



Glint and Glare Assessment

Blythe Solar Farm

23/10/2023



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1. EXECUTIVE SUMMARY

- 1.1. This assessment considers the potential impacts on ground-based receptors such as roads, rail and residential dwellings as well as aviation assets. A 1km study area around the Application Site is considered adequate for the assessment of ground-based receptors, whilst a 30km study area is chosen for aviation receptors. Within 1km of the Application Site, there are 34 residential receptors, including two residential areas, 34 road receptors and 17 rail receptors which were considered. As per the methodology section, where there are a number of residential receptors within close proximity, a representative dwelling or dwellings is/are chosen for full assessment as the impacts will not vary to any significant degree. Where small groups of receptors have been evident, the receptors on either end of the group have been assessed in detail. 18 residential receptors, including one residential area, 17 road receptors and four rail receptors were dismissed as they are located within the no reflection zones. 10 aerodromes are located within the 30km study area; None of which required a detailed assessment due to the Proposed Development falling outside their respective safeguarding buffer zones, which are outlined in **paragraph 4.25**.
- 1.2. Geometric analysis was conducted at 16 individual residential receptors, including one residential area, 17 road receptors and 13 rail receptors.
- 1.3. The assessment concludes that:
- Solar reflections are possible at nine of the 16 residential receptors assessed within the 1km study area. The initial bald-earth scenario identified potential impacts as **High** at four receptors, **Medium** at one receptor, **Low** at four receptors and **None** at the remaining seven receptors, including one residential area. Upon reviewing the actual visibility of the receptors, glint and glare impacts remain **High** at two receptors and reduce to **Low** at two receptors and **None** at all remaining receptors. Once mitigation measures were considered impacts reduce to **Low** at two receptors and to **None** at all remaining receptors.
 - Solar reflections are possible at 12 of the 17 road receptors assessed within the 1km study area. The initial bald-earth scenario identified potential impacts as **High** at 12 receptors, and **None** at the remaining five receptors. Upon reviewing the actual visibility of the receptors, glint and glare impacts remain **High** at one receptor and reduce to **None** at all remaining receptors. Once mitigation measures were considered impacts reduce to **None** at all receptors.
 - Solar reflections are possible at 11 of the 13 rail receptors assessed within the 1km study area. The initial bald-earth scenario identified potential impacts as **High** at eight

receptors, **Low** at three receptors and **None** at the remaining two receptors. Upon reviewing the actual visibility of the receptors, glint and glare impacts reduce to **None** at all receptors.

- **No impact** on aviation assets is predicted.
- 1.4. Mitigation is required to screen the **High** impact views from Residential Receptors 4 and 15 and Road Receptor 3. Mitigation is also included to screen the **Low** impact views from Residential Receptors 2 and 5. This includes native hedgerows to be planted/infilled and maintained to a height of at least 3.5m along the southern half of the eastern boundary, the western half of the southern boundary and the eastern half of the northern boundary in the West Array and along a southern section of the eastern boundary in the East Array.
- 1.5. The effects of glint and glare and their impact on local receptors has been analysed in detail and is predicted to be only **Low** and **None** impacts, and therefore **No Significant Effects**.

2. INTRODUCTION

BACKGROUND

- 2.1. Neo Environmental Ltd has been appointed by Innova Renewables Developments Ltd (the “Applicant”) to undertake a Glint and Glare Assessment for the proposed **installation of a solar array, substation and associated works forming an extension to Blythe Solar Farm (ref: SMD/2022/0160)** (the “Proposed Development”) on lands c. 1.6km southwest of Upper Tean, Staffordshire Moorlands (the “Application Site”).

PROPOSED DEVELOPMENT DESCRIPTION

- 2.2. The Proposed Development will consist of the construction of ground-based PV panels mounted on metal frames, transformer, storage containers, fencing, CCTV cameras, access gates, access tracks and all ancillary grid infrastructure and associated works.

SITE DESCRIPTION

- 2.3. The Application Site is located c. 1.6km to the southwest of the town of Upper Tean. Centred at approximate Grid Reference N338257 E399536, the Application Site covers a total area of c. 49 hectares. Comprising of 14 fields, the Proposed Development will be accessed via existing roads from Draycott Road via an unnamed local road to the west of the Proposed Development.

SCOPE OF REPORT

- 2.4. Although there may be small amounts of glint and glare from the metal structures associated with the solar farm, 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 glint and glare report will assess potential impacts from both the Proposed Development and the approved Blythe Solar Farm (**planning ref: SMD/2022/0160**) adjacent to the Application Site.
- 2.8. This report will concentrate on the effects of glint and glare and its impact on local receptors and will be supported with the following Figures and Appendices.
- Appendix A: Figures
 - Figure 1: Residential Based Receptors
 - Figure 2: Road Based Receptors
 - Figure 3: Rail Based Receptors
 - Figure 4: Site Layout
 - Figure 5: Panel Area Labels
 - Figure 6: G&G Mitigation Planting
 - Appendix B: Residential Receptor Glare Results (20 degrees)
 - Appendix C: Residential Receptor Glare Results (25 degrees)
 - Appendix D: Road Receptor Glare Results (20 degrees)
 - Appendix E: Road Receptor Glare Results (25 degrees)
 - Appendix F: Rail Receptor Glare Results (20 degrees)
 - Appendix G: Rail Receptor Glare Results (25 degrees)
 - Appendix H: Visibility Evidence Assessment
 - Appendix I: Solar Module Glare and Reflectance Technical Memo¹

1 Sunpower Corporation (September 2009), T09014 Solar Module Glare and Reflectance Technical Memo

STATEMENT OF AUTHORITY

- 2.9. 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

- 2.10. 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”*² have defined the terms ‘Glint’ and ‘Glare’ as meaning;
- Glint – *“A momentary flash of bright light”*
 - Glare – *“A continuous source of bright light”*
- 2.11. 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

- 2.12. 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

² 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>

characteristics to water, which is much lower than the likes of glass, steel, snow and white concrete by comparison (See Appendix I). 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...”*³.

