Aviation Glint and Glare Assessment

Hillingdon Watersports Facility Solar Array

26/02/2024

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1. EXECUTIVE SUMMARY

1.1. A 30km study area is chosen for aviation receptors. 17 aviation assets are located within 30km of the Proposed Development. Four of which, Denham Airport, Elstree Airport, RAF Northolt and London Heathrow Airport required a detailed assessment due to the Proposed Development falling within its respective safeguarding buffer zone outlined in **paragraph 4.20**.

1.2. Geometric analysis was conducted for 12 runway approach paths and four Air Traffic Control Towers (ATCT) at Denham Airport, Elstree Airport, RAF Northolt and London Heathrow Airport.

1.3. The assessment concludes that:

- Denham: No glare is predicted to impact the Runway 24 and 30 approach paths. Only green glare is predicted to impact upon the Runway 06 and 12 approach paths and the ATCT, which is an **acceptable impact** when pilots are approaching runways/helipads and a **not acceptable impact** upon an ATCT according to FAA guidance. Upon reviewing the actual visibility of the ATCT, impacts upon the ATCT reduce to **None**. Therefore, the impact upon Denham Airport is **Not Significant**.
- Elstree: No glare is predicted to impact the runway approach paths or the ATCT. Therefore, the impact upon Elstree Airport is **None**.
- RAF Northolt: No glare is predicted to impact the Runway 07 approach path or the ATCT. Only green glare is predicted to impact upon the Runway 25 approach path, which is an **acceptable impact** when pilots are approaching runways/helipads according to FAA guidance. Therefore, the impact upon RAF Northolt is **Not Significant**.
- London Heathrow: No glare is predicted to impact the runway approach paths or the ATCT. Therefore, the impact upon London Heathrow Airport is **None**.
- Overall impacts on aviation receptors are **acceptable and Not Significant**.

1.4. Mitigation measures are not required due to the impacts being **acceptable and Not Significant**.

2. INTRODUCTION

BACKGROUND

2.1. Neo Environmental Ltd has been appointed by London Borough of Hillingdon (the "Applicant") to undertake a Glint and Glare Assessment for a proposed solar array development (the "Proposed Development") on the roofs of the Hillingdon Watersports Facility (the "Application Site").

2.2. Please see **Figure 1: Appendix A** for the roof layout of the Proposed Development.

DEVELOPMENT DESCRIPTION

2.3. Redevelopment of the site to create the Hillingdon Watersports Facility and Activity Centre including demolition of existing Broadwater Lake Sailing Club (BSC) clubhouse at the north of the lake and erection of a building to be occupied by HOAC and BSC including changing facilities, meeting rooms, storage, Workshop and seasonal worker accommodation (sui generis), activity shelters; installation of pontoons and concrete slipways; boat shed; equipment storage huts (north of lake and at entrance); boat parking and racking areas; camping area; outdoor activity areas; ecological enhancement throughout the site; new pedestrian routes through the peninsula; landscaping including new woodland, dense vegetation screens and boundary treatment; new access and access road; localised dredging and land reclamation; relocation of existing sailing area and creation of floating and fixed islands within the lake; coach drop off and turning area; vehicle parking; cycle parking; and associated works.

SCOPE OF REPORT

2.4. Although there may be small amounts of glint and glare from the metal structures associated with the solar array, the main source of glint and glare will be from the panels themselves and this will be the focus of this assessment.

2.5. Solar panels are designed to absorb as much light as possible and not to reflect it. However, glint can be produced as a reflection of the sun from the surface of the solar PV panel. This can also be described as a momentary flash. This may be an issue due to visual impact and viewer distraction on ground-based receptors and on aviation.

2.6. Glare is significantly less intense in comparison to glint and can be described as a continuous source of bright light, relative to diffused lighting. This is not a direct reflection of the sun, but a reflection of the sky around the sun.

2.7. This report will concentrate on the impacts of glint and glare and their effects on aviation assets and will be supported with the following Appendices:

- Appendix A: Figures
  - Figure 1: Site Layout
  - Figure 2: Denham Airport Aerodrome Chart
  - Figure 3: Elstree Airport Aerodrome Chart
  - Figure 4: RAF Northolt Aerodrome Chart
  - Figure 5: London Heathrow Airport Aerodrome Chart
- Appendix B: Aviation Receptor Glare Results
- Appendix C: Visibility Assessment Evidence
- Appendix D: Solar Module Glare and Technical Memo

STATEMENT OF AUTHORITY

2.8. This Glint and Glare Assessment has been produced by Tom Saddington, Michael McGhee and David Thomson of Neo Environmental. Having completed a civil engineering degree in 2012, Michael has produced Glint and Glare assessments for over 1GW of solar farm developments across the UK and Ireland. Tom has an undergraduate degree in Bioengineering and graduated with an MSc in Environmental and Energy Engineering in January 2020. He has been working on various technical assessments including glint and glare reports for numerous solar farms in Ireland and the UK. David has an undergraduate degree in physics, as well as a MSc in sensor design, a MSc in nanoscience and a Diploma in Acoustics and Noise Control. He is an Environmental Engineer who has worked on numerous Glint and Glare assessments for solar farms across the UK and Ireland.

