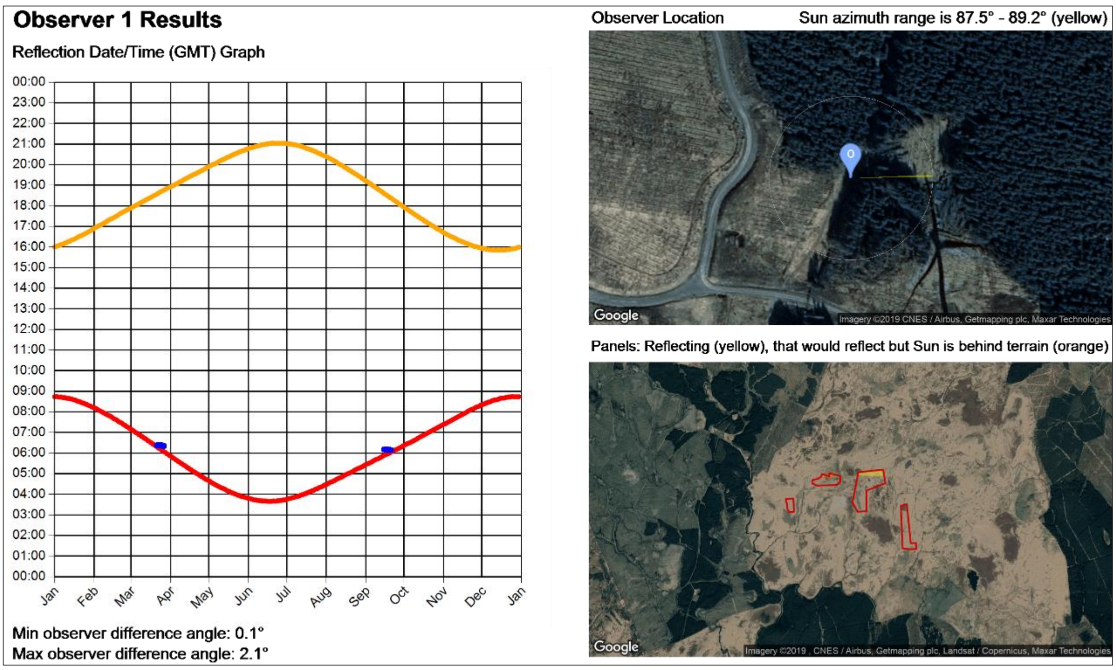
Site 4: modelled reflector area details

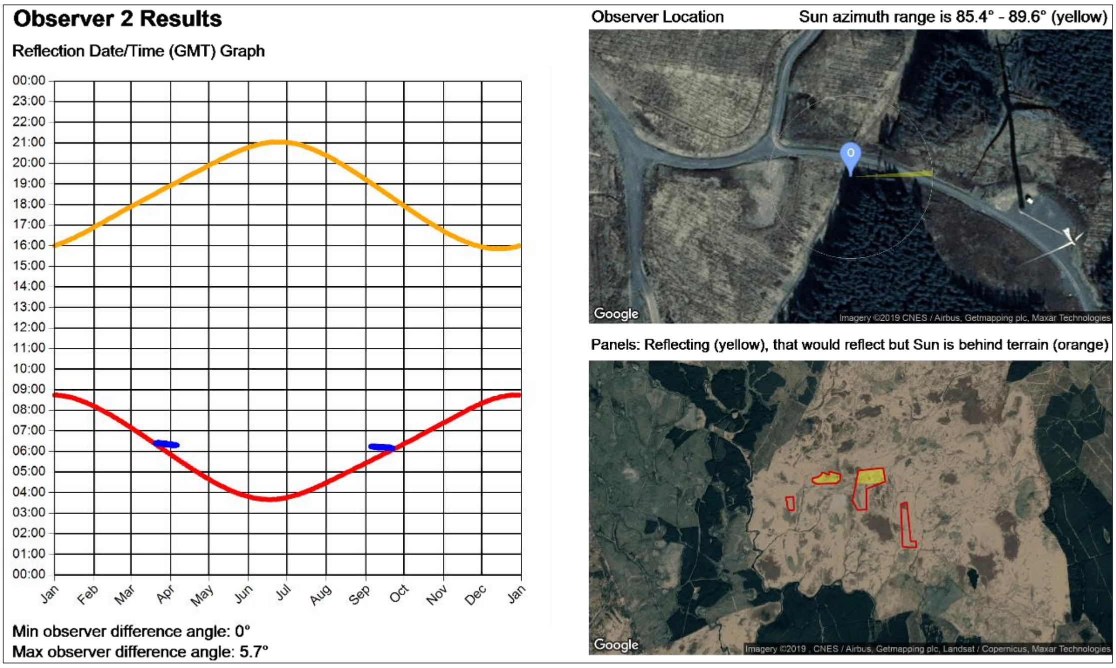
APPENDIX H – GEOMETRIC CALCULATION