

Glint & Glare Assessment: Barnsley District General Hospital

For: Custom Solar Ltd

Site: Barnsley Hospital NHS Foundation Trust, Gawber Road, Barnsley, South Yorkshire, S75 2EP

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1. Introduction

1.1 Background

Custom Solar Ltd ('the Client') are proposing the installation of solar canopies at the southernmost car park at Barnsley District General Hospital, Barnsley Hospital NHS Foundation Trust, Gawber Road, Barnsley, South Yorkshire, S75 2EP (hereafter referred to as the 'proposed development').

It is understood that the Local Planning Authority have requested assessment of glare impact on residential dwellings located nearby to the proposed development.

Subsequently, Arthian Ltd has been commissioned by the Client to assist by preparing a Glint and Glare Assessment report.

1.2 Glint & Glare

Reflectivity refers to light that is reflected off surfaces (e.g. glazed surfaces or areas of metal cladding). The potential effects of reflectivity are glint and glare. The Federal Aviation Administration's (FAA) '*Technical Guidance for Evaluating Selected Solar Technologies on Airports*' provides the following glint and glare definitions:

- *Glint* – "a momentary flash of bright light"
- *Glare* – "a continuous source of bright light"

These present an ocular hazard to light sensitive receptors such as road users, train drivers, occupants of nearby dwellings, pilots, and air-traffic control personnel, as they can cause a brief, temporary or permanent eye damage (ocular impact categories and significance further discussed in Section 4.3).

In general, solar photovoltaic (PV) systems are constructed of dark, light-absorbing material designed to maximise light adsorption and minimise reflection. However, the glass surfaces of solar PV systems also reflect sunlight to varying degrees throughout the day and year, based on the incidence angle of the sun relative to ground-based receptors. Lower incidence angles amount to increased reflection.



As such, the amount of light reflected off a solar PV panel surface or an array of solar panels depends on a variety of factors to include:

- The amount of sunlight hitting the surface;
- Its surface reflectivity;
- Its geographic location;
- Time of the year;
- Cloud coverage; and
- Surface orientation.

1.3 Scope of Work

Based on definitions and factors described in Section 1.2 and in combination with available guidance and good practice recommendations, a desk-based evaluation was undertaken to evaluate the potential to experience the effects of glint and glare towards residential receptors. A solar glare analysis tool was utilised to model the solar PV arrays and examine the times of the year and days such effects may occur, as well as the magnitude of their impact. The results of this study were subsequently interpreted, and appropriate recommendations made.

Section 4.0 provides further details on methodology followed to complete this study.



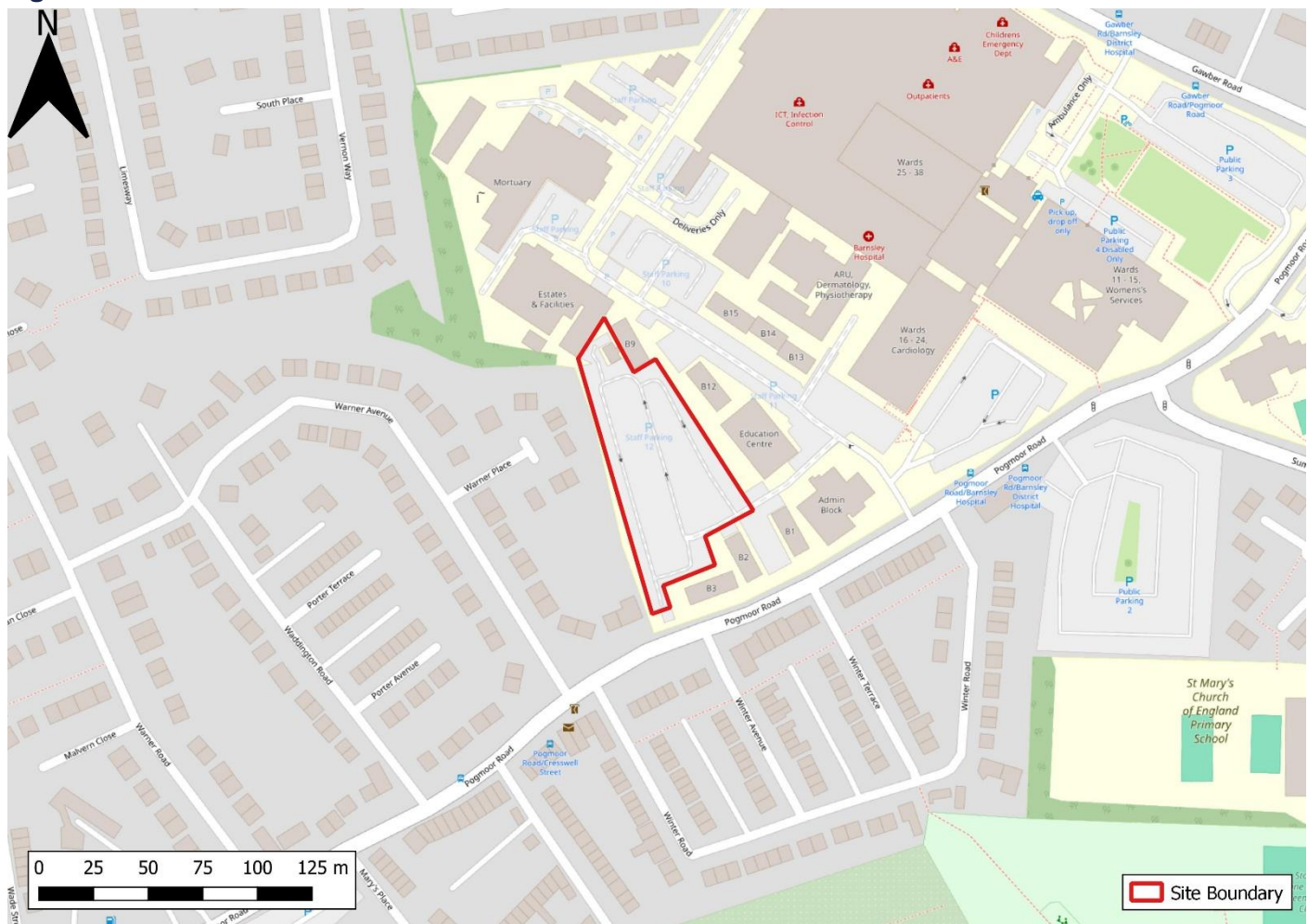
2. Development Characteristics

2.1 Site Description

The site (centred at National Grid Reference, NGR 433247, 406971) is located at Barnsley District General Hospital, Barnsley Hospital NHS Foundation Trust, Gawber Road, Barnsley, South Yorkshire, S75 2EP. The site is bounded to the west by residential properties, to the south by a mix of residential properties and hospital infrastructure along Pogmoor Road, and to the north and east by hospital infrastructure.

The site location is shown in Figure 2.1 below.

