

Project No: 314826

George Kenyon Hall, The University of Manchester - Glint & Glare Assessment

Prepared for:

Halliday Meecham Architects Ltd

111 Piccadilly
Manchester, U.K.
M1 2HY

Contents Amendment Record

This report has been issued and amended as follows:

Revision	Description	Date	Signed
1.0	First Issue	24 March 2024	L Hart
2.0	Second Issue	25 March 2024	L Hart



SAFETY
SCHEMES IN
PROCUREMENT



Acknowledgement

This report has been prepared for the sole and exclusive use of Halliday Meecham Architects Ltd (Halliday Meecham Architects) in accordance with the scope of work presented in Mabbett & Associates Ltd (Mabbett) Letter Agreement (314826/AC/270224/3.0), dated 27 February 2024. This report is based on information and data collected by Mabbett. Should any of the information be incorrect, incomplete or subject to change, Mabbett may wish to revise the report accordingly.

This report has been prepared by the following Mabbett personnel:

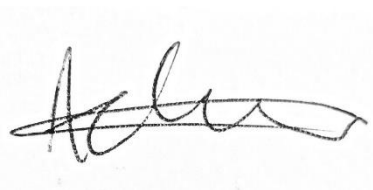
MABBETT & ASSOCIATES LTD



Lily Hart, BSc (Hons)
Environmental Consultant

This report has been reviewed and approved by the following Mabbett personnel:

MABBETT & ASSOCIATES LTD



Alexandra Clacy, MSc
Environmental Engineer

MABBETT & ASSOCIATES LTD



Josh Jones, BSc, MSc, MIAQM, MIEEnvSc
Senior Environmental Consultant

Table of Contents

Section 1.0: Introduction	1
1.1 Introduction	1
1.2 Glint & Glare	1
1.3 Scope of Work	1
Section 2.0: Development Characteristics	2
2.1 Site Description	2
2.2 Proposed Development	2
Section 3.0: Legislation & Guidance	5
3.1 Planning Guidance	5
3.1.1 City of London Planning Advice Note	5
3.2 Aviation Guidance	6
3.2.1 UK Civil Aviation Authority Guidance	6
3.2.2 US Federal Aviation Administration Guidance	8
Section 4.0: Methodology	10
4.1 Solar Reflection Model	10
4.2 Receptor Identification	10
4.3 Magnitude of Impact	11
4.3.1 Ocular Impact	11
4.3.2 Glint & Glare Impact Significance	12
4.4 Time Zone / Datum	13
4.5 Assumptions, Limitations & Fixed Model Variables	13
Section 5.0: Receptor Screening & Modelling Considerations	14
5.1 Aviation Infrastructure – Manchester Royal Infirmary Helipad	14
5.2 Modelling Considerations	15
5.2.1 Reflectivity	15
5.2.1 Slope Error (Surface Texture)	17
Section 6.0: Modelling Results & Interpretation	18
6.1 Modelling Results	18
6.1.1 South Façade	18
6.1.2 North Façade	18
6.2 Further Review	19
6.2.1 North	19
6.2.2 East	21
6.2.3 South-East	22
6.2.4 South	23
6.2.5 South-West	25
6.2.6 West	26
6.3 Residual Overall Impact	27
Section 7.0: Conclusions	29

Section 1.0: Introduction

1.1 Introduction

Halliday Meecham Architects is assisting with the project to replace the zinc cladding façade with aluminium cladding at George Kenyon Hall of Residence, University of Manchester.

A glint and glare assessment has been requested to assess the impact of the potential glare from the aluminium façade on the nearby helipad at Manchester Royal Infirmary.

This report presents the findings of the glint and glare assessment undertaken for the Proposed Development.

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 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).

Reflective surfaces on buildings and other vertical structures 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 vertical reflective surface 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 light-sensitive receptors. A solar glare analysis tool was utilised to model the building façades 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.

Section 2.0: Development Characteristics

2.1 Site Description

The site (centred at National Grid Reference, NGR 384692, 396775) is located at the George Kenyon Hall of Residence, University of Manchester. It is bounded on all sides by other University of Manchester buildings.

The site location is shown in Figure 2.1 below.

Figure 2.1 Site Location



2.2 Proposed Development

The Proposed Development comprises of the replacement of the zinc cladding façade with aluminium cladding on the north and south faces of the building. The modelled façade lower and upper edge heights are summarised in the below table.

Reflecting Façade	Lower Edge Height	Upper Edge Height
South Façade	0m	44m
North Façade	0m	44m

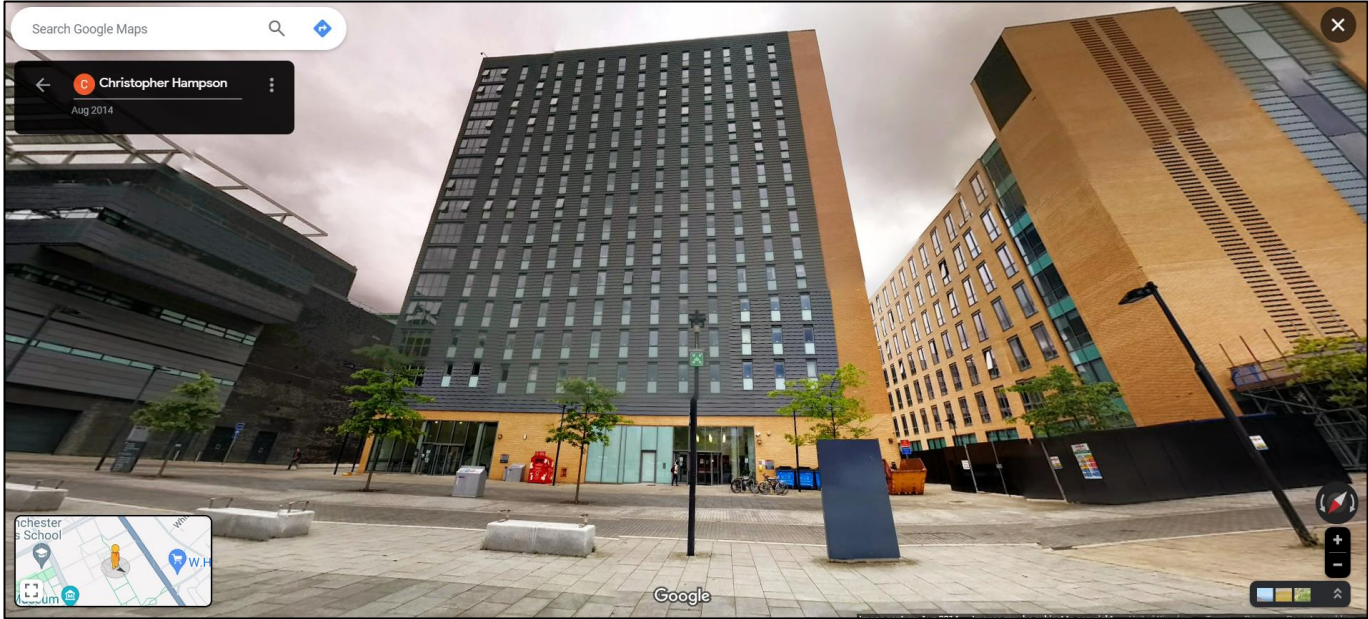
The proposed aluminium cladding is to be finished using three different paint coatings:

- Anodic Bronze = Light Reflectance Value¹ 6 / Gloss 15%
- C2 Light Gold = Light Reflectance Value 33 / Gloss 15%
- Sakura Pink - Green = Light Reflectance Value 22 / Gloss 85%

¹ Light Reflectance Value is measured on a scale that ranges from zero (absolute black, absorbing all light and heat) to 100 percent (pure white, reflecting all light).

The existing elevation of the hall of residence is shown in Figure 2.2 below.

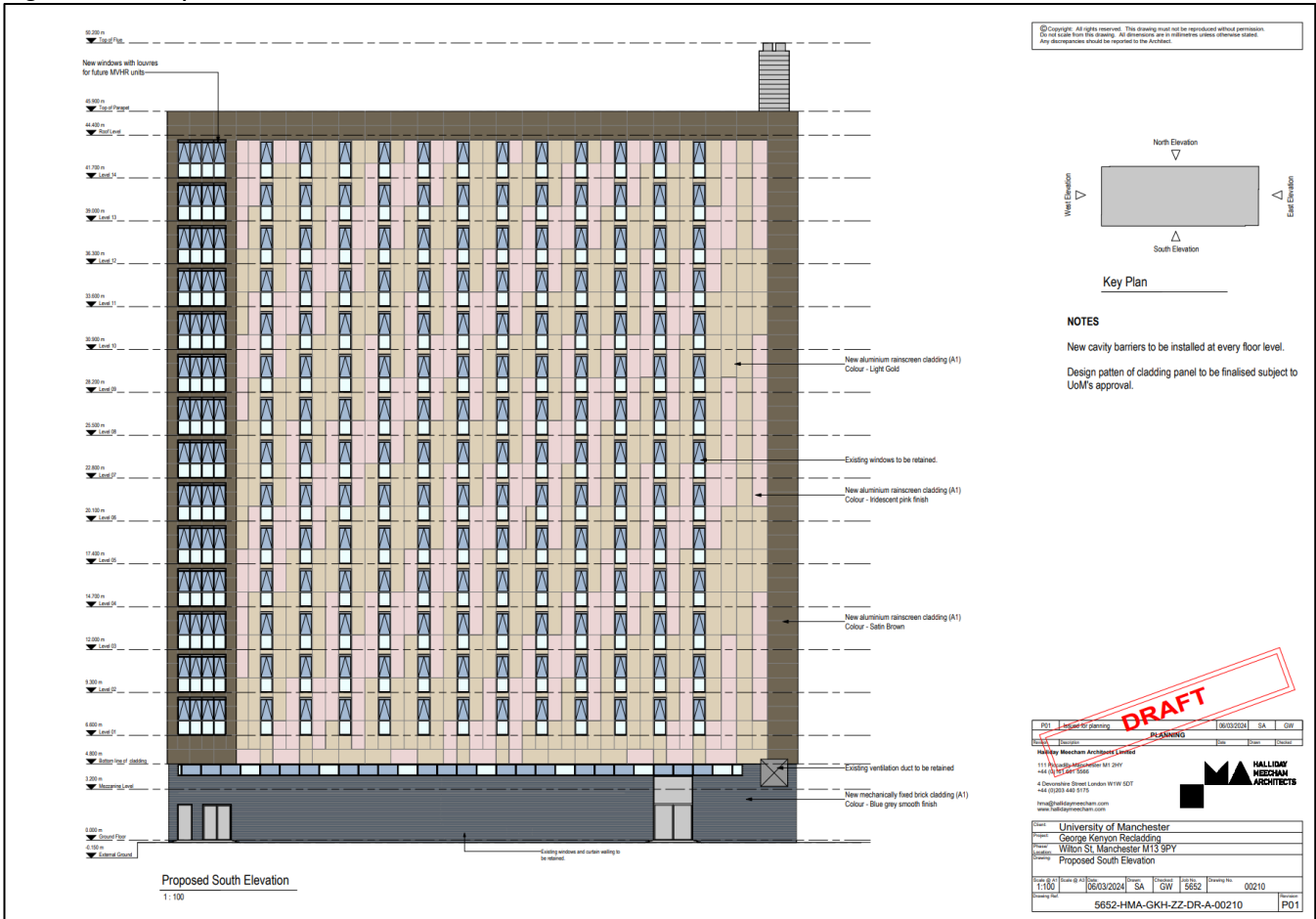
Figure 2.2 Existing Elevation (North Facing Façade)



