Green Hill Solar Farm

EN010170

Environmental Statement

Appendix 15.6: Easton Maudit Airfield Aviation Receptor Results

Prepared by: Arthian

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APFP Regulation 5(2)(a)

Appendix 15.6: Green Hill Solar Farm - Easton Maudit Airfield Aviation Receptor Results

For: Green Hill Solar Farm

Site: Easton Maudit Airfield

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Contents

Appendices

1. Introduction

1.1 Background

Green Hill Solar Farm Ltd (the Applicant) are involved in the development of a Nationally Significant Infrastructure Project (NSIP) solar scheme on land to the north of Northampton. The development is made up of a disparate number of sites, incorporating ground mounted solar panels.

A Glint and Glare Assessment has been undertaken to evaluate the potential light-sensitive receptors which may be impacted by glint and glare from Green Hill Solar Farm (hereafter referred to as the 'Scheme').

Easton Maudit Airfield is located adjacent to the solar scheme. As such, Arthian have undertaken a Glint and Glare Assessment to assess the impact of the Scheme at the airfield.

The results of the modelling for the Environmental Statement (ES) Technical Appendix are presented within this 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).

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

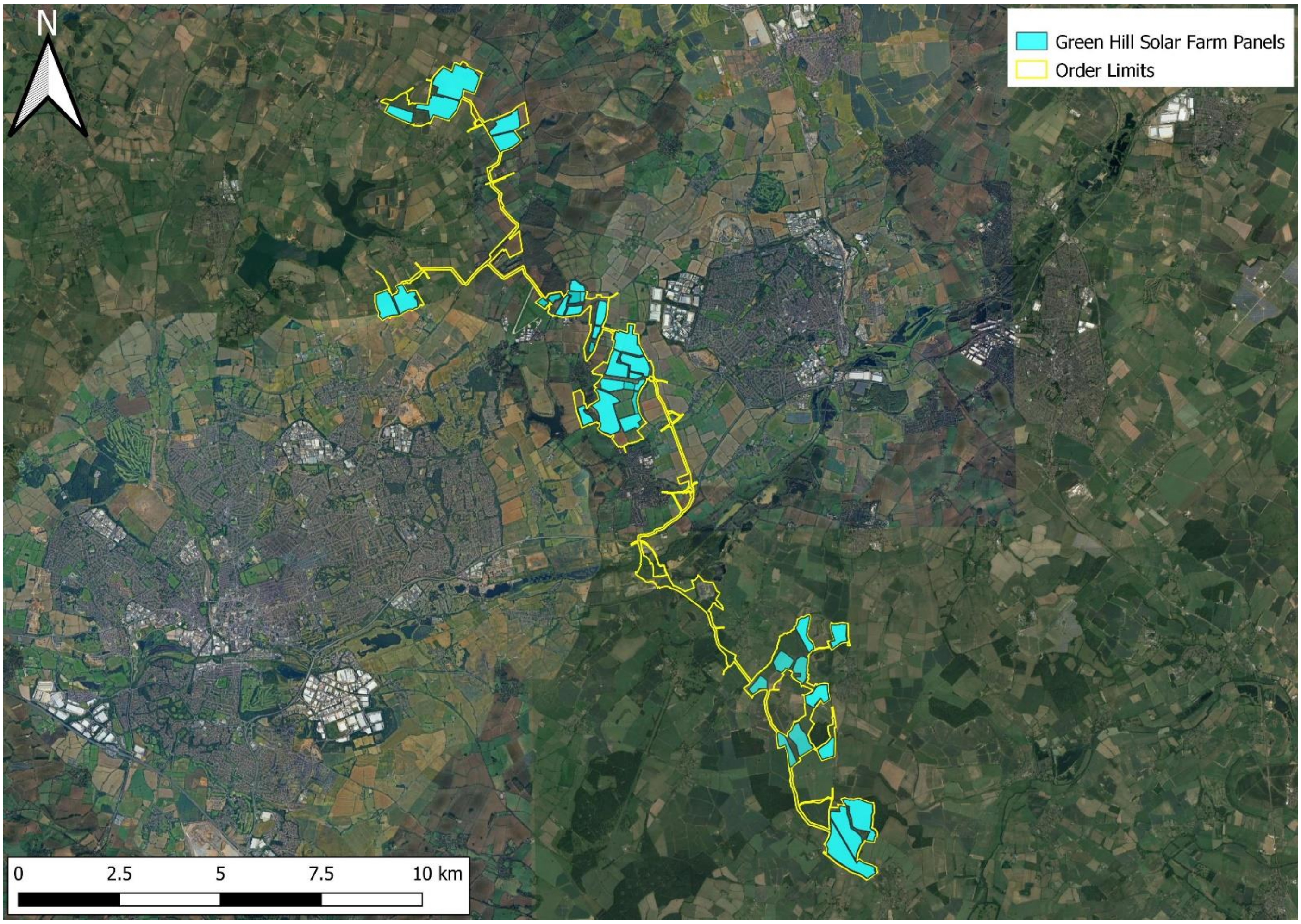
Based on definitions and factors described in Section 1.2 and in combination with available guidance and good practice recommendations, a desk-based evaluation was undertaken to evaluate the potential to experience the effects of glint and glare towards aviation receptors.

2. Development Characteristics

2.1 Site Description

The Scheme is situated on land north of Northampton and is made up of a disparate number of sites, as can be seen below in Figure 2.1 below.