Figure 2.1: Site Location



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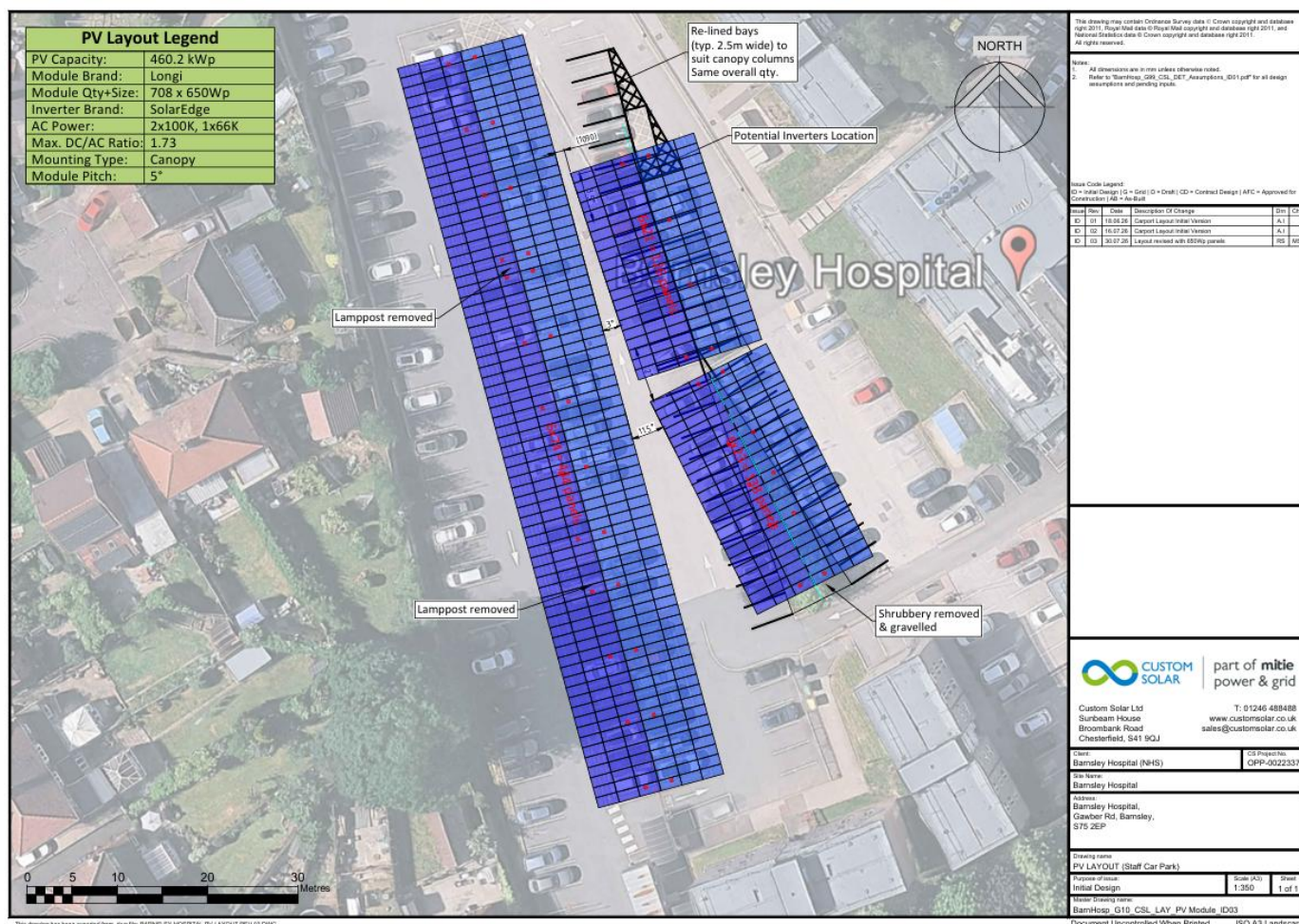


2.2 Proposed Development

The proposed development comprises of solar arrays installed on a mounting framework above the Barnsley District General Hospital southwestern car park. It is understood that the proposed canopies are to be installed based on a double gull-wing design (sloping towards the centre line of each array) as specified by the Client.

The proposed site plan is shown in Figure 2.2 with the arrays marked up.

Figure 2.2: Proposed Site Plan

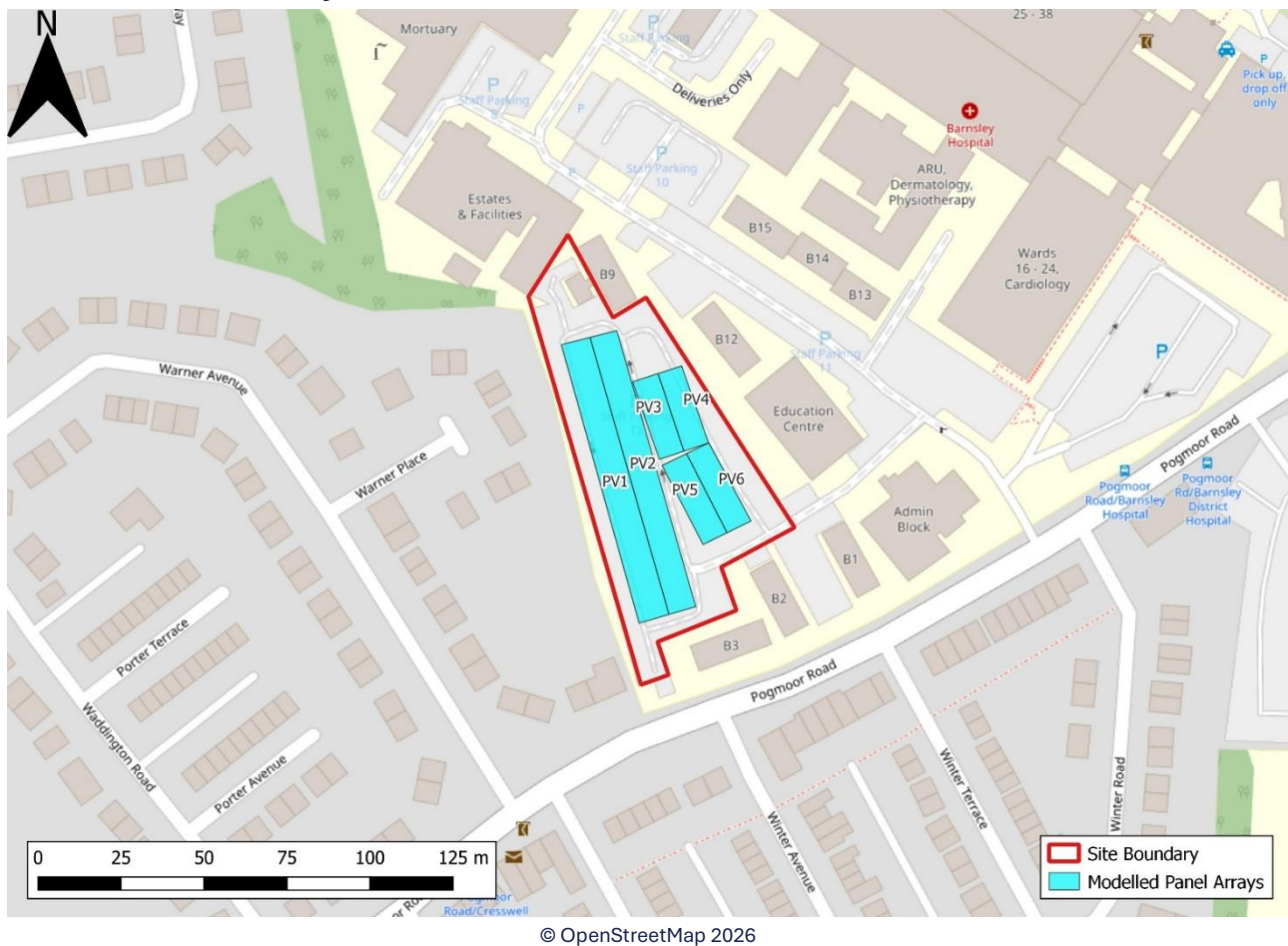


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The simplified PV layout used for modelling is shown in Figure 2.3.