© 2024 Google Photos

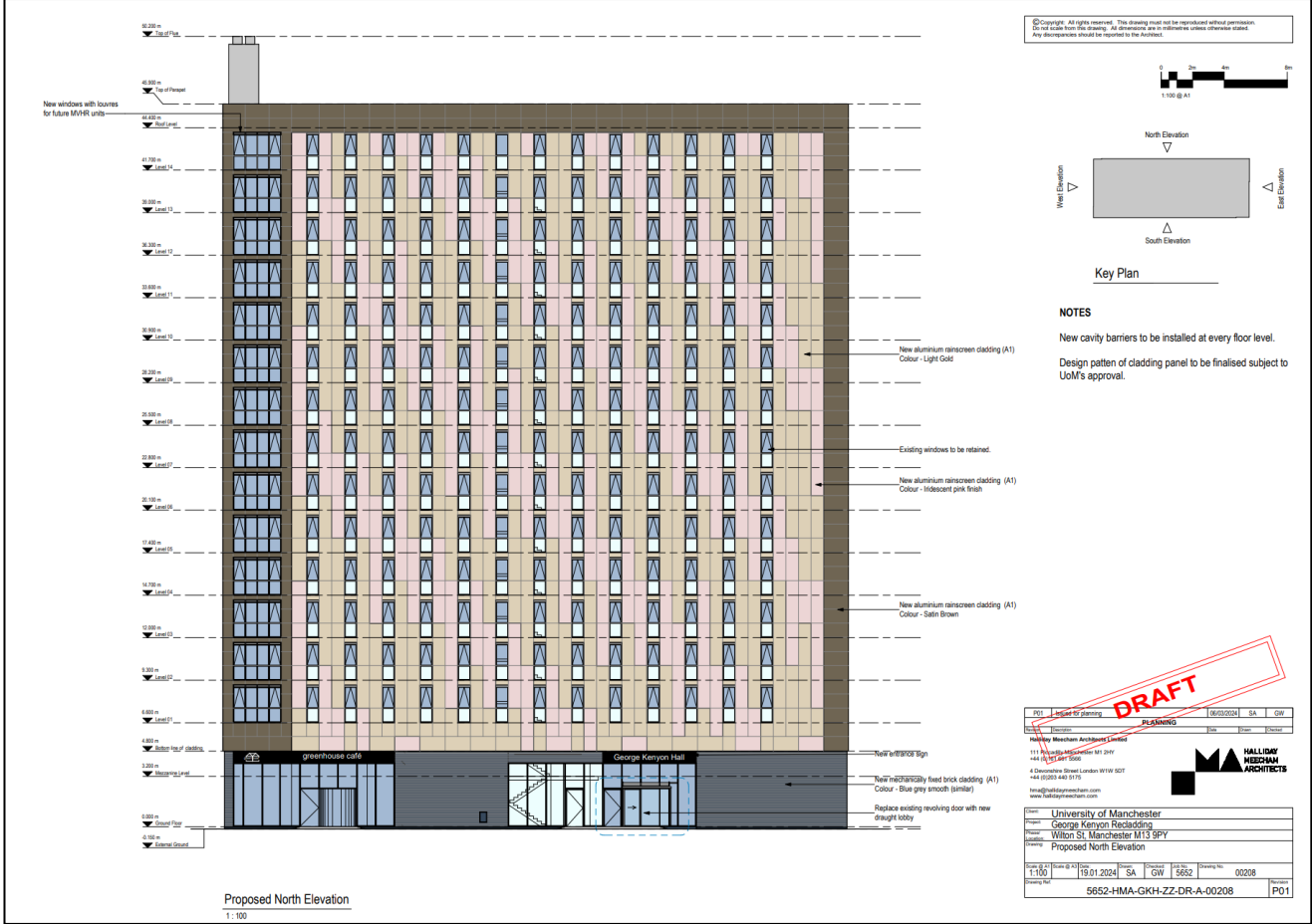
The proposed façade for the hall of residence is shown in Figure 2.3 and Figure 2.4 below. The modelled façade extent is shown below in Figure 2.5.

Figure 2.3 Proposed South Elevation



© 2024 Halliday Meecham

Figure 2.4 Proposed North Elevation



© 2024 Halliday Meecham

Figure 2.5 Modelled Facades



Imagery © 2024 Google

Section 3.0: Legislation & Guidance

3.1 Planning Guidance

In the absence of national and local planning guidance relating to building glare impacts from tall buildings, planning guidance from the City of London has been reviewed.

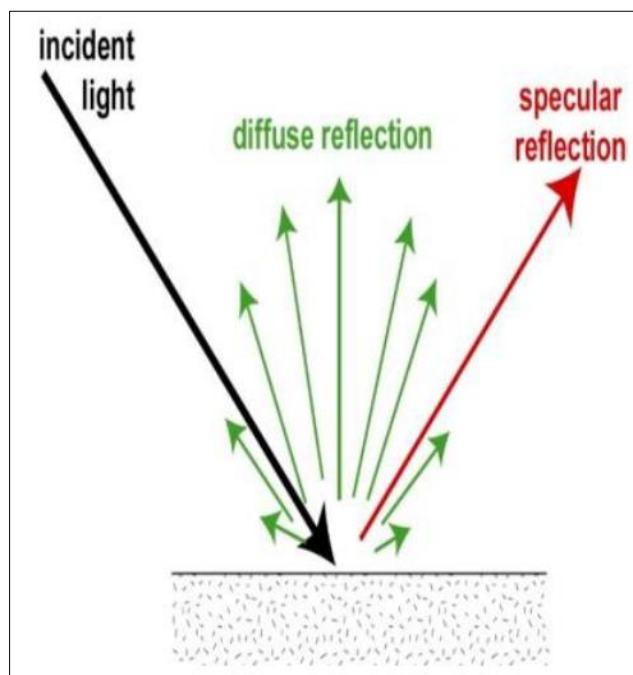
3.1.1 City of London Planning Advice Note

A Planning Advice Note was released by the City of London in July 2017 entitled '*Guidelines and best practice for assessing solar glare in the City of London*'². This guidance discusses causes, impacts and mitigating measures of solar glare from reflective surfaces.

The guidance states:

"Solar glare can occur either when there are large areas of reflective glass or cladding on the façade, or when there are areas of glass or cladding which slope back so that high altitude sunlight can be reflected along the ground. Photovoltaic panels tend to cause less glare because they are designed to absorb light.

The severity of glare depends on the type of glazing or cladding. The glare caused depends on the specular reflectance of the glazing. This is the mirror-like direct reflection of sunlight. For glasses, the reflection is nearly all specular. Metals often combine specular reflection with diffuse reflection (where the reflected light is scattered in all directions). Surfaces like brick or matt cladding give mainly diffuse reflection, which is unlikely to cause disability glare.

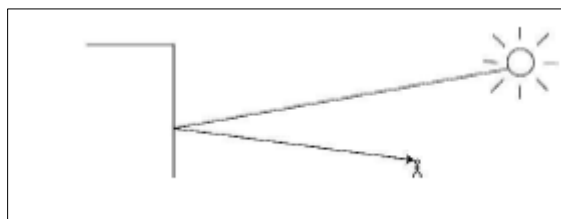


It is therefore possible to reduce reflected glare by choosing glazing or cladding with a low specular reflectance. For glare, the visible light reflectance is important, rather than the total solar reflectance."

² Available at: <https://www.cityoflondon.gov.uk/assets/Services-Environment/solar-glare-planning-advice-note.pdf>

With regard to the origin of glare, the guidance states that:

“The slope of the glass is important. With a vertical façade, the worst disability glare normally occurs when the sun is low in the sky.”



In terms of glare assessment, the guidance recommends that:

“The first stage in the assessment is to identify key locations from which the building could be seen and where solar glare could be an issue. These could include road junctions, traffic lights, pedestrian crossings and railway lines at the approach to signals. The most important locations are those where drivers will be travelling directly towards the building; glare is much less likely if the building is well to one side of the field of view.

...

The next stage is to work out whether sunlight can be reflected to these viewpoints, and if so at which times of year... Sometimes a façade, especially a north facing one, may only reflect the sky or other buildings, and not direct sunlight.”

The guidance also includes mitigation measures to reduce potential building glare at the design stage.

3.2 Aviation Guidance

The requirement for glint and glare assessments for building developments, specifically those with large reflective façades, has grown in recent years. However, there is no specific guidance relating to glint and glare impacts from reflective building façades on aviation. As such, a review of literature relating to glint and glare impacts arising from solar photovoltaic (PV) developments on aviation has been undertaken to formulate a foundation to base this assessment upon.

3.2.1 UK Civil Aviation Authority Guidance

3.2.1.1 Interim Solar PV Systems Guidance

The UK Civil Aviation Authority (CAA) issued interim guidance relating to solar PV systems on 17 December 2010 but this was withdrawn on 7 September 2012. The guidance is provided in Appendix A.

In general, the interim guidance recommends that solar PV developments in the vicinity of or within an aerodrome's boundaries should provide safety assurance documentation (e.g. glint and glare assessment) regarding the full potential impact of the proposed installation on aviation interests, as part of the relevant planning application. It is further suggested that this information should be consulted with the CAA, particularly if the proposed development is within aerodrome boundaries, and during the installation process the developer should liaise with the affected aerodrome. Beyond these recommendations, no specific methodology or frame of reference are defined for assessing the impact of glint and glare on aviation infrastructure.

3.2.1.2 Combined Aerodrome Safeguarding Team Aerodrome Safeguarding Guidance Note

In July 2024, guidance was published by both the 'Technical focus group for renewable energy developments' and 'General Aviation focus group' as part of the Combined Aerodrome Safeguarding Team (CAST), supported by the CAA. CAST is a forum for aerodrome safeguarding stakeholders with representatives from government organisations, aviation and the private sector. The content of the guidance note is intended to provide guidance only and does not necessarily constitute the position of CAST members. This guidance note aims to provide safeguarding advice in relation to solar photovoltaic developments.

Section 2 'Safety Considerations' outlines the following safety considerations that must be assessed for the design of the planned solar photovoltaic development. Points 1 and 2 are relevant to glare assessment:

- *"ATS personnel – The control tower (if applicable) is the most important location for visual surveillance across an aerodrome for monitoring operations on the ground as well as in the air. It is therefore of critical importance that the development of solar photovoltaic developments does not significantly hinder the view from a control tower's visual control room (VCR). This may be from redesigning the layout and design of the proposed solar development to avoid glare from the solar panels or by avoiding the physical blocking of key viewpoints.*
 - *Pilot – A pilot's ability to safely navigate the airspace around an aerodrome is paramount. A pilot is required to look for other aircraft and obstructions on the ground, as well as navigate towards a runway or reference points. This applies to both pilots of fixed wing aircraft and helicopters in the air, and sometimes on the ground. The standard operations that should be considered are:*
 - *pilots on approach*
 - *pilots in a visual circuit*
 - *pilots on the ground (departing and taxiing aircraft).*
- ...

Section 3.1 'Safety impacts - Glint & Glare' states:

"A key safety concern when considering a solar photovoltaic panel development on- or off-aerodrome is related to the reflection of sunlight off the photovoltaic panels commonly referred to as glint and glare. 'Glint and glare' is the general term used to describe the reflection of sunlight from a reflective surface, typically one that is capable of producing specular solar reflections. The definition of glint and glare 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.*

Typical surfaces that are considered with respect to glint and glare are glass, metallic structures e.g. roofs, and solar PV panels. The orientation of a solar panel (azimuth and elevation angle) as well as its height will determine whether glint and glare effects are possible towards the assessed receptors.

The receptors that should be considered are usually ATS personnel in a control tower and pilots of aircraft within a suitable distance of an aerodrome. It is essential to conduct a glint and glare assessment when a reflective surface is to be located on or immediately adjacent to an aerodrome. In most cases, an assessment should be undertaken for a solar PV development which is being proposed within a specific distance (indicated by the aerodrome authority) from an aerodrome. For many aerodromes, 5km is the distance of choice but it could be considered out to 10km. In exceptional circumstances, assessments may be required beyond 10km.

The UK CAA and US FAA have produced guidance with respect to glint and glare however neither of them mandates a specific methodology for assessing the effects of glint and glare.

The effects of glare may mean that some solar PV developments are unacceptable, however layout modifications (such as changes to panel tilt and elevation angle) can often alleviate these concerns and overcome objections. The benefit of early consultation with the aerodrome authority cannot be understated."

Section 4 'Aerodrome Operator Safety Assurance' states:

"The aerodrome operator in conjunction with any ATS personnel should, as part of the change management process in their safety management system, consider all the potential hazards posed by solar photovoltaic developments / BESS on or in the vicinity to their aerodrome and within the aerodrome's physical and technical safeguarded areas, in order to ensure the safety of the overall operation. The developer should provide the aerodrome with a safety survey which should include:

- *a glint and glare survey when a development is within a distance specified by the aerodrome from an Aerodrome Reference Point (ARP) (5km in most cases)*

...

The aerodrome operator should also ensure both impact and safety assessments are undertaken to provide assurance that any on- or off-aerodrome planned development does not introduce unacceptable hazards to aircrew, ATS personnel, RFFS and aerodrome vehicle operators undertaking their tasks.

As part of the aerodrome and or ATS change management process, safety assurances should take into account any potential adverse effect to critical ATS infrastructure and equipment.

The assessment must also consider any impacts to aircraft utilising instrument flight procedures and aircraft in the visual circuit.

Developers should apply the same principals for safety assurance for unlicensed aerodromes and airfields as required by this policy that are not officially safeguarded.

The developer in conjunction with the aerodrome operator, ATS personnel, RFFS and aerodrome operations should develop adequate mitigation to mitigate any risks identified.

Should risk mitigation or agreement not be possible, the aerodrome operator should follow Local Planning Authority procedures and lodge an objection regarding the development under their statutory obligations.”

3.2.2 US Federal Aviation Administration Guidance

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

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

The most comprehensive FAA 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*’) and subsequently updated in 2013 (entitled ‘*Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports*’).

3.2.2.2 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).

Key points from the latest FAA guidance produced in 2018 are presented in Appendix B. The full document can be accessed [here](#).

Overall, the 2018 update offers three assessment options:

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

3.2.2.3 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 Plot³ 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 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. Further details are provided in Section 4.1 of this report.

³ Plot provided in Section 4.4.1.

Section 4.0: 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 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.

