Glint and Glare Assessment

Swaffham Solar Farm

16/07/2020

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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 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 these study areas, there are 18 residential receptors and 23 road receptors which were considered. However, several residential and road-based receptors were dismissed as they are located within the no reflection zones. Cambridge Airport was the only aerodrome within 30km which required a detailed analysis.

1.2. Geometric analysis was conducted at six residential receptors and 11 road receptors. At Oxford airport, four runways were assessed as well as the ATCT.

1.3. Following an initial assessment, rail receptors were scoped out as assets that will be impacted upon from the Proposed Development. The assessment concludes that:

- Solar reflections are possible at three of the six residential receptors assessed in detail. The initial bald-earth scenario identified potential impacts at all three was **Low**. Upon reviewing the actual visibility of the receptors, glint and glare impacts reduce to **Low** at one receptor and **None** at all others. Once the mitigation was considered, the resultant (residual) effects were reduced to **None** at all receptors.

- Solar reflections are possible at six of the 11 road receptors assessed in detail. The initial bald-earth scenario identified potential impacts at four of these receptors as **Low** and two were **High**. Only the receptor points with a High impact were assessed further and upon reviewing the actual visibility of the receptors, glint and glare effects reduce to **None** at one of the receptors and **Low** at the other. Once the mitigation was considered, the resultant (residual) effects were reduced to **None** at all receptors.

- **No effects** for train drivers or railway infrastructure are predicted.

- A detailed assessment of Cambridge Airport concluded that there would be an impact at two of the four runway approach paths, however due to the low intensity of impact it is deemed an **acceptable impact** according to the FAA guidance. There is no impact at the ATCT.

1.4. The mitigation measures proposed is for a hedgerow to be installed around the perimeter of the Proposed Development.

1.5. The effects of glint and glare and their impact on local receptors has been analysed in detail and there is predicted to be low to none impacts, and therefore No Significant Effects.

2. INTRODUCTION

BACKGROUND

2.1. Neo Environmental Ltd has been appointed by Prospus Ltd (the "Applicant") to undertake a Glint and Glare Assessment for a proposed solar farm development (the "Proposed Development") on lands near to Swaffham Prior, East Cambridgeshire (the "Application Site").

2.2. Please see **Figure 3** for the layout of the Proposed Development.

DEVELOPMENT DESCRIPTION

2.3. The Proposed Development will consist of the construction of PV panels mounted on metal frames, underground cabling, perimeter fencing with CCTV cameras and access gates, and all ancillary grid infrastructure and associated works.

SCOPE OF REPORT

2.4. Although there may be small amounts of glint and glare from the metal structures associated with the solar 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 report will concentrate on the effects of glint and its impact on local receptors and will be supported with the following Figures and Appendices.

- Appendix A: Figures
  - Figure 1: Residential Receptors
  - Figure 2: Road Based Receptors

  - Figure 3: Infrastructure Layout
  - Figure 4: Cambridge Aerodrome Chart
- Appendix B: Residential Receptor Results
- Appendix C: Road Receptor Results
- Appendix D: Aviation Receptor Glare Results
- Appendix E: Photo Register
- Appendix F: Solar Module Glare and Reflectance Technical Memo[1]

STATEMENT OF AUTHORITY

2.8. This Glint and Glare Assessment has been produced by 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.

DEFINITIONS

2.9. This study examined the potential hazard and nuisance effects of glint and glare in relation to ground-based receptors, this includes the occupants of surrounding dwellings as well as road users. The Federal Aviation Guidance (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"

2.10. Glint and glare are essentially the unwanted reflection of sunlight from reflective surfaces. This study used a multi-step process of elimination to determine which receptors had the potential to experience the effects of glint and glare. It then examined, using a computer-

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

[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 generated geometric model, the times of the year and the times of the day such effects could occur. This is based on the relative angles between the sun, the panels and the receptor throughout the year.

General Nature of Reflectance from Photovoltaic Panels

2.11. In terms of reflectance, photovoltaic solar panels are not highly reflective surfaces. 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 glass, steel, snow and white concrete by comparison (see **Appendix F** for details). Similar levels of reflectance can be found in rural environments from 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 several 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 which used a number of case studies and expert opinions, including from Neo Environmental. 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

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

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

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[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 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."*

[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

3.5. 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).

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

US Federal Aviation Administration Policy

3.1. 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."

3.2. 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.

3.3. Crucially, the policy provides a quantitative threshold which is lacking in the Irish 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 Ireland, this US document has been utilised as guidance for this report.