DEFINITIONS

2.9. This study examined the potential hazard and nuisance effects of glint and glare in relation to ground-based receptors, this includes the occupants of surrounding dwellings as well as road users. The FAA in their "*Technical Guidance for Evaluating Selected Solar Technologies on Airports*"[1] have defined the terms 'Glint' and 'Glare' as meaning;

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

2.10. Glint and glare are essentially the unwanted reflection of sunlight from reflective surfaces. This study used a multi-step process of elimination to determine which receptors have the potential to experience the effects of glint and glare. It then examined, using a computer-generated geometric model, the times of the year and the times of the day such effects could occur. This is based on the relative angles between the sun, the panels, and the receptor throughout the year.

General Nature of Reflectance from Photovoltaic Panels

2.11. In terms of reflectance, photovoltaic solar panels are by no means a highly reflective surface. They are designed to absorb sunlight and not to reflect it. Nonetheless, photovoltaic panels have a flat polished surface, which omits 'specular' reflectance rather than a 'diffuse' reflectance, which would occur from a rough surface. Several studies have shown that photovoltaic panels (as opposed to Concentrated Solar Power) have similar reflectance characteristics to water, which is much lower than the likes of glass, steel, snow and white concrete by comparison (See Appendix C). Similar levels of reflectance can be found in rural environments from the likes of shed roofs and the lines of plastic mulch used in cropping. In terms of the potential for reflectance from photovoltaic panels to cause hazard and/ or nuisance effects, there have been a number of studies undertaken in respect of schemes in close proximity to airports. The most recent of these was compiled by the Solar Trade Association (STA) in April 2016 and used a number of case studies and expert opinions, including that from Neo. The summary of this report states that "*the STA does not believe that there is cause for concern in relation to the impact of glint and glare from solar PV on aviation and airports…*"[2].

Time Zones / Datum's

2.12. Locations in this report are given in Eastings and Northings using the 'British National Grid' grid reference system unless otherwise stated.

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1 Harris, Miller, Miller & Hanson Inc. (April 2018). Technical Guidance for Evaluating Selected Solar Technologies on Airports; 3.1.2 Reflectivity. Technical Guidance for Evaluating Selected Solar Technologies on Airports. Available at: https://www.faa.gov/sites/faa.gov/files/airports/environmental/FAA-Airport-Solar-Guide-2018.pdf

2 Solar Trade Association. (April 2016). Summary of evidence compiled by the Solar Trade Association to help inform the debate around permitted development for non - domestic solar PV in Scotland. Impact of solar PV on aviation and airports. Available at: http://www.solar-trade.org.uk/wp-content/uploads/2016/04/STA-glint-and-glare-briefing-April-2016-v3.pdf

2.13. England uses British Summer Time (BST, UTC + 01:00) in the summer months and Greenwich Mean Time (UTC+0) in the winter period. For the purposes of this report all time references are in GMT.

3. LEGISLATION AND GUIDANCE

NATIONAL PLANNING POLICY GUIDANCE (NPPG) ON RENEWABLE AND LOW CARBON ENERGY (UK) [3]

3.1. Paragraph 013 (Reference ID: 5-013-20150327) sets out planning considerations that relate to large scale ground-mounted solar PV farms. This determines that 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. Considerations to be taken into account by local planning authorities are;

- *"the proposal's visual impact, the effect on landscape of glint and glare 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."*

PLANNING GUIDANCE FOR THE DEVELOPMENT OF LARGE-SCALE GROUND MOUNTED SOLAR PV SYSTEMS

3.2. As outlined within the BRE document 'Planning Guidance for the Development of Large-Scale Ground Mounted Solar PV Systems'[4]

"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, 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

[3] NPPG Renewable and Low Carbon Energy. Available at: http://planningguidance.communities.gov.uk/blog/guidance/renewable-and-low-carbon-energy/particular-planning-considerations-for-hydropower-active-solar-technology-solar-farms-and-wind-turbines/#paragraph_012

[4] BRE (2013) *Planning Guidance for the Development of Large Scale Ground Mounted Solar PV Systems*. Available at: https://www.bre.co.uk/filelibrary/pdf/other_pdfs/KN5524_Planning_Guidance_reduced.pdf

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."