Vertical reflective surfaces are represented by a path of two or more vertices defined by a latitude, longitude and elevation, and lower and upper edge heights which bound the portion of the surface that is reflective. The lower edge height, upper edge height and slope error are considered to be the same across the entire vertical surface. 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.

During analysis, sunlight is reflected over each vertical surface on a minute-by-minute basis according to the specified reflecting surface orientation. 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 reflective surface 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

Aviation	Aerodromes In accordance with CAA CAST guidance, aerodromes located: ▪ Within less than 5 km of proposed development, will be assessed for glint and glare. ▪ Within 5-10 km away from the proposed development will be identified but not necessarily modelled. Assessment may be requested by relevant aerodrome safeguarding authority during consultation. ▪ Beyond 10 km radius from the proposed development are not considered.
	In accordance with US FAA guidance, the recommended modelling assessment methodology is: ▪ Additional height above ground level will be considered to represent the viewing height of an air controller within the ATCT (ATCT height). ▪ 2-mile approach path thresholds towards runway(s) will be assessed, with starting points taken at 15.2 m above runway threshold at a 3-degree descent path (unless otherwise stated). ▪ Reference aircraft location receptor points will be taken at no more than ¼ miles intervals, with a minimum of 9 points, over the 2-mile approach paths identified. ▪ A pilot azimuthal field-of-view (FOV) of 100° will be applied (50° view angle either side of direction of travel). According to the FAA, glare that appears beyond this FOV range is mitigated. ▪ A pilot vertical FOV of 30° will be applied. Anything appearing beyond this FOV is not visible to the pilot and is acceptable to FAA.

- The in-built 2-mile flight approach path tool within ForgeSolar enables field of view of pilots to be considered in the assessment.

Heliports & Helipads

Industry guidance suggests that heliports and helipads may be assessed where glare poses a potential hazard to safety.

The approach paths are considered to be the most critical stage of helicopter flight. However, the associated modelling assessment methodology for heliports and helipads is not standardised as it is for airport runway approaches.

The modelling assessment methodology adopted by Mabbett in this assessment is based on the CAA's CAP1264 – Standards for helicopter landing areas at hospitals:

- Approach paths will be assessed which start 2 m above the heliport centre (approximate eye level of a helicopter pilot) and spread out at a length of 2 miles and 152 m above the elevation of the heliport (e.g. ~2.6-degree decent path)⁴.

Receptors are modelled along the approach paths in 8 cardinal directions⁵. Similar pilot vertical and azimuthal FOVs as for fixed-wing aircraft pilots will be applied.

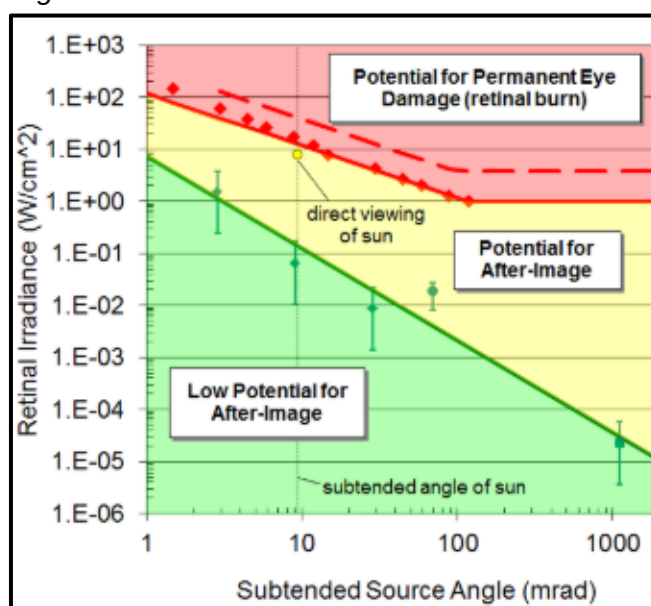
4.3 Magnitude of Impact

4.3.1 Ocular Impact

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

Figure 4.1: Ocular Hazard Plot



⁴ Final approach path dimensions as defined under CAA's CAP1264 – Standards for helicopter landing areas at hospitals (<http://publicapps.caa.co.uk/docs/33/CAP1264HelicopterlandingathospitalsAugust2019.pdf>).

⁵ North (N), north-east (NE), east (E), south-east (SE), south (S), south-west (SW), west (W) and north-west (NW).

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

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 Aviation

Helicopter Approaches	Whilst the new CAA CAST guidance has provided additional information on the receptors that may require assessment within a Glint and Glare Assessment, it does not provide clarity with regards to how to interpret glint and glare assessment results. The guidance produced by CAST also does not provide a summary of what different impacts mean and recommends that the aviation safeguarding authority review their own risk assessments and make a judgement as to what the results will mean.	
	The FAA 2013 and 2018 guidance for impact of solar panels on aviation (which has now been superseded) stated:	
	Acceptable	‘No potential for glare’ or ‘low potential for after-image’ along the final approach path for any existing or future landing thresholds.
	Unacceptable	Glare with ‘potential for temporary after-image’ predicted towards the final approach path.
	The FAA 2021 guidance states that: <i>“Initially, FAA believed that solar energy systems could introduce a novel glint and glare effect to pilots on final approach. FAA has subsequently concluded that in most cases, the glint and glare from solar energy systems to pilots on final approach is similar to glint and glare pilots routinely experience from water bodies, glass façade buildings, parking lots, and similar features.”</i> In accordance with industry guidance, it is recommended that any predicted solar reflection is assessed pragmatically. Therefore, the following mitigating factors will also be considered when determining whether a solar reflection is significant: 1. The relative position and visibility of the reflecting panels relative to final approach path and whether the glare is within the field of view of pilots; 2. Solar reflection duration per day; 3. Number of days a solar reflection is geometrically possible per year; 4. The time of day when a solar reflection is geometrically possible. 5. The length of the section of the final approach that is potentially affected by glare; 6. Reflectors in the existing environment; 7. The extent to which impacts coincide with effects of direct sunlight; and 8. Likely aerodrome traffic volumes, operational procedures or restrictions specific to the aerodrome, where applicable/provided. Industry guidance states:	
	No or Insignificant Impact	Solar reflection is not geometrically possible or will not be visible from the assessed receptor.
	Low	Under the following scenarios, low impact may be designated: • Solar reflections originate outside a pilot’s main field of view.

		- Glare has a “low potential for temporary after-image” (green glare). - Glare has a “potential for temporary after-image” (yellow glare) with sufficient mitigating factors. - Aerodrome has confirmed the level of glare is acceptable. Mitigation is not considered necessary.
	Moderate	Glare has a “potential for temporary after-image” (yellow glare) and there are insufficient mitigating factors. Mitigation may be required at regulator’s discretion.
	High	Glare has a “potential for permanent eye damage” (red glare). Mitigation recommended 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 C is a list of assumptions, limitations and fixed variables of the model and assessment methodology.

Section 5.0: Receptor Screening & Modelling Considerations

5.1 Aviation Infrastructure – Manchester Royal Infirmary Helipad

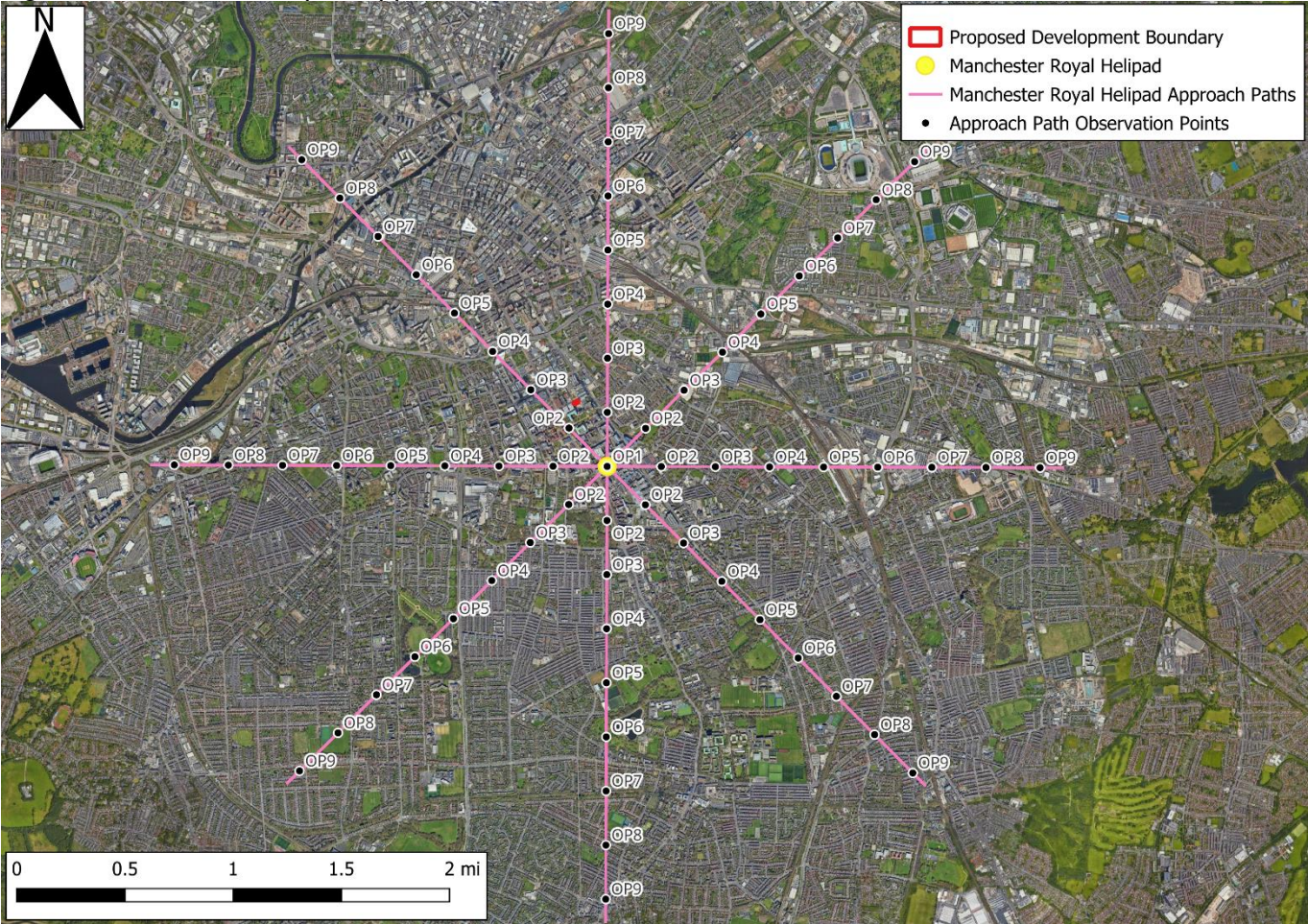
A receptor review indicates that Manchester Royal Infirmary Helipad is located 500m south-east of the Proposed Development. The helipad is located on a roof approximately 24 m above ground level.

Potential impacts on helicopter pilots on approach to Manchester Royal Infirmary Helipad was considered in the modelling assessment. Modelling was undertaken of glare impacts toward helipad approach path receptors in eight cardinal directions, with flight paths in accordance with CAA CAP1264 guidance.

The approach paths were modelled as observation points (OPs) at 0.25 mile intervals along the flight paths up to 2 miles from the helipad landing site.

The assessed approach paths and observation points are illustrated in Figure 5.1 below, where the central point represents the helipad location.

Figure 5.1 Modelled Helipad Approach Path Observation Points



The first OP starts at 2 m above the helipad centre (total height of 26 m above ground) and the final OP is 152 m above the elevation of the helipad (total height of 176 m above ground level). Assessment of observation points is a conservative approach as this does not include the field of view of the pilots.

The flight path height at each OP follows the below altitude profile:

Observation Point	Distance from threshold (Miles)	Altitude Above Ground (m)
OP1	Helicopter Landing Site (0 mi)	26.0
OP2	0.25 mi	47.0

Observation Point	Distance from threshold (Miles)	Altitude Above Ground (m)
OP3	0.5 mi	68.0
OP4	0.75 mi	89.1
OP5	1 mi	110.1
OP6	1.25 mi	131.1
OP7	1.5 mi	152.1
OP8	1.75 mi	173.2
OP9	2 mi	176.0

5.2 Modelling Considerations

Within ForgeSolar, vertical reflective surfaces are represented by a path of two or more vertices defined by a latitude, longitude and elevation, and lower and upper edge heights which bound the portion of the surface that is reflective. Vertical surfaces are further defined by two parameters, slope error and reflectivity. The evidence base which informed the selection of slope error and reflectivity for the assessment is discussed here.

5.2.1 Reflectivity

Reflectivity is fraction of light reflecting toward receptor. Reflectivity depends on material and sun position.