3.4. 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)

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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 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.

3.5. 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 will follow the methodology required by the FAA as it offers the most robust assessment method currently available.

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 assessed is 2020.

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 previous text and **Appendix F** outline the reflective properties of solar glass and compares it to other reflective surfaces. Although the exact figures in this report are not conclusive, 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.

Relevant Parameters of the Proposed Development

4.10. 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 between 20 degrees.

4.11. The maximum above ground level height of the panels is 2.5m and points at the top, middle and bottom of the panels are used to determine the potential for glint and glare generation.

IDENTIFICATION OF RECEPTORS

Ground Based Receptors

4.12. 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.

4.13. 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.

4.14. An observer height of 2m was utilised for residential receptors, as this is a typical height for a ground-floor window. Upper floor windows are not analysed geometrically; however, are considered as part of the visual analysis. 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.

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

Aviation

4.16. 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.

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

4.18. Buffer zones to identify aviation assets varies depending on the safeguarding criteria of that asset. For large aerodromes a safeguarding zone of 30km is standard, however for small private airstrips this can be reduced to approximately 5km.

Magnitude of Impact

Static Receptors

4.19. 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)

4.20. 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.

4.21. 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).

Moving Receptors (Aviation)

Approach Paths

4.22. Each final approach path which has the potential to receive glint is assessed using the Solar Glare Hazard Analysis Tool (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.

4.23. 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.

4.24. 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 in order for the proposed Development to be acceptable.

Air Traffic Control Tower (ATCT)

4.25. 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 aviation activity. The key areas on an aerodrome are the views towards the runway thresholds, taxiways and aircraft bays.

4.26. The FAA guidance states that no solar reflection towards the ATCT should be produced by a proposed solar development (see Policy and Guidance Chapter), however this should be assessed on a site by site basis and will depend on the operations at a particular aerodrome.

4.27. 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.

Determination of Ocular Impact

4.28. 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.

4.29. 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.

4.30. 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).

4.31. 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.

Assessment Limitations

4.32. 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.

[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).

- 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. In the northern hemisphere, there will never be solar reflections due south of a solar PV development as the position of the sun is always south. Furthermore, due to the slant of a solar panel (where the sun is due south, with an azimuth angle of 180 degrees), reflections will be directed skyward and not impact on ground-based receptors. The ground-based receptor reflection zone is a procedure which eliminates certain areas in order to reduce the assessment procedure, much in the same way a zone of theoretical visibility (ZTV) map allows a Landscape Architect to focus their assessment on areas where the solar PV development will be visible.

5.2. 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.

5.3. Further analysis showed that this will only occur between the azimuth of 248.4 degrees and 291.6 degrees in the western direction (late day reflections) and 68.4 degrees and 111.6 degrees in the eastern direction (morning reflections) and therefore any ground-based receptor outside these arcs will not have any impact from solar reflections.

5.4. **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 5.3.**

Residential Receptors

5.5. Residential receptors located within 1km 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.

5.6. The ground receptor no-reflection zones are clearly identifiable on **Figure 1, Appendix A** and the process of how these are calculated is explained in **paragraphs 5.1 to 5.3** of this report.

5.7. There were a large number of receptors within the study area in the town of Swaffham Prior. Therefore, a selection of these has been included on the assessment as there will only be limited changes in the analysis from receptor to receptor. Should there be any major impacts at a receptor point in this area then this should investigate in more detail.

Table 5-1: Residential Receptors

Receptor	Easting	Northing	Glint and Glare Possible
1	556975	263806	Yes
2	557089	263948	Yes
3	557211	264031	Yes
4	557273	264109	Yes
5	557381	264153	Yes
6	558813	264426	Yes
7	557875	263458	No
8	557895	263383	No
9	557924	263372	No
10	557915	263357	No
11	557933	263338	No
12	557938	263332	No
13	557984	263281	No
14	557433	262955	No
15	558295	262964	No
16	557349	264337	No
17	557347	264529	No
18	557444	264670	No

Road / Rail Receptors

5.8. There are no railway lines near the site which require assessment and therefore the impact on railway infrastructure is **None**.

5.9. There are five roads within the 1km study area that requires a detailed glint and glare analysis; the B1102, Heath Road, Cage Hill, High Street, and Lower End. 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 reduced risk of safety impacts from glint and glare.

5.10. 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 5.3** of this report. Assessment points 200m apart are used.