Figure 2.3: Modelled PV Arrays



The modelled PV module orientation and inclination, as well as PV panel height above ground, is summarised in in Table 2.1.

Table 2.1: Modelled PV Array Details

PV Array	Orientation (Azimuth)*	Panel Tilt*	Average Height Above Ground^
PV1	74°	5°	3.75m
PV2	254°	5°	3.75m
PV3	71°	5°	3.75m
PV4	251°	5°	3.75m
PV5	62.5°	5°	3.75m
PV6	242.5°	5°	3.75m

*North located at 0°.

*Based on data provided by the Client.

^Based on the average of the maximum (4.5m) and minimum (3m) panel heights provided by the Client.



For the purpose of this assessment the PV panels will be modelled as 'Smooth Glass without Anti-Reflective Coating (ARC)'.



3. Legislation & Guidance

3.1 Planning Legislation & Guidance

3.1.1 The Town and County Planning, (General Permitted Development) (England) Order

The Town and County Planning, (General Permitted Development) (England) Order 2015¹ states that a written application from the developer to the local planning authority must be made before development has commenced.

With regard to potential glare from solar panels, it states:

“... development is permitted subject to the condition that before beginning the development the developer must apply to the local planning authority for a determination as to whether the prior approval of the authority will be required as to the design or external appearance of the development, in particular the impact of glare on occupiers on neighbouring land ...”

The term ‘neighbouring land’ is not defined within the legislation and there is not a standard definition. The request for glare assessment may be determined by local authority following consultation with relevant stakeholders. Relevant stakeholders for glare assessment commonly include aviation safeguarding teams, Network Rail, highways and local residents of neighbouring dwellings.

3.1.2 National Planning Practice Guidance

In the absence of specific guidance on solar development, the National Planning Practice Guidance for ‘Renewable and Low Carbon Energy’² dictates the following with respect to large-scale solar PV developments and glint and glare:

“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;...*
- *great care should be taken to ensure heritage assets are conserved in a manner appropriate to their significance, including the impact of proposals on views important to their setting. As the significance of a heritage asset derives not only from its physical presence, but also from its setting, careful consideration should be given to the impact of large-scale solar farms on such assets. Depending on*

¹ https://www.legislation.gov.uk/uksi/2015/596/pdfs/ukxi_20150596_en.pdf

² <https://www.gov.uk/guidance/renewable-and-low-carbon-energy>



their scale, design and prominence, a large-scale solar farm within the setting of a heritage asset may cause substantial harm to the significance of the asset;

- *the potential to mitigate landscape and visual impacts through, for example, screening with native hedges;...*

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.”

3.1.3 National Policy Statement for Renewable Energy Infrastructure

The National Policy Statement for Renewable Energy Infrastructure (EN-3)³ sets out the primary policy for decisions by the Secretary of State for nationally significant renewable energy infrastructure.

The above policy is applicable to significant renewable energy infrastructure (i.e. solar photovoltaic >50 MW in England, where MW is measured as alternating current). However, the principles should be extended to infrastructure <50MW.

Sections 2.10.27 and 2.10.102-2.10.106 outlines the potential impact of glint and glare that the applicants may consider:

“2.10.27 Utility-scale solar farms are large sites that may have a significant zone of visual influence. The two main impact issues that determine distances to sensitive receptors are therefore likely to be visual amenity and glint and glare. These are considered in Landscape, Visual and Residential Amenity (paragraphs 3.10.84-3.10.92) and Glint and Glare (paragraphs 3.10.93 – 3.10.97) impact sections below.”

...

2.10.102 Solar panels are specifically designed to absorb, not reflect, irradiation⁴. However, solar panels may reflect the sun’s rays at certain angles, causing glint and glare. Glint is defined as a momentary flash of light that may be produced as a direct reflection of the sun in the solar panel. Glare is a continuous source of excessive brightness experienced by a stationary observer located in the path of reflected sunlight from the face of the panel. The effect occurs when the solar panel is stationed between or at an angle of the sun and the receptor.

2.10.103 Applicants should map receptors to qualitatively identify potential glint and glare issues and determine if a glint and glare assessment is necessary as part of the application.

2.10.104 When a quantitative glint and glare assessment is necessary, applicants are expected to consider the geometric possibility of glint and glare affecting nearby receptors and provide an assessment of potential impact and impairment based on the angle and duration of incidence and the intensity of the reflection.

³ <https://www.gov.uk/government/publications/national-policy-statement-for-renewable-energy-infrastructure-en-3-2025>

⁴ Most commercially available solar panels are designed with anti-reflective glass or are produced with anti-reflective coating and have a reflective capacity that is generally equal to or less hazardous than other objects typically found in the outdoor environment, such as bodies of water or glass buildings.



2.10.105 The extent of reflectivity analysis required to assess potential impacts will depend on the specific project site and design. This may need to account for ‘tracking’ panels if they are proposed as these may cause differential diurnal and/or seasonal impacts.

2.10.106 When a glint and glare assessment is undertaken, the potential for solar PV panels, frames and supports to have a combined reflective quality may need to be assessed, although the glint and glare of the frames and supports is likely to be significantly less than the panels.”

Sections 2.10.134-2.10.136 outlines the potential mitigations for glint and glare impacts that the applicants may consider:

“2.10.134 Applicants should consider using, and in some cases the Secretary of State may require, solar panels to comprise of (or be covered with) anti-glare/anti-reflective coating with a specified angle of maximum reflection attenuation for the lifetime of the permission.

2.10.135 Applicants may consider using screening between potentially affected receptors and the reflecting panels to mitigate the effects.

2.10.136 Applicants may consider adjusting the azimuth alignment of or changing the elevation tilt angle of a solar panel, within the economically viable range, to alter the angle of incidence. In practice this is unlikely to remove the potential impact altogether but in marginal cases may contribute to a mitigation strategy.”

Sections 2.10.158-2.10.159 outlines further detail on the potential glint and glare impacts that the Secretary of State may consider as part of their decision making:

“2.10.158 Solar PV panels are designed to absorb, not reflect, irradiation. However, the Secretary of State should assess the potential impact of glint and glare on nearby homes, motorists, public rights of way, and aviation infrastructure (including aircraft departure and arrival flight paths).

2.10.159 Whilst there is some evidence that glint and glare from solar farms can be experienced by pilots and air traffic controllers in certain conditions, there is no evidence that glint and glare from solar farms results in significant impairment on aircraft safety. Therefore, unless a significant impairment can be demonstrated, the Secretary of State is unlikely to give any more than limited weight to claims of aviation interference because of glint and glare from solar farms.”

3.2 Glare Modelling Guidance

3.2.1 US Federal Aviation Administration Guidance

In general, aviation stakeholders in the UK, as well as internationally, make use of the US FAA relevant guidance on solar energy systems as it provides the most detailed methodology for assessing glint and glare internationally.

3.2.1.1 Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports

The most comprehensive guidelines available for the assessment of solar PV developments near aerodromes were initially produced in November 2010 (entitled ‘Technical Guidance for Evaluating Selected Solar Technologies on Airports’) by the FAA and updated in 2013 (entitled ‘Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports’).