Figure 2.1: Site Location



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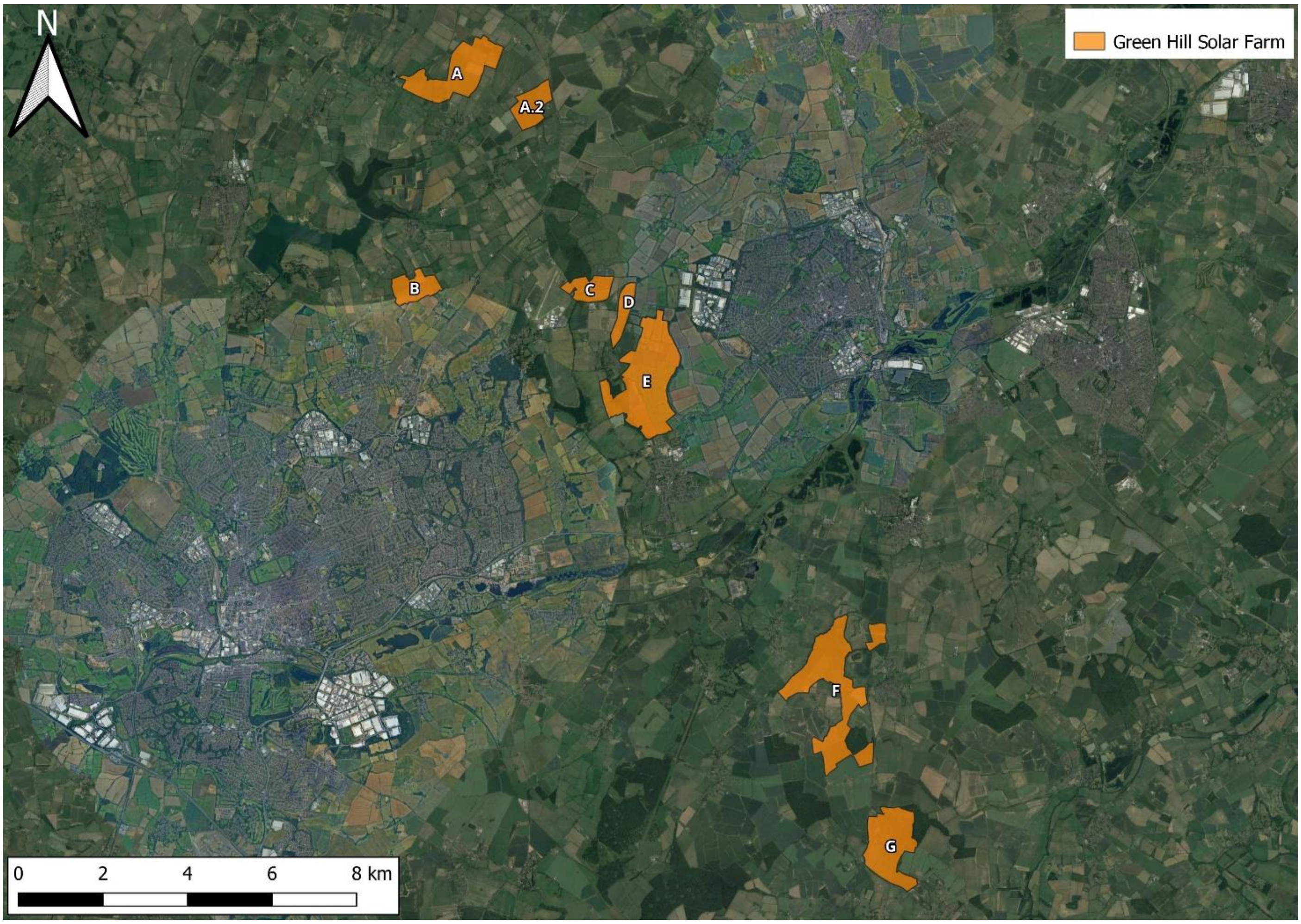
The Scheme will accommodate panels and Battery Energy Storage System (BESS). Green Hill BESS is allocated for a Battery Energy Storage System (BESS) and will not include the installation of any solar arrays. Therefore, this area will not be relevant for a glint and glare assessment. Flexibility has been sought to have BESS also on Green Hill C. An aerial view of the remaining areas (that will include solar panels) is shown below in Figure 2.2.

Figure 2.2: Green Hill Solar Farm



2.2 Proposed Development

The Proposed Development comprises of the installation of ground mounted solar PV arrays across eight areas of agricultural land. At this stage it is understood that two options are being considered for the Proposed Development: fixed tilt and single axis tracker.

The modelled PV module orientations and inclinations, as well as the modelled panel height, are summarised in the below tables.

For the fixed tilt option, a range of tilts are being considered from 10-35°. As such, a tilt of 22.5° has been modelled to represent the average tilt proposed. The average height[1] of the solar panels will be 1.95m above ground. It is noted that a small variation in average panel height will not change the conclusions of the report because the modelling results are unlikely to be meaningfully affected.

[1] The heights of the panels (minimum = 0.40m and maximum = 3.5m) have been provided. A centre height of 1.95m (0.4+((3.5-0.4)/2) has been used for the assessment.

The proposed PV module orientation and inclination, as well as PV panel height above ground, is summarised in in Table 2.1[2].