Interim CAA Guidance – Solar Photovoltaic Systems (2010)

3.3. There is little guidance on the assessment of glint and glare from solar farms with regards to aviation safety. The Civil Aviation Authority (CAA) has published interim guidance on 'Solar Photovoltaic Systems[5]', they also intend to undertake a review of the potential impacts of solar PV developments upon aviation, however this is yet to be published.

3.4. The interim guidance identifies the key safety issues with regards to aviation, including *"glare, dazzling pilots leading them to confuse reflections with aeronautical lights."* It is outlined that solar farm developers should be aware of the requirements to comply with the Air Navigation Order (ANO), published in 2016 and amended in 2022. In particular, developers should be cognisant of the following articles of the ANO[6], including:

- *Article 240 – Endangering safety of an aircraft – "A person must not recklessly or negligently act in a manner likely to endanger an aircraft, or any person in an aircraft."*
- *Article 224 - Lights liable to endanger – "A person must not exhibit in the United Kingdom any light which:*

– *a) by reason of its glare is liable to endanger aircraft taking off or from landing at an aerodrome; or*

– *b) by reason of its liability to be mistaken for an aeronautical ground light liable to endanger aircraft"*

- *Article 225 – Lights which dazzle or distract – "A person must not in the United Kingdom direct or shine any light at any aircraft in flight so as to dazzle or distract the pilot of the aircraft."*

3.5. Relevant studies generally agree that there is potential for glint and glare from photovoltaic panels to cause a hazard or nuisance for surrounding receptors, but that the intensity of such

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[5] *CAA (2010) Interim CAA Guidance – Solar Photovoltaic Systems. Available at: https://publicapps.caa.co.uk/modalapplication.aspx?catid=1&appid=11&mode=detail&id=4370*

[6] CAA (2016) Air Navigation: The Order and Regulations. Available at: https://www.caa.co.uk/media/1a2cigrq/air-navigation-order-2016-amended-april-2022-version.pdf

reflections is similar to that emanating from still water. This is considerably lower than for other manmade materials such as glass, steel or white concrete (SunPower – 2009).

3.6. These Articles are considered within the assessment of glint and glare of the Proposed Development.

CAA – CAP738: Safeguarding of Aerodromes 3rd Edition[7]

3.7. In 2003 the CAA first introduced the CAP738 document to help provide advice and guidance to ensure aerodrome safeguarding. Subsequently, there have been two updates to this document in 2006 and 2020.

3.8. Within the latest edition of CAP738, it outlines that the purpose of the document is to protect an aerodrome and to ensure safe operation. Specifically stating:

"Its purpose is to protect:

Aircraft from the risk of glint and glare e.g. solar panels."

3.9. Within the section named as "Appendix C – Solar Photovoltaic Cells", the following is stated:

"Policy

1. In 2010 the CAA published interim guidance on Solar Photovoltaic Cells (SPCs). At that time, it was agreed that we would review our policy based on research carried out by the Federal Aviation Authorities (FAA) in the United States, in addition to reviewing guidance issued by other National Aviation Authorities. New information and field experience, particularly with respect to compatibility and glare, has resulted in the FAA reviewing its original document 'Technical Guidance for Evaluating Selected Solar Technologies on Airports', which is likely to be subject to change, see link; https://www.federalregister.gov/documents/2013/10/23/2013-24729/interimpolicy-faa-review-of-solar-energy-system-projects-on-federally-obligated-airports

2. In the United Kingdom there has been a further increase in SPV cells, including some located close to aerodrome boundaries; to date the CAA has not received any detrimental comments or issues of glare at these established sites. Whilst this early indication is encouraging, those responsible for safeguarding should remain vigilant to the possibility."

3.10. The above is stating that to date, there has not been any complications on airfields due to glare originating from solar farms across the UK.

[7] Civil Avaition Authority (2020). CAP738 – Safeguarding of Aerodromes 3rd Edition. Available at: https://publicapps.caa.co.uk/docs/33/CAP738%20Issue%203.pdf

US Federal Aviation Administration Policy

3.11. The US Federal Aviation Administration (FAA) in their Solar Guide (Federal Aviation Authority, 2018)[8] incorporates a chapter on the impact and assessment of glint from solar panels. It concludes that (although subject to revision):

"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."

3.12. The interim policy (Federal Register, 2013)[9] demands that an ocular impact assessment must be assessed at 1-minute intervals from when the sun rises above the horizon until the sun sets below the horizon. Specifically, the developer must use the 'Solar Glare Hazard Analysis Tool' (SGHAT) tool specifically and reference its results as this was developed by the FAA and Sandia National Laboratories as a standard and approved methodology for assessing potential impacts on aviation interests, although it notes other assessment methods may be considered. The SGHAT tool has since been licensed to a private organisation who were also involved in its development and it is the software model used in this assessment.

