# Technical Appendix 6: Glint and Glare Assessment

Ballyteige Solar Farm amendment (Planning ref. 2198)

Original Report: 28/08/2020

Amendment: 24/11/2025

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# EXECUTIVE SUMMARY

6.1 There is no guidance or policy available across Ireland in relation to the assessment of glint and glare from a Proposed Development. However, as identified by UK policy, it is recognised as a potential impact which needs to be considered for a proposed solar development.

6.2 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 1km of the Application Site, there are 53 residential receptors, including six residential areas, and 21 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 the glint and glare analysis 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 included in the glint and glare analysis with some context to all receptors given in the visual analysis. 20 residential receptors, including two residential area, and nine road receptors were dismissed as they are located within the no reflection zones and therefore, will not be impacted upon by the Proposed Development. The Grand Canal has been considered for a visibility assessment due to its proximity to the Proposed Development. Four aerodromes are located within 30km of the Proposed Development: Ballyduff Airfield, Clonbullogue Airfield, Limetree Airfield and Eyne Airfield. One aerodrome, Clonbullogue Airfield, requires a detailed assessment due to its size and orientation in relation to the Proposed Development.

6.3 The solar panels will face south and will be inclined at an angle of between 10 and 20 degrees. The maximum above ground level height of the panels is 2.5m and points at the top of the panels are used to determine the potential for glint and glare generation.

6.4 Geometric analysis was conducted for 33 individual residential receptors, including four residential areas, and 12 road receptors as well as two runway approach paths.

6.5 Following an initial assessment, rail receptors were scoped out as assets that will be impacted upon from the Proposed Development as no rail receptors fell within the 1km study area. The assessment concludes that:

- Solar reflections are possible at 10 of the 33 residential receptors assessed within the 1km study area. Initial impacts were **Medium** at four receptors, including one residential area, **Low** at six receptors and **None** at the remaining 23 receptors, including three residential areas. Upon reviewing the actual visibility of the receptors, glint and glare impacts reduce to **None** at all receptors, including four residential areas.

- Solar reflections are possible at 10 of the 12 road receptors assessed within the 1km study area. Initial impacts were **Low** at 10 receptors and **None** at the remaining two receptors. Upon reviewing the actual visibility of the receptors, glint and glare impacts reduce to **None** at all receptors.

- **No impact** on train drivers or railway infrastructure is predicted.
- **No impact** on the Grand Canal boat drivers is predicted.
- Only green glare is predicted to impact upon the Runway 27 approach path at Clonbullogue Airfield. Green glare is an **acceptable impact** when pilots are approaching runways/helipads, according to FAA guidance. No glare impacts are predicted upon the Runway 09 approach path at Clonbullogue Airfield. Therefore, the impact on aviation assets is **Low** and **Not Significant**.

6.6 Mitigation measures are not required due to all impacts upon ground-based receptors being **None**.

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

# INTRODUCTION

## Background

6.8 Neo Environmental Ltd has been appointed by Renewable Energy Systems (RES) Ltd on behalf of Ballyteige Solar Limited (the "Applicant") to undertake a Glint and Glare assessment for the revised proposed solar farm layout (the "Proposed Development") in the townlands of Ballyteige Little, Ballyteige Big and Colehill, Tullmaore, Co. Offaly (the "Application Site").

6.9 Please see **Figure 203 of Volume 2** for the layout of the Proposed Development.

## Development Description

6.10 The Proposed Development will consist of an amendment to a previously consented development (planning reference: 2198). The proposed amendment seeks minor modifications to the Consented development in relation to the following, which could impact the Glint & Glare assessment:

- Removal of the 38kV substation and infrastructure within the most northern field (Field 1),
- Table layout updated (reduced),
- PV angle reduced from 10º and 30º to 10º and 20º,

## Site Description

6.11 The Application Site is located in a rural setting, approximately 4.8km east of Tullamore and 3.9km northwest of Ballinagar. The main Grand Canal runs in a general east to west direction, circa 150m to the south of the Proposed Development (at its closest point). A narrower section of the canal runs northwest to southeast to the west of, and paralleled to, the Wood of O road circa 350m to the east of the main application site. Centred at approximate Irish Grid Reference (IGR) N 39618 26489, the Application Site is relatively flat and lies at an elevation of approximately 68 – 74m above ordnance datum (AOD), covering a total area of circa 60.53ha.

