Glint and Glare Assessment

Low Solar Farm

25/06/2021

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Contents

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 750m survey 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 750m of the Application Site, there are 67 residential receptors and 35 road 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. 15 residential and five road receptors were dismissed as they are located within the no reflection zones. Two aerodromes are located within the 30km study area; however, no aviation receptors required a detailed assessment due to the Proposed Development falling outside their respective safeguarding buffer zones, which are outlined in **paragraph 4.24**.

1.2. Geometric analysis was conducted at 52 individual residential receptors (including seven residential areas) and 30 road receptors.

1.3. The assessment concludes that:

- Solar reflections are possible at 49 of the 52 residential receptors assessed within the 750m study area. The initial bald-earth scenario identified potential impacts as **High** at 34 receptors (including four residential areas), **Medium** at seven receptors (including one residential area), **Low** at eight receptors (including two residential areas) and **None** at the remaining three receptors. Upon reviewing the actual visibility of the receptors, glint and glare impacts reduced to **None** for all receptors (including seven residential areas).
- Solar reflections are possible at 29 of the 30 road receptors assessed within the 750m study area. The initial bald-earth scenario identified potential impacts as **High** at 29 receptors and **None** at the remaining receptor. Upon reviewing the actual visibility of the receptors, glint and glare impacts remain **High** at seven receptors and reduce to **Low** at one receptor and **None** at the remaining 22 receptors. Once mitigation measures were considered, impacts reduce to **None** for all receptors.
- **No impacts** are predicted on aviation receptors.

1.4. Mitigation measures are required to be put in place due to the **High** impact that was found during the visibility analysis at road receptors 5, 6, 7, 8, 10 and 12. This includes hedgerows to be infilled/gapped up and maintained to a height of between 2 – 2.5m around the Proposed

Development. Locations of these hedgerows to be gapped up/erected can be found within the Landscape Strategy drawings, which will be submitted in conjunction to this report.

1.5. The effects of glint and glare and their impact on local receptors has been analysed in detail and taking into account distances between the development and receptors, undulating landform, intervening structures and vegetation, the actual impact on all receptors is predicted to be **acceptable and not significant** once all mitigation measures have been implemented.

2. INTRODUCTION

BACKGROUND

2.1. Neo Environmental Ltd has been appointed by Boom Power Ltd (the "Applicant") to undertake a Glint and Glare Assessment for a proposed solar farm development (the "Proposed Development") on lands approximately 1.2km east of Grange Moor (the "Application Site").

PROPOSED DEVELOPMENT DESCRIPTION

2.2. The Proposed Development will consist of the construction of PV panels mounted on metal frames, maintenance tracks, transformers, Inverters, substation, Temporary Construction Compound, perimeter fencing and Storage Buildings.

SITE DESCRIPTION

2.3. The area of the Proposed Development (the "Application Site") comprises of approximately 85ha of land contained within 11 fields. The field boundaries consist of a mixture of trees and hedgerows. Ground levels within the Application Site vary from approximately 121m AOD at the northeast boundaries to 208m AOD in western areas of the Application Site.

2.4. The Application Site is centred at approximate grid reference E 424068, N416123. The wider landscape contains the village of Flockton, which is located c. 0.4km to the southt of the Application Site.

SCOPE OF REPORT

2.5. 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.

2.6. 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.

2.7. 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.

2.8. 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 Receptor Map
  - Figure 2: Road Receptor Map
  - Figure 3: Site Layout
- Appendix B: Residential Receptor Glare Results
- Appendix C: Road Receptor Glare Results
- Appendix D: Visibility Evidence Assessment
- Appendix E: Solar Module Glare and Reflectance Technical Memo[1]

Statement of Authority

2.9. This Glint and Glare Assessment has been produced by Tom Saddington and Michael McGhee 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.

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

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

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 characteristics to water, which is much lower than the likes of glass, steel, snow and white concrete by comparison (**See Appendix E**). 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 Harris, Miller, Miller & Hanson Inc. (November 2010). 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/airports/environmental/policy_guidance/media/airport-solar-guide.pdf

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

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. 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.

[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

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 2009. In particular, developers should take cognisant of the following articles of the ANO[7], including:

- *"Article 137 – 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 221 - 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 222 – 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 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).

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[6] CAA (2010) Interim CAA Guidance – Solar Photovoltaic Systems. Available at: http://www.enstoneflyingclub.co.uk/files/caa_view_on_solar_panel_instalations.pdf?PHPSESSID=8900a41db8a205da84fca7bbc14eae69

[7] CAA (2015) Air Navigation: The Order and Regulations. Available at: http://publicapps.caa.co.uk/docs/33/CAP%20393%20Fourth%20edition%20Amendment%201%20April%202015.pdf

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

US Federal Aviation Administration Policy

3.7. 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.

3.8. The US Federal Aviation Administration (FAA) in their Solar Guide (Federal Aviation Authority, 2010)[8] incorporates a chapter on the impact and assessment of glint from solar panels. It concludes that (although subject to revision):

> *"…evidence suggests that either significant glare is not occurring during times of operation or if glare is occurring, it is not a negative effect and is a minor part of the landscape to which pilots and tower personnel are exposed."*

3.9. The current 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.

3.10. 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 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.