3.13. Crucially, the policy provides a quantitative threshold which is lacking in the English guidance. This outlines that a solar development will not automatically receive an objection on glint grounds if low intensity glint is visible to pilots on final approach. In other words, low intensity glint with a low potential to form a temporary after-image (Green Glare) would be considered acceptable under US guidance. Due to the lack of legislation and guidance within England, this US document has been utilised as guidance for this report.

3.14. The FAA guidance states that for a solar PV development to obtain FAA approval or to receive no objection, the following two criteria must be met:

- No potential for glint or glare in the existing or planned Air Traffic Control Tower (ATCT); and

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[8] FAA (2018), Technical Guidance for Evaluating Selected Solar Technologies on Airports. Available at https://www.faa.gov/sites/faa.gov/files/airports/environmental/FAA-Airport-Solar-Guide-2018.pdf

[9] FAA (2013), Interim Policy, *FAA Review of Solar Energy System Projects on Federally Obligated Airports*. Available at https://www.federalregister.gov/documents/2013/10/23/2013-24729/interim-policy-faa-review-of-solar-energy-system-projects-on-federally-obligated-airports

- No potential for glare or "low potential for after-image" (Green Glare) along the final approach path for any existing or future runway landing thresholds (including planned or interim phases), as shown by the approved layout plan (ALP). The final approach path is defined as 2 miles from 50 feet above the landing threshold using a standard 3-degree glide path.

3.15. The geometric analysis included later in this report, which defines the extent and time at which glint may occur, is required by the FAA as the methodology to be used when assessing glint and glare impacts on aviation receptors. This report follows the methodology required by the FAA as it offers the most robust assessment method currently available.

FAA Policy: Review of Solar Energy Systems Projects on Federally - Obligated Airports[10]

3.16. The FAA updated their Interim Policy from 2013 as part of their commitment to "*update policies and procedures as part of an iterative process as new information and technologies become available.*" The main development regarding Glint and Glare since the Interim Policy is the following:

> *"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. However, FAA has continued to receive reports of potential glint and glare from on-airport solar energy systems on personnel working in ATCT cabs."*

3.17. This is outlining that solar panels are similar to nuisances that are already caused by other existing infrastructure, such as; car parks, glass buildings and water bodies. Furthermore, the ATCT has been outlined as the key receptor to be assessed when determining Glint and Glare impacts from a solar farm.

[10] FAA (2021). FAA Policy: Review of Solar Energy Systems Projects on Federally – Obligated Airports. Available at: https://www.federalregister.gov/documents/2021/05/11/2021-09862/federal-aviation-administration-policy-review-of-solar-energy-system-projects-on-federally-obligated

Review of Local Plan

Hillingdon Local Plan

3.18. The Hillingdon Local Plan[11] was adopted by the Council of the London Borough of Hillingdonon 8 November 2012.

3.19. There are no policies contained within the Plan which are of relevance to this glint and glare report.

3.20. The Council is currently gathering evidence and preparing technical documents to undertake a review of the Local Plan.

[11] Hillingdon Local Plan, available at: https://www.hillingdon.gov.uk/local-plan

4. METHODOLOGY

4.1. A desk-based assessment was undertaken to identify when and where glint and glare may be visible at aviation receptors within the vicinity of the Proposed Development, throughout the day and the year.

SUN POSITION AND REFLECTION MODEL

Sun Data Model

4.2. The calculations in the solar position calculator are based on equations from Astronomical Algorithms[12]. The sunrise and sunset results are theoretically accurate to within a minute for locations between +/- 72° latitude, and within 10 minutes outside of those latitudes. However, due to variations in atmospheric composition, temperature, pressure, and conditions, observed values may vary from calculations.

Solar Reflection Model

4.3. The position of the sun is calculated at one-minute intervals of a typical year, in this instance the year assessed is 2024.

4.4. To determine if a reflection will reach a receptor, the following variables are required:

- Sun position;
- Observer location; and
- Tilt, orientation, and extent of the modules in the solar array.

4.5. The model assumes that the azimuth and horizontal angle of the sun is the same across the whole solar farm. This is considered acceptable due to the distance of the sun from the Proposed Development and the miniscule differences in location of the sun over the Proposed Development.

4.6. Once the position of the sun is known for each time interval, a vector reflection equation determines the reflected sun vector, based on the normal vector of the solar array panels. This assumes that the angle of reflection is equal to the angle of incidence reflected across a normal plane. In this instance, the plane being the vector which the solar panels are facing.

4.7. On knowing the vector of the solar reflection, the azimuth is calculated and the horizontal reflection from multiple points within the solar farm. These are then compared with the

[12] Jean Meeus, *Astronomical Algorithms* (Second Edition), 1999

azimuth and horizontal angle of the receptor from the solar farm to determine if it is within range to receive solar reflections.