6.12 Comprising 16 fields, the Application Site primarily consists of pastureland, with one field to the southwest corner under arable crop. Fields are bound by a mixture of trees, hedgerows and post-and-wire fencing. Access to the Application Site is gained from the Wood of O road to the east of the Application Site.

## Scope of Report

6.13 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.

6.14 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.

6.15 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.

6.16 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 6A: Figures
  - Figure 6.1: Residential Receptors
  - Figure 6.2: Road Based Receptors
- Appendix 6B: Residential Receptor Glare Results (10 degrees)
- Appendix 6C: Residential Receptor Glare Results (20 degrees)
- Appendix 6D: Road Receptor Glare Results (10 degrees)
- Appendix 6E: Road Receptor Glare Results (20 degrees)
- Appendix 6F: Aviation Receptor Glare Results (10 degrees)
- Appendix 6G: Aviation Receptor Glare Results (20 degrees)
- Appendix 6H: Visibility Assessment Evidence
- Appendix 6I: Solar Module Glare and Reflectance Technical Memo[1]

## Statement of Authority

6.17 This Glint and Glare Assessment has been produced by Tom Saddington, Michael McGhee and David Thomson of Neo Environmental.

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

6.18 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.

6.19 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.

6.20 David has an undergraduate degree in physics, as well as a MSc in sensor design, a MSc in nanoscience and nanotechnology and a Diploma in acoustics and noise control. He is an Environmental Engineer who has worked on numerous glint and glare assessments for solar farms across the UK and Ireland.

## Definitions

6.21 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*"

6.22 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

6.23 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 6I** for details). Similar levels of reflectance can be found in rural environments from shed roofs and

[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 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

6.24 Locations in this report were given in Eastings and Northings using the 'OSNI 1952 Irish National Grid' grid reference system unless otherwise stated. Ireland uses Irish Standard Time (IST, 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 were in GMT, however if reference was made to a time which falls within the IST then this was outlined in the report.

[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

# LEGISLATION AND GUIDANCE

## Planning Policy

6.25 The National Planning Framework (NPF) was adopted by the Irish Government on the 29th of May 2018. However, this policy document provides no current provision within the Irish Planning System for the requirement of Glint and Glare Assessments to support applications for the installation of ground mounted solar PV systems. It is therefore considered appropriate to defer to extant policy guidance within the UK planning system; the National Planning Policy Guidance (NPPG) on Renewable and Low Carbon Energy[4].

6.26 Paragraph 013 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."*

## Interim CAA Guidance – Solar Photovoltaic Systems (2010)

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

6.28 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

[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] *CAA (2010) Interim CAA Guidance – Solar Photovoltaic Systems. Available at:* *https://webarchive.nationalarchives.gov.uk/ukgwa/20141202114709/https://www.caa.co.uk/docs/697/srg_asd_solarphotovoltaicsystguidance.pdf*

Order (ANO), published in 2016 and amended in 2022. In particular, developers should be cognisant of the following articles of the ANO[6], including:

- ***Article 240*** *– Endangering safety of an aircraft – "A person must not recklessly or negligently act in a manner likely to endanger an aircraft, or any person in an aircraft."*
- ***Article 224*** *- Lights liable to endanger – "A person must not exhibit in the United Kingdom any light which:*
  - *a) by reason of its glare is liable to endanger aircraft taking off or from landing at an aerodrome; or*
  - *b) by reason of its liability to be mistaken for an aeronautical ground light liable to endanger aircraft"*
- ***Article 225*** *– Lights which dazzle or distract – "A person must not in the United Kingdom direct or shine any light at any aircraft in flight so as to dazzle or distract the pilot of the aircraft."*

6.29 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).