3.11. 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:

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[8] FAA (2010), Technical Guidance for Evaluating Selected Solar Technologies on Airports. Available at https://www.faa.gov/airports/environmental/policy_guidance/media/airport-solar-guide-print.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 glint or glare in the existing or planned Air Traffic Control Tower (ATCT); and
- No potential for glare (glint) 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). The final approach path is defined as 2 miles from 50 feet above the landing threshold using a standard 3-degree glide path.

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 Algorithms[10]. 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 2021.

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.

[10] 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 E** 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 and that the amount of reflective energy drops as the angle of incidence decreases.

4.9. Most modern panels have a slight surface texture which should have a small effect on diffusing the solar radiation further. Although, this has not been modelled to conform with the worst-case scenario assessment.

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[11] 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 ground based 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 ground-based 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.

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[11] 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).

Relevant Parameters of the Proposed Development

4.15. 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 south and will be inclined at an angle of 15 degrees.

4.16. The height of the panels above ground level is a maximum of 2.8m 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

4.17. 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.

4.18. A 750m 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.

4.19. 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.

4.20. An assessment was undertaken to determine zones where solar reflections will never be directed near ground level.

4.21. 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

4.22. 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. Enroute activities are not considered an issue as the flight will most likely be at a higher altitude than the solar reflection.

4.23. 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.

4.24. 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

4.25. 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 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

Moving Receptors (Road and Rail)

4.26. 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.

4.27. 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 (glint) 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).

4.28. The FAA produced an evaluation of glare as a hazard and concluded in their report[12] 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."*

4.29. 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 **low**.

Moving Receptors (Aviation)

Approach Paths

4.30. 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.

4.31. 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 90 degrees left and right from the front of the cockpit whilst the VFOV is modelled at 30 degrees.

4.32. 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)

4.33. 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.

[12] 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

4.34. 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.

4.35. 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

4.36. 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; and
- The model does not account for the effects of diffraction; however, buffers are applied as a factor of safety.

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 298.73 degrees in the western direction (late day reflections) and 64.76 degrees and 129.14 degrees in the eastern direction (morning reflections) and therefore any ground-based receptor outside these arcs 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 750m of the Application Site have been identified (**Table 5-1**). Glint was assumed to be possible if the receptor is located within the ground-based receptor zones outlined previously.

5.5. There are 15 residential receptors (Receptors 53 to 67) 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 Receptors

Receptor	Easting	Northing	Glint and Glare Possible
1	422958	415685	Yes
2	422878	415687	Yes
3	422868	415680	Yes
4	422856	415671	Yes
5	422690	415525	Yes
6	423301	414908	Yes
7	424236	415279	Yes

8	424448	415204	Yes
9	424579	415253	Yes
10	424588	415382	Yes
11	424706	415422	Yes
12	424845	415413	Yes
13	424890	415439	Yes
14	424973	415343	Yes
15	425018	415278	Yes
16	424071	415770	Yes
17	424114	415771	Yes
18	424142	415774	Yes
19	424654	416121	Yes
20	424711	416108	Yes
21	424888	415932	Yes
22	424919	415924	Yes
23	425068	415837	Yes
24	425079	415850	Yes
25	425090	415859	Yes
26	425037	415969	Yes
27	425066	416033	Yes
28	425086	416041	Yes
29	425103	416045	Yes
30	425426	416465	Yes
31	425438	416473	Yes
32	425447	416479	Yes
33	425556	416518	Yes
34	424033	416788	Yes
35	424061	416748	Yes

36	423716	416511	Yes
37	423658	416472	Yes
38	423583	416450	Yes
39	423396	416910	Yes
40	422990	416729	Yes
41	422950	416668	Yes
42	422873	416568	Yes
43	422732	416460	Yes
44	422777	416451	Yes
45	422796	416392	Yes
46	422723	416215	Yes
47	422644	416201	Yes
48	423206	416324	Yes
49	423377	416203	Yes
50	423358	416002	Yes
51	423309	415953	Yes
52	423210	415960	Yes
53	423540	414986	No
54	423689	415009	No
55	423822	415025	No
56	423927	415014	No
57	424013	415092	No
58	424132	415111	No
59	424206	415106	No
60	423582	414723	No
61	423567	414684	No
62	423611	414684	No
63	423737	414664	No

64	424948	416967	No
65	424286	417082	No
66	424305	417009	No
67	424226	416940	No

Road / Rail Receptors

5.6. There are four roads within the 750m study area that require a detailed Glint and Glare Assessment; the A642, A637, Old Road and Hardcastle Lane. 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	422560	415573	Yes
2	422755	415618	Yes
3	422951	415659	Yes
4	423148	415626	Yes
5	423346	415601	Yes
6	423545	415623	Yes
7	423741	415659	Yes
8	423936	415703	Yes
9	424131	415751	Yes
10	424309	415841	Yes
11	424487	415932	Yes
12	424675	416003	Yes
13	424859	416081	Yes

