Glint and Glare Assessment

Cefn Park Solar Farm

22/10/2021

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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 1km study area around the Application Site is considered adequate for the assessment of ground-based receptors, whilst a 30km study area is chosen for aviation receptors. Within 1km of the Application Site, there are 49 residential receptors and 26 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 receptors and seven road receptors were dismissed as they are located within the no reflection zones. Six aerodromes are located within the 30km study area; One of which, Hawarden Airport, required an assessment due to the Proposed Development falling within its safeguarding buffer zone, which is outlined in **paragraph 4.24**.

1.2. Geometric analysis was conducted at 34 individual residential receptors and 18 road receptors.

1.3. The assessment concludes that:

- Solar reflections are possible at eight of the 34 residential receptors assessed within the 1km study area. The initial bald-earth scenario identified potential impacts as **High** at four receptors, **Low** at four receptors, including one residential area, and **None** at the remaining 26 receptors. Upon reviewing the actual visibility of the receptors, glint and glare remains **High** at one receptor, **Low** at one receptor and reduces to **None** at all remaining receptors. Once mitigation measures were considered all impacts reduce to **Low** at one receptor and **None** at all other receptors.
- Solar reflections are possible at 11 of the 19 road receptors assessed within the 1km study area. Upon reviewing the actual visibility of the receptors, glint and glare impacts remain **High** at five receptors and reduce to **None** at all remaining receptors. Once mitigation measures were considered all impacts reduce to **None**.
- **No impact** on train drivers or railway infrastructure is predicted.
- **No impact** was found at the runway or ATCT assessed at Hawarden Airport.

1.4. Mitigation measures are required to be put in place due to the **High** impact that was found during the visibility analysis at Residential Receptor14 Road Receptors 6 – 9 and 14. This includes woodland to be planted/infilled along the southern and western boundaries of the

Western Array and hedgerows to be planted/ infilled and maintained to a height of 3-4m along the eastern boundaries of the Eastern Array.

1.5. The effects of glint and glare and their impact on local receptors has been analysed in detail and the impact on all receptors is predicted to be **Not significant**.

2. INTRODUCTION

BACKGROUND

2.1. Neo Environmental Ltd has been appointed by Novus Renewable Services Ltd (the "Applicant") to undertake a Glint and Glare Assessment for a proposed solar farm development (the "Proposed Development") on lands approximately 0.77km west of the village of Pentre Maelor, 1.25km northeast of the village of Marchwiel and 1.84km north of the village of Cross Lanes (the "Application Site").

PROPOSED DEVELOPMENT DESCRIPTION

2.2. The Proposed Development will consist of the construction of PV panels mounted on metal frames, Access Tracks, Substation, Security Gates, Temporary Compound, Perimeter Fencing, Batteries and ancillary infrastructure.

SITE DESCRIPTION

2.3. The area of the Proposed Development (the "Application Site") comprises of approximately 14.8ha of land contained within nine fields. The field boundaries consist of a mixture of trees and hedgerows. Ground levels within the Application Site vary from approximately 34m AOD at the southern corner to 42m AOD at the eastern boundary of the Application Site.

2.4. The Application Site is centred at approximate grid reference E336789, N348625. The wider landscape contains the village of Pentre Maelor, which is located c. 0.77km to the east of the Application site.

2.5. The Proposed Development is adjacent to the existing Solar Park at the Maelor Gas Works in Marchwiel to the southwest and the existing Wrexham Solar Park to the east.

SCOPE OF REPORT

2.6. 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.

2.7. 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.

2.8. 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.

2.9. 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
  - Figure 4: Hawarden Airport Aerodrome Chart
- Appendix B: Residential Receptor Glare Results (20deg)
- Appendix C: Residential Receptor Glare Results (25deg)
- Appendix D: Road Receptor Glare Results (20deg)
- Appendix E: Road Receptor Glare Results (25deg)
- Appendix F: Aviation Receptor Glare Results (20deg)
- Appendix G: Aviation Receptor Glare Results (25deg)
- Appendix H: Visibility Evidence Assessment
- Appendix I: Solar Module Glare and Reflectance Technical Memo[1]

STATEMENT OF AUTHORITY

2.10. This Glint and Glare Assessment has been produced by Tom Saddington, Michael McGhee and David Thomson of Neo Environmental. Having completed a civil engineering degree in 2012, Michael has produced Glint and Glare assessments for over 1GW of solar farm developments

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

across the UK and Ireland. Tom has an undergraduate degree in Bioengineering and graduated with an MSc in Environmental and Energy Engineering in January 2020. He has been working on various technical assessments including glint and glare reports for numerous solar farms in Ireland and the UK. David has an undergraduate degree in physics, as well as a MSc in sensor design and a MSc in nanoscience. He is an Environmental Engineer currently being trained in Glint and Glare assessments.