Table 2.1: Proposed Fixed Panel Details

PV Array	Orientation (Azimuth)[3]	Panel Tilt	Height Above Ground (m)[4]
Green Hill F			
Arrays 1-9	180°	22.5°	1.95
Green Hill G			
Arrays 1-3	180°	22.5°	1.95

For the single axis track option, the tracking range will be between +/- 60°, where 0° refers to the solar panel laying horizontal. The average height[5] of the solar panels will be 2.45m above ground. The proposed PV module orientation and inclination, as well as PV panel height above ground, is summarised in Table 2.2[2].

Table 2.2: Proposed Tracking Panel Details

PV Array	Backtracking Method	Tracking Axis Orientation (Azimuth)	Tracking Axis Tilt	Maximum Tracking Angle	Height Above Ground (m)[4]
Green Hill F					
Arrays 1-9	None	180°	0°	60°	2.45
Green Hill G					
Arrays 1-3	None	180°	0°	60°	2.45

For the purpose of this assessment, 'Smooth Glass with Anti-Reflective Coating (ARC)' modules have been used to model the surface material of the arrays.

For modelling purposes, the array layouts have been simplified, as shown below in Figure 2.3 and Figure 2.4.

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[2] Based on information provided by Green Hill Solar Farm Ltd

[3] North referenced at 0°

[4] The middle of the solar panel has been used as the assessed height in metres above ground level, which has been chosen as it represents the smallest possible variation in height from the bottom and top od the solar panels. The small variation in panel height will not change the conclusions of the report because the modelling results are unlikely to be meaningfully affected. When the visibility of the solar panels for ground-based receptors is discussed, the maximum height of the panel is considered since it will be the most visible part of the panel.

[5] The heights of the panels (minimum = 0.40m and maximum = 4.5m) have been provided. A centre height of 2.45m (0.4+((4.5-0.4)/2) has been used for the assessment.

Figure 2.3: Modelled PV Panels at Green Hill F

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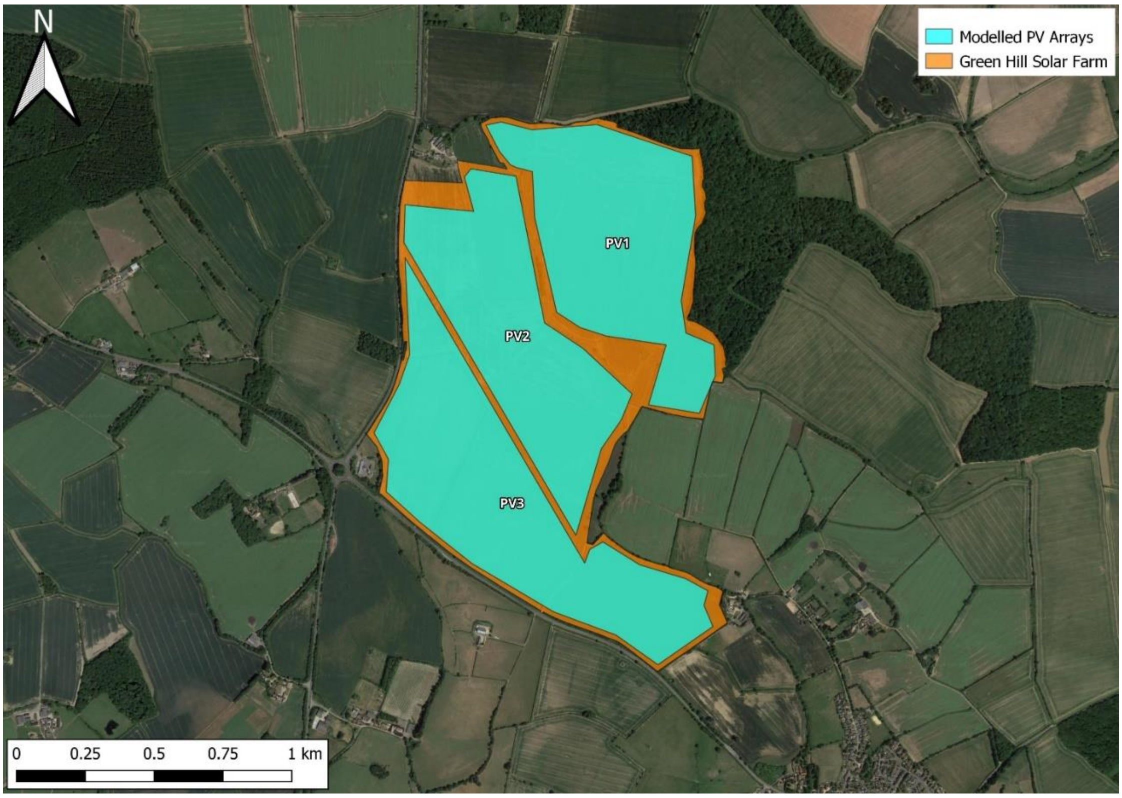
Figure 2.4: Modelled PV Panels at Green Hill F



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3. Legislation & Guidance

3.1 National Planning Policy

3.1.1 National Policy Statement for Energy

The National Policy Statement for energy (EN-1)[6] sets out the overarching policy for decisions by the Secretary of State for nationally significant energy infrastructure. It is noted that Glint and Glare is not specifically mentioned within EN-1.