RESULTS – PAGER POWER RESULTS

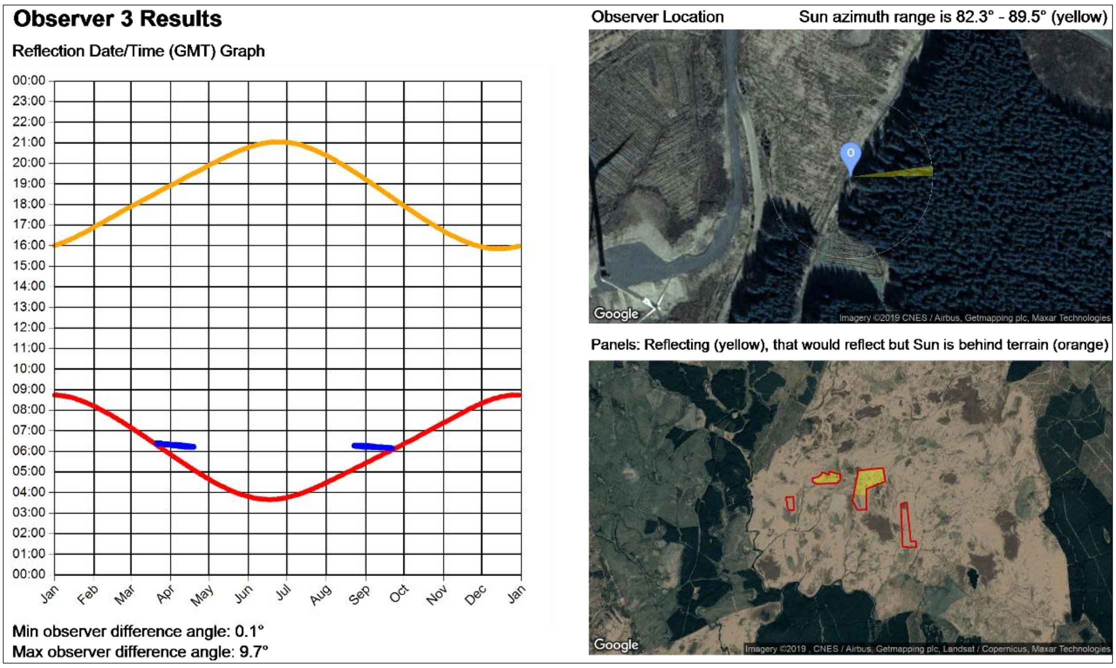
The charts for the receptors are shown on the following pages. Each chart shows:

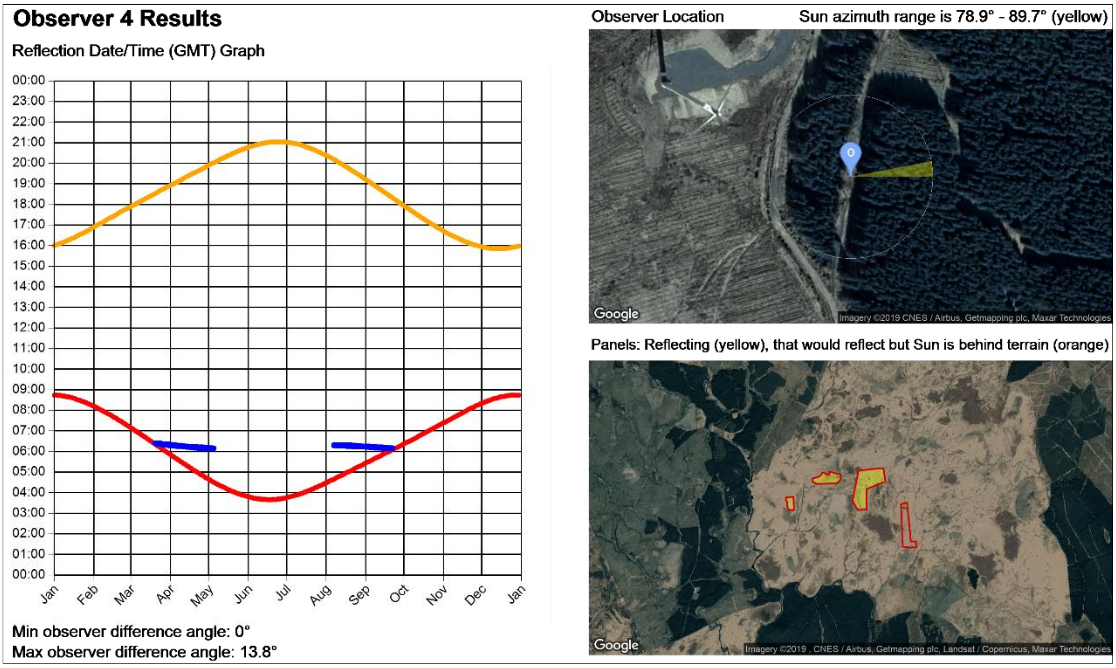
- The receptor (observer) location – top right image. This also shows the azimuth range of the Sun itself at times when reflections are possible. If sunlight is experienced from the same direction as the reflecting panels, the overall impact of the reflection is reduced as discussed within the body of the report;
- The reflecting areas – bottom right image. The reflecting area is shown in red. If the red 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 red areas only;
- In the same graph the red line shows the time at which the sun is rising while the red line shows when the sun is setting for each specific month.