DEFINITIONS

2.11. This study examined the potential hazard and nuisance effects of glint and glare in relation to ground-based receptors, this includes the occupants of surrounding dwellings as well as road users. The FAA in their "*Technical Guidance for Evaluating Selected Solar Technologies on Airports*"[2] have defined the terms 'Glint' and 'Glare' as meaning;

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

2.12. 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

2.13. 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 I**). Similar levels of reflectance can be found in rural environments from the likes of shed roofs and the lines of plastic mulch used in cropping. In terms of the potential for reflectance from photovoltaic panels to cause hazard and/ or nuisance effects, there have been a number of studies undertaken in respect of schemes in close proximity to airports. The most recent of these was compiled by the Solar Trade Association (STA) in April 2016 and used a number of case studies and expert opinions,

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 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

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

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

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

3. LEGISLATION AND GUIDANCE

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

3.1. Paragraph 013 (Reference ID: 5-013-20150327) sets out planning considerations that relate to large scale ground-mounted solar PV farms. This determines that the deployment of large-scale solar farms can have a negative impact on the rural environment, particularly in undulating landscapes. However, the visual impact of a well-planned and well-screened solar farm can be properly addressed within the landscape if planned sensitively. Considerations to be taken into account by local planning authorities are;

- *"the proposal's visual impact, the effect on landscape of glint and glare and on neighbouring uses and aircraft safety;*
- *the extent to which there may be additional impacts if solar arrays follow the daily movement of the sun."*

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

3.2. As outlined within the BRE document 'Planning Guidance for the Development of Large-Scale Ground Mounted Solar PV Systems'[5]

"Glint may be produced as a direct reflection of the sun in the surface of the solar PV panel. It may be the source of the visual issues regarding viewer distraction. Glare is a continuous source of brightness, relative to diffused lighting. This is not a direct reflection of the sun, but rather a reflection of the bright sky around the sun. Glare is significantly less intense than glint.

Solar PV panels are designed to absorb, not reflect, irradiation. However, the sensitivities associated with glint and glare, and the landscape/ visual impact and the potential impact on aircraft safety, should be a consideration. In some instances, it may be necessary to seek a glint and glare assessment as part of a planning application. This may be particularly

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[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

3.7. 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."*

3.8. 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.

3.9. 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.

3.10. 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:

[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.

3.11. 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.

REVIEW OF LOCAL PLAN

Wrexham Unitary Development Plan

3.12. Wrexham Council adopted the Unitary Development Plan (UDP) 1996 - 2011[10] on February 14, 2005. The plan covers the administrative area of Wrexham County Borough Council. It supersedes previous adopted development plans (the Wrexham Maelor Local Plan: Forward to 2001, the Glyndwr District Local Plan, and the Clwyd Structure Plan: First Alteration).

3.13. The plan states in **Renewable Energy Policy PS12**:

'Proposals for the generation of energy from renewable sources will be supported provided that the wider environmental benefits are not outweighed by any detrimental impacts of the proposed development (including any electricity transmission facilities needed) on the landscape, public safety, and the local environment.'

3.14. There are no policies contained within this Local Development Plan which are of relevance to this Glint and Glare Assessment.

3.15. Wrexham Borough County Council are preparing the Local Development Plan (LDP) 2013 - 2028[11] which will replace the current adopted Unitary Development Plan.

3.16. The Deposit Local Development Plan (LDP) sets out the Council's proposed planning policy up to the year 2028, identifying what can be built and where. On 28 March 2018 the Council approved the Deposit LDP, together with the supporting documents including the

[10] Wrexham Unitary Development Plan. Available at: https://www.wrexham.gov.uk/service/development-plans-and-other-planning-policy/wrexham-unitary-development-plan

[11] Draft Wrexham Local Development Plan. Available at: https://wrexham-consult.objective.co.uk/portal/ldp/dldp/local_development_plan

Sustainability Appraisal Report for public consultation. The consultation ran for a seven week period between 9th April and 31st May 2018 and was extended until 16th July 2018 to allow for comments to be made on additional information added to the consultation portal.