Section 5.5 of EN-1 sets out the primary policy for the relationship between aviation and new energy:

> "5.5.1 All aerodromes, covering civil and military activities, as well as aviation technical sites, meteorological radars and other types of defence interests (both onshore and offshore) can be affected by new energy development.
>
> 5.5.2 Collaboration and co-existence between aviation, defence and energy industry stakeholders should be strived for to ensure scenarios such that neither is unduly compromised.
>
> ...
>
> 5.5.5 UK airspace is important for both civilian and military aviation interests. It is essential that new energy infrastructure is developed collaboratively alongside aerodromes, aircraft, air systems and airspace so that safety, operations and capabilities are not adversely affected by new energy infrastructure. Likewise, it is essential that aerodromes, aircraft, air systems and airspace operators work collaboratively with energy infrastructure developers essential for net zero. Aerodromes can have important economic and social benefits, particularly at the regional and local level, but their needs must be balanced with the urgent need for new energy developments, which bring about a wide range of social, economic and environmental benefits.
>
> ...
>
> 5.5.7 The approaches and flight patterns to aerodromes can be irregular owing to a variety of factors including the performance characteristics of the aircraft concerned and the prevailing meteorological conditions. It may be possible to adapt flight patterns to work alongside new energy infrastructure without impacting on aviation safety.
>
> ...
>
> 5.5.55 Lighting must also be designed in such a way as to ensure that there is no glare or dazzle to pilots and/or ATC, aerodrome ground lighting is not obscured and that any lighting does not diminish the effectiveness of aeronautical ground lighting and cannot be confused with aeronautical lighting. Lighting may also need to be compatible with night vision devices for military low flying purposes."

[6] https://assets.publishing.service.gov.uk/media/65bbfbdc709fe1000f637052/overarching-nps-for-energy-en1.pdf

3.1.2 National Policy Statement for Renewable Energy Infrastructure

The National Policy Statement for Renewable Energy Infrastructure (EN-3)[7] 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, irradiation[8]. 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.*
>
> *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."*

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[7] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1147382/NPS_EN-3.pdf

[8] 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.

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 Local Planning Policy

3.2.1 West Northampton Joint Core Strategy Local Plan

15.3.8 The West Northampton Joint Core Strategy Local Plan[9] sets out the long-term vision and objectives for the whole area covered by the former Daventry District, Northampton Borough, and South Northamptonshire Councils for the plan period up to 2029, including strategic policies for steering and shaping development. The West Northamptonshire Joint Core Strategy Local Plan (Part 1) states in paragraph 4.44:

> *"Development that aims to secure sustainable communities is designed to minimise its impact on the environment and so combat climate change. A realistic and serious response to meeting climate change objectives must be made through the JCS direction on policies. Larger scale developments, including Sustainable Urban Extensions (SUEs), provide the opportunity to secure exemplary standards of design, renewable or low carbon energy generation and through the location of development reduce the need to travel. All development proposals will need to fully consider climate change adaption to meet the vision of sustainable development."*

[9] https://www.westnorthants.gov.uk/west-northamptonshire-joint-core-strategy/west-northamptonshire-joint-core-strategy-local-plan-part

In relation to Glint and Glare, Policy S10 – Sustainable Development Principles describes how visual intrusion from renewable energy developments should be limited:

> *"When considering planning applications for low carbon and renewable energy, an assessment will need to take account of impacts on landscape, townscape, natural, historical and cultural features and areas and nature conservation interests. Proposals should also use high quality design to minimise impacts on the amenity of the area, in respect of visual intrusion, noise, dust, and odour and traffic generation."*

3.2.2 North Northamptonshire Joint Core Strategy

The North Northamptonshire Joint Core Strategy [10] provides the strategic planning policies for the future development of the area from 2016 to 2031.

Policy 26: Renewable and Low Carbon Energy states that renewable and low carbon energy generation will be supported where the proposal meets the following criteria relevant to glint and glare:

> *"The siting of development does not significantly adversely affect the amenity of existing, or proposed, residential dwellings and/or businesses, either in isolation or cumulatively, by reason of noise, odour intrusion, dust, traffic generation, visual impact or shadow flicker;"*

3.2.3 Wind and Solar Energy Supplementary Planning Document

The Wind and Solar Energy Supplementary Planning Document[11] provides guidance on the information to be submitted with a planning application and sets out the key issues that will be taken into consideration by the Council.

Section 16 of the Wind and Solar Energy Supplementary Planning Documents states the following on Glint and Glare:

> *"The effect of glint and glare on landscape, neighbouring uses and aircraft safety is identified in the NPPG as an important factor to consider when assessing proposals for large scale solar PV farms. The guidance further indications that there may be additional impacts if solar arrays track the daily movement of the sun.*
>
> *Solar panels are designed to absorb as much light as possible rather than reflect it. Nevertheless, there is the potential for glint and glare effects. 'Glint' refers to a momentary flash of light produced as direct reflection of the sun whilst 'glare' is a more continuous source of brightness relative to the ambient lighting. These effects can have a visual impact on the landscape and can act as a potential hazard or distraction for motorists, pilots, pedestrians and occupiers' of nearby properties. Specifically in respect to aviation, the Civil Aviation Authority has issued interim guidance on solar photovoltaic systems. There is also potential for glint and glare to have an affect on nearby heritage assets.*
>
> *The potential for glint and glare to occur should therefore be assessed. This should address the additional impacts of 'tracking' panels, which follow the movement of the sun across the sky to maximise solar gain,*

[10] https://www.northnorthants.gov.uk/planning-strategies-and-plans/north-northamptonshire-local-plan
[11] https://www.northnorthants.gov.uk/planning-strategies-and-plans/supplementary-planning-documents-spd

where proposed. Modelling tools are available to evaluate solar farm projects. Undertaking an assessment at an early stage will enable variables such as the orientation and tilt angles of arrays to be changed, where necessary, to minimise any adverse impacts."