14	425034	416177	Yes
15	425186	416307	Yes
16	425340	416433	Yes
17	425467	416587	Yes
18	425607	416510	Yes
19	425428	416441	Yes
20	425318	416278	Yes
21	425223	416104	Yes
22	425161	415916	Yes
23	425042	415757	Yes
24	425014	415561	Yes
25	424944	415373	Yes
26	425106	415165	Yes
27	424928	415238	Yes
28	424739	415178	Yes
29	424555	415104	Yes
30	424363	415071	Yes
31	424193	414975	No
32	424014	414891	No
33	423815	414891	No
34	423616	414879	No
35	423417	414857	No

Aviation Receptors

5.9. Aerodromes within 30km of the Proposed Development can be found in **Table 5-3.**

Table 5-3: Airfields within close proximity

Airfield	Distance	Use
Crosland Moor Airfield	11.93km	Small Unlicensed Aerodrome

Leeds-Bradford Airport	23.79km	International Airport

5.10. The Proposed Development is not located within the safeguarding buffer zones, outlined in **paragraph 4.24**, of any of the two aviation receptors identified in **Table 5-3**. Therefore, detailed assessment of the aviation receptors will not be required.

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.

6.3. The 15 receptors 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** shows the analysis with the solar panels at a tilt angle of 15. **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
	AM	PM	Minutes	Hours	
1	Yes	No	6306	105.1	High
2	Yes	No	6235	103.9	High
3	Yes	No	6507	108.5	High
4	Yes	No	6469	107.8	High
5	Yes	No	7797	130.0	High
6	Yes	No	684	11.4	Low
7	No	Yes	5315	88.6	High
8	No	Yes	4983	83.1	High

9	No	Yes	3693	61.6	High
10	No	Yes	5376	89.6	High
11	No	Yes	5868	97.8	High
12	No	Yes	5597	93.3	High
13	No	Yes	5065	84.4	High
14	No	Yes	5155	85.9	High
15	No	Yes	4819	80.3	High
16	Yes	Yes	10084	168.1	High
17	Yes	Yes	10702	178.4	High
18	Yes	Yes	11055	184.3	High
19	No	Yes	4411	73.5	High
20	No	Yes	4443	74.1	High
21	No	Yes	6887	114.8	High
22	No	Yes	6796	113.3	High
23	No	Yes	8983	149.7	High
24	No	Yes	9096	151.6	High
25	No	Yes	9095	151.6	High
26	No	Yes	7925	132.1	High
27	No	Yes	6056	100.9	High
28	No	Yes	5533	92.2	High
29	No	Yes	5257	87.6	High
30	No	Yes	1050	17.5	Low
31	No	Yes	1139	19.0	Low
32	No	Yes	1000	16.7	Low
33	No	Yes	899	15.0	Low
34	No	No	0	0.0	None
35	No	No	0	0.0	None
36	Yes	No	1544	25.7	Medium

37	Yes	No	1606	26.8	Medium
38	Yes	No	1591	26.5	Medium
39	Yes	No	0	0.0	None
40	Yes	No	162	2.7	Low
41	Yes	No	363	6.1	Low
42	Yes	No	749	12.5	Low
43	Yes	No	1232	20.5	Medium
44	Yes	No	1276	21.3	Medium
45	Yes	No	1532	25.5	Medium
46	Yes	No	2201	36.7	High
47	Yes	No	2114	35.2	High
48	Yes	No	1946	32.4	High
49	Yes	No	1137	19.0	Medium
50	Yes	No	7152	119.2	High
51	Yes	No	4771	79.5	High
52	Yes	No	3524	58.7	High

6.5. As can be seen in **Table 6-1,** there is a **High** impact at 34 receptors, including four residential areas, **Medium** at seven receptors, including one receptor area, **Low** at eight receptors, including two residential areas and **None** impact for the remaining three receptors. **Appendix B** shows detailed analysis of when the glare impacts are possible, whilst also showing which parts of the solar farm the solar glint is reflected from.

6.6. **Appendix D** shows Google Earth images that give an insight into how each receptor will be impacted by the 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 1 - 4

6.7. The 'Glare Reflections on the PV Footprint' chart shown in **Appendix B**, shows that a central section of Array 1, northern section of Array 2 and all but a northern section of Array 3 in the Proposed Development can potentially impact on the receptors.

6.8. The first image in **Appendix D** is an aerial image which shows the location of the receptors in relation to the Proposed Development. Also, it shows that there is likely to be sufficient vegetation located to the east of the receptors, which will screen all views of the Proposed Development where glint and glare is possible. The second image has been taken where the red point is located on the aerial image and shows the vegetation that is located to the east of the receptors. This image confirms that the vegetation located to the east of the receptors will screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact is reduced to **None**.

Receptor 5

6.9. The 'Glare Reflections on the PV Footprint' chart shown in **Appendix B**, shows that a central section of Array 1, northern section of Array 2 and all but a northern section of Array 3 in the Proposed Development can potentially impact on the receptor.

6.10. The first image in **Appendix D** is an aerial image which shows the location of the receptor in relation to the Proposed Development. Also, it shows that there is likely to be sufficient vegetation located to the east of the receptor, which will screen all views of the Proposed Development where glint and glare is possible. The second image has been taken where the red point is located on the aerial image and shows the vegetation that is located to the east of the receptor. This image confirms that the vegetation located to the east of the receptor will screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact is reduced to **None**.