3.17. There are no policies contained within this draft LDP which are of relevance to this Glint and Glare Assessment.

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

Solar Reflection Model

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

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

4.7. On knowing the vector of the solar reflection, the azimuth is calculated and the horizontal reflection from multiple points within the solar farm. These are then compared with the azimuth and horizontal angle of the receptor from the solar farm to determine if it is within range to receive solar reflections.

4.8. The solar reflection in the model is considered to be specular as a worst-case scenario. In practice the light from the sun will not be fully reflected as solar panels are designed to absorb light rather than reflect it. The text above and **Appendix I** outlines the reflective properties of solar glass and compares it to other reflective surfaces. Although the exact figures in this report could be argued, it is included as a visual guide and it agrees with most other reports, in that solar glass has less reflective properties than other types of glass 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[13] of viewed glare can be classified into three levels based on the retinal irradiance and subtended source angle: low potential for after-image (green), potential for after-image (yellow), and potential for permanent eye damage (red).

4.13. Green glare can be ignored when looking at 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.

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

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 between 20 and 25 degrees.

4.16. The height of the panels above ground level is a maximum of 3.1m and points at the top of the panels are used to determine the potential for glint and glare generation.

Identification of Receptors

Ground Based Receptors

4.17. 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 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.

4.19. 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[14] 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.

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[14] 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 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.

5.5. There are six residential receptors (Receptors 35 - 49) which are within the no-reflection zones and are clearly identifiable in **Figure 1: Appendix A.** The process of how these are calculated is explained in **paragraphs 5.1 to 5.2** of this report.

Table 5 - 1: Residential Based Receptors

Receptor	Easting	Northing	Glint and Glare Possible
1	336048	349503	Yes
2	336094	349422	Yes
3	335875	349370	Yes
4	335636	349199	Yes
5	335700	349153	Yes
6	335654	349082	Yes
7	335587	349077	Yes

8	335602	349043	Yes
9	335557	349045	Yes
10	336094	348970	Yes
11	336049	348807	Yes
12	336010	348771	Yes
13	336431	348694	Yes
14	336579	348498	Yes
15	336600	348490	Yes
16	335712	347986	Yes
17	335774	347978	Yes
18	335823	347993	Yes
19	335848	347922	Yes
20	335827	347881	Yes
21	337481	348118	Yes
22	337190	348374	Yes
23	337267	348823	Yes
24	337309	348912	Yes
25	337293	348947	Yes
26	337201	348882	Yes
27	337139	348927	Yes
28	337195	349011	Yes
29	337309	349088	Yes
30	337433	349146	Yes
31	337346	349003	Yes
32	337335	348962	Yes
33	337514	349034	Yes
34	337532	349072	Yes
35	336045	347729	No

36	336100	347704	No
37	336164	347672	No
38	336331	347611	No
39	337387	347731	No
40	337175	349075	No
41	337263	349129	No
42	337003	348933	No
43	336941	348990	No
44	336943	349154	No
45	336990	349156	No
46	337059	349653	No
47	336827	349541	No
48	336576	349541	No
49	336507	349770	No

Road / Rail Receptors

5.1. There are no railway lines within the 1km study area around the site which require assessment and therefore the impact on railway infrastructure is **None**.

5.2. There are four roads within the 1km study area that require a detailed Glint and Glare Assessment; Cefn Road to the south of the Proposed Development, Sesswick Way to the South of the Proposed Development, Clyweldog Road South to the east of the Proposed Development and Bridge Road South to the east of the Proposed Development. 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.

5.3. 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.

5.4. **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	335644	349217	Yes
2	335822	349126	Yes
3	335977	349003	Yes
4	336153	348909	Yes
5	336311	348787	Yes
6	336441	348637	Yes
7	336603	348520	Yes
8	336795	348465	Yes
9	336992	348447	Yes
10	337124	348335	Yes
11	337157	348138	Yes
12	337052	348905	Yes
13	337099	348711	Yes
14	337152	348523	Yes
15	337248	348680	Yes
16	337336	348860	Yes
17	337495	348976	Yes
18	337636	349109	Yes
19	337765	349262	Yes
20	337297	349786	No
21	337290	349616	No
22	337161	349464	No
23	337061	349291	No
24	337008	349100	No
25	337188	347940	No
26	337219	347742	No