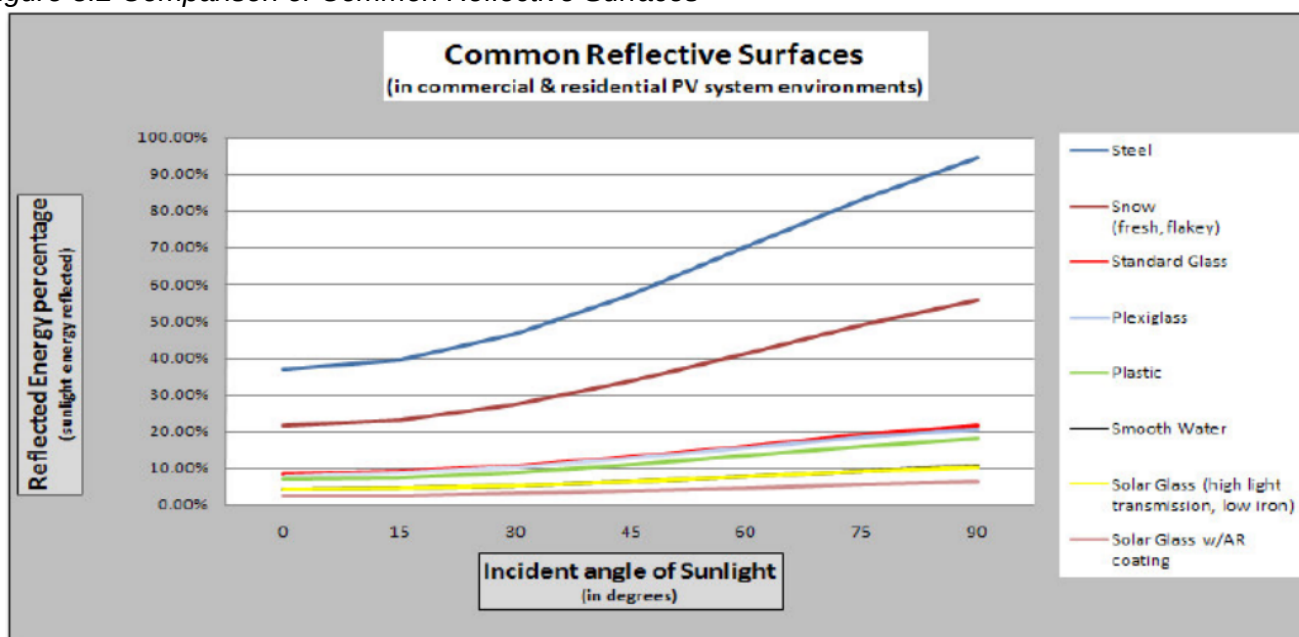
5.2.1.1 Material

The reflectivity of non-coated metal can be much higher than other materials such as standard glass, particularly at higher incident angles of sunlight (i.e. when the sun is low in the sky for vertical surfaces).

Figure 5.2 shows the potential reflectivity of steel compared to other materials including snow, plastic, water and solar panel glass⁷. Steel is shown to have a much higher reflected energy percentage at higher incidence angles than other materials.

Figure 5.3 shows another comparison of materials from the US FAA 2010 aviation guidance⁸. Bare aluminium is listed as having a similar reflectivity as snow and white concrete. This is much higher than water and solar PV panels.

Figure 5.2 Comparison of Common Reflective Surfaces

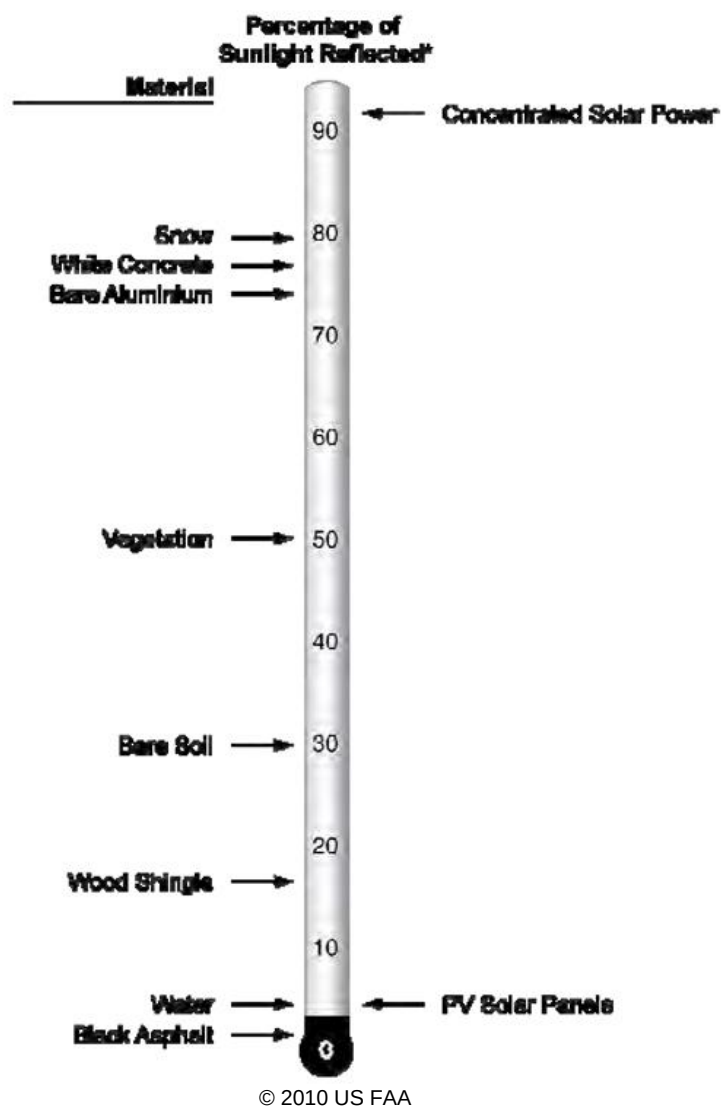


© 2010 SunPower

⁷ SunPower 2010. PV Systems: Low Levels of Glare and Reflectance vs. Surrounding Environment

⁸ US FAA 2010. Technical Guidance for Evaluating Selected Solar Technologies on Airports

Figure 5.3 Reflectivity Produced by Different Surfaces



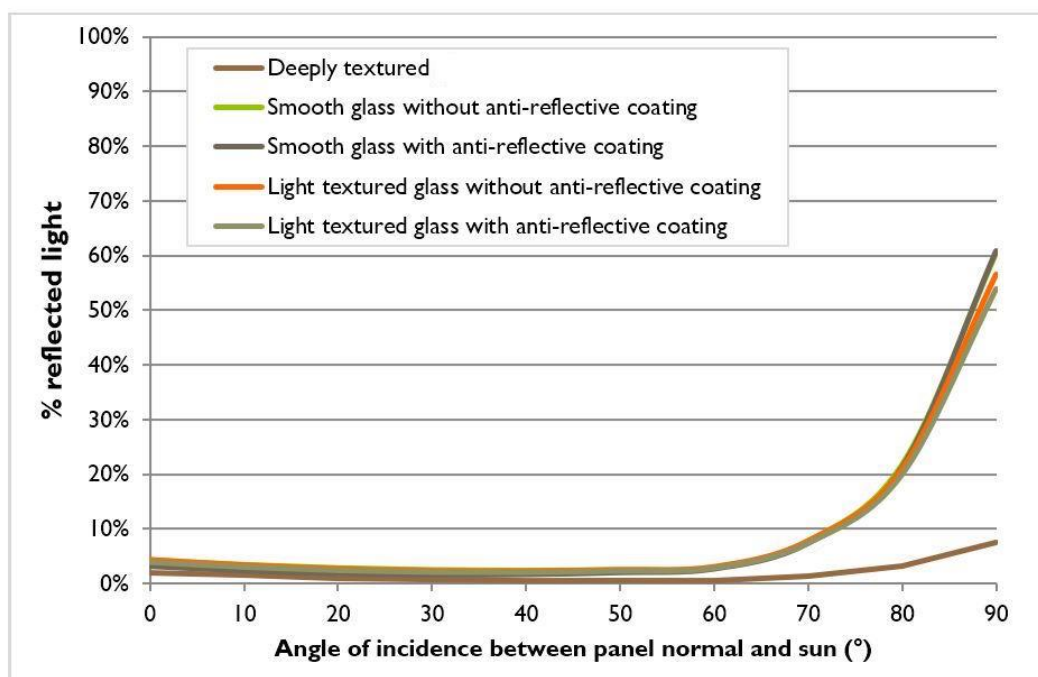
5.2.1.2 Sun Position

A review of draft modelling results indicated that the majority of the solar reflections from the modelled surfaces occur early in the morning. This means that the sun is low in the sky and the angle of incidence would be closer to 90 degrees, which corresponds to a higher potential reflected energy percentage, as shown in Figure 5.2.

5.2.1.3 Summary

ForgeSolar includes a default “smooth glass profile” for solar panels within its vertical surface assessment software. However, as noted above the profile for reflectivity of metal surfaces is different to that for solar panels. Further review is therefore required to determine an appropriate custom reflectivity factor for use within the ForgeSolar model.

Figure 5.4 ForgeSolar Module Reflectance Profile



© 2024 ForgeSolar

For the purposes of providing a conservative assessment at the predicted times of glare impact (early morning), a custom higher factor of 0.9 (90% reflectivity) has been used to model the reflectivity of the vertical surfaces. Whilst the custom factor is a constant surface reflectivity value for all time-steps, this better matches the reflectance profile for non-coated metal at the time of day when impacts are predicted. This approach has been agreed to be more appropriate in consultation with ForgeSolar.

This is considered to be a conservative approach as it is noted that the aluminium surface is to be coated with three different paint coatings with relatively low light reflectance values. The addition of paint coating is likely to reduce the potential reflectivity of the aluminium surface.

5.2.1 Slope Error (Surface Texture)

Slope error specifies the amount of scatter that occurs from the surface. Mirror-like surfaces that produce specular reflections will have a slope error closer to zero, while rough surfaces that produce more scattered (diffuse) reflections have higher slope errors.

The default slope error for modelling glass-like surfaces is 10 mrad. Whilst a specific slope error for aluminium cladding is not available, the slope error is likely to be higher for metal cladding than glass-like surfaces. City of London guidance states that “*metals often combine specular reflection with diffuse reflection (where the reflected light is scattered in all directions)*”. Furthermore, the guidance states that “*Surfaces like brick or matt cladding give mainly diffuse reflection*”.

As a conservative approach, the slope error for both vertical surfaces have therefore been modelled at 15mrad. The slope error may extend beyond 15 mrad for metal cladding with rough surfaces and/or texturing.

Section 6.0: Modelling Results & Interpretation

6.1 Modelling Results

6.1.1 South Façade

Helipad Approach (From)	Results	Impact
North	No glare predicted toward OPs 9-2. Glare with ' potential for temporary after-image ' is predicted towards OP1. However, the source of the glare is behind the pilot on approach to the helicopter landing site.	No Impact
North-East	No glare predicted toward OPs 9-2. Glare with ' potential for temporary after-image ' is predicted towards OP1. However, the source of the glare is behind the pilot on approach to the helicopter landing site.	No Impact
East	No glare predicted toward OPs 9-2. Glare with ' potential for temporary after-image ' is predicted towards OP1.	Further Review
South-East	No glare predicted toward OPs 9-2. Glare with ' potential for temporary after-image ' is predicted towards OP1.	Further Review
South	Glare with ' low potential for temporary after-image ' is predicted toward OPs 9-3. Glare with ' potential for temporary after-image ' is predicted towards OPs 2-1.	Further Review
South-West	Glare with ' low potential for temporary after-image ' is predicted toward OPs 9-3. Glare with ' potential for temporary after-image ' is predicted towards OPs 2-1.	Further Review
West	No glare predicted toward OPs 9-4. Glare with ' low potential for temporary after-image ' is predicted toward OP3. Glare with ' potential for temporary after-image ' is predicted towards OPs 2-1.	Further Review
North-West	No glare predicted toward OPs 9-2. Glare with ' potential for temporary after-image ' is predicted towards OPs 2-1. However, the source of the glare is behind the pilot on approach to the helicopter landing site.	No Impact

Total glare received by each receptor may include duplicate times of glare from multiple reflective surfaces. Detailed results are available on request.

6.1.2 North Façade

Helipad Approach (From)	Results	Impact
North	No glare predicted toward OPs 8-6 and 2-1. Glare with ' low potential for temporary after-image ' is predicted toward OPs 9 and 5. Glare with ' potential for temporary after-image ' is predicted towards OPs 4-3.	Further Review
North-East	No glare predicted toward OPs 7-1. Glare with ' low potential for temporary after-image ' is predicted toward OPs 9-8.	Low Impact
East	No glare predicted toward OPs 9-1.	No Impact
South-East	No glare predicted toward OPs 9-1.	No Impact
South	No glare predicted toward OPs 9-1.	No Impact
South-West	No glare predicted toward OPs 9-1.	No Impact

Helipad Approach (From)	Results	Impact
West	No glare predicted toward OPs 9-6 and 3-1. Glare with ' low potential for temporary after-image ' is predicted toward OPs 5-4.	Low Impact
North-West	No glare predicted toward OPs 9-1.	No Impact

Total glare received by each receptor may include duplicate times of glare from multiple reflective surfaces. Detailed results are available on request.