Time Zones / Datum's

- 2.13. Locations in this report are given in Eastings and Northings using the 'British National Grid' grid reference system unless otherwise stated.
- 2.14. 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 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>

3. LEGISLATION AND GUIDANCE

NATIONAL PLANNING POLICY GUIDANCE (NPPG) ON RENEWABLE AND LOW CARBON ENERGY (UK) ⁴

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’⁵

“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

⁴ 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

⁵ 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'⁶, 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 ANO⁷, 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

⁶ 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>

⁷ 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 EDITION⁸

- 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.

⁸ Civil Aviation 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)⁹ 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)¹⁰ 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

⁹ 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>

¹⁰ 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 AIRPORTS¹¹

- 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.

¹¹ 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

Staffordshire Moorlands Local Plan 2014 - 2033

3.18. The Local Plan¹² was adopted on 9th September 2020.

3.19. The Plan states in **Policy SD 2: Renewable/Low-Carbon Energy** that:

‘The Council will strive to meet part of the District's future energy demand through renewable or low-carbon energy sources (which could be through a variety of technologies, for example solar energy, biomass etc), in line with current evidence which identifies the feasibility of these forms of energy across the District. The Council will assess wind turbine schemes in line with the Government's specific policy on wind turbines. For all other forms of renewable energy the Council will support small- and large- scale stand alone renewable or low-carbon energy schemes subject to the following considerations:

- the degree to which the developer has demonstrated any environmental/economic/social benefits of a scheme, as well as how any environmental or social impacts have been minimised (e.g. visual, noise or smell);*
- the impact on the amenity of residents and other interests of acknowledged importance, including the historic environment’*

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

¹² Staffordshire Moorlands Adopted Local Plan 2014 - 2033, available at: <https://www.staffsmoorlands.gov.uk/localplan>

4. METHODOLOGY

- 4.1. A desk-based assessment was undertaken to identify when and where glint and glare may be visible at 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 Algorithms¹³. 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 being assessed was 2023.
- 4.4. In order to determine if a solar 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.

¹³ Jean Meeus, Astronomical Algorithms (Second Edition), 1999

- 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 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 I** 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 impact¹⁴ 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.

¹⁴ 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).

- 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 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 panels are oriented in a southwards direction to maximise solar gain 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). The panels will face southwards and will be inclined at an angle of between 20 and 25 degrees.
- 4.17. The height of the panels above ground level is a maximum of 3.1m and points at the top of the panels are used to determine the potential for glint and glare generation.

IDENTIFICATION OF RECEPTORS

Ground Based Receptors

- 4.18. Glint is most likely to impact upon a ground-based receptor close to dusk and dawn, when the sun is at its lowest in the sky. Therefore, any effect would likely occur early in the day or late in the day, reflected to the west at dawn and east at dusk.
- 4.19. A 1km study area from the panels was deemed appropriate for the assessment of ground-based receptors as this seemed to contain a good spread of residential and road receptors in most directions from the Proposed Development. The further distance a receptor is from a solar farm, the less chance it has of being affected by glint and glare due to scattering of the reflected beam and atmospheric attenuation, in addition to obstructions from ground sources, such as any intervening vegetation or buildings.
- 4.20. An observer height of 2m was utilised for residential receptors, as this is a typical height for a ground-floor window. With regards to road users, a receptor height of 1.5m was employed as this is typical of eye level. Rail driver's eye level was assumed to be 2.75m above the rail for signal signing purposes and therefore this is the height used for assessment purposes.
- 4.21. An assessment was undertaken to determine zones where solar reflections will never be directed near ground level.

- 4.22. Where there are several residential receptors within close proximity, a representative dwelling or dwellings is/are chosen for full assessment as the impacts will not vary to any significant degree. Where small groups of receptors have been evident, the receptors on either end of the group have been analysed in detail with the worst-case impacts attributed to that receptor.

Aviation

- 4.23. Glint is only considered to be an issue with regards to aviation safety when the solar farm lies within close 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.
- 4.24. Should a solar farm be proposed within the safeguarded zone of an aerodrome then a full geometric study may be required which would determine if there is potential for glint and glare at key locations, most likely on the descent to land.
- 4.25. 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

Static Receptors

- 4.26. Although there is no specific guidance set out to identify the magnitude of impact from solar reflections, the following criteria has been set out for the purposes of this report:
- **High** - Solar reflections impacts of over 30 hours per year or over 30 minutes per day
 - **Medium** - Solar reflections impacts between 20 and 30 hours per year or between 20 minutes and 30 minutes per day
 - **Low** - Solar reflections impacts up to 20 hours per year or up to 20 minutes per day
 - **None** - Effects not geometrically possible or no visibility of reflective surfaces likely due to high levels of intervening screening

Moving Receptors (Road and Rail)

- 4.27. Again, no specific guidance is available to identify the magnitude of impact from solar reflections on moving receptors except in aviation, however it is thought that a similar

approach should be applied to moving receptors as aviation, based on the ocular impact and the potential for after-image.

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

- No potential for glare or “*low potential for after-image*” 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).

4.29. The following criteria has been set out for the purposes of this report:

- **High** - Solar reflections impacts consisting of any amount of yellow glare.
- **Low** - Solar reflections impacts consisting of any amount of only green glare.
- **None** - Effects not geometrically possible or no visibility of reflective surfaces likely due to high levels of intervening screening.

4.30. The FAA produced an evaluation of glare as a hazard and concluded in their report¹⁵ that:

“The more forward the glare is and the longer the glare duration, the greater the impairment to the pilots’ ability to see their instruments and to fly the aircraft. These results taken together suggest that any sources of glare at an airport may be potentially mitigated if the angle of the glare is greater than 25 deg from the direction that the pilot is looking in. We therefore recommend that the design of any solar installation at an airport consider the approach of pilots and ensure that any solar installation that is developed is placed such that they will not have to face glare that is straight ahead of them or within 25 deg of straight ahead during final approach.”

4.31. It is reasonable to assume that although this report was assessing pilots vision impairment that it can be also used to drivers of other vehicles. Therefore, the driver’s field of view will also be analysed where required and if the glare is out with 25 degrees either side of their line of sight then any impacts will reduce to **None**.