Aviation Receptors

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

Table 5 - 3: Airfields within close proximity

Airfield	Distance	Use
Chirk Helipad	11.37	Helipad
Hawarden Airport	15.94	Licensed Aerodrome
Llandegla	18.12	Small grass strip
Sleap	24.34	Licensed Aerodrome
Knockin	25.23	Small grass strip
Ashcroft Airfield	28.49	Unlicensed small grass strip

5.6. Hawarden Airport requires a detailed assessment due to this airfield being within its respective safeguarding buffer zone outlined in **paragraph 4.24.**

Hawarden Airport

5.1. Hawarden Airport (ICAO code EGNR) is designated as an IFR/VFR Aerodrome. It is located approximately 3.5NM (6.5km) west-southwest of Chester.

5.2. The elevation of the aerodrome at the Aerodrome Reference Point (ARP) is 45ft (13.72m). It has one grooved concrete and asphalt runway, details of which are given in **Table 5 - 4**.

Table 5 - 4: Runways at Hawarden Airport

Runway Designation	True Bearing (°)	Length (m)	Width (m)
04	040.99	2093	45
22	221.00	2093	45

5.3. The threshold location and height of the runway at Hawarden Airport are given in **Table 5 - 5**.

Table 5 - 5: Runway Threshold Locations and Heights

Runway Designation	Threshold Latitude	Threshold Longitude	Height AOD (m)
04	53° 10′ 23.65″ N	002° 59′ 04.94″ W	9.63
22	53° 10′ 58.86″ N	002° 58′ 14.02″ W	5.18

5.4. The ARP is located at the centre of Runway 04/22. The actual location of the ARP and the ATCT is given in **Table 5 - 6**. The height of the ATCT is estimated to be 8m.

Table 5 - 6: Hawarden Airport Reference Point

	Latitude	Longitude	Eastings	Northings
ARP	53° 10’ 41.18’’ N	002° 58’ 39.56’’ W	334757	365003
ATCT	53° 10’ 34.26’’ N	002° 59’ 10.51’’ W	334180	364797

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 and C** shows the analysis with the solar panels between a tilt angle of 20 – 25 degrees. **Table 6 - 1** shows the worst-case impact at each receptor.

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

Receptor	Glint Possible from Site		Potential Glare Impact (per year)		Magnitude of Impact	Worst Case Tilt
	AM	PM	Minutes	Hours		
1	No	No	0	0	None	N/A
2	No	No	0	0	None	N/A
3	No	No	0	0	None	N/A
4	No	No	0	0	None	N/A
5	No	No	0	0	None	N/A
6	No	No	0	0	None	N/A
7	No	No	0	0	None	N/A
8	No	No	0	0	None	N/A

9	No	No	0	0	**None**	N/A
10	No	No	0	0	**None**	N/A
11	Yes	No	591	9.85	**Low**	20
12	Yes	No	899	14.98	**Low**	20
13	Yes	No	5349	89.15	**High**	20
14	Yes	No	4501	75.02	**High**	20
15	Yes	No	3528	58.80	**High**	20
16	No	No	0	0	**None**	N/A
17	No	No	0	0	**None**	N/A
18	No	No	0	0	**None**	N/A
19	No	No	0	0	**None**	N/A
20	No	No	0	0	**None**	N/A
21	No	Yes	458	7.63	**Low**	20
22	No	Yes	2155	35.92	**High**	20
23	No	Yes	115	1.92	**Low**	25
24	No	No	0	0	**None**	N/A
25	No	No	0	0	**None**	N/A
26	No	No	0	0	**None**	N/A
27	No	No	0	0	**None**	N/A
28	No	No	0	0	**None**	N/A
29	No	No	0	0	**None**	N/A
30	No	No	0	0	**None**	N/A
31	No	No	0	0	**None**	N/A
32	No	No	0	0	**None**	N/A
33	No	No	0	0	**None**	N/A
34	No	No	0	0	**None**	N/A

6.5. As can be seen in **Table 6 - 1,** there is a **High** impact at four receptors, **Low** impact at four receptors, including one residential area, and **None** impact for the remaining 26 receptors, including one residential area. **Appendix B and C** shows detailed analysis of when the glare impacts are possible, whilst also showing which parts of the solar farm the solar glare is reflected from.

6.6. **Appendix H** shows Google Earth images that give an insight into how each receptor will be impacted by 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. Also, where appropriate images that have been taken from within the Application Site have been used to show up to date imagery.