6.2 Further Review

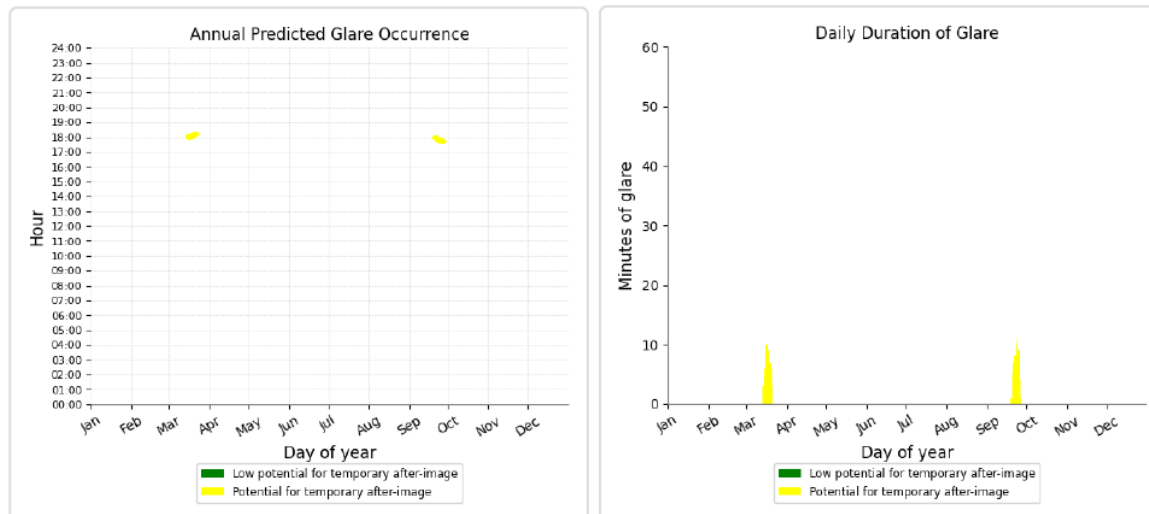
In accordance with industry guidance, it is recommended that any predicted solar reflection is assessed pragmatically. Therefore, the following mitigating factors will also be considered when determining whether a solar reflection is significant:

1. The relative position and visibility of the reflecting panels relative to final approach path and whether the glare is within the field of view of pilots;
2. Solar reflection duration per day;
3. Number of days a solar reflection is geometrically possible per year;
4. The time of day when a solar reflection is geometrically possible.
5. The length of the section of the final approach that is potentially affected by glare;
6. Reflectors in the existing environment;
7. The extent to which impacts coincide with effects of direct sunlight; and
8. Likely aerodrome traffic volumes, operational procedures or restrictions specific to the aerodrome, where applicable/provided.

6.2.1 North

Yellow glare from the north façade is predicted to occur towards OP3 between 17:00-18:00 in mid-March and late September for less than 10 minutes per day.

Figure 6.1 Predicted glare toward north path OP3 (north façade)



A review of line of sight indicates that George Kenyon Hall is on the right within the main field of view for pilots on approach to the helicopter landing site (HLS).

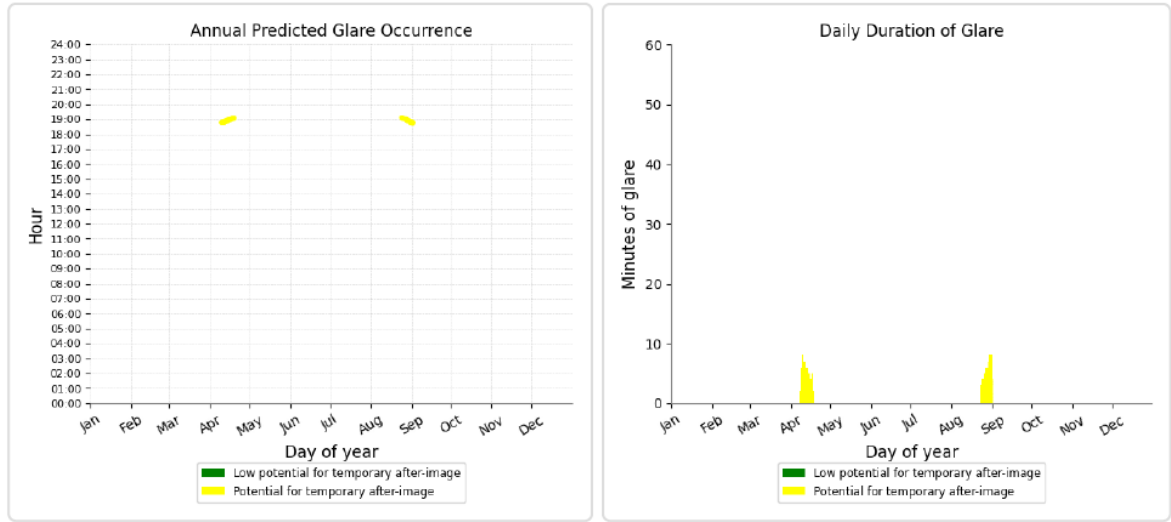
However, the solar reflection is limited in its annual and daily duration. It is also noted that the timing of the glare coincides with the time of day when Sun is lower in the sky. The Sun is considered to be a more prominent source of light at this time as its origin is within the same direction as the potential reflection relative to the helicopter approach path. On this basis, the potential impact toward OP3 is considered to be 'low'.

Figure 6.2 North approach view from OP3 toward HLS (orange = George Kenyon Hall, red = HLS)



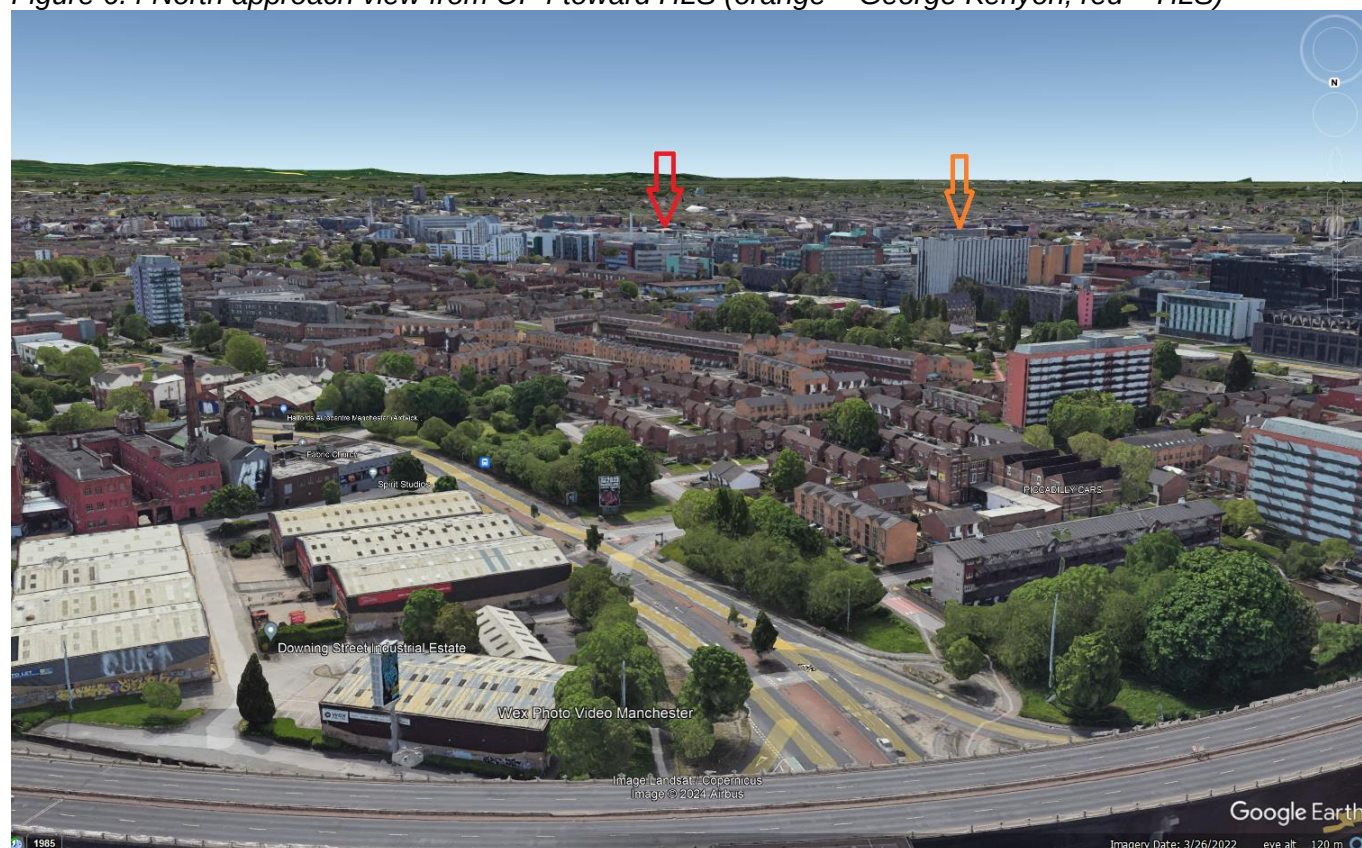
Yellow glare from the north façade is predicted towards OP4 between 18:00-19:00 in mid-April and late August for less than 10 minutes per day.

Figure 6.3 Predicted glare toward north path OP4 (north façade)



A review of line of sight indicates that the Henry Royce Institute provides substantial obstruction to the view of George Kenyon Hall at OP4. The solar reflection is limited in its annual and daily duration and coincides with the time of day when the Sun is lower in the sky. On this basis, the potential impact toward OP4 is considered to be ‘low’.

Figure 6.4 North approach view from OP4 toward HLS (orange = George Kenyon, red = HLS)

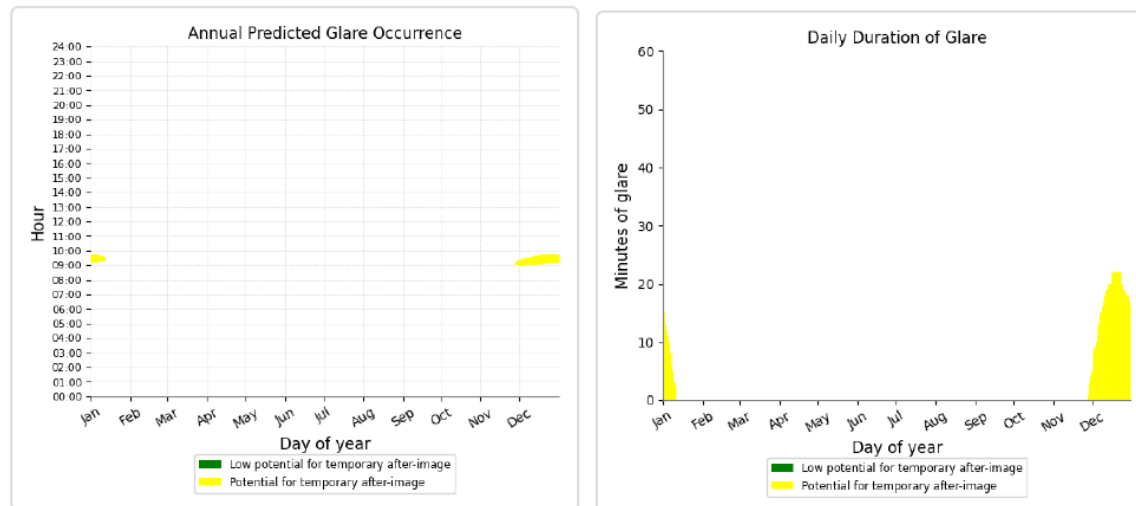


© 2024 Google Earth

6.2.2 East

Yellow glare from the south façade is predicted to occur towards OP1 between 09:00-10:00 from late November to early January for less than 25 minutes per day.

Figure 6.5 Predicted glare toward east path OP1 (south façade)



For an approach from the east, the source of the glare is outside of the pilot's main field-of-view (FOV) of 100° (50° view angle either side of direction of travel) once at OP1. According to the FAA, glare that appears beyond the 100° FOV range is mitigated.

The solar reflection is also limited in its annual and daily duration. On this basis, the potential impact toward OP1 is considered to be 'low'.

6.2.3 South-East

Yellow glare from the south façade is predicted to occur towards OP1 between 09:00-10:00 from late November to early January for less than 25 minutes per day.