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

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

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

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

*"Its purpose is to protect:*

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

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

[6] CAA (2016) Air Navigation: The Order and Regulations. Available at: https://www.legislation.gov.uk/uksi/2017/1112/contents/made

[7] Civil Aviation Authority (2020). CAP738 – Safeguarding of Aerodromes 3rd Edition. Available at: https://www.caa.co.uk/publication/download/12346

*"Policy*

*1. In 2010 the CAA published interim guidance on Solar Photovoltaic Cells (SPCs). At that time, it was agreed that we would review our policy based on research carried out by the Federal Aviation Authorities (FAA) in the United States, in addition to reviewing guidance issued by other National Aviation Authorities. New information and field experience, particularly with respect to compatibility and glare, has resulted in the FAA reviewing its original document 'Technical Guidance for Evaluating Selected Solar Technologies on Airports', which is likely to be subject to change, see link;*

*https://www.federalregister.gov/documents/2013/10/23/2013-24729/interimpolicy-faa-review-of-solar-energy-system-projects-on-federally-obligated-airports*

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

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

## US Federal Aviation Administration Policy

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

*"Depending on site specifics (e.g., existing land uses, location and size of the project) an acceptable evaluation could involve one or more of the following levels of assessment:*

*(1) A qualitative analysis of potential impact in consultation with the Air Traffic Control Tower, pilots, and airport officials*

*(2) A demonstration field test with solar panels at the proposed site in coordination with Air Traffic Control Tower personnel*

*(3) A geometric analysis to determine days and times when there may be an ocular impact."*

6.36 The interim policy (Federal Register, 2013)[9] demands that an ocular impact assessment must be assessed at 1-minute intervals from when the sun rises above the horizon until the sun sets below the horizon. Specifically, the developer must use the 'Solar Glare Hazard Analysis Tool'

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

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

(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.

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

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

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

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

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

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

> *"Initially, FAA believed that solar energy systems could introduce a novel glint and glare effect to pilots on final approach. FAA has subsequently concluded that in most cases, the glint and glare from solar energy systems to pilots on final approach is similar to glint and glare pilots*

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

*routinely experience from water bodies, glass-façade buildings, parking lots, and similar features. However, FAA has continued to receive reports of potential glint and glare from on-airport solar energy systems on personnel working in ATCT cabs."*

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

## Offaly County Development Plan 2021 - 2027

6.42 The Offaly County Development Plan 2021 – 2027[11] was adopted on 10th September 2021 and came into effect 20th October 2021.

6.43 The plan states in **Section 3.1.6** that:

*'Offaly County Council recognises the potential economic benefit of a transition from fossil fuel based energy production through to investment in renewable energy, the promotion of the green enterprise sector and the creation of green collar jobs; all components of a local 'smart green economy'.'*

6.44 The plan states in **Policy CAEP-25** that:

*'It is Council policy to encourage and facilitate the production of energy from renewable sources, such as from bioenergy, waste material, solar, hydro, geothermal and wind energy, subject to proper planning and environmental considerations'*

6.45 The plan states the following in **Section 13.9.12: DMS-110 Solar Farms** in relation to Glint and Glare:

*'The Council will consider the following factors in assessing a planning application for a solar farm;*

- *The effect of glint and glare on landscapes, traffic and aircraft safety.'*

[11] Offaly County Development Plan 2021 – 2027, available at: https://www.offaly.ie/eng/Services/Planning/County-Development-Plan-2021-2027/Stage-4-Final-Plan/Volume%20I%20Written%20Statement.html

# METHODOLOGY

6.46 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

6.47 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

6.48 The position of the sun is calculated at one-minute intervals of a typical year, in this instance the year assessed is 2025.

6.49 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.

6.50 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.

6.51 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.

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

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

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

6.53 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 6I** 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.

6.54 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.

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

## Determination of Ocular Impact

6.56 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.

6.57 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.

6.58 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).

[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).

6.59 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 (ATCT), but not for when affecting pilots. Therefore, it can be assumed that green glare is acceptable for ground-based receptors.

6.60 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.

### Relevant Parameters of the Proposed Development

6.61 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 10 and 20 degrees.

6.62 The maximum above ground level height of the panels is 2.5m 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

6.63 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.

6.64 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.

6.65 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.

6.66 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 has been analysed in detail with the worst-case impacts attributed to that receptor.

### Aviation

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

6.68 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.

6.69 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

6.70 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)

6.71 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.

6.72 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 ALP.