Receptors 11 and 12

6.7. The 'Glare Reflections on PV Footprint' chart in **Appendix B** shows that reflections from the northern half of the Eastern Array and a small northern section of the Western Array of the Proposed Development can potentially impact on the receptors.

6.8. The first image in **Appendix H** is an aerial view which shows the location of the receptors (yellow pins) in relation to the Proposed Development, and the location from which the second image was taken (red pin). The second image is a street view image with a view towards the Proposed Development. This image confirms that there is sufficient intervening vegetation, topography and buildings to screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact reduces to **None**.

Receptor 13

6.9. The 'Glare Reflections on PV Footprint' chart in **Appendix B** shows that reflections from the northern half of the Eastern Array and a northern section of the Western Array of the Proposed Development can potentially impact on the receptor.

6.10. The first image in **Appendix H** is an aerial view which shows the location of the receptor (yellow pin) in relation to the Proposed Development. The second image has been taken from within the Western Array with a view towards the receptor and of the vegetation located along the northern boundary of the Western Array. The second image shows that the vegetation will screen the majority of the views into the Proposed Development, with there only being limited views where glint and glare is possible. Therefore, the impact reduces to **Low**.

Receptor 14

6.11. The 'Glare Reflections on PV Footprint' chart in **Appendix B** shows that reflections from the southern half of the Eastern Array and a small southern section of the Western Array of the Proposed Development can potentially impact on the receptor.

6.12. The first image in **Appendix H** is an aerial view which shows the location of the receptors (yellow pins) in relation to the Proposed Development, and the location from which the second image was taken (red pin). The second image is a street view image with a view towards the Proposed Development. This image confirms that there is insufficient vegetation to screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact remains **High**.

Receptor 15

6.13. The 'Glare Reflections on PV Footprint' chart in **Appendix B** shows that reflections from the southern half of the Eastern Array and a small southern section of the Western Array of the Proposed Development can potentially impact on the receptors.

6.14. The first image in **Appendix H** is an aerial view which shows the location of the receptors (yellow pins) in relation to the Proposed Development, and the location from which the second image was taken (red pin). The second image is a street view image with a view towards the receptor. This image confirms that there is sufficient vegetation to screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact reduces to **None**.

Receptor 21

6.15. The 'Glare Reflections on PV Footprint' chart in **Appendix B** shows that reflections from the western boundary of the Western Array of the Proposed Development can potentially impact on the receptor.

6.16. The first image in **Appendix H** is an aerial view which shows the location of the receptor (yellow pin) in relation to the Proposed Development, and the location from which the second image was taken (red pin). The second image is a street view image with a view towards the receptor. This image confirms that there is sufficient vegetation to screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact reduces to **None**.

Receptor 22

6.17. The 'Glare Reflections on PV Footprint' chart in **Appendix B** shows that reflections from the western half of the of the Western Array of the Proposed Development can potentially impact on the receptor.

6.18. The first image in **Appendix H** is an aerial view which shows the location of the receptor (yellow pin) in relation to the Proposed Development, and the location from which the second image was taken (red pin). The second image is a street view image with a view towards the receptor. This image confirms that there is sufficient vegetation to screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact reduces to **None**.

Receptor 23

6.19. The 'Glare Reflections on PV Footprint' chart in **Appendix B** shows that reflections from a small northern section of the Eastern Array of the Proposed Development can potentially impact on the receptor.

6.20. The first image in **Appendix H** is an aerial view which shows the location of the receptor (yellow pin) in relation to the Proposed Development, and the location from which the second image was taken (red pin). The second image is a street view image with a view towards the receptor. This image confirms that there is sufficient vegetation to screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact reduces to **None**.

Residential Area 1

6.21. This encompasses a number of residential receptors including those at Receptors 23 – 34 and (assessed previously) (See **Figure 1: Appendix A**). Each receptor assessed represents multiple receptors as they are in close proximity of each other, so the worst-case scenario is assumed for the impact of glint and glare. All receptors were considered within the visibility analysis, and it was concluded their impacts were similar. As per the assessments of these ten receptors, the impacts on the other receptors within this area are assessed as being **None (worst case scenario)**

Road Receptors

6.22. **Table 6 - 2** shows a summary of the modelling results for each of the Road Receptor Points whilst the detailed results and ocular impact charts can be viewed in **Appendix D and E**.

6.23. The seven receptors within the no-reflection zones outlined previously have been excluded from the detailed modelling as they will never receive glint and glare impacts from the Proposed Development.