Table 5-2: Road Based Receptors

Receptor	Easting	Northing	Glint and Glare Possible
1	556999	264267	Yes
2	556973	264197	Yes
3	556871	264119	Yes
4	556854	263711	Yes
5	557011	263835	Yes
6	557126	263998	Yes
7	557133	264078	Yes
8	557234	264167	Yes
9	557290	263956	Yes
10	557445	263828	Yes
11	557594	263695	Yes
12	557733	263551	No
13	557867	263402	No
14	557985	263240	No
15	558113	263084	No
16	558259	262946	No
17	557997	264798	No
18	557832	264686	No
19	557666	264573	No
20	557500	264461	No
21	557352	264328	No

22	557094	264441	No
23	557196	264613	No

Aviation Receptors

5.11. Aerodromes within 30km of the proposed solar development can be found in **Table 5-3.**

Table 5-3: Airfields within close proximity

Airfield	Distance	Use
Cambridge Airport	9.5km	Small Regional Airport
Bourn Airfield	22.8km	Small Unlicensed Aerodrome

5.12. Only Cambridge Airport will be assessed in detail due to its short distance from the solar farm and the fact that two of its runways are directed towards the Proposed Development.

Oxford Airport

5.13. Cambridge Airport (ICAO code EGSG) is designated as a licenced aerodrome and is located approximately 2km north east of Cambridge. The aerodrome chart for this airport can be found in **Figure 4. Appendix A**.

5.14. The elevation of the aerodrome at the Aerodrome Reference Point (ARP) is 14.32m. It has two asphalt strip runways, details of which are given in **Table 5-4**.

Table 5-4: Runways

Runway Designation	Bearing (°)	Length (m)	Width (m)
05	049.87	1,965	45
23	229.89	1,965	45
05G	049.91	899	35
23G	229.92	899	35

5.15. The threshold locations and heights of the runways at Oxford Airport are given in **Table 5-5**.

Table 5-5: Runway Threshold Locations and Heights

Runway Designation	Threshold Latitude	Threshold Longitude	Height AOD (m)
05	52.200586	0.166457	10.97

23	52.209884	0.184412	14.32
05G	52.203079	0.175580	10.97
23G	52.208385	0.185832	10.97

5.16. The height Above Ground Level (AGL) of the Control Tower Building has been estimated as 20m AOD.

Table 5-6: ATCT

	Latitude	Longitude	Height AOD (m)	ATCT Height (m)
ATC	52.208077	0.172764	20.0	20.0

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 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** contains the detailed analysis of the glint and glare impacts. **Table 6.1** shows the impact at each receptor.

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

	Glint Possible from Site		Potential Glare Impact (per year)		Magnitude of Impact
Receptor	AM	PM	Minutes	Hours	
1	Yes	No	121	2.0	Low
2	Yes	No	95	1.6	Low
3	No	No	0	0.0	None
4	No	No	0	0.0	None
5	No	No	0	0.0	None
6	Yes	No	71	1.2	Low

6.5. As it can be seen in **Table 6-1** there is a low impact at three receptors and a **None** impact at the three others. The amount of glare is extremely low and is also of low intensity and there are therefore **No Significant Effects**.

6.6. **Appendix E** shows two Google Earth images taken toward the proposed solar farm location the roadside 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.

6.7. As can be seen in **Appendix E**, receptors 1 and 2 will have views of the site blocked by intervening vegetation and topography and therefore the impact can be reduced to **None**. There may be some views of the site from the upper floor of receptor 6 therefore this will remain at **Low**.

Road Receptors

6.8. **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**

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	0	0	0	None
2	0	0	0	None
3	0	0	0	None
4	32	0	0	Low
5	97	0	0	Low
6	30	0	0	Low
7	0	0	0	None
8	0	0	0	None
9	62	0	0	Low
10	69	46	0	High
11	0	1126	0	High

6.9. As can be seen in **Table 6-2**, there are two receptor points analysed in detail that have potential glare impacts and "potential for after-image" (yellow glare) when analysed in detail, which is a **High** impact. The other receptors have either a low or None impact and therefore **No Significant Effects**. **Appendix C** shows 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.

6.10. **Appendix E** shows two Google Earth images taken toward the proposed solar farm 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.

6.11. As can be seen in **Appendix E**, most impacts along Heath Road will be blocked by intervening vegetation, however there may be some very limited views near to receptor 11 and therefore the impact at that receptor will reduce to **Low**.