Figure 6.6 Predicted glare toward south-east path OP1 (south façade)

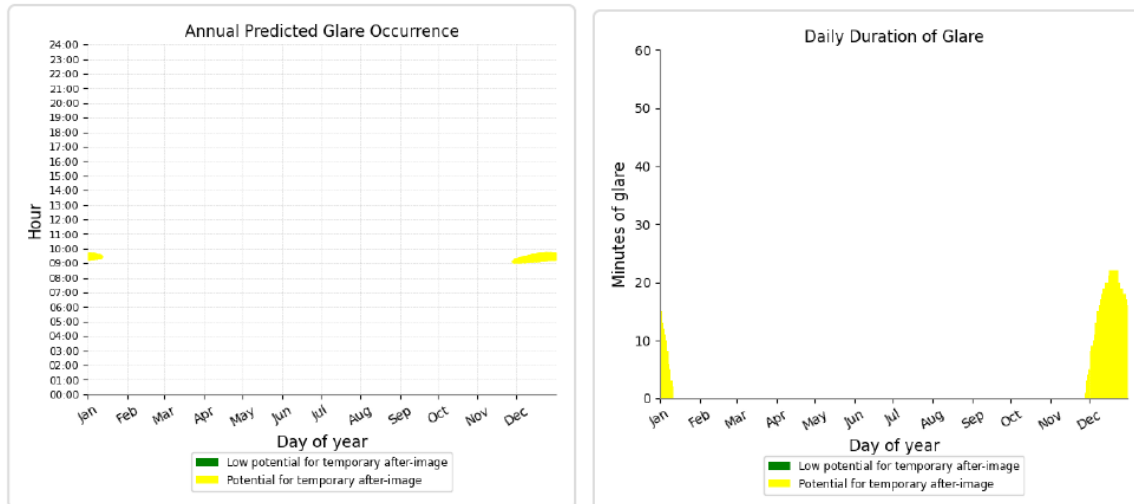


Figure 6.7 South-east approach view from OP1 (orange = George Kenyon, red = HLS, OP1)



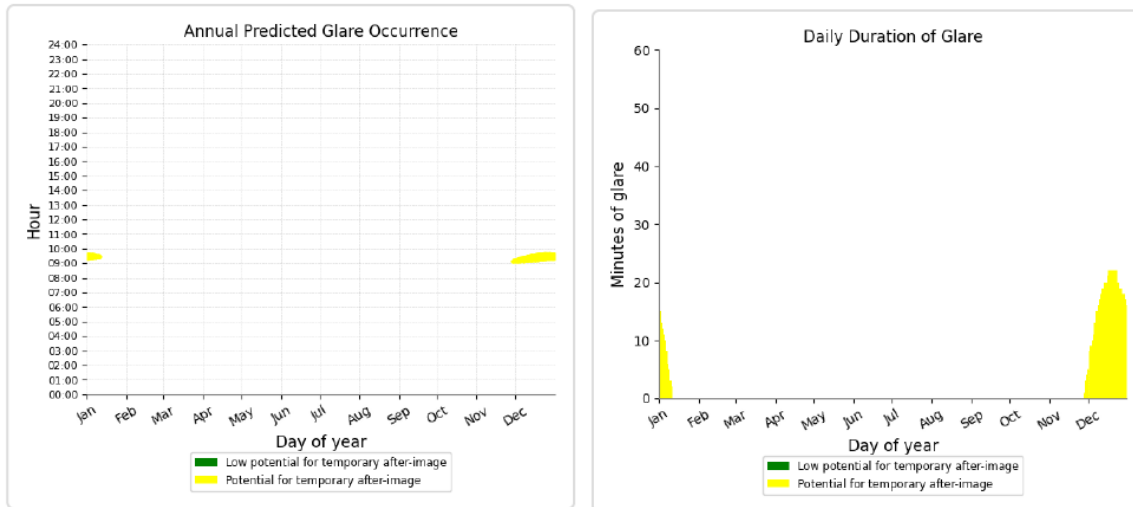
A review of line of sight indicates that George Kenyon Hall is on the right within the main field of view for pilots on approach to the helicopter landing site (HLS). In the wider field of view, it is noted that the timing of the glare coincides with the time of day when Sun is lower in the sky. The Sun is considered to be a more prominent source of light at this time as its origin is within the same direction as the potential reflection relative to the helicopter approach path.

The solar reflection is limited in its annual and daily duration. On this basis, the potential impact toward OP1 is considered to be 'low'.

6.2.4 South

Yellow glare from the south façade is predicted to occur towards OP1 between 09:00-10:00 from late November to early January for less than 25 minutes per day.

Figure 6.8 Predicted glare toward south path OP1 (south façade)



A review of line of sight indicates that George Kenyon Hall is on the left within the main field of view for pilots on approach to the helicopter landing site (HLS). In the wider field of view, it is noted that the timing of the glare coincides with the time of day when Sun is lower in the sky. The Sun is considered to be a more prominent source of light at this time as its origin is within the same direction as the potential reflection relative to the helicopter approach path.

The solar reflection is limited in its annual and daily duration. On this basis, the potential impact toward OP1 is considered to be 'low'.

Figure 6.9 South approach view from OP1 (orange = George Kenyon, red = HLS, OP1)



© 2024 Google Earth

Yellow glare from the south façade is predicted to occur towards OP2 between 08:00-09:30 from mid-November to late January for a maximum of 40 minutes per day.

Figure 6.10 Predicted glare toward south path OP2 (south façade)

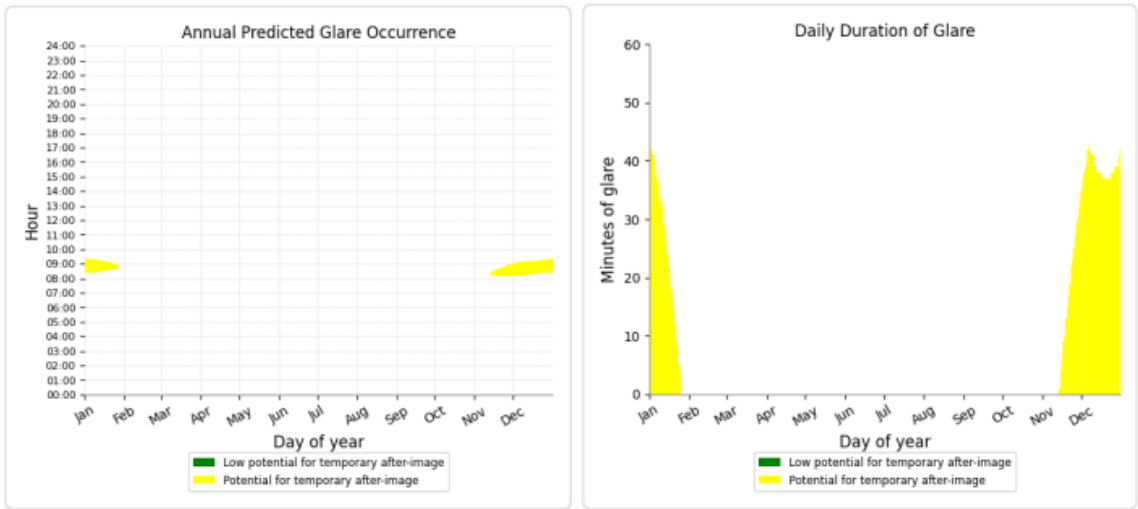


Figure 6.11 South approach view from OP2 (orange = George Kenyon, red = HLS)



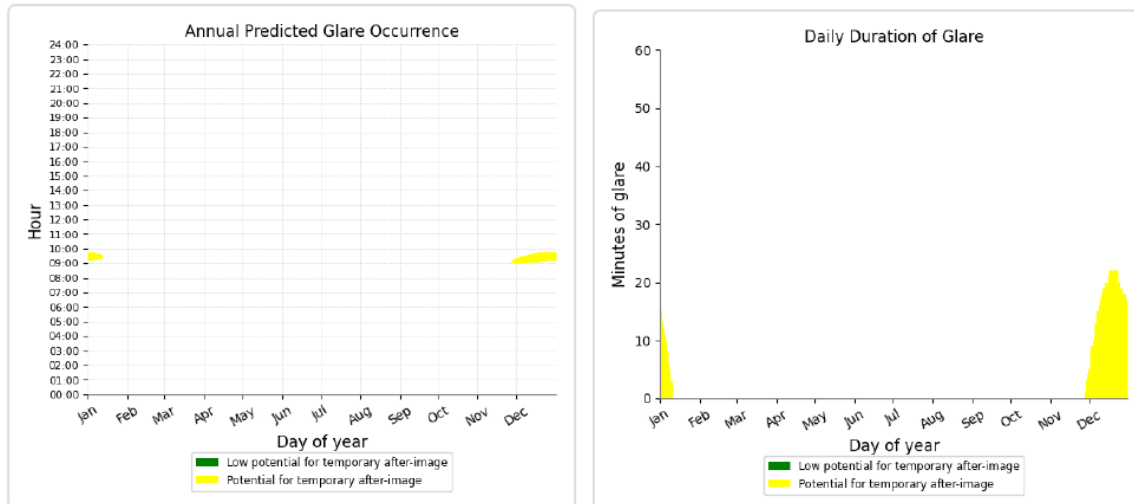
A review of line of sight indicates that George Kenyon Hall is on the left within the main field of view for pilots on approach to the helicopter landing site (HLS). In the wider field of view, it is noted that the timing of the glare coincides with the time of day when Sun is lower in the sky. The Sun is considered to be a more prominent source of light at this time as its origin is within the same direction as the potential reflection relative to the helicopter approach path.

The solar reflection is limited in its annual and daily duration. On this basis, the potential impact toward OP1 is considered to be 'low'.

6.2.5 South-West

Yellow glare from the south façade is predicted to occur towards OP1 between 09:00-10:00 from late November to early January for less than 25 minutes per day.

Figure 6.12 Predicted glare toward south-west path OP1 (south façade)

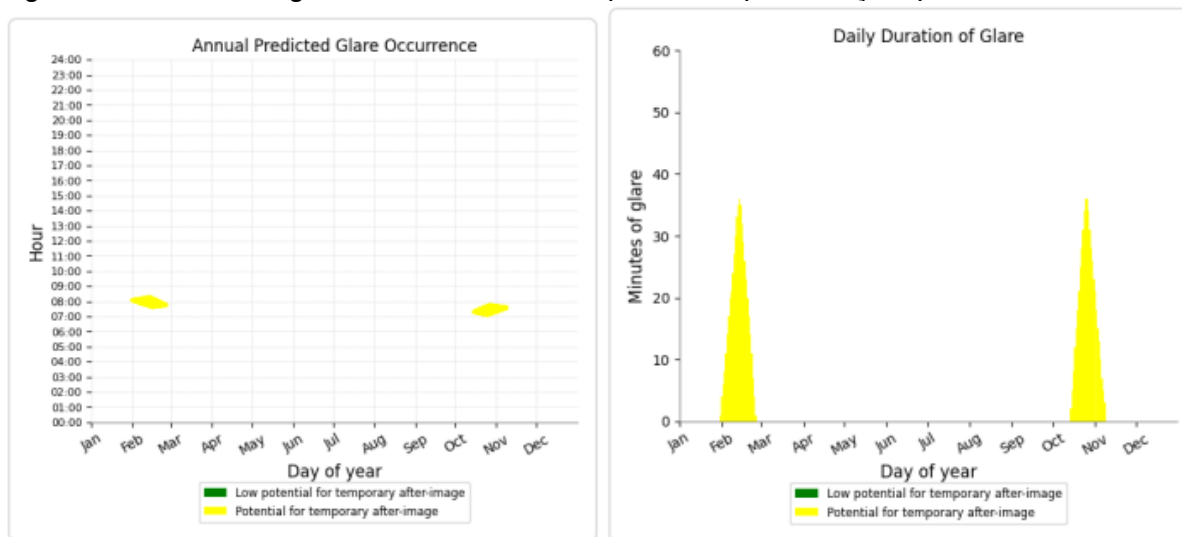


For an approach from the south-west, the source of the glare is outside of the pilot's main field-of-view (FOV) of 100° (50° view angle either side of direction of travel) once at OP1. According to the FAA, glare that appears beyond the 100° FOV range is mitigated.

The solar reflection is also limited in its annual and daily duration. On this basis, the potential impact toward OP1 is considered to be 'low'.

Yellow glare from the south façade is predicted to occur towards OP2 between 07:00-08:30 from late January to late February and from mid-October to early November for a maximum of 35 minutes per day.

Figure 6.13 Predicted glare toward south-west path OP2 (south façade)



A review of line of sight indicates that George Kenyon Hall is on the left within the main field of view for pilots on approach to the helicopter landing site (HLS). In the wider field of view, it is noted that the timing of the glare coincides with the time of day when Sun is lower in the sky. The Sun is considered to be a more prominent source of light at this time as its origin is within the same direction as the potential reflection relative to the helicopter approach path.

The solar reflection is limited in its annual and daily duration. On this basis, the potential impact toward OP2 is considered to be 'low'.