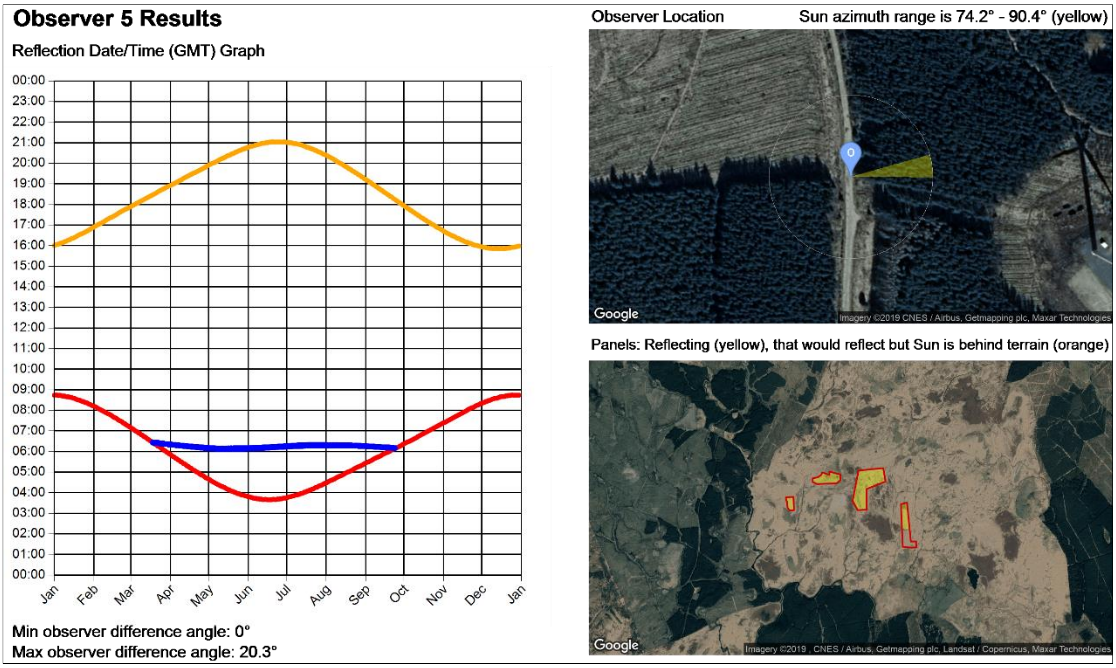
Southern Upland Way Footpath

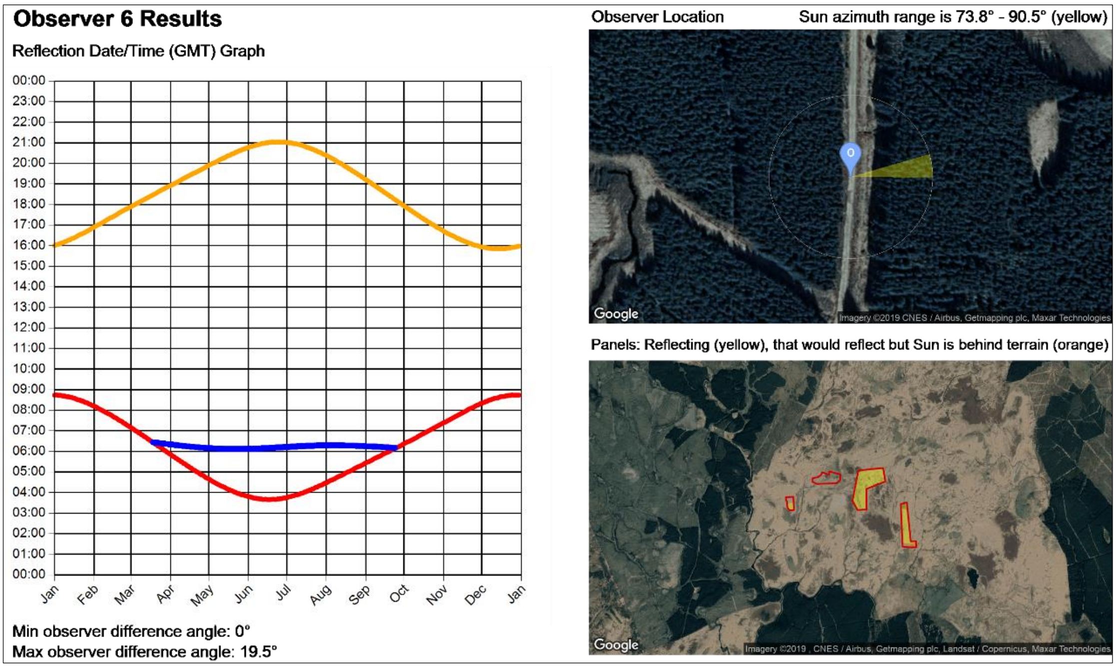


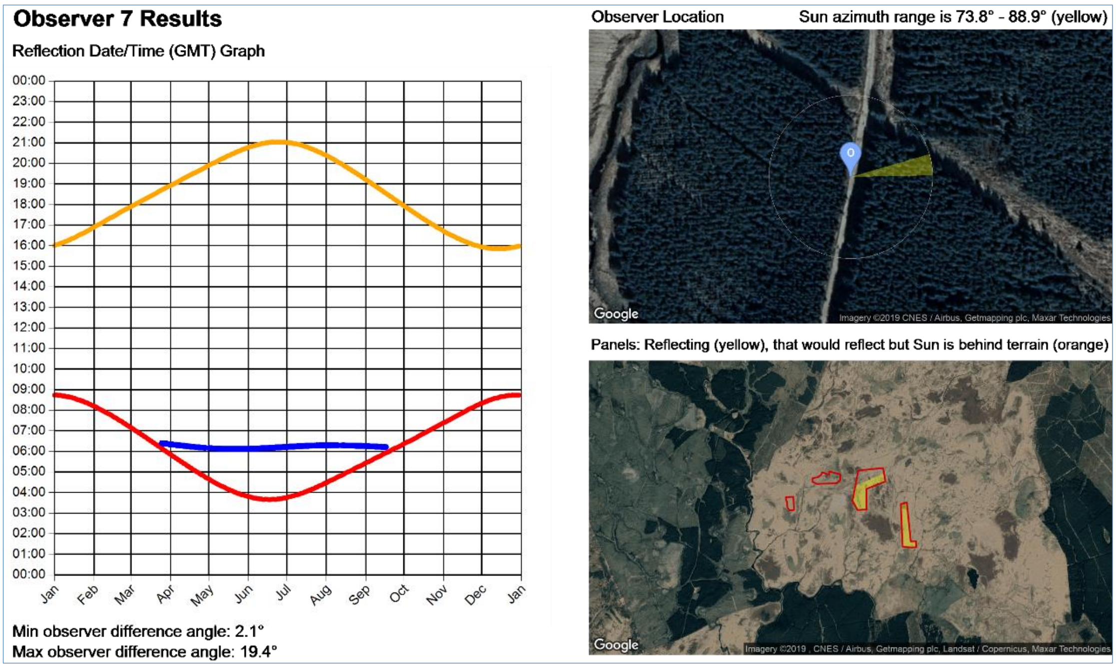

Observer 2 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 0°
Max observer difference angle: 5.7°
Observer Location
Sun azimuth range is 85.4° - 89.6° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