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

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

6.74 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."*

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

## Moving Receptors (Aviation)

### Approach Paths

6.76 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.

6.77 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

[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

horizontal field of view measured in degrees left and right from directly in front of the cockpit. The vertical field of view (VFOV) refers to the extents of the pilot's vertical field of view measured in degrees from directly in front of the cockpit. The HFOV is modelled at 50 degrees left and right from the front of the cockpit whilst the VFOV is modelled at 30 degrees.

6.78 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)

6.79 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.

6.80 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 basis and will depend on the operations at a particular aerodrome.

6.81 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

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

- The model does not consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc;
- The model does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results;
- Due to variations in atmospheric composition, temperature, pressure and conditions, observed values may vary slightly from calculated positions;
- The model does not account for the effects of diffraction; however, buffers are applied as a factor of safety; and

- The model assumes clear skies at all times and does not account for meteorological effects such as cloud cover, fog, or any other weather event which may screen the sun.

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

# BASELINE CONDITIONS

## Ground Based Receptors Reflection Zones

6.84 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.

6.85 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 Development within this arc have the potential to be seen by receptors at or near ground level.

6.86 Further analysis showed that this will only occur between the azimuth of 238.92 degrees and 298.18 degrees in the western direction (late day reflections) and 64.36 degrees and 129.27 degrees in the eastern direction (morning reflections) and therefore any ground-based receptor outside these arcs will not have any impact from solar reflections.

6.87 **Figure 6.1 and 6.2 of Appendix 6A** 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 6.84 to 6.86.**

## Residential Receptors

6.88 Residential receptors located within 1km of the Application Site have been identified in **Table 6 - 1** below. Glint was assumed to be possible if the receptor is located within the ground-based receptor zones outlined previously. The number in brackets indicates which residential area the receptor belongs.

6.89 There are 20 residential receptors (Receptors 34 - 53) which are within the no-reflection zones and is clearly identifiable in **Figure 6.1: Appendix 6A**. The process of how these are calculated is explained in **paragraphs 6.84 to 6.86** of this report.

Table 6 - 1: Residential Based Receptors

| Receptor | Easting | Northing | Glint and Glare Possible |
|---|---|---|---|
| 1 | 238746 | 226594 | Yes |
| 2 (1) | 238635 | 226272 | Yes |
| 3 (1) | 238562 | 226199 | Yes |
| 4 (1) | 238476 | 226269 | Yes |

| Receptor | Easting | Northing | Glint and Glare Possible |
|---|---|---|---|
| 5 (1) | 238359 | 226251 | Yes |
| 6 (1) | 238252 | 226212 | Yes |
| 7 (1) | 238315 | 226151 | Yes |
| 8 (1) | 238317 | 226051 | Yes |
| 9 (1) | 238320 | 226000 | Yes |
| 10 | 238579 | 225473 | Yes |
| 11 | 238637 | 225473 | Yes |
| 12 (2) | 238833 | 225475 | Yes |
| 13 (2) | 238939 | 225519 | Yes |
| 14 | 240770 | 225651 | Yes |
| 15 | 241397 | 225375 | Yes |
| 16 | 241426 | 225552 | Yes |
| 17 (3) | 241582 | 226633 | Yes |
| 18 (3) | 241605 | 226756 | Yes |
| 19 | 241394 | 227024 | Yes |
| 20 (4) | 241270 | 227036 | Yes |
| 21 (4) | 241226 | 226964 | Yes |
| 22 (4) | 241156 | 227022 | Yes |
| 23 (4) | 241058 | 227023 | Yes |
| 24 | 240884 | 227045 | Yes |
| 25 | 240712 | 227124 | Yes |
| 26 | 240593 | 227117 | Yes |
| 27 | 240562 | 227133 | Yes |