Receptor 6

6.11. The 'Glare Reflections on the PV Footprint' chart shown in **Appendix B**, shows that a southern section of Array 2 in the Proposed Development can potentially impact on the receptor.

6.12. The first image in **Appendix D** is an aerial image which shows the location of the receptor in relation to the Proposed Development. Also, it shows that there is likely to be sufficient vegetation located to the northeast of the receptor, which will screen all views of the Proposed Development where glint and glare is possible. The second image has been taken where the red point is located on the aerial image and shows the vegetation that is located to the northeast of the receptor by using Google Earth's 3D modelling. This image confirms that the vegetation located to the northeast of the receptor will screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact is reduced to **None**.

Receptor 7

6.13. The 'Glare Reflections on the PV Footprint' chart shown in **Appendix B**, shows that a southeast section of Array 1 and a southern section of Array 2 in the Proposed Development can potentially impact on the receptor.

6.14. The first image in **Appendix D** is an aerial image which shows the location of the receptor in relation to the Proposed Development. Also, it shows that there is likely to be sufficient vegetation located to the northwest of the receptor, which will screen all views of the Proposed Development where glint and glare is possible. The second image has been taken where the red point is located on the aerial image and shows the vegetation that is located to the northwest of the receptor by using Google Earth's 3D modelling. This image confirms that the vegetation located to the northwest of the receptor will screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact is reduced to **None**.

Receptor 8

6.15. The 'Glare Reflections on the PV Footprint' chart shown in **Appendix B**, shows that a southeast section of Array 1 and a southern section of Array 2 in the Proposed Development can potentially impact on the receptor.

6.16. The first image in **Appendix D** is an aerial image which shows the location of the receptor in relation to the Proposed Development. Also, it shows that there is likely to be sufficient vegetation located to the northwest of the receptor, which will screen all views of the Proposed Development where glint and glare is possible. The second image has been taken where the red point is located on the aerial image and shows the vegetation that is located to the northwest of the receptor. This image confirms that the vegetation located to the northwest of the receptor will screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact is reduced to **None**.

Receptor 9

6.17. The 'Glare Reflections on the PV Footprint' chart shown in **Appendix B**, shows that a southeast section of Array 1 and southwest half of Array 2 in the Proposed Development can potentially impact on the receptor.

6.18. The first image in **Appendix D** is an aerial image which shows the location of the receptor in relation to the Proposed Development. Also, it shows that there is likely to be sufficient vegetation located to the west of the receptor, which will screen all views of the Proposed Development where glint and glare is possible. The second image has been taken where the red point is located on the aerial image and shows the vegetation that is located to the west of the receptor. This image confirms that the vegetation located to the west of the receptor will screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact is reduced to **None**.

Receptor 10

6.19. The 'Glare Reflections on the PV Footprint' chart shown in **Appendix B**, shows that a southeast section of Array 1 and southwest half of Array 2 in the Proposed Development can potentially impact on the receptor.

6.20. The first image in **Appendix D** is an aerial image which shows the location of the receptor in relation to the Proposed Development. Also, it shows that there is likely to be sufficient vegetation located to the west of the receptor, which will screen all views of the Proposed Development where glint and glare is possible. The second image has been taken where the red point is located on the aerial image and shows the vegetation that is located to the west of the receptor by using Google Earth's 3D modelling. This image confirms that the vegetation located to the west of the receptor will screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact is reduced to **None**.

Receptors 11 - 15

6.21. The 'Glare Reflections on the PV Footprint' chart shown in **Appendix B**, shows that all but a northeast section of Array 1 and all but a southern section of Array 2 in the Proposed Development can potentially impact on the receptors.

6.22. The first image in **Appendix D** is an aerial image which shows the location of the receptors in relation to the Proposed Development. Also, it shows that there is likely to be sufficient vegetation located to the west of the receptors, which will screen all views of the Proposed Development where glint and glare is possible. The second image has been taken where the red point is located on the aerial image and shows the vegetation that is located to the west of the receptors by using Google Earth's 3D modelling. This image confirms that the vegetation located to the west of the receptors will screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact is reduced to **None**.

Receptors 16 - 18

6.23. The 'Glare Reflections on the PV Footprint' chart shown in **Appendix B**, shows that a central section of Array 1, a southern section of Array 3 and all but a southern section of Array 4 in the Proposed Development can potentially impact on the receptors.

6.24. The first image in **Appendix D** is an aerial image which shows the location of the receptors in relation to the Proposed Development. Also, it shows that there is likely to be sufficient vegetation located to the east and west of the receptors, which will screen all views of the Proposed Development where glint and glare is possible. The second image has been taken where one of the red points are located on the aerial image and shows the vegetation that is located to the west of the receptors. The third image has been taken where one of the red points are located on the aerial image and shows the topography and vegetation that is located to the east of the receptors. These images confirm that the topography and vegetation located to the east and west of the receptors will screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact is reduced to **None**.