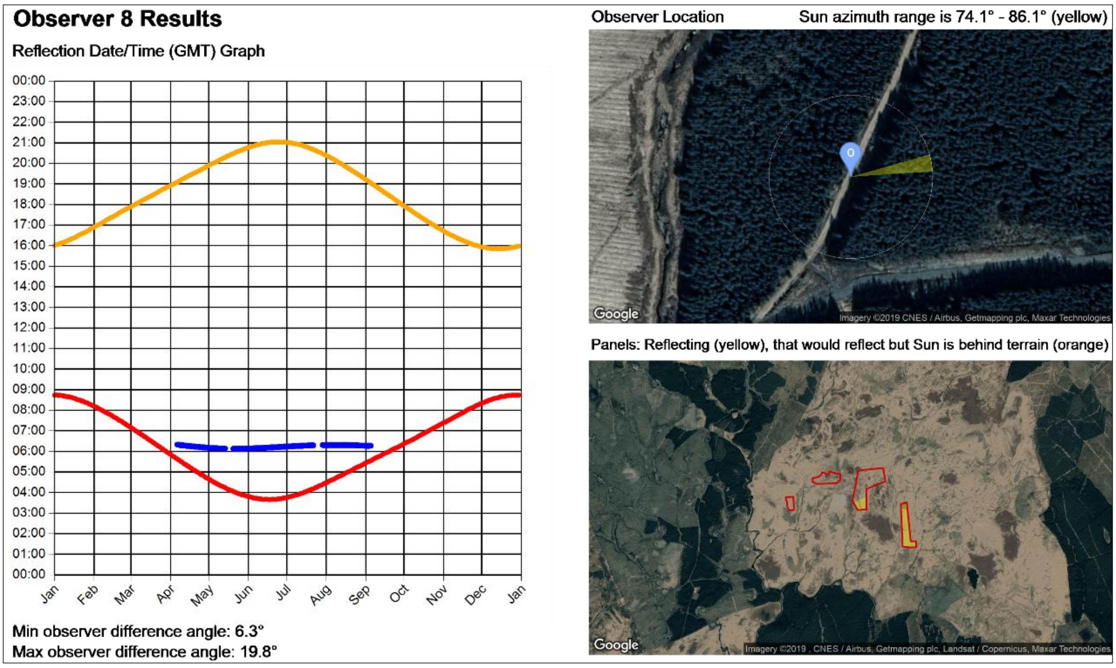

Observer 3 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 0.1°
Max observer difference angle: 9.7°
Observer Location
Sun azimuth range is 82.3° - 89.5° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