Moving Receptors (Aviation)

Approach Paths

4.32. 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.

¹⁵ Federal Aviation Authority, Evaluation of Glare as a Hazard for General Aviation Pilots on Final Approach (2015), Available at <https://libraryonline.erau.edu/online-full-text/faa-aviation-medicine-reports/AM15-12.pdf>

- 4.33. 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.
- 4.34. 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)

- 4.35. 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.
- 4.36. 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.
- 4.37. 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

- 4.38. 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.
- 4.39. 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

GROUND BASED RECEPTORS REFLECTION ZONES

- 5.1. Based on the relatively flat topography in the area, solar reflections between five degrees below the horizontal plane to five degrees above it are described as near horizontal. Reflections from the proposed solar farm within this arc have the potential to be seen by receptors at or near ground level.
- 5.2. Further analysis showed that this will only occur between the azimuth of 238.15 degrees and 129.14 degrees in the and therefore any ground-based receptor outside this arc will not have any impact from solar reflections.
- 5.3. **Figure 1 and 2 of Appendix A** show the respective study areas whilst also subtracting from this the areas where solar reflections will not impact on ground-based receptors due to the reasons set out in **paragraphs 5.1 to 5.2**.

Residential Receptors

- 5.4. Residential receptors located within 1km of the Application Site have been identified (**Table 5 - 1**). The number in brackets indicates which residential area the receptor belongs. Glint was assumed to be possible if the receptor is located within the ground-based receptor zones outlined previously.
- 5.5. There are 18 residential receptors (Receptors 17 - 34) which are within the no-reflection zones and are clearly identifiable in **Figure 1: Appendix A**. The process of how these are calculated is explained in **paragraphs 5.1 to 5.2** of this report.

Table 5 - 1: Residential Based Receptors

Receptor	Easting	Northing	Glint and Glare Possible
1	397896	339203	Yes
2	398836	338986	Yes
3	398770	338977	Yes
4	398730	338883	Yes
5	398653	338633	Yes
6	398556	338021	Yes
7 (1)	399995	339420	Yes

Receptor	Easting	Northing	Glint and Glare Possible
8 (1)	400068	339442	Yes
9 (1)	400056	339377	Yes
10	399901	338594	Yes
11	400422	338947	Yes
12	400562	338821	Yes
13	400624	338857	Yes
14	401019	338143	Yes
15	399914	337815	Yes
16	400707	337856	Yes
17	398591	340011	No
18	398622	339999	No
19	398661	339987	No
20	398900	339814	No
21 (2)	399269	339812	No
22 (2)	399248	339701	No
23 (2)	399298	339735	No
24 (2)	399333	339749	No
25 (2)	399363	339786	No
26 (2)	399436	339782	No
27 (2)	399456	339930	No
28 (2)	399473	339859	No
29 (2)	399562	339864	No
30 (2)	399497	339773	No
31 (2)	399504	339711	No
32	398472	339414	No
33	399760	336691	No

Receptor	Easting	Northing	Glint and Glare Possible
34	399798	336655	No

Road / Rail Receptors

- 5.6. There are two roads within the 1km study area that require a detailed Glint and Glare Assessment; the A50 and Cresswell Old Road. There are some minor roads which serve dwellings; however, these have been dismissed as vehicle users of these roads will likely be travelling at low speeds and therefore, there is a negligible risk of safety impacts resulting from glint and glare of the Proposed Development.
- 5.7. The ground receptor no-reflection zones are clearly identifiable on **Figure 2: Appendix A** and the process of how these are calculated is explained in **paragraphs 5.1 to 5.2** of this report.
- 5.8. **Table 5 - 2** shows a list of receptors points within the study area which are 200m apart.

Table 5 - 2: Road Based Receptors

Receptor	Easting	Northing	Glint and Glare Possible
1	399128	339068	Yes
2	399272	338929	Yes
3	399421	338795	Yes
4	399572	338668	Yes
5	399725	338545	Yes
6	399891	338432	Yes
7	400063	338325	Yes
8	400231	338235	Yes
9	400399	338146	Yes
10	400574	338055	Yes
11	400752	337961	Yes
12	400923	337879	Yes
13	401096	337790	Yes
14	397927	339325	Yes

Receptor	Easting	Northing	Glint and Glare Possible
15	398111	339403	Yes
16	398293	339378	Yes
17	398481	339391	Yes
18	398100	339610	No
19	398287	339556	No
20	398471	339493	No
21	398659	339423	No
22	398825	339318	No
23	398984	339198	No
24	398516	339972	No
25	398702	339901	No
26	398892	339847	No
27	399098	339816	No
28	399282	339770	No
29	399479	339756	No
30	399672	339740	No
31	399461	339820	No
32	398620	339511	No
33	398804	339590	No
34	398907	339750	No

- 5.9. There is on railway line within the 1km study area that require a detailed Glint and Glare Assessment.
- 5.10. The ground receptor no-reflection zones are clearly identifiable on **Figure 3: Appendix A** and the process of how these are calculated is explained in **paragraphs 5.1 to 5.2** of this report.
- 5.11. **Table 5 - 3** shows a list of receptors points within the study area which are 200m apart.

Table 5 - 3: Rail Based Receptors

Receptor	Easting	Northing	Glint and Glare Possible
1	397869	339120	Yes
2	398040	339017	Yes
3	398213	338915	Yes
4	398386	338814	Yes
5	398548	338705	Yes
6	398696	338576	Yes
7	398832	338429	Yes
8	398966	338269	Yes
9	399094	338115	Yes
10	399220	337966	Yes
11	399351	337811	Yes
12	399479	337659	Yes
13	399605	337510	Yes
14	399727	337344	No
15	399847	337191	No
16	399962	337039	No
17	400088	336883	No

Aviation Receptors

5.12. Aerodromes within 30km of the Proposed Development can be found in Table 5 - 4.

Table 5 - 4: Airfields within close proximity

Airfield	Distance (km)	Use
Palmer Moor Farm	13.85	Small grass strip
Yeatsall Farm	14.58	Small grass strip
Sieghford Airfield	17.46	Small grass strip
Tatenhill Airfield	20.81	Small concrete strip

Airfield	Distance (km)	Use
Valley Farm	20.89	Small grass strip
Teddesley Park Airfield	22.38	Small grass strip
Holly Meadow Farm	23.74	Small grass strip
Otherton	25.69	Small grass strip
Egginton Airfield	27.04	Small grass strip
Arclid Airfield	29.39	Small grass strip

- 5.13. There are no aerodromes which require detailed assessments due to the proposed site being outside the airfields' safeguarding buffer zones outlined in **paragraph 4.25**.