Figure 6.14 South-west approach view from OP2 (orange = George Kenyon, red = HLS)

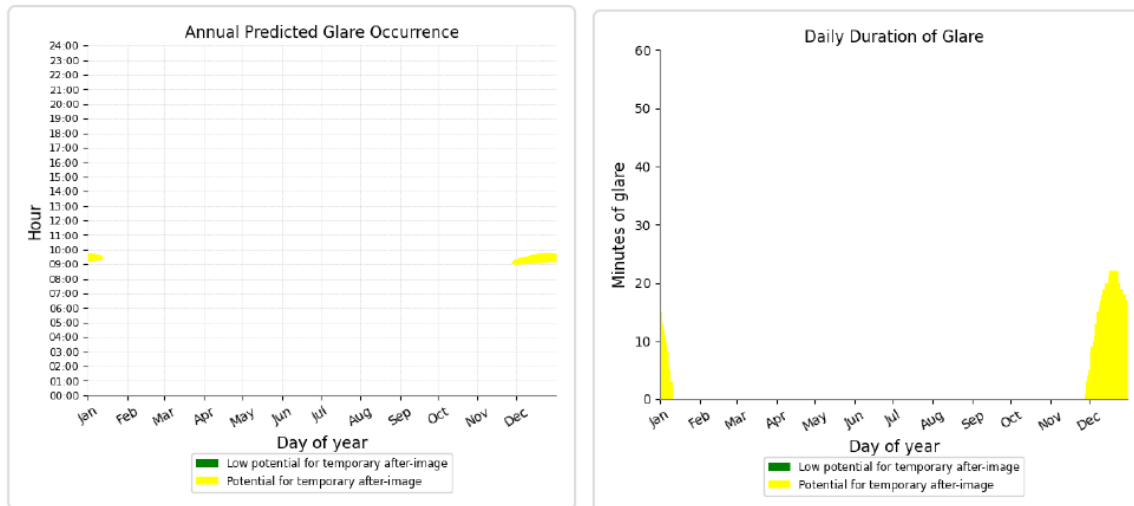


© 2024 Google Earth

6.2.6 West

Yellow glare from the south façade is predicted to occur towards OP1 between 09:00-10:00 from late November to early January for less than 25 minutes per day.

Figure 6.15 Predicted glare toward west path OP1 (south façade)

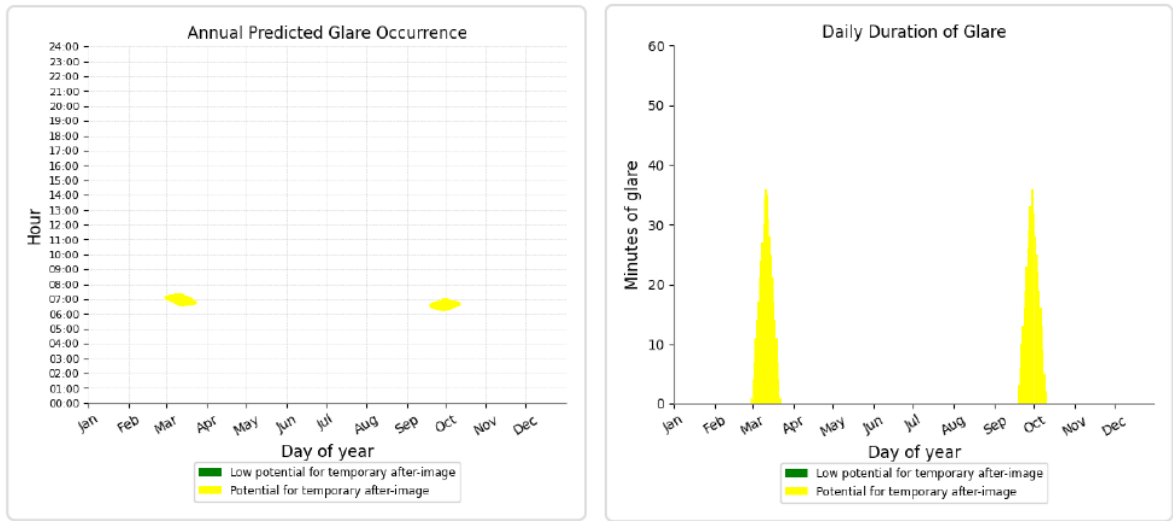


For an approach from the west, the source of the glare is outside of the pilot's main field-of-view (FOV) of 100° (50° view angle either side of direction of travel) once at OP1. According to the FAA, glare that appears beyond the 100° FOV range is mitigated.

The solar reflection is also limited in its annual and daily duration. It is also noted that the timing of the glare coincides with the time of day when Sun is lower in the sky. The Sun is considered to be a more prominent source of light at this time as its origin is within the same direction as the potential reflection relative to the helicopter approach path. On this basis, the potential impact toward OP1 is considered to be 'low'. On this basis, the potential impact toward OP1 is considered to be 'low'.

Yellow glare from the south façade is predicted to occur towards OP 2 between 06:00-07:30 from early to mid-March and late to early October for a maximum of 35 minutes per day.

Figure 6.16 Predicted glare toward west path OP2 (south façade)



For an approach from the west, the source of the glare is outside of the pilot’s main field-of-view (FOV) of 100° (50° view angle either side of direction of travel) once at OP2. According to the FAA, glare that appears beyond the 100° FOV range is mitigated.

The solar reflection is also limited in its annual and daily duration. It is also noted that the timing of the glare coincides with the time of day when Sun is lower in the sky. The Sun is considered to be a more prominent source of light at this time as its origin is within the same direction as the potential reflection relative to the helicopter approach path. On this basis, the potential impact toward OP2 is considered to be ‘low’.

6.3 Residual Overall Impact

In addition to the above review of mitigating factors, it should be noted that the assessment has considered a low slope error to simulate the texture of the aluminium cladding surface and high reflectivity factor. This is a conservative approach as the slope error may be higher due to greater texturing of the surface and the reflectivity lower due to the application of paints on the aluminium surface.

The overall residual impact toward pilots on approach to the Manchester Royal Infirmary Helipad is considered to be “low”.

The result associated with the hospital heliport should be discussed with the helipad operator, to determine whether, given the results and considerations presented in this report, they find the predicted glare towards this receptor an acceptable risk.

It is recommended that a revision to the operator’s landing site directory operating procedures is made as a precaution for Incoming Pilots.

Helipad Approach (From)	South Façade		North Façade		Overall Impact
	Modelled	Further Review	Modelled	Further Review	
North	No Impact	-	Further Review	Low Impact	Low Impact
North-East	No Impact	-	Low Impact	-	Low Impact
East	Further Review	Low Impact	No Impact	-	Low Impact

Helipad Approach (From)	South Façade		North Façade		Overall Impact
	Modelled	Further Review	Modelled	Further Review	
South-East	Further Review	Low Impact	No Impact	-	Low Impact
South	Further Review	Low Impact	No Impact	-	Low Impact
South-West	Further Review	Low Impact	No Impact	-	Low Impact
West	Further Review	Low Impact	Low Impact	-	Low Impact
North-West	No Impact	-	No Impact	-	No Impact

Section 7.0: Conclusions

Following glare modelling assessment of the cladding façade and a review of mitigating factors, the overall residual impact toward pilots on approach to the Manchester Royal Infirmary Helipad is considered to be “low”. On this basis, no mitigation is recommended.

The result associated with the hospital heliport should be discussed with the helipad operator, to determine whether, given the results and considerations presented in this report, they find the assessed glare towards this receptor an acceptable risk.

It is recommended that a revision to the operator’s landing site directory operating procedures is made as a precaution for Incoming Pilots.

Appendix A: Interim CAA Guidance on Solar Photovoltaic Systems



Interim CAA Guidance - Solar Photovoltaic Systems

BACKGROUND

- 1 Airport interest in solar energy is growing rapidly as a way to reduce operating costs and to demonstrate a commitment to renewable energy and sustainable development. In response, the CAA is seeking to develop its policy on the installation of Solar Photovoltaic (SPV) Systems and their impact on aviation. In doing so, it is reviewing the results of research having been carried out in the United States by the Federal Aviation Administration (FAA) culminating in the publication of [Technical Guidance for Evaluating Solar Technologies on Airports](#) and also reviewing guidance issued by other National Aviation Safety Administrations and Authorities on this subject.
- 2 On completion of the review, the CAA, together with the assistance of other aviation stakeholders, will develop a policy and provide formal guidance material on the installation of SPV, principally on or in the vicinity¹ of licensed aerodromes but will also include guidance on installations away from aerodromes (or 'en-route'²). This document therefore constitutes interim CAA guidance until a formal policy has been developed.

DISCUSSION

- 3 At present the key safety issue is perceived to be the potential for reflection from SPV to cause glare, dazzling pilots or leading them to confuse reflections with aeronautical lights. Whilst permission is not required from the CAA for any individual or group to shine or reflect a light or lights into the sky, SPV developers should be aware of the requirements to comply with the [Air Navigation Order \(ANO\) 2009](#). In particular, developers and Local Planning Authorities (LPA) should be cognisant of the following articles of the ANO with respect to any SPV development regardless of location:
 - Article 137 – Endangering safety of an aircraft.
 - Article 221 – Lights liable to endanger.
 - Article 222 – Lights which dazzle or distract.
- 4 The potential for SPV installations to cause electromagnetic or other interference with aeronautical Communications Navigational and Surveillance equipment (CNS) must be considered by the SPV developer, in coordination with the CAA, the aerodrome Air Traffic Service provider (ATS), the Air Navigation Service Provider (ANSP) and/or NATS and the MoD, as required.

¹ In this context, the term 'in the vicinity' refers to officially safeguarded aerodromes noted in the Planning Circulars ([see Paragraph 10](#)) and a distance of up to 15km from the 'Aerodrome Reference Point' or the centre of the longest runway.

² SPV installations proposed further than 15km from an aerodrome are considered 'en-route' developments, and may still require consultation with the CAA for an assessment on the impact, if any, to CNS equipment.

- 5 Where SPV systems are installed on structures that, for example, extend above the roofline of tall buildings (either on, or 'off-aerodrome'), or where they are installed in the vertical plane (on plinths or towers), then there may be the potential for creating an obstacle hazard to aircraft and - in addition to the potential for creating turbulence hazard to aircraft - any infringement of the aerodrome Obstacle Limitation Surfaces (OLS) shall also need to be considered by the Aerodrome Licence Holder (ALH).
- 6 For all planned SPV installations it is best practice for the developer to consult with the operators of nearby aerodromes before any construction is initiated.
- 7 An ALH, in agreement with their LPA, may wish to initiate procedures so that it is only consulted on SPV planning applications at shorter distances from the aerodrome (for example within a 5 km radius), or at distances that would limit SPV development from within the aircraft operating visual circuit; however, this is at the discretion of the ALH and no CAA approval or endorsement of this decision is necessary.

RECOMMENDATIONS

- 8 It is recommended that, as part of a planning application, the SPV developer provide safety assurance documentation (including risk assessment) regarding the full potential impact of the SPV installation on aviation interests.
- 9 Guidance on safeguarding procedures at CAA licensed aerodromes is published within [CAP 738 Safeguarding of Aerodromes](#) and advice for unlicensed aerodromes is contained within [CAP 793 Safe Operating Practices at Unlicensed Aerodromes](#).
- 10 Where proposed developments in the vicinity of aerodromes require an application for planning permission³ the relevant LPA normally consults aerodrome operators or NATS when aeronautical interests might be affected. This consultation procedure is a statutory obligation in the case of certain major airports, and may include military establishments and certain air traffic surveillance technical sites. These arrangements are explained in [Department for Transport Circular 1/2003](#) and for Scotland, [Scottish Government Circular 2/2003](#).
- 11 In the event of SPV developments proposed under the Electricity Act, the relevant government department should routinely consult with the CAA. There is therefore no requirement for the CAA to be separately consulted for such proposed SPV installations or developments.
- 12 If an installation of SPV systems is planned **on**-aerodrome (i.e. within its licensed boundary) then it is recommended that data on the reflectivity of the solar panel material should be included in any assessment before installation approval can be granted. Although approval for installation is the responsibility of the ALH, as part of a condition of a CAA Aerodrome Licence, the ALH is required to obtain prior consent from CAA Aerodrome Standards Department before any work is begun or approval to the developer or LPA is granted, in accordance with the procedures set out in [CAP 791 Procedures for Changes to Aerodrome Infrastructure](#).
- 13 During the installation and associated construction of SPV systems there may also be a need to liaise with nearby aerodromes if cranes are to be used; CAA notification and permission is not required.

³ The CAA is aware of changes to planning legislation that may provide for 'Permitted Development Rights' for certain micro-generation equipment on both domestic and non-domestic property, under the General Permitted Development Order (1995).

- 14 The CAA aims to replace this informal guidance with formal policy in due course and reserves the right to cancel, amend or alter the guidance provided in this document at its discretion upon receipt of new information.
- 15 Further guidance may be obtained from CAA's Aerodrome Standards Department via aerodromes@caa.co.uk.

17 December 2010

Appendix B: Technical Guidance for Evaluating Selected Solar Technologies on Airports (2018)

16. Abstract

“Airport interest in solar energy is growing rapidly as a way to reduce airport operating costs and to demonstrate a commitment to sustainable development. In response, the Federal Aviation Administration (FAA) has prepared Technical Guidance for Evaluating Selected Solar Technologies on Airports to meet the regulatory and informational needs of the FAA Airports organization and airport sponsors.