Receptors 19 and 20

6.25. The 'Glare Reflections on the PV Footprint' chart shown in **Appendix B**, shows that a northern section of Array 1 and a central section of Array 3 in the Proposed Development can potentially impact on the receptors.

6.26. The first image in **Appendix D** is an aerial image which shows the location of the receptors in relation to the Proposed Development. Also, it shows that there is likely to be sufficient vegetation located to the west of the receptors, which will screen all views of the Proposed Development where glint and glare is possible. The second image has been taken where the red points is located on the aerial image and shows the vegetation that is located to the west of the receptors. This image confirms that the vegetation located to the west of the receptors will screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact is reduced to **None**.

Receptors 21 and 22

6.27. The 'Glare Reflections on the PV Footprint' chart shown in **Appendix B**, shows that a northern half of Array 1, a central section of Array 3 and a central section of Array 5 in the Proposed Development can potentially impact on the receptors.

6.28. The first image in **Appendix D** is an aerial image which shows the location of the receptors in relation to the Proposed Development. Also, it shows that there is likely to be sufficient vegetation located to the northwest of the receptors, which will screen all views of the Proposed Development where glint and glare is possible. The second image has been taken where the red points is located on the aerial image and shows the vegetation that is located to the northwest of the receptors. This image confirms that the vegetation located to the northwest of the receptors will screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact is reduced to **None**.

Receptors 23 – 25

6.29. The 'Glare Reflections on the PV Footprint' chart shown in **Appendix B**, shows that the northern half of Array 1, the southern half of Array 3, the northern half of Array 4 and the western half of Array 5 in the Proposed Development can potentially impact on the receptors.

6.30. The first image in **Appendix D** is an aerial image which shows the location of the receptors in relation to the Proposed Development. Also, it shows that there is likely to be sufficient vegetation located to the northwest of the receptors, which will screen all views of the Proposed Development where glint and glare is possible. The second image has been taken where the red points is located on the aerial image and shows the vegetation that is located to the northwest of the receptors. This image confirms that the vegetation located to the northwest of the receptors will screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact is reduced to **None**.

Receptor 26

6.31. The 'Glare Reflections on the PV Footprint' chart shown in **Appendix B**, shows that the northern half of Array 1, a central section of Array 3 and all but an eastern section of Array 5 in the Proposed Development can potentially impact on the receptor.

6.32. The first image in **Appendix D** is an aerial image which shows the location of the receptor in relation to the Proposed Development. Also, it shows that there is likely to be sufficient vegetation located to the northwest of the receptor, which will screen all views of the Proposed Development where glint and glare is possible. The second image has been taken where the red points is located on the aerial image and shows the vegetation that is located to the northwest of the receptor. This image confirms that the vegetation located to the northwest of the receptor will screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact is reduced to **None**.

Receptors 27 - 29

6.33. The 'Glare Reflections on the PV Footprint' chart shown in **Appendix B**, shows that the northern half of Array 1, a central section of Array 3 and a northern section of Array 5 in the Proposed Development can potentially impact on the receptors.

6.34. The first image in **Appendix D** is an aerial image which shows the location of the receptors in relation to the Proposed Development. Also, it shows that there is likely to be sufficient vegetation located to the west of the receptors, which will screen all views of the Proposed Development where glint and glare is possible. The second image has been taken where the red point is located on the aerial image and shows the vegetation that is located to the west of the receptors. This image confirms that the vegetation located to the west of the receptors will screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact is reduced to **None**.

Receptors 30 - 32

6.35. The 'Glare Reflections on the PV Footprint' chart shown in **Appendix B**, shows that the northern section of Array 3 in the Proposed Development can potentially impact on the receptors.

6.36. The first image in **Appendix D** is an aerial image which shows the location of the receptors in relation to the Proposed Development. Also, it shows that there is likely to be sufficient vegetation located to the west of the receptors, which will screen all views of the Proposed Development where glint and glare is possible. The second image has been taken where the red point is located on the aerial image and shows the vegetation that is located to the west of the receptors. This image confirms that the vegetation located to the west of the receptors will screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact is reduced to **None**.

Receptor 33

6.37. The 'Glare Reflections on the PV Footprint' chart shown in **Appendix B**, shows that the northern section of Array 3 in the Proposed Development can potentially impact on the receptor.

6.38. The first image in **Appendix D** is an aerial image which shows the location of the receptor in relation to the Proposed Development. Also, it shows that there is likely to be sufficient vegetation located to the west of the receptor, which will screen all views of the Proposed Development where glint and glare is possible. The second image has been taken where the red point is located on the aerial image and has a view towards the Proposed Development and of the vegetation located to the west of the receptor. This image confirms that the vegetation located to the west of the receptor will screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact is reduced to **None**.

Receptors 36 - 38

6.39. The 'Glare Reflections on the PV Footprint' chart shown in **Appendix B**, shows that the northern section of Array 3 in the Proposed Development can potentially impact on the receptors.

6.40. The first image in **Appendix D** is an aerial image which shows the location of the receptors in relation to the Proposed Development. Also, it shows that there is likely to be sufficient vegetation located to the east of the receptors, which will screen all views of the Proposed Development where glint and glare is possible. The second image has been taken where the red point is located on the aerial image and shows the vegetation that is located to the east of the receptors by using Google Earth's 3D modelling. This image confirms that the vegetation located to the east of the receptors will screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact is reduced to **None**.