| Receptor | Easting | Northing | Glint and Glare Possible |
|---|---|---|---|
| 28 | 240426 | 227297 | Yes |
| 29 | 239672 | 227082 | Yes |
| 30 | 240054 | 226818 | Yes |
| 31 | 240179 | 226586 | Yes |
| 32 | 240138 | 226458 | Yes |
| 33 | 240055 | 226374 | Yes |
| 34 (5) | 238484 | 227835 | No |
| 35 (5) | 238623 | 227901 | No |
| 36 (5) | 238740 | 227952 | No |
| 37 (5) | 238803 | 227973 | No |
| 38 (5) | 238825 | 228035 | No |
| 39 (5) | 238903 | 228085 | No |
| 40 (5) | 239011 | 228113 | No |
| 41 (5) | 239074 | 228097 | No |
| 42 | 239199 | 228157 | No |
| 43 | 239015 | 227769 | No |
| 44 | 239147 | 227589 | No |
| 45 | 239282 | 227870 | No |
| 46 | 239295 | 227769 | No |
| 47 | 239427 | 227695 | No |
| 48 | 239578 | 227619 | No |
| 49 | 239782 | 227467 | No |
| 50 | 238917 | 225077 | No |

| Receptor | Easting | Northing | Glint and Glare Possible |
|---|---|---|---|
| 51 (6) | 239084 | 224787 | No |
| 52 (6) | 239142 | 224777 | No |
| 53 (6) | 239215 | 224748 | No |

## Road / Rail Receptors

6.90 There are three roads within the 1km study area that require a detailed glint and glare analysis, which are the L1025, and two unnamed local roads located to the northeast of the Proposed Development.

6.91 The ground receptor no-reflection zones are clearly identifiable on **Figure 6.2: Appendix 6A** and the process of how these are calculated is explained in **paragraphs 6.84 to 6.86** of this report.

6.92 **Table 6 - 2** shows a list of receptors points within the study area which are 200m apart.

Table 6 - 2: Road Based Receptors

| Receptor | Easting | Northing | Glint and Glare Possible |
|---|---|---|---|
| 1 | 239957 | 227382 | Yes |
| 2 | 240123 | 227276 | Yes |
| 3 | 240289 | 227170 | Yes |
| 4 | 240465 | 227077 | Yes |
| 5 | 240638 | 227017 | Yes |
| 6 | 240803 | 226998 | Yes |
| 7 | 241000 | 226977 | Yes |
| 8 | 241199 | 226995 | Yes |
| 9 | 241396 | 226986 | Yes |
| 10 | 241563 | 226908 | Yes |
| 11 | 241660 | 226733 | Yes |

| Receptor | Easting | Northing | Glint and Glare Possible |
|---|---|---|---|
| 12 | 241783 | 226576 | Yes |
| 13 | 238638 | 227939 | No |
| 14 | 238823 | 228017 | No |
| 15 | 238995 | 228118 | No |
| 16 | 239071 | 228144 | No |
| 17 | 239168 | 227968 | No |
| 18 | 239290 | 227816 | No |
| 19 | 239456 | 227706 | No |
| 20 | 239622 | 227597 | No |
| 21 | 239789 | 227490 | No |

6.93 There are no railway lines within the 1km study area which require a detailed assessment.

## Aviation Receptors

6.94 Aerodromes within 30km of the proposed solar development can be found in **Table 6 - 3.**

Table 6 - 3: Airfields within close proximity

| Airfield | Distance (km) | Use |
|---|---|---|
| Ballyduff Airfield | 7.34 | Small grass strip |
| Clonbullogue Airfield | 17.89 | Licensed aerodrome |
| Limetree Airfield | 21.22 | Small grass strip |
| Eyne Airfield | 23.55 | Small grass strip |

6.95 There is one aerodrome, Clonbullogue Airfield, which requires a detailed assessment due to this airfield being located within its respective safety buffer zone outlined in **paragraph 6.69**.

### Clonbullogue Airfield

6.96 Clonbullogue Airfield (ICAO code EICL) is designated as a VFR Aerodrome. It is located approximately 6NM (11.11 km) South of Edenderry.

6.97 The elevation of the aerodrome at the Aerodrome Reference Point (ARP) is 240 (73.156m). It has one grass strip runway, details of which are given in **Table 6 - 4**.