AVIATION RECEPTORS

6.12. **Table 6-3** shows a summary of the modelling results for each of the runway approach paths as well at the ATCT, whilst the detailed results and ocular impact charts can be viewed in **Appendix D.**

Table 6-3: Summary of Glare Results

Component	Green Glare (mins)	Yellow Glare (mins)	Red Glare (mins)
05	187	0	0
23	0	0	0
05G	149	0	0
23G	0	0	0
ATCT	0	0	0

6.13. As can be seen in **Table 6-3**, the only runway approach path that has potential for glint and glare is Runway 05 and 05G. The green glare is described as 'Low Potential for After Image' which is an **acceptable impact** according to the FAA guidance.

6.14. There is no impact at the ATCT.

7. GROUND BASED RECEPTOR MITIGATION

7.1. As part of the design of the Proposed Development, mitigation measures have been proposed to screen views of the site from sensitive receptors. These include:

- New hedgerow around the perimeter of the Proposed Development. These measures will reduce the impacts at road receptors 11 and residential receptor 6 from **Low** to **None**.

7.2. **Tables 6-10 and 6-11** 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 6 - 1: Potential Residual Glint and Glare Impacts on Residential Receptors

	Magnitude of Impact		
Receptor	After Geometric Analysis	After Visibility Analysis	Residual Impacts
1	Low	None	None
2	Low	None	None
3	None	None	None
4	None	None	None
5	None	None	None
6	Low	Low	None

Table 6 - 2: Potential Residual Glint and Glare Impacts on Road Receptors

	Magnitude of Impact		
Receptor	After Geometric Analysis	After Visibility Analysis	Residual Impacts
1	None	Low	None
2	None	Low	None
3	None	None	None
4	Low	Low	Low
5	Low	Low	Low
6	Low	Low	Low

7	None	None	None
8	None	None	None
9	Low	Low	Low
10	High	None	None
11	High	Low	None

8. SUMMARY

8.1. As identified by UK policy, glint and glare is recognised as a potential impact which needs to be considered for a proposed solar development.

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 1km 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 these study areas, there are 18 residential receptors and 23 road receptors which were considered. However, several residential and road-based receptors were dismissed as they are located within the no reflection zones. Cambridge Airport was the only aerodrome within 30km which required a detailed analysis.

8.3. Geometric analysis was conducted at six residential receptors and 11 road receptors. At Oxford airport, four runways were assessed as well as the ATCT.

8.4. Following an initial assessment, rail receptors were scoped out as assets that will be impacted upon from the Proposed Development. The assessment concludes that:

- Solar reflections are possible at three of the six residential receptors assessed in detail. The initial bald-earth scenario identified potential impacts at all three was **Low**. Upon reviewing the actual visibility of the receptors, glint and glare impacts reduce to **Low** at one receptor and **None** at all others. Once the mitigation was considered, the resultant (residual) effects were reduced to **None** at all receptors.
- Solar reflections are possible at six of the 11 road receptors assessed in detail. The initial bald-earth scenario identified potential impacts at four of these receptors as **Low** and two were **High**. Only the receptor points with a High impact were assessed further and upon reviewing the actual visibility of the receptors, glint and glare effects reduce to **None** at one of the receptors and **Low** at the other. Once the mitigation was considered, the resultant (residual) effects were reduced to **None** at all receptors.
- **No effects** for train drivers or railway infrastructure are predicted.
- A detailed assessment of Cambridge Airport concluded that there would be an impact at two of the four runway approach paths, however due to the low intensity of impact it is deemed an **acceptable impact** according to the FAA guidance. There is no impact at the ATCT.

8.5. The mitigation measures proposed is for a hedgerow to be installed around the perimeter of the Proposed Development.

8.6. The effects of glint and glare and their impact on local receptors has been analysed in detail and there is predicted to be **low** to **none** impacts, and therefore **No Significant Effects**.

9. APPENDICES

APPENDIX A: FIGURES

- Figure 1: Residential Receptors
- Figure 2: Road Based Receptors
- Figure 3: Infrastructure Layout
- Figure 4: Cambridge Aerodrome Chart

APPENDIX B: RESIDENTIAL RECEPTOR RESULTS

APPENDIX C: ROAD RECEPTOR RESULTS

APPENDIX D: AVIATION RECEPTOR GLARE RESULTS

APPENDIX E: PHOTO REGISTER

APPENDIX F: SOLAR MODULE GLARE AND REFLECTANCE TECHNICAL MEMO

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