Receptor 40

6.41. The 'Glare Reflections on the PV Footprint' chart shown in **Appendix B**, shows that the northern section of Array 3 in the Proposed Development can potentially impact on the receptor.

6.42. The first image in **Appendix D** is an aerial image which shows the location of the receptor in relation to the Proposed Development. Also, it shows that there is likely to be sufficient vegetation located to the east of the receptor, which will screen all views of the Proposed Development where glint and glare is possible. The second image has been taken where the red point is located on the aerial image and has a view of the vegetation located to the east of the receptor. This image confirms that the vegetation located to the east of the receptor will screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact is reduced to **None**.

Receptor 42

6.43. The 'Glare Reflections on the PV Footprint' chart shown in **Appendix B**, shows that the northern section of Array 3 in the Proposed Development can potentially impact on the receptor.

6.44. The first image in **Appendix D** is an aerial image which shows the location of the receptor in relation to the Proposed Development. Also, it shows that there is likely to be sufficient vegetation located to the east of the receptor, which will screen all views of the Proposed Development where glint and glare is possible. The second image has been taken where the red point is located on the aerial image and has a view towards the Proposed Development and of the vegetation located to the east of the receptor. This image confirms that the topography vegetation located to the east of the receptor will screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact is reduced to **None**.

Receptors 43 and 44

6.45. The 'Glare Reflections on the PV Footprint' chart shown in **Appendix B**, shows that the northern half of Array 3 in the Proposed Development can potentially impact on the receptors.

6.46. The first image in **Appendix D** is an aerial image which shows the location of the receptors in relation to the Proposed Development. Also, it shows that there is likely to be sufficient vegetation located to the east of the receptors, which will screen all views of the Proposed Development where glint and glare is possible. The second image has been taken where the red point is located on the aerial image and has a view towards the Proposed Development and of the vegetation located to the east of the receptors. This image confirms that the vegetation located to the east of the receptors will screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact is reduced to **None**.

Receptor 45

6.47. The 'Glare Reflections on the PV Footprint' chart shown in **Appendix B**, shows that the northern half of Array 3 in the Proposed Development can potentially impact on the receptor.

6.48. The first image in **Appendix D** is an aerial image which shows the location of the receptor in relation to the Proposed Development. Also, it shows that there is likely to be sufficient vegetation located to the east of the receptor, which will screen all views of the Proposed Development where glint and glare is possible. The second image has been taken where the red point is located on the aerial image and has a view towards the Proposed Development and of the vegetation located to the east of the receptor. This image confirms that the topography vegetation located to the east of the receptor will screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact is reduced to **None**.

Receptors 46 and 47

6.49. The 'Glare Reflections on the PV Footprint' chart shown in **Appendix B**, shows that a northern section of Array 1 and the northern half of Array 3 in the Proposed Development can potentially impact on the receptors.

6.50. The first image in **Appendix D** is an aerial image which shows the location of the receptors in relation to the Proposed Development. Also, it shows that there is likely to be sufficient vegetation located to the east of the receptors, which will screen all views of the Proposed Development where glint and glare is possible. The second image has been taken where the red point is located on the aerial image and has a view towards the Proposed Development and of the vegetation located to the east of the receptors. This image confirms that the vegetation located to the east of the receptors will screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact is reduced to **None**.

Receptor 48

6.51. The 'Glare Reflections on the PV Footprint' chart shown in **Appendix B**, shows that the northern half of Array 3 in the Proposed Development can potentially impact on the receptor.

6.52. The first image in **Appendix D** is an aerial image which shows the location of the receptor in relation to the Proposed Development. Also, it shows that there is likely to be sufficient vegetation located to the east of the receptor, which will screen all views of the Proposed Development where glint and glare is possible. The second image has been taken where the red point is located on the aerial image and shows the vegetation that is located to the east of the receptor by using Google Earth's 3D modelling. This image confirms that the vegetation located to the east of the receptor will screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact is reduced to **None**.

Receptor 49

6.53. The 'Glare Reflections on the PV Footprint' chart shown in **Appendix B**, shows that the northern half of Array 3 in the Proposed Development can potentially impact on the receptor.

6.54. The first image in **Appendix D** is an aerial image which shows the location of the receptor in relation to the Proposed Development. Also, it shows that there is likely to be sufficient vegetation located to the east of the receptor, which will screen all views of the Proposed Development where glint and glare is possible. The second image has been taken where the red point is located on the aerial image and shows the vegetation that is located to the east of the receptor by using Google Earth's 3D modelling. This image confirms that the vegetation located to the east of the receptor will screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact is reduced to **None**.

Receptors 50 - 52

6.55. The 'Glare Reflections on the PV Footprint' chart shown in **Appendix B**, shows that the northern half of Array 1 and all of Array 3 in the Proposed Development can potentially impact on the receptors.