Table 6 - 4: Runways at Clonbullogue Airfield

| Runway Designation | True Bearing (°) | Length (m) | Width (m) |
|---|---|---|---|
| 09 | 085.30 | 770 | 18 |
| 27 | 263.70 | 770 | 18 |

6.98 The threshold location and height of the runway at Clonbullogue Airfield are given in **Table 6 - 5**.

Table 6 - 5: Runway Threshold Locations and Heights

| Runway Designation | Threshold Latitude | Threshold Longitude | Height AOD (m) |
|---|---|---|---|
| 09 | 53° 14′ 57.08″ N | 007° 07′ 46.60″ W | 70.00 |
| 27 | 53° 14′ 59.89″ N | 007° 07′ 01.09″ W | 72.89 |

6.99 The Airfield Reference Point (ARP) is located at the midpoint of the main runway. The actual location of the ARP is given in **Table 6 - 6**. There is no ATCT at Clonbullogue Airfield.

Table 6 - 6: Clonbullogue Airfield Reference Point

| | Latitude | Longitude | Eastings | Northings |
|---|---|---|---|---|
| ARP | 53° 14’ 58.71’’ N | 007° 07’ 23.56’’ W | 258572 | 222473 |

# IMPACT ASSESSMENT

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

## Ground Based Receptors

### Residential Receptors

6.101 **Table 6 - 7** 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.

6.102 The 20 receptors (receptors 34 – 53) 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.

6.103 **Appendix 6B and 6C** contains the detailed analysis of the glint and glare impacts. **Table 6 - 7** shows the worst-case impact at each receptor (bald earth scenario – not including actual visibility or actual visibility with mitigation).

Table 6 - 7: Potential for Glint and Glare Impact on Residential Based Receptors

| Receptor | Glint Possible from Site | | Potential Glare Impact (per year) | | Magnitude of Impact | Worst Case Tilt (degrees) |
|---|---|---|---|---|---|---|
| | AM | PM | Minutes | Hours | | |
| 1 | No | No | 0 | 0 | None | N/A |
| 2 (1) | No | No | 0 | 0 | None | N/A |
| 3 (1) | No | No | 0 | 0 | None | N/A |
| 4 (1) | No | No | 0 | 0 | None | N/A |
| 5 (1) | No | No | 0 | 0 | None | N/A |
| 6 (1) | No | No | 0 | 0 | None | N/A |
| 7 (1) | No | No | 0 | 0 | None | N/A |
| 8 (1) | No | No | 0 | 0 | None | N/A |
| 9 (1) | Yes | No | 16 | 0.27 | Low | 20 |

| Receptor | Glint Possible from Site | | Potential Glare Impact (per year) | | Magnitude of Impact | Worst Case Tilt (degrees) |
|---|---|---|---|---|---|---|
| | AM | PM | Minutes | Hours | | |
| 10 | Yes | No | 1553 | 25.88 | Medium | 10 |
| 11 | Yes | No | 1251 | 20.85 | Medium | 10 |
| 12 (2) | Yes | No | 1384 | 23.07 | Medium | 10 |
| 13 (2) | Yes | No | 1386 | 23.10 | Medium | 10 |
| 14 | No | Yes | 929 | 15.48 | Low | 10 |
| 15 | No | Yes | 41 | 0.68 | Low | 10 |
| 16 | No | Yes | 136 | 2.27 | Low | 20 |
| 17 (3) | No | No | 0 | 0 | None | N/A |
| 18 (3) | No | No | 0 | 0 | None | N/A |
| 19 | No | No | 0 | 0 | None | N/A |
| 20 (4) | No | No | 0 | 0 | None | N/A |
| 21 (4) | No | No | 0 | 0 | None | N/A |
| 22 (4) | No | No | 0 | 0 | None | N/A |
| 23 (4) | No | No | 0 | 0 | None | N/A |
| 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 | Yes | 413 | 6.88 | Low | 20 |
| 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 | Yes | 509 | 8.48 | Low | 20 |

6.104 As detailed in **Table 6 - 7**, under the 'bald earth scenario', there is a **Medium** impact at four receptors, including one residential area, **Low** impact at six receptors and a **None** impact at the remaining 23 receptors, including three residential areas. **Appendix 6B and 6C** shows detailed analysis of when the glare impacts are possible, whilst also showing which parts of the solar farm glint is reflected from.

6.105 **Appendix 6H** 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.