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 take into account obstructions such as vegetation and buildings, discussion on the potentially impacted receptors is provided where necessary.

GROUND BASED RECEPTORS

Residential Receptors

- 6.2. **Table 6 - 1** identifies the receptors that will experience solar reflections based on solar reflection modelling and whether the reflections will be experienced in the morning (AM), evening (PM), or both. The number in brackets indicates which residential area the receptor belongs.
- 6.3. The 18 receptors (Receptors 17 - 34) which were within the no-reflection zones outlined previously have been excluded from the detailed modelling as they will never receive any glint and glare impacts from the Proposed Development.
- 6.4. **Appendix B and C** shows the analysis with the ground mounted solar panels at a tilt angle of between 20 and 25 degrees. **Table 6 - 1** shows the worst-case impact at each receptor.

Table 6 - 1: Potential for Glint and Glare impact on Residential Receptors

Receptor	Glint Possible from Site		Potential Glare Impact (per year)		Magnitude of Impact	Worst Case Tilt Angle (degrees)
	AM	PM	Minutes	Hours		
1	No	No	0	0	None	N/A
2	Yes	No	2207	36.78	High	25
3	Yes	No	1095	18.25	Low	25
4	Yes	No	2203	36.72	High	25
5	Yes	No	983	16.38	Low	25
6	Yes	No	983	16.38	Low	25
7 (1)	No	No	0	0	None	N/A
8 (1)	No	No	0	0	None	N/A

Receptor	Glint Possible from Site		Potential Glare Impact (per year)		Magnitude of Impact	Worst Case Tilt Angle (degrees)
	AM	PM	Minutes	Hours		
9 (1)	No	No	0	0	None	N/A
10	No	Yes	1600	26.67	Medium	20
11	No	No	0	0	None	N/A
12	No	No	0	0	None	N/A
13	No	No	0	0	None	N/A
14	No	Yes	314	5.23	Low	25
15	No	Yes	2054	34.23	High	25
16	No	Yes	2273	37.88	High	25

- 6.5. As can be seen in **Table 6 - 1**, there is a **High** impact at four receptors, **Medium** impact at one receptor, **Low** impact at four receptors and a **None** impact at the remaining seven receptors, including one residential area. **Appendix B and C** shows detailed analysis of when the glare impacts are possible, whilst also showing which parts of the solar farm the solar glare is reflected from.
- 6.6. **Appendix H** shows Google Earth images that give an insight into how each receptor will be impacted by glint and glare from the Proposed Development. There is a mixture of images used, which include aerial, ground level and street level. The aerial images show the location of the receptor with the solar farm drawn as a white polygon and can be seen on the images when the solar farm is theoretically visible. The area of the solar farm from where reflections may be possible has been drawn as a yellow polygon. The ground level terrain is based on the height data of the surrounding land showing no intervening vegetation or buildings. The white and yellow polygons can be seen in this view also. The street view gives a good indication as to whether the area of the solar farm where reflections are theoretically possible will be visible from the receptor point.

Receptors 2 and 3

- 6.7. The 'Glare Reflections on PV Footprint' chart in **Appendix C** shows that reflections from a northern section of the West Array (see **Figure 5: Appendix A**) in the Proposed Development can potentially impact on the receptors.
- 6.8. The first image in **Appendix H** is an aerial image showing the position of the receptors (yellow pins) in relation to the Proposed Development, and the location from which the second image was taken (red dot). This image shows vegetation to the east of the receptors. The second image is a photo taken from the northwestern fields with a view towards the receptors. This

image confirms that the vegetation is sufficient to screen all views of the Proposed Development from Receptor 3, and the vegetation and topography are sufficient to screen ground floor views of the Proposed Development from Receptor 2. Therefore, the impact upon Receptor 2 reduces to **Low** and the impact upon Receptor 3 reduces to **None**.

Receptor 4

- 6.9. The 'Glare Reflections on PV Footprint' chart in **Appendix C** shows that reflections from a northern section of the West Array (see **Figure 5: Appendix A**) in the Proposed Development can potentially impact on the receptor.
- 6.10. The first image in **Appendix H** is an aerial image showing the position of the receptor (yellow pin) in relation to the Proposed Development, and the location from which the second image was taken (red dot). This image shows vegetation and intervening buildings to the east of the receptor. The second image is a photo taken from the southern edge of the northwestern fields with a view towards the receptor. 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 remains **High**.

Receptor 5

- 6.11. The 'Glare Reflections on PV Footprint' chart in **Appendix C** shows that reflections from a central section of the West Array (see **Figure 5: Appendix A**) in the Proposed Development can potentially impact on the receptor.
- 6.12. The first image in **Appendix H** is an aerial image showing the position of the receptor (yellow pin) in relation to the Proposed Development, and the location from which the second image was taken (red dot). This image shows vegetation to the east of the receptor. The second image is a photo taken from the the northwestern fields with a view towards the receptor. This image confirms that the vegetation is insufficient to screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact remains **Low**.

Receptor 6

- 6.13. The 'Glare Reflections on PV Footprint' chart in **Appendix C** shows that reflections from a northern section of the East Array (see **Figure 5: Appendix A**) in the Proposed Development can potentially impact on the receptor.
- 6.14. The first image in **Appendix H** is an aerial image showing the position of the receptor (yellow pin) in relation to the Proposed Development, and the location from which the second image was taken (red dot). This image shows vegetation to the east of the receptor. The second image is a photo taken from the northwestern fields with a view towards the receptor. 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 reduces to **None**.