6.56. The first image in **Appendix D** is an aerial image which shows the location of the receptors in relation to the Proposed Development. Also, it shows that there is likely to be sufficient vegetation located to the east of the receptors, which will screen all views of the Proposed Development where glint and glare is possible. The second image has been taken where the red point is located on the aerial image and has a view towards the Proposed Development and of the vegetation located to the east of the receptors. This image confirms that the vegetation located to the east of the receptors will screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact is reduced to **None**.

Residential Area 1

6.57. This encompasses a number of residential receptors including those at receptor point 6 (assessed above) (See **Figure 1: Appendix A**). Each receptor assessed represents multiple receptors as they are in close proximity to each other, so the worst-case scenario is assumed for the impact of glint and glare. All receptors had no initial impacts from glint and glare, so not requiring a visibility analysis. Therefore, as per the initial bald-earth assessment for this one receptor, the impacts on the other receptors within this area are assessed as being **None (worst case scenario)**.

Residential Area 2

6.58. This encompasses a number of residential receptors including those at receptor points 7-15 (assessed above) (See **Figure 1: Appendix A**). Each receptor assessed represents multiple receptors as they are in close proximity to 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 that their impacts were similar. As per the assessments of these ninereceptors, the impacts on the other receptors within this area are assessed as being **None (worst case scenario).**

Residential Area 3

6.59. This encompasses a number of residential receptors including those at receptor points 16-18 (assessed above) (See **Figure 1: Appendix A**). Each receptor assessed represents multiple receptors as they are in close proximity to 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 that 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).**

Residential Area 4

6.60. This encompasses a number of residential receptors including those at receptor points 19 - 20 (assessed above) (See **Figure 1: Appendix A**). Each receptor assessed represents multiple receptors as they are in close proximity to 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 that their impacts were similar. As per the assessments of these two receptors, the impacts on the other receptors within this area are assessed as being **None (worst case scenario).**

Residential Area 5

6.61. This encompasses a number of residential receptors including those at receptor point 33 (assessed above) (See **Figure 1: Appendix A**). Each receptor assessed represents multiple receptors as they are in close proximity to 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 that their impacts were similar. As per the assessments of this one receptor, the impacts on the other receptors within this area are assessed as being **None (worst case scenario).**

Residential Area 6

6.62. This encompasses a number of residential receptors including those at receptor points 36 - 38 (assessed above) (See **Figure 1: Appendix A**). Each receptor assessed represents multiple receptors as they are in close proximity to 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 that 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).**

Residential Area 7

6.63. This encompasses a number of residential receptors including those at receptor points 50 - 52 (assessed above) (See **Figure 1: Appendix A**). Each receptor assessed represents multiple receptors as they are in close proximity to 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 that 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

6.64. **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 C**.

6.65. The five 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 Based Receptors

Receptor	Green Glare (mins)	Yellow Glare (mins)	Red Glare (mins)	Magnitude of Impact
1	2178	7035	0	High
2	1755	7265	0	High
3	1034	6641	0	High
4	1411	8129	0	High
5	2140	9753	0	High
6	2098	10485	0	High
7	1945	6495	0	High
8	1962	8009	0	High
9	1	9922	0	High
10	0	13372	0	High
11	0	7669	0	High
12	47	7119	0	High
13	115	4320	0	High
14	132	4091	0	High
15	17	3459	0	High
16	0	677	0	High
17	0	0	0	None
18	0	918	0	High
19	0	841	0	High
20	94	2040	0	High
21	269	3203	0	High
22	425	9305	0	High
23	173	7870	0	High

24	355	8523	0	High
25	284	4754	0	High
26	731	4210	0	High
27	193	3096	0	High
28	88	4429	0	High
29	34	4419	0	High
30	0	1858	0	High

6.66. As can be seen in **Table 6-2**, there are 29 receptor points which have potential glare impacts with the "potential for after-image" (yellow glare), which is a **High** impact. **Appendix C** show detailed analysis of when the glint and glare impacts are possible, whilst also showing from which parts of the solar farm the solar glint is reflected from.

6.67. **Appendix D** shows two Google Earth images taken towards the Proposed Development location at each of the receptor points where an impact is anticipated. The first image is a ground level terrain view and is based on the height data of the surrounding land showing no intervening vegetation or buildings. The solar farm has been 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 second image is a street view image pointing in the same direction as the terrain image. This 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.

6.68. As can be seen in **Appendix D**, views of the Proposed Development from all receptors, except for receptors 5, 6, 7, 8, 10, 12 and 23, are blocked by a mixture of intervening vegetation, buildings, and topography. Therefore, impacts upon these receptors reduce to **None**.

6.69. The impacts on Road Receptor 23 occur when the sun is directly behind the Proposed Development and low in the sky. The images in **Appendix D** show examples of where the sun will be in relation to the Proposed Development. In these images it shows the sun, areas where glare occurs from the Proposed Development and view of the driver at the time of which glare impacts will occur. The reflections from the Proposed Development will be much less intense than the suns direct glare and therefore it will be this which will be the main impact on the drivers' vision, not the reflections from the Proposed Development. Therefore, as the suns glare will be the main impact on road users at these receptor points, during the times when glare occurs form the Proposed Development, the impact can be reduced to **low**.