## Receptor 9

6.106 The 'Glare Reflections on PV Footprint' chart in **Appendix 6C** shows that reflections from an eastern section in the Proposed Development can potentially impact on the receptor.

6.107 The first image in **Appendix 6H** is an aerial image showing the position of the receptor (yellow pin) in relation to the Proposed Development, and the location from which the second image was taken (red dot). The second image is a photo taken from the western area of the Proposed Development with a view towards the receptor. This image confirms that the vegetation and topography are sufficient to screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact reduces to **None**.

## Receptors 10 and 11

6.108 The 'Glare Reflections on PV Footprint' chart in **Appendix 6B** shows that reflections from a southern section in the Proposed Development can potentially impact on the receptors.

6.109 The first image in **Appendix 6H** is an aerial image showing the position of the receptors (yellow pins) in relation to the Proposed Development, and the location from which the second image was taken (red dot). The second image is a street view image with a view towards the Proposed Development. This image confirms that the vegetation is sufficient to screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact reduces to **None**.

## Receptors 12 and 13

6.110 The 'Glare Reflections on PV Footprint' chart in **Appendix 6B** shows that reflections from a southern section in the Proposed Development can potentially impact on the receptors.

6.111 The first image in **Appendix 6H** is an aerial image showing the position of the receptors (yellow pins) in relation to the Proposed Development, and the location from which the second image was taken (red dot). The second image is a street view image with a view towards the Proposed Development. This image confirms that the vegetation is sufficient to screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact reduces to **None**.

### Receptor 14

6.112 The 'Glare Reflections on PV Footprint' chart in **Appendix 6B** shows that reflections from a southwest section in the Proposed Development can potentially impact on the receptor.

6.113 The first image in **Appendix 6H** is an aerial image showing the position of the receptor (yellow pin) in relation to the Proposed Development, and the location from which the second image was taken (red dot). The second image is a street view image with a view towards receptor. This image confirms that the vegetation is sufficient to screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact reduces to **None**.

### Receptors 15 and 16

6.114 The 'Glare Reflections on PV Footprint' chart in **Appendix 6B and 6C** shows that reflections from a central section in the Proposed Development can potentially impact on the receptors.

6.115 The first image in **Appendix 6H** is an aerial image showing the position of the receptors (yellow pins) in relation to the Proposed Development, and the location from which the second image was taken (red dot). The second image is a street view image with a view towards receptors. This image confirms that the vegetation is sufficient to screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact reduces to **None**.

### Receptor 29

6.116 The 'Glare Reflections on PV Footprint' chart in **Appendix 6C** shows that reflections from a northern section in the Proposed Development can potentially impact on the receptor.

6.117 The first image in **Appendix 6H** is an aerial image showing the position of the receptor (yellow pin) in relation to the Proposed Development, and the location from which the second image was taken (red dot). The second image is a photo taken from a field to the east of the northern area of the Proposed Development with a view towards the receptor. This image confirms that the vegetation is sufficient to screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact reduces to **None**.

### Receptor 33

6.118 The 'Glare Reflections on PV Footprint' chart in **Appendix 6C** shows that reflections from a central in the Proposed Development can potentially impact on the receptor.

6.119 The first image in **Appendix 6H** is an aerial image showing the position of the receptor (yellow pin) in relation to the Proposed Development, and the location from which the second image was taken (red dot). The second image is a photo taken from a field in the central area of the Proposed Development with a view towards the receptor. This image confirms that the vegetation and intervening buildings are sufficient to screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact reduces to **None**.

## Residential Area 1

6.120 This encompasses a number of residential receptors including those at Receptors 2 - 9 (assessed previously) (See **Figure 6.1: Appendix 6A**). 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 eight receptors, the impacts on the other receptors within this area are assessed as being **None (worst case scenario)**.

## Residential Area 2

6.121 This encompasses a number of residential receptors including those at Receptors 12 and 13 (assessed previously) (See **Figure 6.1: Appendix 6A**). 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 two receptors, the impacts on the other receptors within this area are assessed as being **None (worst case scenario)**.