4.8. The solar reflection in the model is considered to be specular as a worst-case scenario. In practice the light from the sun will not be fully reflected as solar panels are designed to absorb light rather than reflect it. The text above and **Appendix C** outlines the reflective properties of solar glass and compares it to other reflective surfaces. Although the exact figures in this report could be argued, it is included as a visual guide and it agrees with most other reports, in that solar glass has less reflective properties than other types of glass, bodies of water and snow, and that the amount of reflective energy drops as the angle of incidence decreases.

4.9. The panel reflectivity has been modelled to assume an anti-reflective coating (ARC) which is the industry standard for photo-voltaic panels and further reduces the reflective properties of the PV panels.

Determination of Ocular Impact

4.10. The software used for this assessment is based on the Sandia Laboratories Solar Glare Hazard Analysis Tool (SGHAT). This tool is specifically mentioned in the FAA guidance as the software which should be used in this type of assessment.

4.11. Determination of the ocular impact requires knowledge of the direct normal irradiance, PV module reflectance, size and orientation of the array, optical properties of the PV module, and ocular parameters. These values are used to determine the retinal irradiance and subtended source angle used in the ocular hazard plot.

4.12. The ocular impact[13] of viewed glare 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).

4.13. Green glare can be ignored when looking at residential and some aviation receptors. Green glare does not cause temporary flash blindness and happens at an instant with very slight disturbance. As per FAA guidelines mitigation is only required for green glare when affecting an Air Traffic Control Tower, but not for when affecting pilots. Therefore, it can be assumed that green glare is acceptable for residential receptors.

4.14. The subtended source angle represents the size of the glare viewed by an observer, while the retinal irradiance determines the amount of energy impacting the retina of the observer. Larger source angles can result in glare of high intensity, even if the retinal irradiance is low.

4.15. The modelling software outputs a hazard plot for each receptor predicted to be impacted by glare from the photovoltaic (PV) array. An orange dot is plotted for each minute of glare

[13] Ho, C.K., C.M. Ghanbari, and R.B. Diver, 2011, Methodology to Assess Potential Glint and Glare Hazards From Concentrating Solar Power Plants: Analytical Models and Experimental Validation, Journal of Solar Energy Engineering-Transactions of the Asme, 133(3).

indicating the irradiance (power density) of the reflected solar light. A yellow dot is plotted to show the irradiance of the Sun when it is viewed directly. The hazard plot shows that the irradiance of the Sun is approximately three orders of magnitude greater than the reflected irradiance, i.e., the power density of solar reflections from photovoltaic panels are approximately 0.1% that of viewing the Sun. Due to the disparity in irradiance, whenever the Sun is observed in the same frame as solar reflections from a PV array, the Sun will be main source of glare impacts upon the observer. In such a case, the impact is deemed to be **Low** as a worst-case scenario.

Relevant Parameters of the Proposed Development

4.16. The photovoltaic (PV) panels are oriented in the roof directions and will remain in a fixed position throughout the day and during the year (i.e. they will not rotate to track the movement of the sun).

4.17. The heights of the buildings have been used as the maximum height of the solar panels for the assessment.

IDENTIFICATION OF RECEPTORS

Aviation

4.18. Glint is only considered to be an issue with regards to aviation safety when the solar development lies within proximity to a runway, particularly when the aircraft is descending to land. En-route activities are not considered an issue as the flight will most likely be at a higher altitude than the solar reflection.

4.19. Should a solar development be proposed within the safeguarded zone of an aerodrome, a full geometric study may be required (depending on the orientation from the Proposed Development) which would determine if there is potential for glint and glare at key locations, most likely on the descent to land.

4.20. Buffer zones to identify aviation assets vary depending on the safeguarding criteria of that asset. All aerodromes within 30km will be identified, however generally the detailed assessments are only required within: 20km for large international aerodromes, 10km for military aerodromes and 5km for small aerodromes.

Magnitude of Impact

Moving Receptors (Aviation)

Approach Paths

4.21. Each final approach path which has the potential to receive glint is assessed using the SGHAT model. The model assumes an approach bearing on the runway centreline, a 3-degree glide path with the origin 50ft (15.24m) above the runway threshold.

4.22. The computer model considers the pilots field of view. The azimuthal field of view (AFOV) or horizontal field of view (HFOV) as it is sometimes referred, refers to the extents of the pilot's horizontal field of view measured in degrees left and right from directly in front of the cockpit. The vertical field of view (VFOV) refers to the extents of the pilot's vertical field of view measured in degrees from directly in front of the cockpit. The HFOV is modelled at 50 degrees left and right from the front of the cockpit whilst the VFOV is modelled at 30 degrees.

4.23. The FAA guidance states that there should be no potential for glare or '*low potential for after-image*' at any existing or future planned runway landing thresholds for the Proposed Development to be acceptable.