6.70. Impacts upon receptors 5, 6, 7, 8, 10 and 12, remain **High.**

7. GROUND BASED RECEPTOR MITIGATION

7.1. Mitigation measures are required to be put in place due to the **High** impact that was found during the visibility analysis at Road Receptors 5, 6, 7, 8, 10 and 12. Mitigation measures are being included as part of the Landscape Plan which will be submitted in conjunction with this Glint and Glare Assessment. These measures include:

- All hedgerows surrounding the Proposed Development to be infilled/gapped up and maintained to a height of between 2 – 2.5m. Once implemented this will screen all views of the Proposed Development from Road Receptors 5, 6, 7, 8, 10 and 12 and reduce the impacts to **None**. Impacts at Road Receptor 23 will remain **Low,** but the hedgerow will give added protection and ensure the impact remains **acceptable and Low**.

7.2. **Tables 7-1 and 7-2** 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

	Magnitude of Impact		
Receptor	After Geometric Analysis	After Visibility Analysis	Residual Impacts
1	High	None	None
2	High	None	None
3	High	None	None
4	High	None	None
5	High	None	None
6	Low	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	High	None	None
15	High	None	None
16	High	None	None
17	High	None	None
18	High	None	None
19	High	None	None
20	High	None	None
21	High	None	None
22	High	None	None
23	High	None	None
24	High	None	None
25	High	None	None
26	High	None	None
27	High	None	None
28	High	None	None
29	High	None	None
30	Low	None	None
31	Low	None	None
32	Low	None	None
33	Low	None	None
34	None	None	None
35	None	None	None
36	Medium	None	None
37	Medium	None	None
38	Medium	None	None
39	None	None	None
40	Low	None	None
41	Low	None	None

42	Low	None	None
43	Medium	None	None
44	Medium	None	None
45	Medium	None	None
46	High	None	None
47	High	None	None
48	High	None	None
49	Medium	None	None
50	High	None	None
51	High	None	None
52	High	None	None

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

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

14	High	None	None
15	High	None	None
16	High	None	None
17	None	None	None
18	High	None	None
19	High	None	None
20	High	None	None
21	High	None	None
22	High	None	None
23	High	Low	Low
24	High	None	None
25	High	None	None
26	High	None	None
27	High	None	None
28	High	None	None
29	High	None	None
30	High	None	None

8. SUMMARY

8.1. There is little guidance or policy available in the UK at present in relation to the assessment of glint and glare from Proposed Development developments. However, it is recognised as a potential impact which needs to be considered for a Proposed Development, therefore this assessment considers the potential impacts on ground-based receptors such as roads, rail, and residential dwellings as well as aviation assets.

8.2. This assessment considers the potential impacts on ground-based receptors such as roads, rail and residential dwellings as well as aviation assets. A 750m survey 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 750m of the Application Site, there are 67 residential receptors and 35 road 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. 15 residential and five road receptors were dismissed as they are located within the no reflection zones. Two aerodromes are located within the 30km study area; however, no aviation receptors required a detailed assessment due to the Proposed Development falling outside their respective safeguarding buffer zones, which are outlined in paragraph 4.24.

8.3. Geometric analysis was conducted at 52 individual residential receptors (including seven residential areas) and 30 road receptors.

8.4. The assessment concludes that:

- Solar reflections are possible at 49 of the 52 residential receptors assessed within the 750m study area. The initial bald-earth scenario identified potential impacts as **High** at 34 receptors (including four residential areas), **Medium** at seven receptors (including one residential area), **Low** at eight receptors (including two residential areas) and **None** at the remaining three receptors. Upon reviewing the actual visibility of the receptors, glint and glare impacts reduced to **None** for all receptors (including seven residential areas).

- Solar reflections are possible at 29 of the 30 road receptors assessed within the 750m study area. The initial bald-earth scenario identified potential impacts as **High** at 29 receptors and **None** at the remaining receptor. Upon reviewing the actual visibility of the receptors, glint and glare impacts remain **High** at seven receptors and reduce to **Low** at one receptor and **None** at the remaining 22 receptors. Once mitigation measures were considered, impacts reduce to **None** for all receptors.

- **No impacts** are predicted on aviation receptors.

8.5. Mitigation measures are required to be put in place due to the **High** impact that was found during the visibility analysis at road receptors 5, 6, 7, 8, 10 and 12. This includes hedgerows to be infilled/gapped up and maintained to a height of between 2 – 2.5m around the Proposed Development. Locations of these hedgerows to be gapped up/erected can be found within the Landscape Strategy drawings, which will be submitted in conjunction to this report.

8.6. The effects of glint and glare and their impact on local receptors has been analysed in detail and taking into account distances between the development and receptors, undulating landform, intervening structures and vegetation, the actual impact on all receptors is predicted to be **acceptable and not significant** once all mitigation measures have been implemented.

9. APPENDICES

Appendix A: Figures

- Figure 1: Residential Receptor Map
- Figure 2: Road Receptor Map
- Figure 3: Site Layout

Appendix B: Residential Receptor Glare Results

Appendix C: Road Receptor Glare Results

Appendix D: Visibility Assessment Evidence

Appendix E: Solar Module Glare and Reflectance Technical Memo[13]

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

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