3.2.1.2 Technical Guidance for Evaluating Selected Solar Technologies on Airports

The 2013 edition was updated in 2018 as version 1.1 and is entitled ‘Technical Guidance for Evaluating Selected Solar Technologies on Airports’. The key changes are as follows:

Version 1.1 (April 2018):

- *Updated Section 3.1.2, Reflectivity, to incorporate the latest information about evaluating solar glint and glare.*
- *Updated corresponding references to glare throughout the document.*
- *Clarified the relationship between solar energy and the FAA’s Voluntary Airport Low Emissions (VALE) program in Section 5.3.2.*
- *Added information about the FAA’s Airport Energy Efficiency Program to Section 5.3.3.*
- *Updated FAA Contact information on Appendix B (where appropriate).*

Overall, the 2018 update offers three assessment options:

- Assessing Baseline Reflectivity Conditions
- Tests in the Field
- Geometric Analysis

3.2.1.3 Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports

A final policy entitled ‘Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports’ was released in 2021, which superseded the all previous guidance. The 2021 final policy has taken a step back and allowed aerodromes to safeguard as they see fit, with no longer a recommendation for any given glare model. However, where a proposed solar development is located where a risk to aviation safety is possible, geometric analysis, as per the 2013 guidance, will likely be the only option available to alleviate concerns. Aerodromes in the UK and internationally safeguard against glint and glare based on the 2018 FAA guidance.

Key points from the 2013 guidance are replicated below:

“...the FAA has determined that glint and glare from solar energy systems could result in an ocular impact to pilots and/or air traffic control (ATC) facilities and compromise the safety of the air transportation system. While the FAA supports solar energy systems on airports, the FAA seeks to ensure safety by eliminating the potential for ocular impact to pilots and/or air traffic control facilities due to glare from such projects.”

- **Standard for Measuring Ocular Impact**

“FAA adopts the Solar Glare Hazard Analysis Plot⁵ as the standard for measuring the ocular impact of any proposed solar energy system on a federally-obligated airport. To obtain FAA approval to revise an airport layout plan to depict a solar installation and/or a “no objection” to a Notice of Proposed Construction Form

⁵ Plot provided in Section 4.3.1.



7460-1, the airport sponsor will be required to demonstrate that the proposed solar energy system meets the following standards:

1. No potential for glint or glare in the existing or planned Airport Traffic Control Tower (ATCT) cab, and
2. No potential for glare or “low potential for after-image” (shown in green in hazard plot) along the final approach path for any existing landing threshold or future landing thresholds (including any planned interim phases of the landing thresholds) as shown on the current FAA-approved Airport Layout Plan (ALP). The final approach path is defined as two (2) miles from fifty (50) feet above the landing threshold using a standard three (3) degree glidepath.

Ocular impact must be analysed over the entire calendar year in one (1) minute intervals from when the sun rises above the horizon until the sun sets below the horizon.”

- **Tool to Assess Ocular Impact**

“In cooperation with the Department of Energy (DOE), the FAA is making available free-of-charge the Solar Glare Hazard Analysis Tool (SGHAT). The SGHAT was designed to determine whether a proposed solar energy project would result in the potential for ocular impact as depicted on the Solar Glare Hazard Analysis Plot shown above.”

- **Required Use of SGHAT**

“As of the date of publication of this interim policy, the FAA requires the use of the SGHAT to demonstrate compliance with the standards for measuring ocular impact stated above for any proposed solar energy system located on a federally-obligated airport. The SGHAT is a validated tool specifically designed to measure glare according to the Solar Glare Hazard Analysis Plot. All sponsors of federally obligated airports who propose to install or to permit others to install solar energy systems on the airport must attach the SGHAT report, outlining solar panel glare and ocular impact, for each point of measurement to the Notice of Proposed Construction Form 7460-1. The FAA will consider the use of alternative tools or methods on a case-by-case basis. However, the FAA must approve the use of an alternative tool or method prior to an airport sponsor seeking approval for any proposed on-airport solar energy system. The alternative tool or method must evaluate ocular impact in accordance with the Solar Glare Hazard Analysis Plot.”

The Glint and Glare evaluation will be undertaken using ForgeSolar software. ForgeSolar succeeds the Solar Glare Hazard Analysis Tool (SGHAT), whose use was required by the FAA to demonstrate compliance with the standards for measuring ocular impact for any proposed solar energy systems at airports. ForgeSolar is the leading software specialist for modelling glare impacts and the software is used extensively across the UK for assessing impacts toward airports, transportation and residential dwellings. Further details are provided in Section 4.1 of this report.



4. Methodology

A desk-based assessment is undertaken to assess glint and glare that may be experienced by light-sensitive receptors within the vicinity of the proposed solar PV development.

4.1 Solar Reflection Model

A computational modelling tool was used, where appropriate/required, to model and assess solar reflectivity of the Proposed Development in relation to specified receptors, in line with FAA guidance.

The tool employs an interactive Google map where the site location, proposed solar energy system and receptor paths/locations can be specified. Latitude, longitude, and elevation are automatically recorded through the Google interface, providing necessary information for sun position and vector calculations.

PV systems are represented by contiguous planar polygon footprints and a set of customisable parameters. Each footprint comprises three or more vertices, defined by a latitude, longitude, elevation, and height. Each distinct PV installation or array is modelled with its own PV array footprint. The PV panel tilt, orientation, and height are considered to be the same across the entire array. This is considered acceptable due to the distance of the sun from the Proposed Development and the relatively small differences in location of the sun over the Proposed Development.

The solar reflectance of the PV modules is specified based on the module surface material. The modelling tool has four general module material reflectance profiles which were developed by analysing different PV module samples. The following options are available:

- Smooth glass without ARC
- Smooth glass with ARC
- Light textured glass without ARC
- Light textured glass with ARC

During analysis, sunlight is reflected over each PV array on a minute-by-minute basis according to the specified module tilt and orientation or axis tracking parameters, if the system is not fixed-mount. The system then checks whether the resulting solar reflections intersect (impact) the specified receptors, thus predicting glint and glare occurrence.

4.2 Receptor Identification

In general, light-sensitive receptors with view of a solar PV development have potential to experience solar reflection. While no technical distance limits/thresholds are reported within which solar reflections are possible for such receptors, the potential or significance of a reflection decreases with distance due to an observer's decreasing field of vision capability with increasing distance, as well as possible obstructions such as shielding caused by terrain and vegetation. For the purpose of this assessment, the following good practice considerations will be applied, incorporating relevant guidance as laid out in Section 3.0.