Air Traffic Control Tower (ATCT)

4.24. An air traffic controller uses the visual control room to monitor and direct aircraft on the ground, approaching and departing the aerodrome. It is essential that air traffic controllers have a clear unobstructed view of the aviation activity. The key areas on an aerodrome are the views towards the runway thresholds, taxiways, and aircraft bays.

4.25. The FAA guidance states that no solar reflection towards the ATCT should be produced by a proposed solar development, however this should be assessed on a site by site case and will depend on the operations at a particular aerodrome.

4.26. In order to determine the impact on the ATCT, the location and height of the tower will need to be fed into the SGHAT model and where there is a potential for 'low potential for After-Image' or more, then mitigation measures will be required.

Assessment Limitations

4.27. Below is a list of assumptions and limitations of the model and methods used within this report:

- The model does not consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc;

- The model 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;
- Due to variations in atmospheric composition, temperature, pressure and conditions, observed values may vary slightly from calculated positions;
- The model does not account for the effects of diffraction; however, buffers are applied as a factor of safety; and
- The model assumes clear skies at all times and does not account for meteorological effects such as cloud cover, fog, or any other weather event which may screen the sun.

4.28. Due to these assumptions and limitations the model overestimates the number of minutes of glint and glare which are possible at each receptor and presents the worst-case scenario. Where glint and glare are predicted a visibility assessment is carried out to determine a more accurate, real-world prediction of the impacts.

5. BASELINE CONDITIONS

Aviation Receptors

5.1. Aerodromes within 30km of the proposed solar development can be found in **Table 5 - 1.**

Table 5 - 1: Airfields within 30km of the Proposed Development

Airfield	Distance (km)	Use
Denham Airport	1.26	Licensed airport
RAF Northolt	6.10	Military
New Model Farm	8.82	Small grass strip
Wogburn Airfield	12.50	Small concrete strip
London Heathrow Airport	12.75	Licensed airport
Elstree Airport	13.06	Licensed airport
Plaistows Airfield	16.67	Small grass strip
Woodview House Farm	17.30	Small grass strip
London Colney Airfield	19.28	Small grass strip
White Waltham Airport	21.56	Licensed airport
Booker Airfield	21.70	Small grass strip
Bell Bar Airfield	25.45	Small grass strip
Coleman Green Airfield	26.41	Small grass strip
Luxters Farm	27.16	Small grass strip
Fairoaks Airport	27.34	Licensed airport
Halton Airfield	27.49	Small grass strip
Harpsden Park Airfield	29.12	Small grass strip

5.2. The Proposed Development is located within the safeguarding buffer zone of four aviation assets. Denham Airport, Elstree Airport, RAF Northolt and London Heathrow Airport will require detailed assessments.

5.3. As the Proposed Development does not fall within the safeguarding buffer zones of the other 13 aviation receptors, there is no need for a detailed assessment. This is in accordance with what was outlined in the methodology chapter above.

Denham Airport

5.4. Denham Airport (ICAO code EGLD) is a VFR only aerodrome. It is located approximately 1.5NM (2.8km) east of Gerrards Cross.

5.5. The elevation of the aerodrome is 249ft (75.9m). It has one asphalt runway and one grass strip runway, details of which are given in **Table 5 - 2.**

Table 5 - 2: Runways at Denham Airport

Runway Designation	True Bearing (°)	Length (m)	Width (m)
06	059.21	775	18
24	239.22	775	18
12	118.11	546	18
30	298.11	546	18

5.6. The threshold location and height of the runways at Denham Airport are given in **Table 5 - 3**.

Table 5 - 3: Runway Threshold Locations and Heights

Runway Designation	Threshold Latitude	Threshold Longitude	Height AOD (m)
06	51° 35′ 12.45″ N	000° 31′ 02.41″ W	75.9
24	51° 35′ 23.29″ N	000° 30′ 33.26″ W	73.5
12	51° 35′ 23.00″ N	000° 30′ 59.20″ W	75.6
30	51° 35′ 14.62″ N	000° 30′ 34.06″ W	74.4

5.7. The ARP is located south at the midpoint of Runway 06/24. The actual location of the ARP and ATCT is given in **Table 5 - 4**. The height of the ATCT is estimated to be 5m based off Google Earth street view images.

Table 5 - 4: Denham Airport Reference Point

	Latitude	Longitude	Eastings	Northings
ARP	51° 35′ 18.35′′ N	000° 30′ 46.68′′ W	503113	188777
ATCT	51° 35′ 11.53′′ N	000° 30′ 44.86′′ W	503157	188567

Elstree Airport

5.8. Elstree Airport (ICAO code EGTR) is a VFR only aerodrome. It is located approximately 2.6NM (4.8km) east of Watford.