Receptor 10

- 6.15. The 'Glint Reflections on PV Footprint' chart in **Appendix B** shows that reflections from a northern section of the West Array (see **Figure 5: Appendix A**) in the Proposed Development can potentially impact on the receptor.
- 6.16. The first image in **Appendix H** is an aerial image showing the position of the receptor (yellow pin) in relation to the Proposed Development, and the location from which the second image was taken (red dot). This image shows vegetation between the receptor and the Proposed Development. The second image is a street view image with a view towards the receptor. This image confirms the vegetation is sufficient to screen all view of the Proposed Development where glint and glare is possible. Therefore, the impact reduces to **None**.

Receptor 14

- 6.17. The 'Glint Reflections on PV Footprint' chart in **Appendix C** shows that reflections from a northern section of the East Array (see **Figure 5: Appendix A**) in the Proposed Development can potentially impact on the receptor.
- 6.18. The first image in **Appendix H** is an aerial image showing the position of the receptor (yellow pin) in relation to the Proposed Development. This image shows dense vegetation between the Proposed Development and the receptor. The second image is a ground level image taken from the position of the receptor with a view towards the Proposed Development. This image confirms the topography is sufficient to screen all view of the Proposed Development where glint and glare is possible. Therefore, the impact reduces to **None**.

Receptor 15

- 6.19. The 'Glint Reflections on PV Footprint' chart in **Appendix C** shows that reflections from a southern section of the East Array (see **Figure 5: Appendix A**) in the Proposed Development can potentially impact on the receptor.
- 6.20. The first image in **Appendix H** is an aerial image showing the position of the receptor (yellow pin) in relation to the Proposed Development, and the location from which the second image was taken (red dot). This image shows vegetation to the east of the receptor. The second image is a photo taken from the southeastern fields with a view towards the receptor. This image confirms that the vegetation is insufficient to screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact remains **High**.

Receptor 16

- 6.21. The 'Glint Reflections on PV Footprint' chart in **Appendix C** shows that reflections from a central section of the East Array (see **Figure 5: Appendix A**) in the Proposed Development can potentially impact on the receptor.

- 6.22. The first image in **Appendix H** is an aerial image showing the position of the receptor (yellow pin) in relation to the Proposed Development. This image shows dense vegetation between the Proposed Development and the receptor. The second image is a ground level image taken from the position of the receptor with a view towards the Proposed Development. This image confirms the topography is sufficient to screen all view of the Proposed Development where glint and glare is possible. Therefore, the impact reduces to **None**.

Residential Area 1

- 6.23. This encompasses a number of residential receptors including those at Receptors 7 - 9 (assessed previously) (See **Figure 1: Appendix A**). Each receptor assessed represents multiple receptors as they are in close proximity of each other, so the worst-case scenario is assumed for the impact of glint and glare. All receptors were considered within the visibility analysis and it was concluded their impacts were similar. As per the assessments of these three receptors, the impacts on the other receptors within this area are assessed as being **None (worst case scenario)**.

Road Receptors

- 6.24. **Table 6 - 2** shows a summary of the modelling results for each of the Road Receptor Points whilst the detailed results and ocular impact charts can be viewed in **Appendix D and E**.
- 6.25. The 17 receptors within the no-reflection zones outlined previously have been excluded from the detailed modelling as they will never receive glint and glare impacts from the Proposed Development.

Table 6 - 2: Potential for Glint and Glare impact on Road Receptors

Receptor	Green Glare (mins)	Yellow Glare (mins)	Red Glare (mins)	Magnitude of Impact	Worst Case Tilt Angle (degrees)
1	1077	355	0	High	25
2	899	1688	0	High	25
3	611	2539	0	High	25
4	0	0	0	None	N/A
5	7583	2929	0	High	20
6	5782	2574	0	High	20
7	5624	2738	0	High	20
8	673	2600	0	High	25

Receptor	Green Glare (mins)	Yellow Glare (mins)	Red Glare (mins)	Magnitude of Impact	Worst Case Tilt Angle (degrees)
9	839	2919	0	High	25
10	1994	2890	0	High	25
11	2135	2549	0	High	25
12	2618	2375	0	High	25
13	2932	2014	0	High	25
14	0	0	0	None	N/A
15	0	0	0	None	N/A
16	0	0	0	None	N/A
17	0	0	0	None	N/A

- 6.26. As can be seen in **Table 6 - 2**, there are 12 receptor points which have potential glare impacts with the “potential for after-image” (yellow glare), which is a **High**. **Appendix D and E** shows detailed analysis of when the glint and glare impacts are possible, whilst also showing from which parts of the solar farm the solar glare is reflected from.
- 6.27. **Appendix H** shows Google Earth images that give an insight into how each receptor will be impacted by glint and glare from the Proposed Development. There is a mixture of images used, which include aerial, ground level and street level. The aerial images show the location of the receptor with the solar farm drawn as a white polygon and can be seen on the images when the solar farm is theoretically visible. The area of the solar farm from where reflections may be possible has been drawn as a yellow or green polygon. The field of view of a driver has been drawn as a red cone. The ground level terrain is based on the height data of the surrounding land showing no intervening vegetation or buildings. The white, yellow and green polygons can be seen in this view also. Field of view cones for drivers have been drawn using red lines. The street view gives a good indication as to whether the area of the solar farm where reflections are theoretically possible will be visible from the receptor point.
- 6.28. As can be seen in **Appendix H**, views of the Proposed Development from all receptors, except Receptor 3, are blocked by a mixture of intervening vegetation, topography and buildings. Therefore, impacts upon these receptors reduce to **None**. As outlined in **paragraph 4.15** the Sun’s reflections will be far greater than those reflections from the solar array. Therefore, impacts upon these receptors reduces to **Low**.

Rail Receptors

- 6.29. **Table 6 - 3** shows a summary of the modelling results for each of the Road Receptor Points whilst the detailed results and ocular impact charts can be viewed in **Appendix F and G**.
- 6.30. The four receptors within the no-reflection zones outlined previously have been excluded from the detailed modelling as they will never receive glint and glare impacts from the Proposed Development.