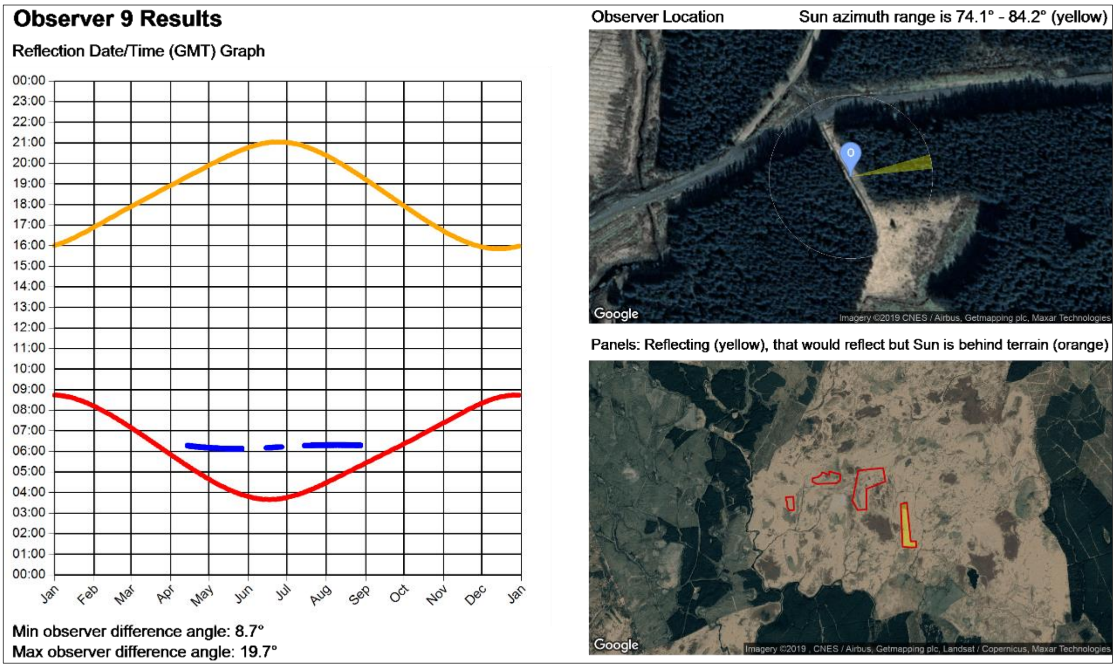

Observer 4 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0°
Max observer difference angle: 13.8°
Observer Location
Sun azimuth range is 78.9° - 89.7° (yellow)
Google
Imagery ©2019 CNES / Airbus, Getmapping plc, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2019 , CNES / Airbus, Getmapping plc, Landsat / Copernicus, Maxar Technologies

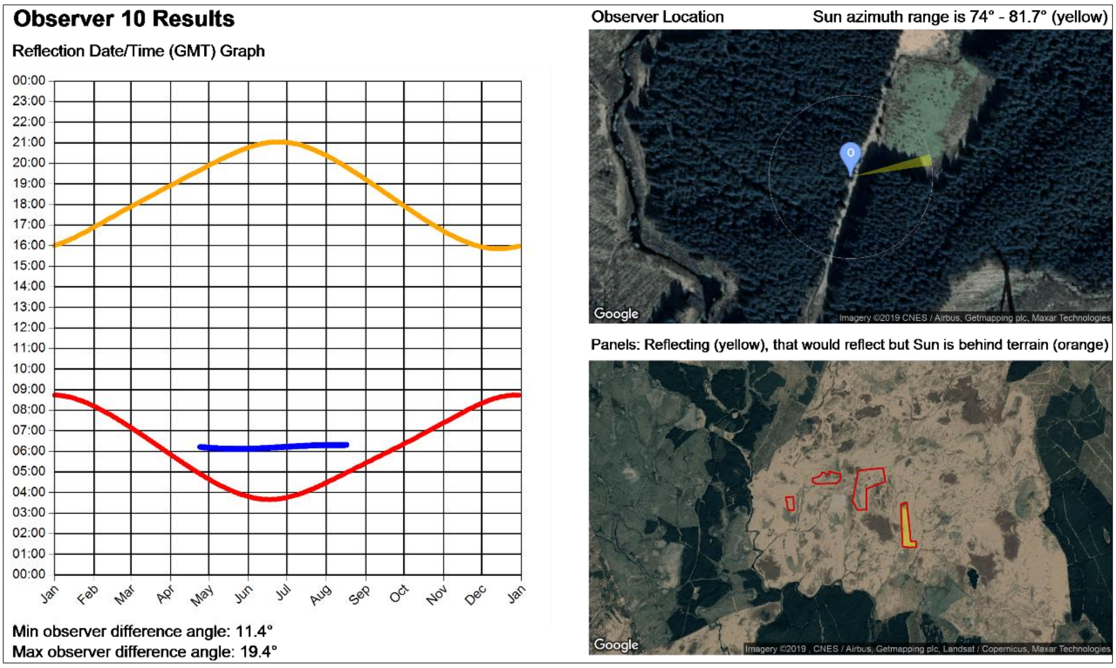

Observer 5 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0°
Max observer difference angle: 20.3°
Observer Location
Sun azimuth range is 74.2° - 90.4° (yellow)
Google
Imagery ©2019 CNES / Airbus, Getmapping plc, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2019 , CNES / Airbus, Getmapping plc, Landsat / Copernicus, Maxar Technologies


Observer 6 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 0°
Max observer difference angle: 19.5°
Observer Location
Sun azimuth range is 73.8° - 90.5° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer 7 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 2.1°
Max observer difference angle: 19.4°
Observer Location
Sun azimuth range is 73.8° - 88.9° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer 8 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: 6.3°
Max observer difference angle: 19.8°
Observer Location
Sun azimuth range is 74.1° - 86.1° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 9 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: 8.7°
Max observer difference angle: 19.7°
Observer Location
Sun azimuth range is 74.1° - 84.2° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 10 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: 11.4°
Max observer difference angle: 19.4°
Observer Location
Sun azimuth range is 74° - 81.7° (yellow)
Google
Imagery ©2019 CNES / Airbus, Getmapping plc, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2019 , CNES / Airbus, Getmapping plc, Landsat / Copernicus, Maxar Technologies

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