Table 4.1: Receptor Identification Criterium

Dwellings	There is not a defined screening distance for consideration of the potential glare impact of solar carport panels on residential dwellings. For residential dwellings very close to a proposed solar carport development, there will be instances where the resident does not have geometric line of sight of the proposed carport. In addition, there may be obstructions to the line of sight such as other buildings or vegetation screening. Line of sight for this assessment is reviewed using satellite and street view imagery. Professional judgement is used to determine a representative number of dwelling points to be modelled. Industry guidance recommends glare modelling for ground floor residential receptors because it is typically the most occupied part of the dwelling during daylight hours. A height of 1.8 m above ground level will be considered to account for observer’s eye level on ground floor (main habitable rooms are generally on the ground floor), unless otherwise stated.
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4.3 Magnitude of Impact

4.3.1 Ocular Impact

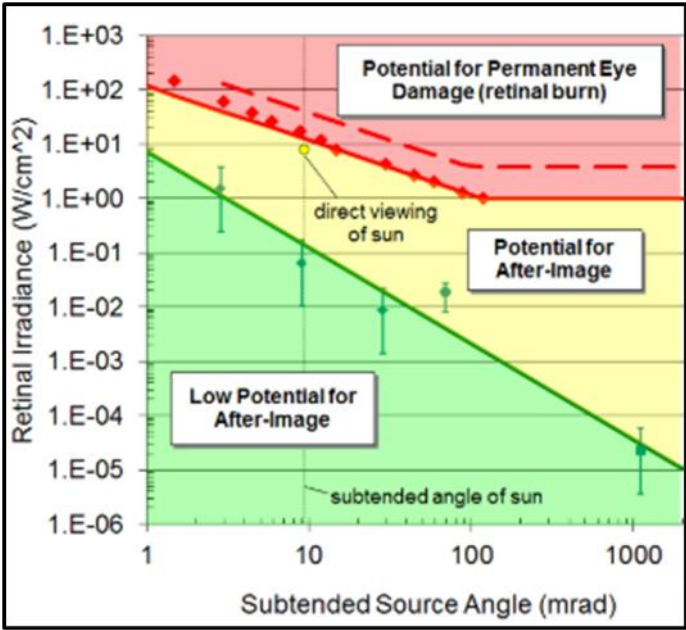
Ocular impact significance depends on the line of sight between the reflector (solar PV panels) and the receptor, the location of the receptor relative to the reflector and thus the solar reflection, the time of the day, they path between the Sun and the reflective surface, and the reflection exposure period (e.g. momentary exposure is less significant that prolonged exposure).

As such, ocular impact can be classified into three levels based on the retinal irradiance and subtended source angle: low potential for after-image (green), potential for after-image (yellow), and potential for permanent eye damage (red). These categories are illustrated in the Ocular Hazard plot⁶ shown in Figure 4.1 (NOTE: this is a universal Ocular Hazard plot and does not represent potential glare conditions that may be experienced at the Proposed Development.).

⁶ Sliney, D.H. and B.C. Freasier, 1973, Evaluation of Optical Radiation Hazards, Applied Optics, 12(1), p. 1-24.



Figure 4.1: Ocular Hazard Plot



The subtended source angle represents the size of glare observed by receptor, while the retinal irradiance is the quantity of energy impacting the retina of the observer. As it can be seen from Figure 4.1, wide subtended source angles can cause retinal irritation/damage even at low retinal irradiance.

4.3.2 Glint & Glare Impact Significance

4.3.2.1 Dwellings

While there is no specific government guidance on glint and glare impact significance evaluation, the following industry guidance classifications⁷ may be used. The guidance classifications have been based on over 1,000 assessments of glare in the UK, as well as drawing upon a review of existing guidance with respect to other light-based environmental impacts. Additionally, through the review of Nationally Significant Infrastructure Projects, the assessment approach has been accepted by the Planning Inspectorate for the assessment of solar panel impacts at sites across the UK.

Table 4.2: Dwelling Impact Significance Guidance

No Impact	Solar reflection is not geometrically possible or will not be visible from the assessed receptor.
Low	Predicted glare of any intensity (green or yellow) occurs for less than 60 minutes per day and for less than three months per year.

⁷ <https://www.pagerpower.com/wp-content/uploads/2022/09/Solar-Photovoltaic-Glint-and-Glare-Guidance-Fourth-Edition.pdf>



	Predicted glare of any intensity (green or yellow) occurs for longer than 60 minutes and for more than 3 months per year. However, there are additional mitigating factors that when considered renders the residual potential glare to be not significant. Additional mitigation is not required.
Moderate	Predicted glare of any intensity (green or yellow) occurs for longer than 60 minutes or for more than 3 months per year. There are additional mitigating factors but the residual potential glare remains significant. Predicted glare of any intensity (green or yellow) occurs for longer than 60 minutes and for more than 3 months per year. There are additional mitigating factors but the residual potential glare remains significant. Additional mitigation may be required at planner's discretion.
High	Predicted glare of any intensity (green or yellow) occurs for longer than 60 minutes per day and for more than 3 months of the year. There are no mitigating factors to consider. Additional mitigation will be required if the proposed development is to proceed.

4.4 Time Zone / Datum

The UK uses British Summer Time (BST, UTC +01:00) in the summer and Greenwich Mean Time (GMT, UTC +0) in the winter. For the purpose of this report all time references are in GMT. All locations are given in Eastings and Northings using the UK National Grid Reference system, unless otherwise specified.

4.5 Assumptions, Limitations & Fixed Model Variables

Provided in Appendix A is a list of assumptions, limitations and fixed variables of the model and assessment methodology.

4.6 Elevation Data

Elevation data for the modelled arrays and residential receptors were obtained using Defra Survey⁸ LiDAR data database. Digital Terrain Model data was downloaded from the most recent survey and was combined with the average of the maximum and minimum panel heights above ground to determine the total PV elevation within the ForgeSolar model.

⁸ <https://environment.data.gov.uk/survey>



5. Receptor Screening & Model Considerations

5.1 Residential Dwellings

At the request of the Local Planning Authority, residential receptors located nearby to the proposed development have been included within the modelling assessment.

Receptors MR1-MR13 represent houses. A height of 1.8 m above ground level has been considered to account for observer's eye level on ground floor (main habitable rooms are generally on the ground floor).

The residential receptors that were included in the model are shown in Figure 5.1.

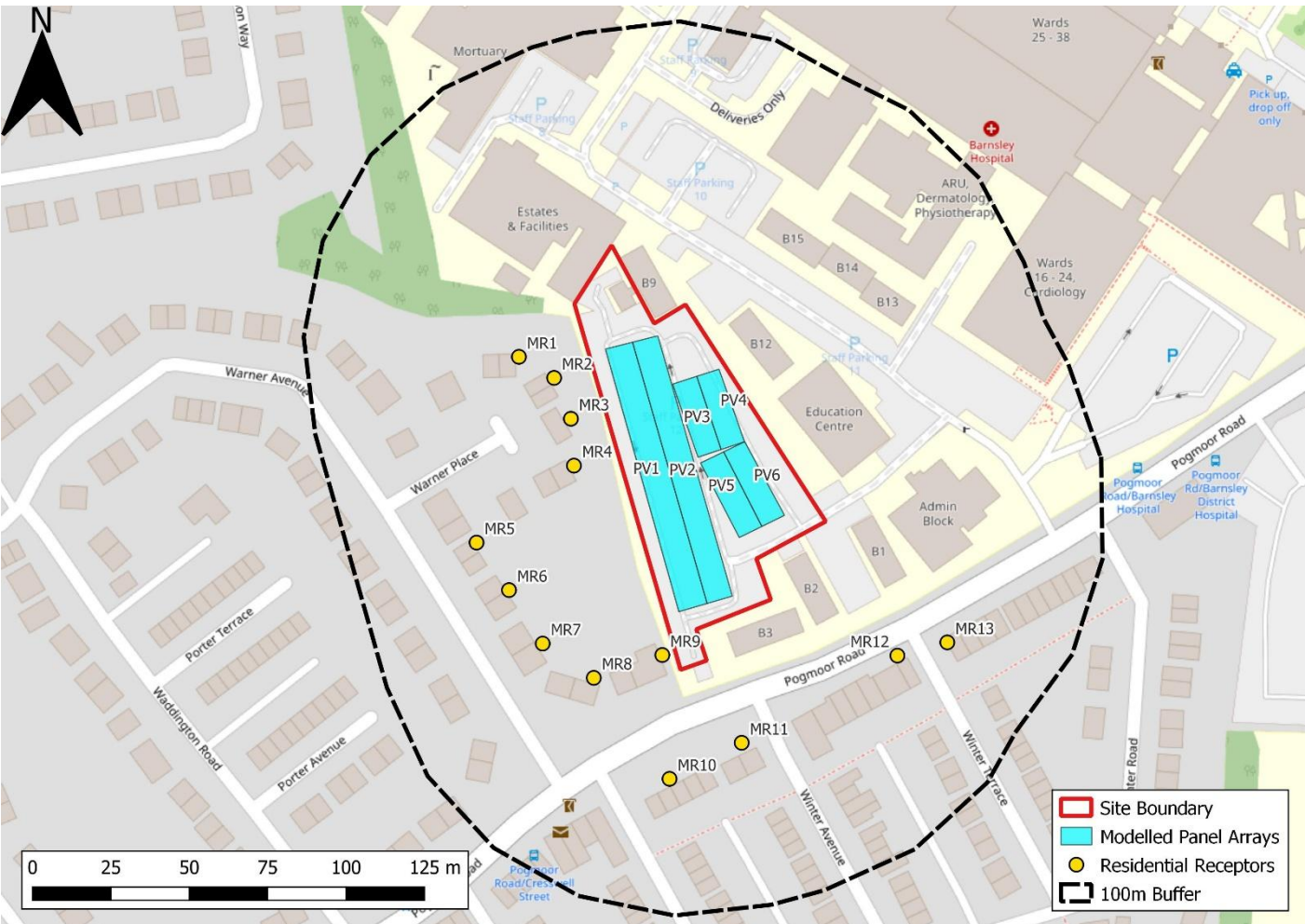
There is not a defined screening distance for consideration of the potential glare impact of canopy solar panels on residential dwellings. For residential dwellings very close to a proposed canopy solar development, there will be instances where the resident does not have geometric line of sight of the proposed solar carport canopy panels. In addition, there may be obstructions to the line of sight such as other buildings or vegetation screening.