3.2.4 MK:Plan (2016-2031)

The MK:Plan (2016-2031)[12] sets out the vision and framework for the future development of the area from 2015 to 2031.

Policy SC3: Low Carbon and Renewable Energy Generation states the following regarding glint and glare:

"A. The Council will encourage proposals for low carbon and renewable energy generation developments that are led by, or meet the needs of local communities.

B. Planning permission will be granted for proposals to develop low carbon and renewable energy sources (including community energy networks) unless there would be:

1. Significant harm to the amenity of residential area, due to noise, traffic, pollution or odour;

2. Significant harm to wildlife species or habitat;

3. Unacceptable landscape and visual impact on the landscape, including cumulative impacts;

4. Unacceptable harm to the significance of heritage assets; and

5. Unacceptable impact on air safety.

C. In addition to the above criteria, wind turbines should avoid unacceptable shadow flicker and electro-magnetic interference and be sited an appropriate distance away from occupied properties, consistent with the size and type of the turbine. Proposals to develop solar PV farms should avoid unacceptable visual impact from the effect of glint and glare on the landscape, on neighbouring uses and aircraft safety. Proposals for large scale renewable energy in the open countryside should be informed by a satisfactory landscape and visual impact assessment."

3.3 Emerging Local Planning Policy

3.3.1 MK City Plan 2050

The MK City Plan 2050[13] sets out the strategy for growth through to 2050 related to the need for homes, creating jobs and supporting businesses, transport around the city, climate change, the natural and built environment, design of streets, and the places which support everyday living (i.e. schools and shops).

Policy CEA6: Low and Zero Carbon Energy Provision states the following regarding low carbon and renewable energy developments:

[12] https://www.milton-keynes.gov.uk/sites/default/files/2022-05/PlanMK%20Adoption%20Version%20%28March%202019%29.pdf
[13] https://www.milton-keynes.gov.uk/planning-and-building/planning-policy/mk-city-plan-2050

"2. Proposals to development low carbon and renewable energy sources (including community energy networks) and infrastructure needed to facilitate the green energy transition (e.g. grid and sub-station upgrades) will be supported, unless there would be

a. Conflict with other policies within the development plan.

b. Unacceptable harm on air safety, in terms of the risk of incidents on approaches/departures from local airfields/airports, as well as radar interference."

3.4 Guidance

3.4.1 National Planning Practice Guidance

In the absence of specific guidance on solar development, the National Planning Practice Guidance for 'Renewable and Low Carbon Energy'[14] 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;...*
- *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."

3.4.2 BRE Planning guidance for the development of large-scale ground mounted solar PV panels

The BRE Planning guidance for the development of large-scale ground mounted solar PV panels[15] sets out guidance relating to different planning application considerations. In relation to Glint and Glare, the guidance states:

"Glint may be produced as a direct reflection of the sun in the surface of the solar PV panel. It may be the source of the visual issues regarding viewer distraction. Glare is a continuous source of brightness,

[14] https://www.gov.uk/guidance/renewable-and-low-carbon-energy

[15] [redacted]

relative to diffused lighting. This is not a direct reflection of the sun, but rather a reflection of the bright sky around the sun. Glare is significantly less intense than glint.

Solar PV panels are designed to absorb, not reflect, irradiation. However the sensitivities associated with glint and glare, and the landscape/ visual impact and the potential impact on aircraft safety, should be a consideration. In some instances it may be necessary to seek a glint and glare assessment as part of a planning application. This may be particularly important if 'tracking' panels are proposed as these may cause differential diurnal and/or seasonal impacts.

The potential for solar PV panels, frames and supports to have a combined reflective quality should be assessed. This assessment needs to consider the likely reflective capacity of all of the materials used in the construction of the solar PV farm."

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.

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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:

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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."

4. Methodology

4.1 Glare Assessment Model

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 software specialist for modelling glare impacts and the software is used extensively across the UK for assessing impacts toward airports, transportation and residential dwellings.

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

Aviation	**Aerodromes** Based on CAA CAST guidance[16], aerodromes located within 5 km of proposed development, will be assessed for glint and glare. The 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). • 900 metre approach path thresholds towards runway(s) will be assessed, with starting points taken at 1.5 m above runway threshold at a 6-degree descent path (unless otherwise stated). • Reference aircraft location receptor points will be modelled with 9 points over the 900 metre approach paths identified. • A pilot's azimuthal field-of-view (FOV) will be considered either side of direction of travel. • A pilot vertical FOV will also be considered.

[16] Available at: [redacted]

4.3 Magnitude of Impact

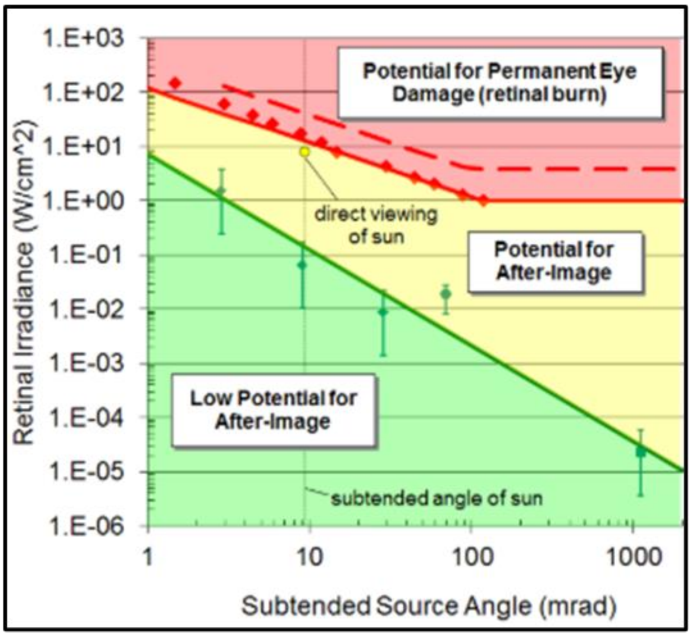
4.3.1 Ocular Impact

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 plot[17] 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.).