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

Receptor	Green Glare (mins)	Yellow Glare (mins)	Red Glare (mins)	Magnitude of Impact	Worst Case Tilt

1	0	0	0	None	N/A
2	0	0	0	None	N/A
3	0	0	0	None	N/A
4	115	145	0	High	20
5	50	1286	0	High	20
6	9	6849	0	High	20
7	0	5701	0	High	20
8	0	291	0	High	20
9	0	2143	0	High	20
10	0	1493	0	High	20
11	0	0	0	None	N/A
12	0	0	0	None	N/A
13	0	3293	0	High	25
14	3	5946	0	High	20
15	50	2958	0	High	20
16	0	1	0	High	25
17	0	0	0	None	N/A
18	0	0	0	None	N/A
19	0	0	0	None	N/A

6.24. As can be seen in **Table 6 - 2**, there are 11 receptor points which have potential glare impacts with the "potential for after-image" (yellow glare), which is a **High** impact. **Appendix D and E** show detailed analysis of when the glint and glare impacts are possible, whilst also showing from which parts of the solar farm the solar glare is reflected from.

6.25. **Appendix H** shows Google Earth images that give an insight into how each receptor will be impacted by glint and glare from the Proposed Development. There is a mixture of images used, which include aerial, ground level and street level. The aerial images show the location of the receptor with the solar farm drawn as a white polygon and can be seen on the images when the solar farm is theoretically visible. The area of the solar farm from where reflections may be possible has been drawn as a yellow polygon. The ground level terrain is based on the height data of the surrounding land showing no intervening vegetation or buildings. The white and yellow polygons can be seen in this view also. The street view gives a good indication as to whether the area of the solar farm where reflections are theoretically possible will be visible from the receptor point.

6.26. As can be seen in **Appendix H**, views of the Proposed Development from all receptors, except receptors 6 – 9 and 14, are blocked by a mixture of intervening vegetation, topography and buildings. Therefore, impacts upon these receptors reduce to **None**.

Aviation Receptors

6.1. **Table 6 - 3** overleaf shows a summary of the modelling results for each of the runway approach paths, whilst the detailed results and ocular impact charts can be viewed in **Appendix F and G.**

Table 6 - 3: Summary of Glare Results

Component	Green Glare (mins)	Yellow Glare (mins)	Red Glare (mins)	Worse Case Tilt
Hawarden Airport				
Runway 04	0	0	0	N/A
Runway 22	0	0	0	N/A
ATCT	0	0	0	N/A

6.2. As can be seen in **Table 6 - 3**, there is no Glint and Glare predicted at Hawarden Airport. Therefore, the impact on all aviation receptors is **None.**

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 Residential Receptor 14 and Road Receptors 6 – 9 and 14. These measures include:

- As shown on the site layout (see **Figure 3: Appendix A**) there is proposed woodland planting along the southern boundary of the Proposed Development and along a small western section of the Western Array. Once implemented this will screen all views of the Proposed Development from Residential Receptor 14 and Road Receptors 6 – 9 and reduce the impacts to **None**.
- Hedgerows along the eastern boundaries of the Eastern Array be planted/infilled and maintained to a height of at least 3-4m. Once implemented this will screen all views of the Proposed Development from Road Receptor 14 and reduce the impacts to **None**.

7.2. **Table 7 - 1 and Table 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	None	None	None
2	None	None	None
3	None	None	None
4	None	None	None
5	None	None	None
6	None	None	None
7	None	None	None
8	None	None	None
9	None	None	None
10	None	None	None
11	Low	None	None

12	Low	None	None
13	High	Low	Low
14	High	High	None
15	High	None	None
16	None	None	None
17	None	None	None
18	None	None	None
19	None	None	None
20	None	None	None
21	Low	None	None
22	High	None	None
23	Low	None	None
24	None	None	None
25	None	None	None
26	None	None	None
27	None	None	None
28	None	None	None
29	None	None	None
30	None	None	None
31	None	None	None
32	None	None	None
33	None	None	None
34	None	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	None	None	None

2	None	None	None
3	None	None	None
4	High	None	None
5	High	None	None
6	High	High	None
7	High	High	None
8	High	High	None
9	High	High	None
10	High	None	None
11	None	None	None
12	None	None	None
13	High	None	None
14	High	High	None
15	High	None	None
16	High	None	None
17	None	None	None
18	None	None	None
19	None	None	None

7.3. **Table 7 - 3 and Table 7 - 4** overleaf show the overall impacts for all residential and road receptors.