Given the density of the surrounding residential area, only those dwellings located 100m of the proposed development have been modelled.

Additionally, only those receptors closest to, and with potential line of sight towards, the proposed development have been modelled. In the wider area, it is expected that receptors further away will be screened by these receptors, as well as topography, vegetation or other buildings found in-between them.



Figure 5.1: Modelled Residential Receptors



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6. Modelling Results & Interpretation

6.1 Residential Dwellings

6.1.1 Modelled Results

Table 6.1: Modelled Results - Residential Dwellings

Receptor	Results	Impact
MR1	Glare is predicted towards MR1 from PV2 from early August to early May between 05:30 – 09:30 for a maximum of 30 minutes per day. Glare is predicted towards MR1 from PV4 from late February to early April and from late August to mid-September between 06:30 – 08:30 for a maximum of 20 minutes per day. Glare is predicted towards MR1 from PV6 from late January to early March and from late September to early November between 07:00 – 09:00 for a maximum of 20 minutes per day. As such, glare is predicted for less than 60 minutes per day, but for more than 3 months per year. Based on the impact significance guidance, a review of mitigation considerations has been undertaken in Section 6.1.2 below.	Further Review (see Section 6.1.2 below)
MR2	Glare is predicted towards MR2 from PV2 year-round between 04:30 – 09:30 for a maximum of 30 minutes per day. Glare is predicted towards MR2 from PV4 from late February to late April and from late August to early October between 06:00 – 08:30 for a maximum of 20 minutes per day. Glare is predicted towards MR2 from PV6 from late January to early March and from late September to early November between 06:30 – 09:00 for a maximum of 25 minutes per day. As such, glare is predicted for less than 60 minutes per day, but for more than 3 months per year. Based on the impact significance guidance, a review of mitigation considerations has been undertaken in Section 6.1.2 below.	Further Review (see Section 6.1.2 below)
MR3	Glare is predicted towards MR3 from PV2 year-round between 04:30 – 09:30 for a maximum of 30 minutes per day. Glare is predicted towards MR3 from PV4 from mid-March to late May and from mid-July to late September and from late August to early October between 05:00 – 07:30 for a maximum of 25 minutes per day. Glare is predicted towards MR3 from PV6 from mid-February to early April and from early September to late October between 06:30 – 08:30 for a maximum of 25 minutes per day.	Further Review (see Section 6.1.2 below)



Receptor	Results	Impact
	As such, glare is predicted for less than 60 minutes per day, but for more than 3 months per year. Based on the impact significance guidance, a review of mitigation considerations has been undertaken in Section 6.1.2 below.	
MR4	Glare is predicted towards MR4 from PV2 from early January to early December between 04:30 – 09:30 for a maximum of 35 minutes per day. Glare is predicted towards MR4 from PV4 from mid-April to late August between 04:30 – 06:30 for a maximum of 25 minutes per day. Glare is predicted towards MR4 from PV6 from early March to early May and from early August to early October between 05:30 – 08:00 for a maximum of 25 minutes per day. As such, glare is predicted for less than 60 minutes per day, but for more than 3 months per year. Based on the impact significance guidance, a review of mitigation considerations has been undertaken in Section 6.1.2 below.	Further Review (see Section 6.1.2 below)
MR5	Glare is predicted towards MR5 from PV2 from mid-March to late September between 04:30 – 08:00 for a maximum of 30 minutes per day. Glare is predicted towards MR5 from PV4 from early May to late July between 04:30 – 06:00 for a maximum of 25 minutes per day. Glare is predicted towards MR5 from PV6 from early April to early June and from early July to early September between 05:00 – 07:00 for a maximum of 25 minutes per day. As such, glare is predicted for less than 60 minutes per day, but for more than 3 months per year. Based on the impact significance guidance, a review of mitigation considerations has been undertaken in Section 6.1.2 below.	Further Review (see Section 6.1.2 below)
MR6	Glare is predicted towards MR6 from PV2 from late March to early September between 04:30 – 07:30 for a maximum of 35 minutes per day. Glare is predicted towards MR6 from PV6 from early April to early June and from early July to early September between 04:30 – 06:30 for a maximum of 30 minutes per day. As such, glare is predicted for less than 60 minutes per day, but for more than 3 months per year. Based on the impact significance guidance, a review of mitigation considerations has been undertaken in Section 6.1.2 below.	Further Review (see Section 6.1.2 below)
MR7	Glare is predicted towards MR7 from PV2 from late April to mid-August between 04:00 – 06:30 for a maximum of 40 minutes per day. Glare is predicted towards MR6 from PV6 from late May to mid-June between 04:30 – 05:30 for a maximum of 30 minutes per day.	Further Review (see Section 6.1.2 below)



Receptor	Results	Impact
	As such, glare is predicted for less than 60 minutes per day, but for more than 3 months per year. Based on the impact significance guidance, a review of mitigation considerations has been undertaken in Section 6.1.2 below.	
MR8	Glare is predicted towards MR8 from PV2 from late May to early July between 04:00 – 05:30 for a maximum of 30 minutes per day. Based on industry guidance, glare predicted for less than 60 minutes per day and for less than 3 months of the year may be classified as ‘low impact’, and no further mitigation is recommended.	Low Impact
MR9	No glare predicted towards MR9.	No Impact
MR10	No glare predicted towards MR10.	No Impact
MR11	No glare predicted towards MR11.	No Impact
MR12	Glare is predicted towards MR12 from PV1 from mid-April to late August between 18:00 – 20:30 for a maximum of 15 minutes per day. As such, glare is predicted for less than 60 minutes per day, but for more than 3 months per year. Based on the impact significance guidance, a review of mitigation considerations has been undertaken in Section 6.1.2 below.	Further Review (see Section 6.1.2 below)
MR13	Glare is predicted towards MR13 from PV1 from mid-April to late August between 18:00 – 20:30 for a maximum of 15 minutes per day. As such, glare is predicted for less than 60 minutes per day, but for more than 3 months per year. Based on the impact significance guidance, a review of mitigation considerations has been undertaken in Section 6.1.2 below.	Further Review (see Section 6.1.2 below)

Detailed results can be provided upon request.