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.

Figure 4.1: Ocular Hazard Plot



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

4.3.2 Glint & Glare Impact Significance

4.3.2.1 Aviation

Table 4.2: Aviation Impact Significance Guidance

<table>
<tr>
<td>Air Traffic Control Towers (ATCT)</td>
<td>
In accordance with industry guidance[18], it is recommended that any predicted solar reflection is assessed pragmatically. Therefore, professional judgement will be applied and the following factors will also be considered when determining whether a solar reflection is significant:

The relative position and visibility of the reflecting panels relative to the aerodrome’s key operational areas – glare originating near sensitive areas such as the runway threshold will have a higher impact upon the ATC Tower personnel than that away from other areas;
Separation distance from panels to ATCT personnel – at longer distances, the proportion of an observer’s field of vision that is taken up by the reflecting area is reduced;
The predicted intensity of the solar reflection;
Solar reflection duration per day;
Number of days a solar reflection is geometrically possible per year; and
The time of day when a solar reflection is geometrically possible.

Industry guidance states:
<table>
<tr><td>No or Insignificant Impact</td><td>Solar reflection is not geometrically possible or will not be visible from the assessed receptor. Mitigation not required.</td></tr>
<tr><td>Low</td><td>Glare has a maximum intensity of “low potential for temporary after-image” (green glare). However, application of professional judgement renders the residual potential glare to be not significant. Mitigation not recommended.</td></tr>
<tr><td>Moderate</td><td>Glare has an intensity of “low potential for temporary after-image” (green glare) or “potential for temporary after-image” (yellow glare). Application of professional judgement does not sufficiently decrease the significance of the potential glare. Mitigation recommended.</td></tr>
<tr><td>High</td><td>Glare has an intensity of “low potential for temporary after-image” (green glare) or “potential for temporary after-image” (yellow glare). Application of professional judgement does not sufficiently decrease the significance of the potential glare. Mitigation required.</td></tr>
</table>
</td>
</tr>
<tr>
<td>Approaching Aircrafts</td>
<td>In accordance with industry guidance, it is recommended that any predicted solar reflection is assessed pragmatically. Therefore, professional judgement will be applied and the following factors will also be considered when determining whether a solar reflection is significant:</td>
</tr>
</table>

[18] Available at: [redacted]

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), however, application of professional judgement renders the residual potential glare to be not significant. • 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 application of professional judgement does not sufficiently decrease the significance of the potential glare. 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.

5. Receptor Screening & Model Considerations

5.1 Aviation Receptors

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. In July 2023, 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.

CAA CAST guidance states:

"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."

Aviation infrastructure modelled at Easton Maudit Airfield is illustrated in Figure 5.1.

Figure 5.1: Modelled Approach Paths and Observation Points

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The approach paths have been modelling using observation points (OPs) modelled along approach paths as 900m from five feet above the landing threshold using a 6-degree glidepath. The flight path height at each OP follows the below altitude profile:

Table 5.1: Observation Points for Assessed Flight Path

Observation Point	Distance from Threshold (m)	Altitude Above Ground (m)
OP1	Threshold – point closest to ground/runway (0 m)	1.5
OP2	112.5	13.3
OP3	225.0	25.2
OP4	337.5	37.0
OP5	450.0	48.8
OP6	562.5	60.6
OP7	675.0	72.5
OP8	787.5	84.3
OP9	900.0	96.1

6. Modelled Results and Interpretation

6.1 Modelled Observation Points along Approach Paths

The Glint and Glare Assessment was originally undertaken using observation points as prescribed in Table 5.1, however, there are limitations with this methodology. The model assumes that observation points have a 360° field-of-view. As such, a modelled observation point may be predicted to receive significant effects, however in reality, it may not be geometrically possible for the pilot to experience the glare.

Based on understanding of FAA guidance, it is considered that a pilot's central field-of-view will be confined to 100° (50° either side of travel). As such, modelling approach paths using observation points may lead to an over-exaggeration of predicted glare. This could lead to significant effects being predicted which may not be experienced in real life.

A brief summary of the results when modelling approach paths with observation points are presented below. To determine the below results, professional judgement has been applied considering the below factors:

- 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;
- Solar reflection duration per day;
- Number of days a solar reflection is geometrically possible per year;
- The time of day when a solar reflection is geometrically possible.
- The length of the section of the final approach that is potentially affected by glare;
- Reflectors in the existing environment;
- The extent to which impacts coincide with effects of direct sunlight; and
- Likely aerodrome traffic volumes, operational procedures or restrictions specific to the aerodrome, where applicable/provided.

Predicted impacts from fixed tilt panels towards observation points modelled along approach paths at Easton Maudit Airfield are presented below in Table 6.1.