5.9. The elevation of the aerodrome is 332ft (101.2m). It has one asphalt runway and one grass strip runway, details of which are given in **Table 5 - 5.**

Table 5 - 5: Runways at Elstree Airport

Runway Designation	True Bearing (°)	Length (m)	Width (m)
08	079.66	651	20
26	259.67	651	20

5.10. The threshold location and height of the runways at Denham Airport are given in **Table 5 - 6**.

Table 5 - 6: Runway Threshold Locations and Heights

Runway Designation	Threshold Latitude	Threshold Longitude	Height AOD (m)
08	51° 39′ 19.12″ N	000° 19′ 49.71″ W	100.5
26	51° 39′ 22.76″ N	000° 19′ 16.32″ W	91.9

5.11. The ARP is located south at the midpoint of Runway 08/26. The actual location of the ARP and ATCT is given in **Table 5 - 7**. The height of the ATCT is estimated to be 5m based off Google Earth photos.

Table 5 - 7: Elstree Airport Reference Point

	Latitude	Longitude	Eastings	Northings
ARP	51° 39′ 21.14′′ N	000° 19′ 31.80′′ W	515930	196558
ATCT	51° 39′ 16.64′′ N	000° 19′ 24.79′′ W	516068	196421

RAF Northolt

5.12. RAF Northolt (ICAO code EGWU) is a military aerodrome. It is located approximately 2NM (3.6km) east by northeast of Uxbridge.

5.13. The elevation of the aerodrome is 126ft (38.4m). It has one asphalt runway, details of which are given in **Table 5 - 8.**

Table 5 - 8: Runways at RAF Northolt

Runway Designation	True Bearing (°)	Length (m)	Width (m)
07	069.83	1683	40
25	249.85	1683	40

5.14. The threshold location and height of the runways at RAF Northolt are given in **Table 5 - 9**.

Table 5 - 9: Runway Threshold Locations and Heights

Runway Designation	Threshold Latitude	Threshold Longitude	Height AOD (m)
07	51° 33′ 01.43″ N	000° 25′ 47.00″ W	34.74
25	51° 33′ 19.07″ N	000° 24′ 29.60″ W	37.88

5.15. The ARP is located south at the midpoint of Runway 07/25. The actual location of the ARP and ATCT is given in **Table 5 - 10**. The height of the ATCT is estimated to be 12m based off a Google Image search.

Table 5 - 10: RAF Northolt Reference Point

	Latitude	Longitude	Eastings	Northings
ARP	51° 33′ 10.58′′ N	000° 25′ 06.57′′ W	509744	184973
ATCT	51° 33′ 15.23′′ N	000° 25′ 31.32′′ W	509262	185101

London Heathrow Airport

5.16. London Heathrow Airport (ICAO code EGLL) is designated as an IFR/VFR/SVFR Aerodrome. It is located approximately 12NM (22.2km) west of London.

5.17. The elevation of the aerodrome at the Aerodrome Reference Point (ARP) is 83ft (25.3m). It has two grooved asphalt runways, details of which are given in **Table 5 - 11**.

Table 5 - 11: Runways at London Heathrow Airport

Runway Designation	True Bearing (°)	Length (m)	Width (m)
09L	089.67	3901	50

Runway Designation	True Bearing (°)	Length (m)	Width (m)
27R	269.71	3901	50
09R	089.68	3658	50
27L	269.72	3658	50

5.18. The threshold location and height of the runway at London Heathrow Airport are given in **Table 5 - 12**.

Table 5 - 12: Runway Threshold Locations and Heights

Runway Designation	Threshold Latitude	Threshold Longitude	Height AOD (m)
09L	51° 28′ 39.05″ N	000° 29′ 05.78″ W	23.9
27R	51° 28′ 39.55″ N	000° 25′ 59.72″ W	23.8
09R	51° 27′ 53.16″ N	000° 28′ 56.20″ W	22.9
27L	51° 27′ 53.86″ N	000° 26′ 02.81″ W	23.5

5.19. The ARP is located south of the midpoint of Runway 09L/27R. The actual location of the ARP and air traffic control tower (ATCT) is given in **Table 5 - 13**. The height of the ATCT at London Heathrow Airport is 87m.

Table 5 - 13: London Heathrow Airport Refence Point

	Latitude	Longitude	Eastings	Northings
ARP	51° 28′ 39.04′′ N	000° 27′ 39.85′′ W	506965	176526
ATCT	51° 28′ 18.55′′ N	000° 27′ 55.59′′ W	506682	175877

6. IMPACT ASSESSMENT

6.1. Following the methodology outlined earlier in this report, geometrical analysis comparing the azimuth and horizontal angle of the receptors from the Proposed Development and the solar reflection was conducted. Although this assessment did not consider obstructions such as intervening vegetation and buildings, discussion on the potentially impacted receptors is provided where necessary.