No glare is predicted towards receptors **MR9 – MR11**. As such, further review of the impacts at these receptors are not undertaken.

With reference to the guidance in Section 4.3.2.1, a ‘low impact’ significance can be classified where glare of any intensity occurs for less than 60 minutes per day and for less than three months per year. **Low impacts are predicted to occur at receptor MR8**. As such, further review of the impacts at this receptor is not undertaken.

With reference to the guidance in Section 4.3.2.1, a ‘moderate impact’ significance may be classified where glare of any intensity occurs for more than 60 minutes per day or for more than three months per year. Glare is predicted to occur for less than 60 minutes per day at ten of the 13 modelled receptors (**MR1 – MR7 and MR12 – MR13**). However, the 3 months criteria is predicted to be exceeded.

A review of mitigation considerations for receptors MR1 – MR7 and MR12 – MR13 has been undertaken in Section 6.1.2 below.



6.1.2 Further Review

Mitigating factors have been considered to determine residual impact significance. These include:

- The extent to which direct sunlight and glare impacts coincide;
- The extent to which cloud cover and glare impacts coincide; and
- Screening by intervening infrastructure/vegetation

6.1.3 Coincidence of Direct Sunlight and Glare Impacts

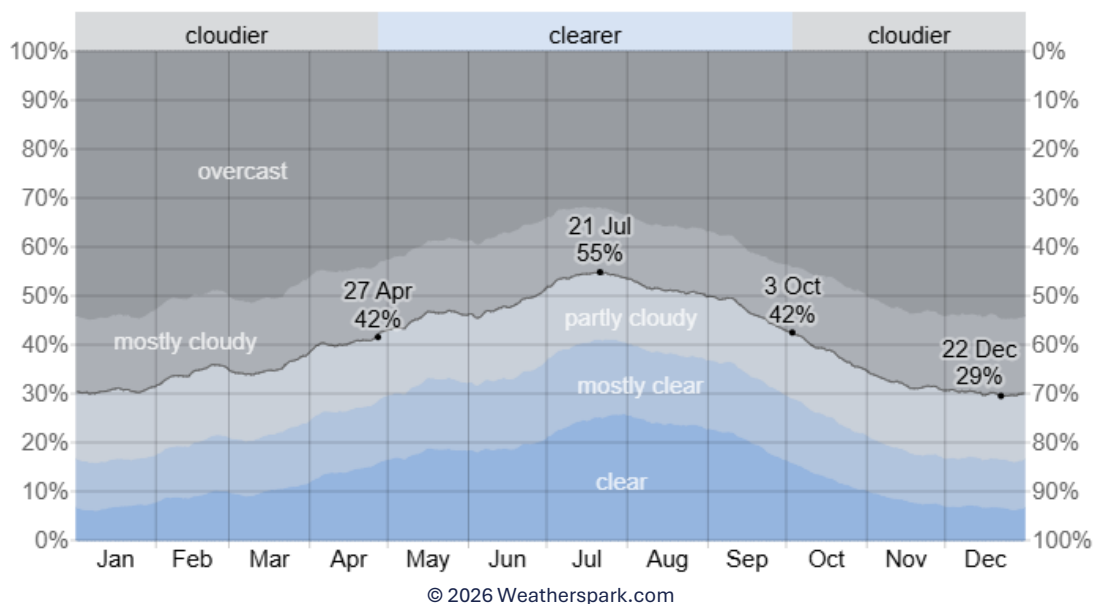
Effects that coincide with direct sunlight appear less prominent than those that do not as the Sun is a far more significant source of light than the reflecting panels. A review of the entirety of the predicted glare towards MR1 – MR7 indicates that it will coincide with morning, when the sun is lower in the sky. Therefore, glare towards MR1 – MR7 is considered mitigated as the glare from the sun and reflective area are predicted to originate from the same point in space.

A review of the entirety of the predicted glare towards MR12 – MR13 indicates that it will coincide with evening, when the sun is lower in the sky. Therefore, glare towards MR12 – MR13 is considered mitigated as the glare from the sun and reflective area are predicted to originate from the same point in space.

6.1.4 Coincidence of Cloud Cover and Glare Impacts

As the worst-case approach, the model assumes clear sky conditions all year round. During the affected months (year-round), cloudier conditions (overcast and mostly cloudy) exist in Harrow (nearest weather data available) for 45-71% of the time, as shown in Figure 6.1⁹.

Figure 6.1: Annual Cloud Cover Percentage in Barnsley



⁹<https://weatherspark.com/y/42115/Average-Weather-in-Barnsley-United-Kingdom-Year-Round>



Considering the cloud cover that is likely to occur in the area year-round, the modelled glare from the Proposed Development is likely to occur at least 45% less often than predicted as a minimum. This would likely reduce the amount of glare experienced at modelled receptors.