For airports with favourable solar access and economics, this report provides a checklist of FAA procedures to ensure that proposed photovoltaic or solar thermal hot water systems are safe and pose no risk to pilots, air traffic controllers, or airport operations. Case studies of operating airport solar facilities are provided, including Denver International, Fresno Yosemite International, and Albuquerque International Sunport.”

Preface

“Over 15 airports around the country are operating solar facilities and airport interest in solar energy is growing rapidly. In response, the Federal Aviation Administration (FAA) has prepared this report, Technical Guidance for Evaluating Selected Solar Technologies on Airports, to meet the regulatory and information needs of FAA personnel and airport sponsors in evaluating airport solar projects.

The guidance is intended to provide a readily usable reference for FAA technical staff who review proposed airport solar projects and for airport sponsors that may be considering a solar installation. It addresses a wide range of topics including solar technology, electric grid infrastructure, FAA safety regulations, financing alternatives, and incentives.

Airport sponsors are interested in solar energy for many reasons. Solar technology has matured and is now a reliable way to reduce airport operating costs. Environmentally, solar energy shows a commitment to environmental stewardship, especially when the panels are visible to the traveling public. Among the environmental benefits are cleaner air and fewer greenhouse gases that contribute to climate change. Solar use also facilitates small business development and U.S. energy independence.

While offering benefits, solar energy introduces some new and unforeseen issues, like possible reflectivity and communication systems interference. The guidance discusses these issues and offers new information that can facilitate FAA project reviews, including a flow chart of FAA procedures to ensure that proposed systems are safe and pose no risks to pilots, air traffic controllers, or airport operations.”

AIRPORTS AND SOLAR ENERGY: CHARTING A COURSE

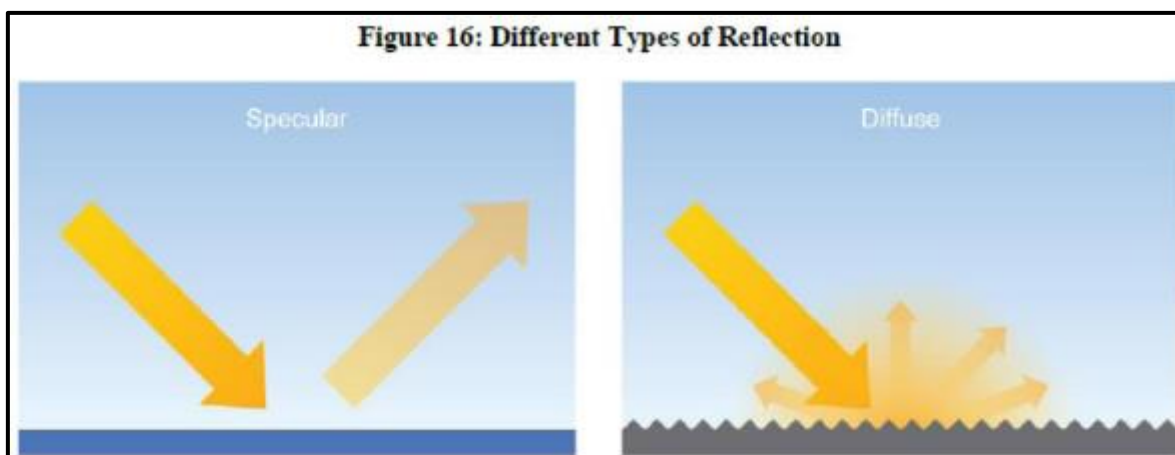
“Though solar energy has been evolving since the early 1990’s as a mainstream form of renewable energy generation, the expansion in the industry over the past 10 years and corresponding decrease in prices has only recently made it a practical consideration for airports. Solar energy presents itself as an opportunity for FAA and airports to produce on-site electricity and to reduce long-term electricity use and energy costs. While solar energy has many benefits, it does introduce some new and unforeseen issues, like possible glare (also referred to as reflectivity) and communication systems interference, which have complicated FAA review and approval of this technology. This guide discusses such issues and how FAA reviews for solar projects can be streamlined and standardized to a greater extent.”

3.1.2 Reflectivity

“Reflectivity refers to light that is reflected off surfaces. The potential effects of reflectivity are glint (a momentary flash of bright light) and glare (a continuous source of bright light). These two effects are referred to hereinafter as “glare,” which can cause a brief loss of vision, also known as flash blindness.

FAA Order 7400.2, Procedures for Handling Airspace Matters, defines flash blindness as “generally, a temporary visual interference effect that persists after the source of illumination has ceased.”

The amount of light reflected off a solar panel surface depends on the amount of sunlight hitting the surface, its surface reflectivity, geographic location, time of year, cloud cover, and solar panel orientation. As illustrated on Figure 16, flat, smooth surfaces reflect a more concentrated amount of sunlight back to the receiver, which is referred to as specular reflection. The more a surface is polished, the more it shines. Rough or uneven surfaces reflect light in a diffused or scattered manner and, therefore, the light will not be received as bright.



CSP systems use mirrors to maximize reflection and focus the reflected sunlight and associated heat on a design point to produce steam, which generates electricity. About 90 percent of sunlight is reflected. However, because the reflected sunlight is controlled and focused on the heat collecting element (HCE) of the system, it generally does not reflect back to other sensitive receptors. Another source of reflection in a CSP system is the light that contacts the back of the HCE and never reaches the mirror. Parts of the metal frame can also reflect sunlight. In central receiver (or power tower) applications, the receiver can receive concentrated sunlight that is up to a thousand times the sun's normal irradiance. Reflections from a central receiver, although approximately 90% absorptive, can still reflect a great deal of sunlight.

Solar PV and SHW panels are constructed of dark, light-absorbing materials and covered with an anti-reflective coating designed to maximize absorption and minimize reflection. However, the glass surfaces of solar PV and SHW systems also reflect sunlight to varying degrees throughout the day and year. The amount of reflected sunlight is based on the incidence angle of the sun relative to the light-sensitive receptor (e.g., a pilot or air traffic tower controller). The amount of reflection increases with lower incidence angles. In some situations, 100% of the sun's energy can be reflected from solar PV and SHW panels.

Because solar energy systems introduce new visual surfaces to an airport setting where reflectivity could result in glare that can cause flash blindness to those that require clear, unobstructed vision, project proponents should evaluate reflectivity during project siting and design.”

Completing an Individual Glare Analysis

“Evaluating glare for a specific project should be an iterative process that looks at one or more of the methodologies described below. Airport sponsors should coordinate closely with the FAA’s Office of Airports to evaluate the potential for glint and glare for solar projects on airport property. These data should include a review of existing airport conditions and a comparison with existing sources of glare, as well as related information obtained from other airports with experience operating solar projects.

Because the FAA has no specific standards for airport solar facilities and potential glare, the type of glare analysis may vary. Depending on site specifics (e.g., existing land uses, location and size of the project) an acceptable evaluation could involve one or more of the following levels of assessment:

- (1) A qualitative analysis of potential impact in consultation with the Air Traffic Control Tower, pilots, and airport officials
- (2) A demonstration field test with solar panels at the proposed site in coordination with Air Traffic Control Tower personnel

(3) A geometric analysis to determine days and times when there may be an ocular impact.

The FAA should be consulted after completing each of the following steps to determine if potential reflectivity issues have been adequately considered and addressed.

The extent of reflectivity analysis required to assess potential impacts will depend on the specific project site and system design.”

1. Assessing Baseline Reflectivity Conditions

“Reflection in the form of glare is present in current aviation operations. The existing sources of glare come from glass windows, auto surface parking, rooftops, and water bodies. At airports, existing reflecting surfaces may include hangar roofs, surface parking, and glassy office buildings. To minimize unexpected glare, windows of air traffic control towers and airplane cockpits are coated with anti-reflective glazing. Operators also wear polarized eye wear. Potential glare from solar panels should be viewed in this context. Any airport considering a solar PV project should first review existing sources of glare at the airport and the effectiveness of measures used to mitigate that glare.”

2. Tests in the Field

“Potential glare from solar panels can easily be viewed at the airport through a field test. A few airports have coordinated these tests with FAA Air Traffic Controllers to assess the significance of glare impacts. To conduct such a test, a sponsor can take a solar panel out to proposed location of the solar project, and tilt the panel in different directions to evaluate the potential for glare onto the air traffic control tower. For the two known cases where a field test was conducted, tower personnel determined the glare was not significant. If there is a significant glare impact, the project can be modified by ensuring panels are not directed in that direction.”

3. Geometric Analysis

“Geometric studies are the most technical approach for reflectivity issues. They are conducted when glare is difficult to assess through other methods. Studies of glare can employ geometry and the known path of the sun to predict when sunlight will reflect off of a fixed surface (like a solar panel) and contact a fixed receptor (e.g., control tower). At any given site, the sun moves across the sky every day and its path in the sky changes throughout year. This in turn alters the destination of the resultant reflections since the angle of reflection for the solar panels will be the same as the angle at which the sun hits the panels. The larger the reflective surface, the greater the likelihood of glare impacts. Figure 17 provides an example of such a geometric analysis (not shown).

Facilities placed in remote locations, like the desert, will be far from receptors and therefore potential impacts are limited to passing aircraft. Because the intensity of the light reflected from the solar panel decreases with increasing distance, an appropriate question is how far you need to be from a solar reflected surface to avoid flash blindness. It is known that this distance is directly proportional to the size of the array in question²³ but still requires further research to definitively answer.

The FAA Airport Facilities Terminal Integration Laboratory (AFTIL), located at the William J. Hughes Technical Centre at Atlantic City International Airport, provides system capabilities to evaluate control tower interior design and layout, site selection and orientation, height determination studies, and the transition of equipment into the airport traffic control tower environment. AFTIL regularly conducts computer assessments of potential penetrations of airspace for proposed airport design projects and has modelled the potential characteristics of glare sources, though not for solar projects. AFTIL may be a resource for regional FAA officials and sponsors who seek to evaluate the potential effects of glare from proposed solar projects.”

Experiences of Existing Airport Solar Projects

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

Appendix C: 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 W/m². 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.^{9,10}
5. Observer pupil diameter is set at the typical value of 0.002 m for daylight.^{9,10}
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.^{9,10}
7. The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between reflective surfaces, variable height of reflective surfaces, 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.¹¹
8. The algorithm assumes that the reflective surface 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.

⁹ 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.

¹⁰ Sliney, D.H. and B.C. Freasier, 1973, Evaluation of Optical Radiation Hazards, Applied Optics, 12(1), p. 1-24.

¹¹ <https://www.forgesolar.com/help/#assumptions>

Mabbett®

Safety

CDOIF Environmental Risk Tolerability Assessment
Chemical Management
COMAH Regulations Compliance Support
Consequence Modelling
Control of Electromagnetic Fields (EMF)
DSEAR & Hazardous Area Classification
Functional Safety
Health & Safety Compliance & Consultancy

Hazard Analysis Critical Control Point (HACCP)
Hazard & Operability Studies (HAZOP)
Local Exhaust Ventilation (LEV) Examination & Testing
Occupational Hygiene
Occupied Building Risk Assessment (OBRA)
Reliability Engineering
Risk Analysis Studies
Risk Assessment & Management

Mabbett®

Environment

Air Quality Assessment
Best Available Technique (BAT) Services
Circular Economy, Waste Reduction & Compliance
Contaminated Land Services
Construction Environment Services
Ecological & Ornithological Surveys
Environmental Impact Assessment (EIA)
Environmental Monitoring

Legal Compliance
Management Systems (ISO 9001, 14001, 45001, 50001)
Noise Impact Support
Permitting Support
Planning Services & Community Consultation
Policy Development
Secondment Services
Flood Risk Assessment

Mabbett®

Engineering

Air Pollution Control
Anaerobic Digestion
Electrical & Mechanical Isolations
Energy, Water & Waste
Industrial Effluent Treatment

Local Exhaust Ventilation (LEV) Design
Management, Operation & Maintenance
Mechanical & Electrical Engineering Design
Process Engineering
Renewable Energy Systems

Mabbett®

Training

Bespoke Environmental, Health & Safety Training
IEMA Approved Environmental Training
IOSH Approved Health & Safety Training

Contact Us: 0141 227 2300
info@mabbett.eu
www.mabbett.eu

Please connect with us at Mabbett Ltd:

LinkedIn: <https://www.linkedin.com/company/mabbett>

Twitter: <https://twitter.com/MabbettEU>



SAFETY
SCHEMES IN
PROCUREMENT



Mabbett & Associates Ltd, Corporate and Registered Office: 13 Henderson Road, Inverness, UK, IV1 1SN

Registered in Scotland No: SC 163378 info@mabbett.eu www.mabbett.eu

© 2024, Mabbett & Associates Ltd. All Rights Reserved. The name Mabbett and the Mabbett logo are Trade Marks licensed to Mabbett & Associates Ltd.