Table 6 - 3: Potential for Glint and Glare impact on Rail Receptors

Receptor	Green Glare (mins)	Yellow Glare (mins)	Red Glare (mins)	Magnitude of Impact	Worst Case Tilt Angle (degrees)
1	129	0	0	Low	20
2	318	0	0	Low	20
3	0	0	0	None	N/A
4	1706	147	0	High	25
5	1254	1016	0	High	25
6	1456	1226	0	High	25
7	4047	0	0	Low	20
8	2681	728	0	High	25
9	3916	2639	0	High	20
10	8576	5898	0	High	20
11	5214	3490	0	High	20
12	4664	3154	0	High	20
13	0	0	0	None	N/A

- 6.31. **Table 6 - 3**, there is a **High** impact at eight receptors, **Low** impact at three receptors and a **None** impact at the remaining two receptors. **Appendix F and G** shows detailed analysis of when the glare impacts are possible, whilst also showing which parts of the solar farm the solar glare is reflected from.
- 6.32. **Appendix H** shows Google Earth images that give an insight into how each receptor will be impacted by glint and glare from the Proposed Development. There is a mixture of images used, which include aerial, ground level and street level. The aerial images show the location of the receptor with the solar farm drawn as a white polygon and can be seen on the images when the solar farm is theoretically visible. The area of the solar farm from where reflections

may be possible has been drawn as a yellow or green polygon. The field of view of a driver has been drawn as a red cone. The ground level terrain is based on the height data of the surrounding land showing no intervening vegetation or buildings. The white, yellow and green polygons can be seen in this view also. Field of view cones for drivers have been drawn using red lines. The street view gives a good indication as to whether the area of the solar farm where reflections are theoretically possible will be visible from the receptor point.

Receptor 1

- 6.33. The 'Glare Reflections on PV Footprint' chart in **Appendix F** shows that reflections from a northern section of the West Array (see **Figure 5: Appendix A**) in the Proposed Development can potentially impact on the receptor.
- 6.34. The first image in **Appendix H** is an aerial image showing the position of the receptor (yellow pin) in relation to the Proposed Development, and the field of view of the train driver (red cones). This image shows vegetation and intervening buildings to the east of the receptors. This image confirms that the areas of the Proposed Development where glint and glare is possible are outside the field of view of the train driver. Therefore, the impact reduces to **None**.

Receptor 2

- 6.35. The 'Glare Reflections on PV Footprint' chart in **Appendix F** shows that reflections from a northern section of the West Array (see **Figure 5: Appendix A**) in the Proposed Development can potentially impact on the receptor.
- 6.36. The first image in **Appendix H** is an aerial image showing the position of the receptor (yellow pin) in relation to the Proposed Development, and the field of view of the train driver (red cones). This image shows vegetation and intervening buildings to the east of the receptors. This image confirms that the areas of the Proposed Development where glint and glare is possible are outside the field of view of the train driver. Therefore, the impact reduces to **None**.

Receptor 4

- 6.37. The 'Glare Reflections on PV Footprint' chart in **Appendix G** shows that reflections from the northern half of the West Array (see **Figure 5: Appendix A**) in the Proposed Development can potentially impact on the receptor.
- 6.38. The first image in **Appendix H** is an aerial image showing the position of the receptor (yellow pin) in relation to the Proposed Development, and the field of view of the train driver (red cones). This image shows vegetation and intervening buildings to the east of the receptors. This image confirms that the areas of the Proposed Development where glint and glare is possible are outside the field of view of the train driver. Therefore, the impact reduces to **None**.

Receptor 5

- 6.39. The 'Glare Reflections on PV Footprint' chart in **Appendix G** shows that reflections from a central section of the West Array (see **Figure 5: Appendix A**) in the Proposed Development can potentially impact on the receptor.
- 6.40. The first image in **Appendix H** is an aerial image showing the position of the receptor (yellow pin) in relation to the Proposed Development, and the field of view of the train driver (red cones). This image shows vegetation and intervening buildings to the east of the receptors. This image confirms that the areas of the Proposed Development where glint and glare is possible are outside the field of view of the train driver. Therefore, the impact reduces to **None**.

Receptor 6

- 6.41. The 'Glare Reflections on PV Footprint' chart in **Appendix G** shows that reflections from the southern half of the West Array and a northern section of the East Array (see **Figure 5: Appendix A**) in the Proposed Development can potentially impact on the receptor.
- 6.42. The first image in **Appendix H** is an aerial image showing the position of the receptor (yellow pin) in relation to the Proposed Development, and the field of view of the train driver (red cones). This image shows vegetation to the east of the receptors. This image confirms that the areas of the Proposed Development where glint and glare is possible are outside the field of view of the train driver. Therefore, the impact reduces to **None**.

Receptor 7

- 6.43. The 'Glare Reflections on PV Footprint' chart in **Appendix F** shows that reflections from a southern section of the West Array and a northern section of the East Array (see **Figure 5: Appendix A**) in the Proposed Development can potentially impact on the receptor.
- 6.44. The first image in **Appendix H** is an aerial image showing the position of the receptor (yellow pin) in relation to the Proposed Development, and the field of view of the train driver (red cones). This image shows vegetation to the east of the receptors. This image confirms that the areas of the Proposed Development where glint and glare is possible are outside the field of view of the train driver. Therefore, the impact reduces to **None**.

Receptor 8

- 6.45. The 'Glare Reflections on PV Footprint' chart in **Appendix G** shows that reflections from a northern section of the East Array (see **Figure 5: Appendix A**) in the Proposed Development can potentially impact on the receptor.
- 6.46. The first image in **Appendix H** is an aerial image showing the position of the receptor (yellow pin) in relation to the Proposed Development, and the field of view of the train driver (red

cones). This image shows vegetation to the east of the receptors. This image confirms that the areas of the Proposed Development where glint and glare is possible are outside the field of view of the train driver. Therefore, the impact reduces to **None**.

Receptor 9

- 6.47. The 'Glint Reflections on PV Footprint' chart in **Appendix F** shows that reflections from a central section of the East Array (see **Figure 5: Appendix A**) in the Proposed Development can potentially impact on the receptor.
- 6.48. The first image in **Appendix H** is an aerial image showing the position of the receptor (yellow pin) in relation to the Proposed Development, and the field of view of the train driver (red cones). This image shows vegetation to the east of the receptors. This image confirms that the areas of the Proposed Development where glint and glare is possible are outside the field of view of the train driver. Therefore, the impact reduces to **None**.