Table 6.1: Predicted Residual Impacts from Fixed Tilt Panels

Receptor	Predicted Residual Impact	
	Site F	Site G
FP16	**Moderate Impact** predicted from PV5 within Green Hill F	**No Impact**
FP34	**Moderate Impact** predicted from PV7 and PV8 within Green Hill F	**No Impact**

Predicted impacts from single-axis tracking panels towards observation points modelled along approach paths at Easton Maudit Airfield are presented below in Table 6.2.

Table 6.2: Predicted Residual Impacts from Single-Axis Tracking Panels

Receptor	Predicted Residual Impact	
	Site F	Site G
FP16	**Moderate Impact** predicted from PV5, PV6 and PV8 within Green Hill F	**No Impact**
FP34	**Moderate Impact** predicted from PV7 and PV8 within Green Hill F	**Low Impact** upon applying professional judgement

After consultation with an aviation specialist, the parameters of the assessment were revised to provide more realistic modelling of glint and glare impacts to the approach paths. This included applying a 50 degree field-of-view (FOV) (25 degrees each side of travel) for the pilots, corresponding to the forward visibility of aircraft cockpits.

The results of the further modelling are shown below in Section 7.

7. Further Modelling Results and Interpretation

7.1 Fixed Panel Results

7.1.1 Modelling Results – Green Hill F

Table 7.1: Results from Green Hill F Fixed Panels

Receptor	Results	Impact
FP16	Glare with 'low potential for temporary after-image' (green glare) is predicted towards approach path FP16 from Green Hill F PV5. With reference to the impact significance guidance (Section 4.3.2.1) flight paths which have a 'low potential for after-image' are predicted to have a 'low' impact.	**Low Impact**
FP34	***No glare predicted towards FP34.***	**No Impact**

7.1.2 Modelling Results – Green Hill G

Table 7.2: Results from Green Hill G Fixed Panels

Receptor	Results	Impact
FP16	***No glare predicted towards FP16.***	**No Impact**
FP34	***No glare predicted towards FP34.***	**No Impact**

7.2 Tracking Panels

7.2.1 Modelling Results – Green Hill F

Table 7.3: Results from Green Hill F Single-Axis Tracking Panels

Receptor	Results	Impact
FP16	Glare with 'low potential for temporary after-image' (green glare) is predicted towards approach path FP16 from Green Hill F PV8 and PV9. Glare with 'potential for temporary after-image' (yellow glare) is predicted towards approach path FP16 from Green Hill F PV8. Further discussion is provided within Section 7.2.2 below.	Further discussion is provided within Section 7.2.2 below.
FP34	Glare with 'low potential for temporary after-image' (green glare) is predicted towards approach path FP16 from Green Hill F PV7. With reference to the impact significance guidance (Section 4.3.2.1) flight paths which have a 'low potential for after-image' are predicted to have a 'low' impact.	**Low Impact**

7.2.2 Results Discussion

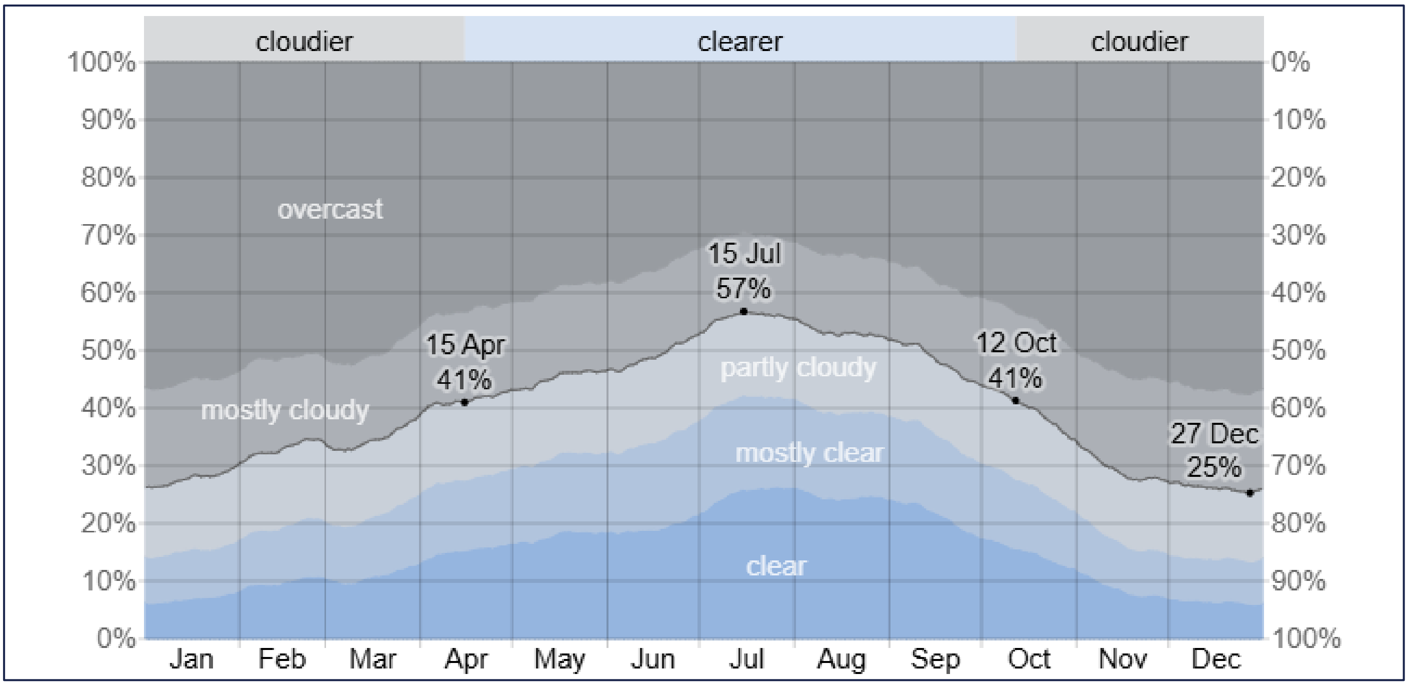
7.2.2.1 Flight Path FP16

Glare with 'potential for temporary after-image' is predicted from Green Hill F PV8 towards flight path FP16. Yellow glare is predicted from late November to mid-January between 08:00-09:30 for a maximum of 15 minutes per day.