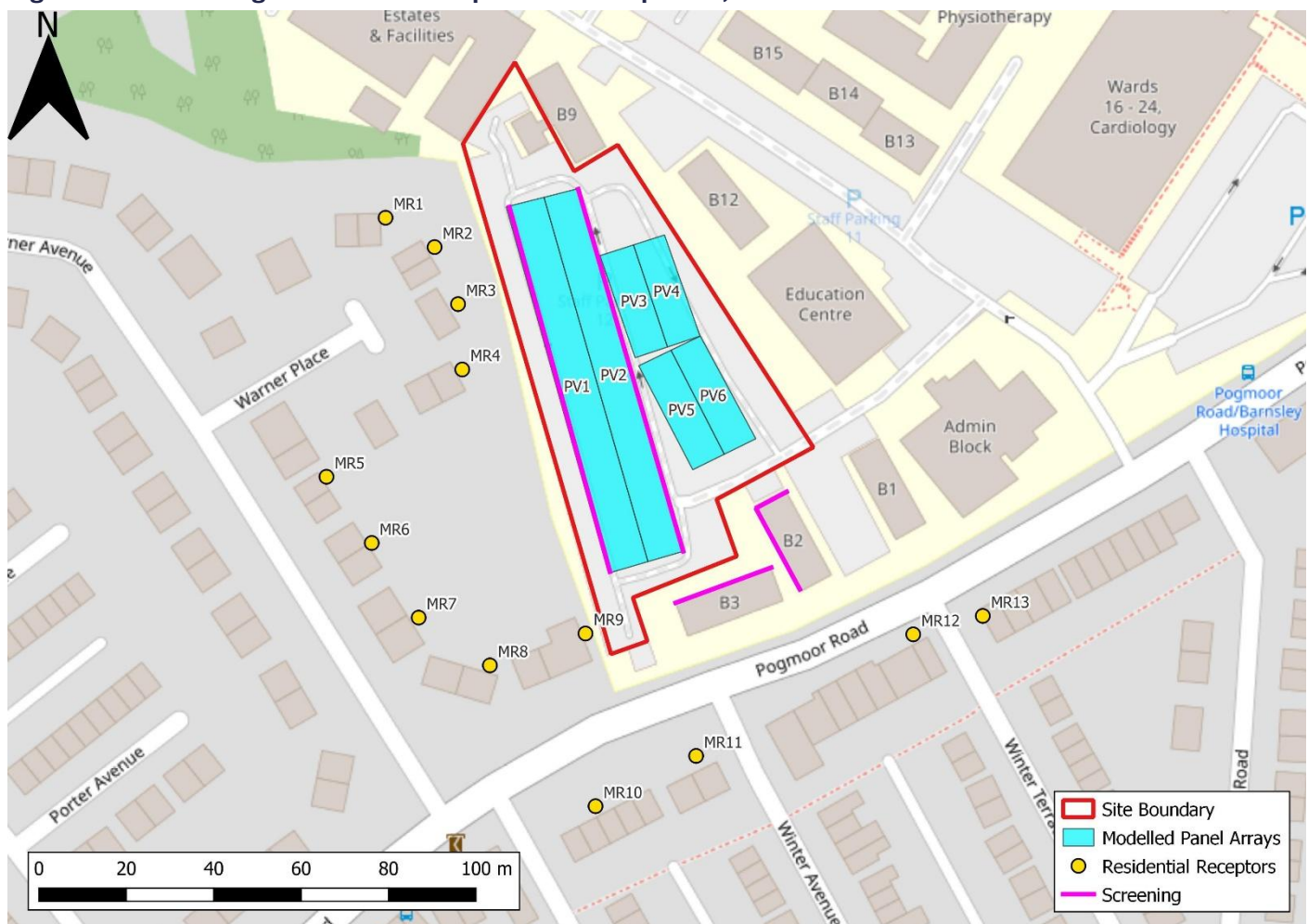
6.1.5 Screening by Infrastructure

In addition, line of sight between residential receptors and the proposed development may be screened by existing infrastructure and vegetation. The proposed panel arrays are based on a double gull-wing structure, meaning that they slope towards the centre line of the arrays.

Subsequently, using ForgeSolar's inbuilt obstruction tool, an obstruction was modelled based on the maximum height above ground (4.5m) of the western edge of PV1, which intervenes line of sight between PV2, PV4 and PV6 and MR1 – MR7. A similar obstruction at 4.5m height above ground was modelled to represent the eastern edge of PV2, which intervenes line of sight between PV1 and MR12 – MR13.

Additional obstructions were modelled based on the on-site hospital buildings to the south of the panels, as these intervene line of sight between PV1 and MR12 - MR13. These were modelled at a LiDAR-derived height of 7.8m. The obstructions are shown below in Figure 6.2.

Figure 6.2: Screening between the Proposed Development, MR1 – MR8 and MR12 – MR13.



© OpenStreetMap 2026



Additional modelling with the above obstructions in place confirmed that the existing screening by the hospital buildings and upper edges of PV1 and PV2 would eliminate glare towards MR2 – MR7 and MR12 – MR13, and would reduce glare towards MR1 to 'low impact'.

6.2 Residual Significance of Impact

Following a further review of mitigation factors, the amount of glare at the identified affected receptors is expected to be reduced to less than 3 months of the year and less than 60 minutes daily resulting in an overall 'low impact'. The residual impacts at all modelled dwellings are detailed in Table 6.4 below.

Table 6.2: Residual Impact Significance at Residential Dwellings

Receptor	Residual Impact
MR1	Low Impact (due to mitigating factors)
MR2	Low Impact (due to mitigating factors)
MR3	Low Impact (due to mitigating factors)
MR4	Low Impact (due to mitigating factors)
MR5	Low Impact (due to mitigating factors)
MR6	Low Impact (due to mitigating factors)
MR7	Low Impact (due to mitigating factors)
MR8	Low Impact
MR9	No Impact
MR10	No Impact
MR11	No Impact
MR12	Low Impact (due to mitigating factors)
MR13	Low Impact (due to mitigating factors)



7. Conclusions

Technical glare modelling was undertaken for the potential impact of the proposed development on nearby light-sensitive receptors.

It is noted that the Local Planning Authority (LPA) have requested modelling of residential receptors located nearby to the proposed development.

Geometric glare modelling was conducted for residential dwellings located within 100m of the proposed development.

No glare was predicted towards 3 out of 13 modelled residential receptors (MR9 – MR11). As such, no further mitigation is recommended towards these receptors.

With reference to the impact significance guidance, glare that is predicted for less than 3 months of the year and for less than 60 minutes per day may be classified as 'low impact'. Low impact glare was predicted at 1 out of 13 modelled residential receptors (MR8). As such, no further mitigation is recommended towards this receptor.

With reference to the impact significance guidance, glare that is predicted for more than 3 months of the year or for more than 60 minutes per day may be classified as 'moderate impact'. Glare was predicted for less than 60 minutes per day, but for more than 3 months of the year at 10 out of 13 modelled residential receptors (MR1 – MR7 and MR12 – MR13).

Following a review of mitigating factors, including cloud cover, coincidence of glare with direct sunlight and screening by intervening infrastructure and panels, it was concluded that a 'low impact' may be classified towards receptors MR1 – MR7 and MR12 – MR13.

As such, the results of this assessment indicate that the proposed development will not introduce an unacceptable impact towards the surrounding residential dwellings.



Appendices



Appendix A: Assumptions, Limitations & Fixed Model Variables



1. The sun position and glare analysis will be determined throughout the year on a 1-minute basis.
2. The maximum amount of solar power striking surface normal to the sun per unit area (Peak direct normal irradiance, DNI) is set at $1,000 \text{ W/m}^2$. This will be scaled for each time step to account for changing sun position.
3. The average subtended angle of the sun as viewed from earth is 9.3 mrad .
4. The ocular transmission coefficient for the radiation that is absorbed in the eye before reaching the retina, is set to 0.5.^{10,11}
5. Observer pupil diameter is set at the typical value of 0.002 m for daylight.^{10,11}
6. Eye focal length for the distance between the nodal point (where rays intersect in the eye) and the retina is set at the typical value of 0.017 m .^{10,11}
7. The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. However, models have been validated against several systems, including a PV array causing glare to the air-traffic control tower at Manchester-Boston Regional Airport and several sites in Albuquerque, and the tool accurately predicted the occurrence and intensity of glare at different times and days of the year.¹²
8. The algorithm assumes that the PV array is aligned with a plane defined by the total heights (ground elevation plus PV array height) of the coordinates outlined in the Google map.
9. The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors. As such, calculated DNI may vary from actual DNI experienced by observer.
10. The system output calculation is a DNI-based approximation that assumes clear, sunny skies all year-round.
11. Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
12. Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
13. Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
14. PV array tracking assumes the modules move instantly when tracking the sun, and when reverting to the rest position.

¹⁰ Ho, C. K., Ghanbari, C. M., and Diver, R. B., 2011, Methodology to Assess Potential Glint and Glare Hazards From Concentrating Solar Power Plants: Analytical Models and Experimental Validation, ASME J. Sol. Energy Eng., 133.

¹¹ Stiney, D.H. and B.C. Freasier, 1973, Evaluation of Optical Radiation Hazards, Applied Optics, 12(1), p. 1-24.

¹² <https://www.forgesolar.com/help/#assumptions>