Table 7 - 3: Solar Reflections: Residential Receptors

Magnitude	Theoretical Visibility	Actual Visibility (No Mitigation)	Actual Visibility with Mitigation
High	4	1	0
Medium	0	0	0
Low	4	1	1
None	26	32	33

- **High –** Solar reflections impacts of over 30 hours per year or over 30 minutes per day
- **Medium -** Solar reflections impacts between 20 and 30 hours per year or between 20 minutes and 30 minutes per day
- **Low -** Solar reflections impacts between 0 and 20 hours per year or between 0 minutes and 20 minutes per day
- **None -** Effects not geometrically possible or no visibility of reflective surfaces likely due to high levels of intervening screening

Table 7 - 4: Solar Reflections: Road Receptors

Magnitude	Theoretical Visibility	Actual Visibility (No Mitigation)	Actual Visibility with Mitigation
High	11	5	0
Medium	0	0	0
Low	0	0	0
None	8	14	19

- **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

8. CUMULATIVE ASSESSMENT

8.1. The Proposed Development is adjacent to an existing solar farm which are southeast and south of the Proposed Development. Impacts are **Low** upon Residential Receptor 13, so a cumulative assessment has been considered. However, upon review of the actual visibility of the existing solar farms, it has been concluded that this will not be visible from the receptor. Therefore, it is **anticipated that there will not be any cumulative effects** on rail receptors as a result of the construction of the Proposed Development.

9. SUMMARY

9.1. 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.

9.2. This assessment considers the potential impacts on ground-based receptors such as roads, rail and residential dwellings as well as aviation assets. A 1km study area around the Application Site is considered adequate for the assessment of ground-based receptors, whilst a 30km study area is chosen for aviation receptors. Within 1km of the Application Site, there are 49 residential receptors and 26 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 receptors and seven road receptors were dismissed as they are located within the no reflection zones. Six aerodromes are located within the 30km study area; One of which, Hawarden Airport, required an assessment due to the Proposed Development falling within its safeguarding buffer zone, which is outlined in **paragraph 4.24**.

9.3. Geometric analysis was conducted at 34 individual residential receptors and 18 road receptors.

9.4. The assessment concludes that:

- Solar reflections are possible at eight of the 34 residential receptors assessed within the 1km study area. The initial bald-earth scenario identified potential impacts as **High** at four receptors, **Low** at four receptors, including one residential area, and **None** at the remaining 26 receptors. Upon reviewing the actual visibility of the receptors, glint and glare remains **High** at one receptor, **Low** at one receptor and reduces to **None** at all remaining receptors. Once mitigation measures were considered all impacts reduce to **Low** at one receptor and **None** at all other receptors.

- Solar reflections are possible at 11 of the 19 road receptors assessed within the 1km study area. Upon reviewing the actual visibility of the receptors, glint and glare impacts remain **High** at five receptors and reduce to **None** at all remaining receptors. Once mitigation measures were considered all impacts reduce to **None**.

- **No impact** on train drivers or railway infrastructure is predicted.

- **No impact** was found at the runway or ATCT assessed at Hawarden Airport.

9.5. Mitigation measures are required to be put in place due to the **High** impact that was found during the visibility analysis at Residential Receptor14 Road Receptors 6 – 9 and 14. This includes woodland to be planted/infilled along the southern and western boundaries of the Western Array and hedgerows to be planted/ infilled and maintained to a height of 3-4m along the eastern boundaries of the Eastern Array.

9.6. The effects of glint and glare and their impact on local receptors has been analysed in detail and the impact on all receptors is predicted to be **Not significant**.

10. APPENDICES

Appendix A: Figures

- Figure 1: Residential Receptor Map
- Figure 2: Road Receptor Map
- Figure 3: Site Layout
- Figure 4: Hawarden Airport Aerodrome Chart

Appendix B: Residential Receptor Glare Results (20deg)

Appendix C: Residential Receptor Glare Results (25deg)

Appendix D: Road Receptor Glare Results (20deg)

Appendix E: Road Receptor Glare Results (25deg)

Appendix F: Road Receptor Glare Results (20deg)

Appendix G: Road Receptor Glare Results (25deg)

Appendix H: Visibility Assessment Evidence

Appendix I: Solar Module Glare and Reflectance Technical Memo[15]

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

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