Receptor 10

- 6.49. The 'Glint Reflections on PV Footprint' chart in **Appendix F** shows that reflections from a central section of the East Array (see **Figure 5: Appendix A**) in the Proposed Development can potentially impact on the receptor.
- 6.50. The first image in **Appendix H** is an aerial image showing the position of the receptor (yellow pin) in relation to the Proposed Development, and the field of view of the train driver (red cones). This image shows vegetation to the east of the receptors. This image confirms that the areas of the Proposed Development where glint and glare is possible are outside the field of view of the train driver. Therefore, the impact reduces to **None**.

Receptor 11

- 6.51. The 'Glint Reflections on PV Footprint' chart in **Appendix F** shows that reflections from a central section and a northeast section of the East Array (see **Figure 5: Appendix A**) in the Proposed Development can potentially impact on the receptor.
- 6.52. The first image in **Appendix H** is an aerial image showing the position of the receptor (yellow pin) in relation to the Proposed Development, and the field of view of the train driver (red cones). This image shows vegetation to the east of the receptors. This image confirms that the areas of the Proposed Development where glint and glare is possible are outside the field of view of the train driver. Therefore, the impact reduces to **None**.

Receptor 12

- 6.53. The 'Glint Reflections on PV Footprint' chart in **Appendix F** shows that reflections from a southern section of the East Array (see **Figure 5: Appendix A**) in the Proposed Development can potentially impact on the receptor.

- 6.54. The first image in **Appendix H** is an aerial image showing the position of the receptor (yellow pin) in relation to the Proposed Development, and the field of view of the train driver (red cones). This image shows vegetation to the east of the receptors. This image confirms that the areas of the Proposed Development where glint and glare is possible are outside the field of view of the train driver. Therefore, the impact reduces to **None**.

7. GROUND BASED RECEPTOR MITIGATION

7.1. Mitigation is required to screen the **High** impact views from Residential Receptors 4 and 15 and Road Receptor 3 into the Proposed Development. Mitigation is also advised to screen the **Low** impact views from Residential Receptors 2 and 5 This includes;

- Native hedgerows to be planted/infilled and maintained to a height of at least 3.5m along the southern half of the eastern boundary, the western half of the southern boundary and the eastern half of the northern boundary in the West Array (see **Figure 5: Appendix A**) and along a southern section of the eastern boundary in the East Array as shown in **Figure 6 of Appendix A**. This will screen views from Residential Receptors 2 and 5 and Road Receptor 3, and ground floor views from Residential Receptors 4 and 15. Therefore, impacts upon Residential Receptors 2 and 5 and Road Receptor 3 reduce to **None** and impacts upon Residential Receptors 4 and 15 reduce to **Low**.

7.2. **Table 7 - 1, Table 7 - 2 and Table 7 - 3** show the impacts at each stage of the glint and glare analysis, with the final residual impacts considered once the mitigation is in place.

Table 7 - 1: Potential Residual Glint and Glare Impacts on Residential Receptors

Receptor	Magnitude of Impact		
	After Geometric Analysis	After Visibility Analysis	Residual Impacts
1	Low	None	None
2	Low	Low	None
3	None	None	None
4	High	High	Low
5	High	Low	None
6	High	None	None
7 (1)	Low	None	None
8 (1)	High	None	None
9 (1)	High	None	None
10	High	None	None
11	High	None	None

Receptor	Magnitude of Impact		
	After Geometric Analysis	After Visibility Analysis	Residual Impacts
12	High	None	None
13	None	None	None
14	Low	None	None
15	Low	High	None
16	None	None	None

Table 7 - 2: Potential Residual Glint and Glare Impacts on Road Receptors

Receptor	Magnitude of Impact		
	After Geometric Analysis	After Visibility Analysis	Residual Impacts
1	High	None	None
2	High	None	None
3	High	High	None
4	None	None	None
5	High	None	None
6	High	None	None
7	High	None	None
8	High	None	None
9	High	None	None
10	High	None	None
11	High	None	None
12	High	None	None
13	High	None	None
14	None	None	None
15	None	None	None
16	None	None	None

Receptor	Magnitude of Impact		
	After Geometric Analysis	After Visibility Analysis	Residual Impacts
17	None	None	None

Table 7 - 3: Potential Residual Glint and Glare Impacts on Rail Receptors

Receptor	Magnitude of Impact		
	After Geometric Analysis	After Visibility Analysis	Residual Impacts
1	Low	None	None
2	Low	None	None
3	None	None	None
4	High	None	None
5	High	None	None
6	High	None	None
7	Low	None	None
8	High	None	None
9	High	None	None
10	High	None	None
11	High	None	None
12	High	None	None
13	None	None	None

7.3. Table 7 - 4, Table 7 - 5 and Table 7 - 6 show the overall impacts for all residential and road receptors.

Table 7 - 4: Solar Reflections: Residential Receptors

Magnitude	Theoretical Visibility	Actual Visibility (No Mitigation)	Actual Visibility with Mitigation
High	4	2	0
Medium	1	0	0
Low	4	2	2
None	7	12	14
High – Solar reflections impacts of over 30 hours per year or over 30 minutes per day Medium - Solar reflections impacts between 20 and 30 hours per year or between 20 minutes and 30 minutes per day Low - Solar reflections impacts between 0 and 20 hours per year or between 0 minutes and 20 minutes per day None - Effects not geometrically possible or no visibility of reflective surfaces likely due to high levels of intervening screening			

Table 7 - 5: Solar Reflections: Road Receptors

Magnitude	Theoretical Visibility	Actual Visibility (No Mitigation)	Actual Visibility with Mitigation
High	12	1	0
Low	0		0
None	5	16	17
High - Solar reflections impacts with yellow glare (potential for after-image). Low - Solar reflections impacts with only green glare (low potential for after-image) None - Effects not geometrically possible or no visibility of reflective surfaces likely due to high levels of intervening screening or being outside the drivers field of view			