The total annual predicted yellow glare form PV8 is 365 minutes, which equates to less than 0.1% of the year.

It should be considered that the modelling software assumes clear sky conditions. In the affected months, November to January, it is predicted to be 70-75% overcast or mostly cloudy as shown in Figure 7.1 below. This amount of cloud cover would further reduce the significance of the yellow glare predicted towards FP16.

Figure 7.1: Cloud Cover at Bozeat



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On the basis of the above, it is considered that there are sufficient factors that will decrease the significance of the predicted yellow glare toward flight path FP16 from PV8 within Green Hill F.

7.2.3 Modelling Results – Green Hill G

Table 7.4: Results from Green Hill G Single-Axis Tracking Panels

Receptor	Results	Impact
FP16	***No glare predicted towards FP16.***	**No Impact**
FP34	***No glare predicted towards FP34.***	**No Impact**

8. Results

Panels predicted to potentially moderately impact light sensitive aviation receptors at Easton Maudit Airfield are shown below.

The table below shows the results of the modelling assessment when modelling approach paths using the Route tool within ForgeSolar, and upon applying the pilots' 25° FOV.

Table 8.1: Fixed Tilt Panels versus Tracking Panels – Approach Paths with 25° FOV

Receptor	Green Hill F	
	Fixed Tilt Panels	Tracking Panels
FP16	**Low Impact**	**Low Impact** upon applying professional judgement
FP34	**No Impact**	**Low Impact**

9. Conclusions

Modelling undertaken as part of the ES Chapter Technical Appendix for Green Hill Solar Farm. Arthian were requested to rerun the glint and glare model with shortened, 900m aviation approach paths and a steeper, 6-degree glidepath.

As highlighted above, glare with ‘potential for temporary after-image’ (yellow glare) was predicted towards observation points along FP16 and FP34 from panels within Green Hill F.

However, upon remodelling the approach paths using the Route tool within ForgeSolar, and applying a 50° FOV (25° each side of travel), glare with ‘low potential for temporary after-image’ (green glare) was predicted towards flight paths FP16 and FP34 from fixed tilt panels. Additionally, green glare was predicted towards FP34 from single-axis tracking panels. With reference to the impact significance guidance (Section 4.3.2.1) flight paths which have a ‘low potential for after-image’ are predicted to have a ‘low’ impact. As such, no mitigation is recommended.

Glare with ‘potential for temporary after-image’ (yellow glare) was predicted towards flight path FP16 from single-axis tracking panels. However, upon applying professional judgement, such as annual duration of predicted yellow glare and cloud cover, a ‘low impact’ may be classified for glare predicted towards FP16.

It is recommended that the findings of this report should be reviewed by the safeguarding team at these aerodromes to determine whether, given the results and considerations presented in this report, the assessed glare can be operationally accommodated.

Appendices

Appendix A: 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."

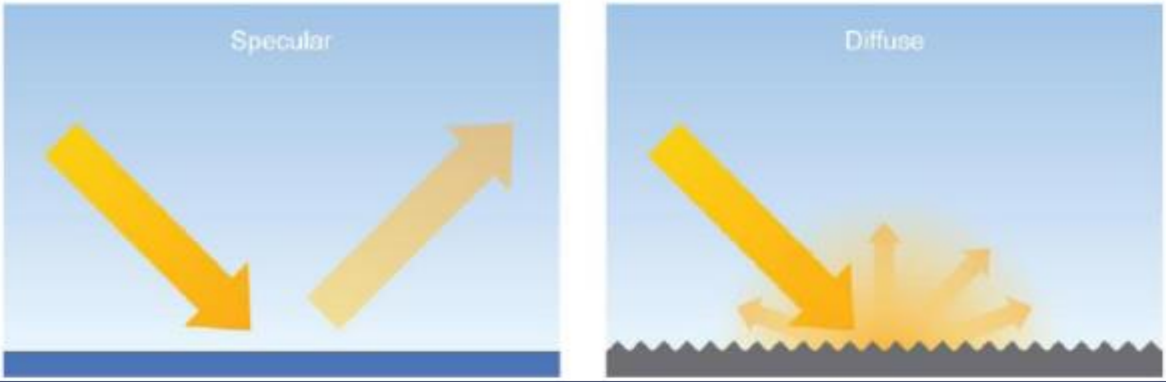
3.1.2 Reflectivity

"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,

Figure 16: Different Types of Reflection



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 B: 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/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.[19,20]
5. Observer pupil diameter is set at the typical value of 0.002 m for daylight.[19,20]
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. [19,20]
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.[21]
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.

[19] 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.
[20] Sliney, D.H. and B.C. Freasier, 1973, Evaluation of Optical Radiation Hazards, Applied Optics, 12(1), p. 1-24.
[21] [redacted]