AVIATION RECEPTORS

6.2. **Table 6 - 1** shows a summary of the modelling results for each of the runway approach paths as well at the ATCT whilst the detailed results and ocular impact charts can be viewed in **Appendix B**.

Table 6 - 1: Summary of Component Glare Results

Component	Green Glare (mins)	Yellow Glare (mins)	Red Glare (mins)
Denham Airport			
Runway 06	1921	0	0
Runway 24	0	0	0
Runway 12	1930	0	0
Runway 30	0	0	0
ATCT	105	0	0
Elstree Airport			
Runway 08	0	0	0
Runway 26	0	0	0
ATCT	0	0	0
RAF Northolt			
Runway 07	0	0	0
Runway 25	1396	0	0
ATCT	0	0	0

Component	Green Glare (mins)	Yellow Glare (mins)	Red Glare (mins)
London Heathrow Airport			
Runway 09L	0	0	0
Runway 27R	0	0	0
Runway 09R	0	0	0
Runway 27L	0	0	0
ATCT	0	0	0

6.3. As can be seen in **Table 6 - 1**, no glare is predicted to impact upon the runway approach paths and ATCT at Elstree Airport, the runway approach paths and ATCT London Heathrow Airport, the Runway 07 approach path and ATCT at RAF Northolt or the Runway 24 and 30 approach paths at Denham Airport. Only green glare is predicted to impact the Runway 06 and 12 approach paths and ATCT at Denham Airport and the Runway 25 approach path at RAF Northolt. Green glare is described as 'Low Potential for After Image' which is an **acceptable impact** when pilots are approaching runways/helipads and a **not acceptable impact** upon ATCTs, according to the FAA guidance. Therefore, the impact upon the Runway 06 and 12 approach paths at Denham Airport and the Runway 25 approach path at RAF Northolt is **Not Significant.**

6.4. As can be seen in **Appendix C**, the first image is an aerial image show the location of Denham Airport ATCT and the Proposed Development, and the location from which the second image was taken (red dot). This image shows dense vegetation between the ATCT and the Proposed Development. The second image is a street view image with a view towards the Proposed Development. This image confirms that the vegetation is sufficient to screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact upon Denham ATCT is **None**.

7. MITIGATION

7.1. Mitigation is not required due to the impacts being **Low** and **Not Significant.**

8. SUMMARY

8.1. A 30km study area is chosen for aviation receptors. 17 aviation assets are located within 30km of the Proposed Development. Four of which, Denham Airport, Elstree Airport, RAF Northolt and London Heathrow Airport required a detailed assessment due to the Proposed Development falling within its respective safeguarding buffer zone outlined in **paragraph 4.20**.

8.2. Geometric analysis was conducted for 12 runway approach paths and four Air Traffic Control Towers (ATCT) at Denham Airport, Elstree Airport, RAF Northolt and London Heathrow Airport.

8.3. The assessment concludes that:

- Denham: No glare is predicted to impact the Runway 24 and 30 approach paths. Only green glare is predicted to impact upon the Runway 06 and 12 approach paths and the ATCT, which is an **acceptable impact** when pilots are approaching runways/helipads and a **not acceptable impact** upon an ATCT according to FAA guidance. Upon reviewing the actual visibility of the ATCT, impacts upon the ATCT reduce to **None**. Therefore, the impact upon Denham Airport is **Not Significant**.
- Elstree: No glare is predicted to impact the runway approach paths or the ATCT. Therefore, the impact upon Elstree Airport is **None**.
- RAF Northolt: No glare is predicted to impact the Runway 07 approach path or the ATCT. Only green glare is predicted to impact upon the Runway 25 approach path, which is an **acceptable impact** when pilots are approaching runways/helipads according to FAA guidance. Therefore, the impact upon RAF Northolt is **Not Significant**.
- London Heathrow: No glare is predicted to impact the runway approach paths or the ATCT. Therefore, the impact upon London Heathrow Airport is **None**.
- Overall impacts on aviation receptors are **acceptable and Not Significant**.

8.4. Mitigation measures are not required due to the impacts being **acceptable and Not Significant**.

9. APPENDICES

APPENDIX A: FIGURES

- Figure 1: Site Layout
- Figure 2: Denham Airport Aerodrome Chart
- Figure 3: Elstree Airport Aerodrome Chart
- Figure 4: RAF Northolt Aerodrome Chart
- Figure 5: London Heathrow Airport Aerodrome Chart

APPENDIX B: AVIATION RECEPTOR GLARE RESULTS

APPENDIX C: VISIBILITY ASSESSMENT EVIDENCE

APPENDIX D: SOLAR MODULE GLARE AND REFLECTANCE TECHNICAL MEMO

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