Table 7 - 6: Solar Reflections: Rail Receptors

Magnitude	Theoretical Visibility	Actual Visibility (No Mitigation)	Actual Visibility with Mitigation
High	8	0	0
Low	3	0	0
None	2	13	13
High - Solar reflections impacts with yellow glare (potential for after-image). Low - Solar reflections impacts with only green glare (low potential for after-image) None - Effects not geometrically possible or no visibility of reflective surfaces likely due to high levels of intervening screening or being outside the drivers field of view			

8. CUMULATIVE ASSESSMENT

- 8.1. The Proposed Development is adjacent to an existing built solar farm, Lower Newton Solar Farm, which adjoins the Proposed Development to the west, the proposed Totmonslow Solar Farm (planning ref: **SMD/2023/0197**) to the northeast, the proposed Upper Tean Solar Farm (planning ref: **SMD/2023/0059**) to the southeast, and a proposed solar farm north of Willow Cottage (planning ref: **SMD/2021/0662**) to the south. Impacts are currently **Low** impacts upon Residential Receptors 4 and 15. The recommended mitigation planting for Residential Receptors 4 and 15 will screen the ground floor views allowing only **Low** impacts upon the upper floor views. However, these impacts will remain **Low** when taking into account the existing solar farm development. The predicted glare impacts from the Proposed Development upon Residential Receptor 4 come from an area north of the existing solar farm and Receptor 4 is inside the existing solar farm's northern non-reflection zone. The predicted glare impacts from the Proposed Development upon Residential Receptor 15 come from an area south of the existing solar farm. There may be a small contribution to glare impacts from the southern areas of the existing solar farm. Due to the relative geometry between the residential receptors and the existing solar farm, in conjunction with existing vegetation and topography and the recommended mitigation planting for the Proposed Development, it is **anticipated that there will not be any significant cumulative effects** on ground-based receptors as a result of the construction of the Proposed Development.

9. SUMMARY

- 9.1. This assessment considers the potential impacts on ground-based receptors such as roads, rail and residential dwellings as well as aviation assets. A 1km study area around the Application Site is considered adequate for the assessment of ground-based receptors, whilst a 30km study area is chosen for aviation receptors. Within 1km of the Application Site, there are 34 residential receptors, including two residential areas, 34 road receptors and 17 rail receptors which were considered. As per the methodology section, where there are a number of residential receptors within close proximity, a representative dwelling or dwellings is/are chosen for full assessment as the impacts will not vary to any significant degree. Where small groups of receptors have been evident, the receptors on either end of the group have been assessed in detail. 18 residential receptors, including one residential area, 17 road receptors and four rail receptors were dismissed as they are located within the no reflection zones. 10 aerodromes are located within the 30km study area; None of which required a detailed assessment due to the Proposed Development falling outside their respective safeguarding buffer zones, which are outlined in **paragraph 4.25**.
- 9.2. Geometric analysis was conducted at 16 individual residential receptors, including one residential area, 17 road receptors and 13 rail receptors.
- 9.3. The assessment concludes that:
- Solar reflections are possible at nine of the 16 residential receptors assessed within the 1km study area. The initial bald-earth scenario identified potential impacts as **High** at four receptors, **Medium** at one receptor, **Low** at four receptors and **None** at the remaining seven receptors, including one residential area. Upon reviewing the actual visibility of the receptors, glint and glare impacts remain **High** at two receptors and reduce to **Low** at two receptors and to **None** at all remaining receptors. Once mitigation measures were considered impacts reduce to **Low** at two receptors and to **None** at all remaining receptors.
 - Solar reflections are possible at 12 of the 17 road receptors assessed within the 1km study area. The initial bald-earth scenario identified potential impacts as **High** at 12 receptors, and **None** at the remaining five receptors. Upon reviewing the actual visibility of the receptors, glint and glare impacts remain **High** at one receptor and reduce to **None** at all remaining receptors. Once mitigation measures were considered impacts reduce to **None** at all receptors.
 - Solar reflections are possible at 11 of the 13 rail receptors assessed within the 1km study area. The initial bald-earth scenario identified potential impacts as **High** at eight

receptors, **Low** at three receptors and **None** at the remaining two receptors. Upon reviewing the actual visibility of the receptors, glint and glare impacts reduce to **None** at all receptors.

- **No impact** on aviation assets is predicted.
- 9.4. Mitigation is required to screen the **High** impact views from Residential Receptors 4 and 15 and Road Receptor 3. Mitigation is also included to screen the **Low** impact views from Residential Receptors 2 and 5. This includes native hedgerows to be planted/infilled and maintained to a height of at least 3.5m along the southern half of the eastern boundary, the western half of the southern boundary and the eastern half of the northern boundary in the West Array and along a southern section of the eastern boundary in the East Array.
- 9.5. The effects of glint and glare and their impact on local receptors has been analysed in detail and is predicted to be only **Low** and **None** impacts, and therefore **No Significant Effects**.

10. APPENDICES

APPENDIX A: FIGURES

- Figure 1: Residential Based Receptors
- Figure 2: Road Based Receptors
- Figure 3: Rail Based Receptors
- Figure 4: Site Layout
- Figure 5: Panel Area Labels
- Figure 6: G&G Mitigation Planting

APPENDIX B: RESIDENTIAL RECEPTOR GLARE RESULTS (20 DEGREES)

APPENDIX C: RESIDENTIAL RECEPTOR GLARE RESULTS (25 DEGREES)

APPENDIX D: ROAD RECEPTOR GLARE RESULTS (20 DEGREES)

APPENDIX E: ROAD RECEPTOR GLARE RESULTS (25 DEGREES)

APPENDIX F: AVIATION RECEPTOR GLARE RESULTS (20 DEGREES)

APPENDIX G: AVIATION RECEPTOR GLARE RESULTS (25 DEGREES)

APPENDIX H: VISIBILITY ASSESSMENT EVIDENCE

APPENDIX I: SOLAR MODULE GLARE AND REFLECTANCE TECHNICAL MEMO¹⁶

¹⁶ Sunpower Corporation (September 2009), T09014 Solar Module Glare and Reflectance Technical Memo



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