## Residential Area 3

6.122 This encompasses a number of residential receptors including those at Receptors 17 and 18 (assessed previously) (See **Figure 6.1: Appendix 6A**). 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 two receptors, the impacts on the other receptors within this area are assessed as being **None (worst case scenario)**.

## Residential Area 4

6.123 This encompasses a number of residential receptors including those at Receptors 20 - 23 (assessed previously) (See **Figure 6.1: Appendix 6A**). 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 four receptors, the impacts on the other receptors within this area are assessed as being **None (worst case scenario)**.

## Road Receptors

6.124 **Table 6 - 8** 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 6D and 6E**.

6.125 There are nine receptors within the no-reflection zones outlined previously, and therefore have been excluded from the detailed modelling of glint and glare impacts from the Proposed Development.

Table 6 - 8: Potential for Glint and Glare Impact on Road Based Receptors

| Receptor | Green Glare (mins) | Yellow Glare (mins) | Red Glare (mins) | Magnitude of Impact | Worst Case Tilt (degreeS) |
|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | None | N/A |
| 2 | 0 | 0 | 0 | None | N/A |
| 3 | 300 | 0 | 0 | Low | 10 |
| 4 | 558 | 0 | 0 | Low | 10 |
| 5 | 756 | 0 | 0 | Low | 10 |
| 6 | 732 | 0 | 0 | Low | 10 |
| 7 | 548 | 0 | 0 | Low | 10 |
| 8 | 517 | 0 | 0 | Low | 10 |
| 9 | 583 | 0 | 0 | Low | 10 |
| 10 | 497 | 0 | 0 | Low | 10 |
| 11 | 867 | 0 | 0 | Low | 10 |
| 12 | 838 | 0 | 0 | Low | 20 |

6.126 As can be seen in **Table 6 - 8**, 10 out of the 12 receptor points have potential glare impacts consisting of "low-potential for after-image" (green glare) which is a **Low** impact. **Appendix 6D and 6E** 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.

6.127 **Appendix 6H** 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 driver's field of view, as outlined in **paragraph 6.75**, has been drawn as red cones. 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 imaging.

6.128 As can be seen in **Appendix 6H**, all receptors will have views of the Proposed Development blocked by intervening vegetation, topography or buildings, and therefore their impact can be reduced to **None**.

## Grand Canal

6.129 Six images have been included in **Appendix 6H** to determine if any glint and glare effects are likely to occur. The first image shows the Grand Canal location in relation to the Proposed Development, and the locations from which the other five images were taken. The Proposed Development is shown as the white polygon. Along the southern boundary of the Proposed Development there is vegetation that will likely block all views into the Proposed Development from the Grand Canal. The second, third, fourth, fifth and sixth images were taken from the positions of the pins on the first image and are towards the Proposed Development. These images show that there will be sufficient vegetation from mature hedgerows and tree lines to block all views into the Proposed Development. Additionally, the canal is at a lower level than the pathway, leading to further screening and resulting in **no impacts** from glint and glare.

# AVIATION RECEPTORS

6.130 **Table 6 - 9** 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 6F and 6G**.

Table 6 - 9: Summary of component Glare Results

| Component | Green Glare (mins) | Yellow Glare (mins) | Red Glare (mins) | Worst Case Tilt (degrees) |
|---|---|---|---|---|
| Clonbullogue Airfield | | | | |
| Runway 09 | 0 | 0 | 0 | N/A |
| Runway 27 | 775 | 0 | 0 | 20 |

6.131 As can be seen in **Table 6 - 9**, only green glare is predicted to impact the Runway 27 approach path at Clonbullogue Airfield. Green glare is described as having "low potential for after image" and is an **acceptable impact** upon pilots approaching runways/helipads, according to FAA guidance. No glare is predicted to impact upon the Runway 09 approach path at Clonbullogue Airfield. The impact on aviation assets is therefore **Low** and **Not Significant**.

# GROUND BASED RECEPTOR MITIGATION

6.132 Mitigation is not required due to all impacts upon ground-based receptors being **None**.

6.133 **Table 6 - 10 and Table 6 - 11** show the impacts at each stage of the glint and glare analysis, with the final residual impacts considered once the mitigation, if any, is in place.

Table 6 - 10: Potential Residual Glint and Glare Impacts on Residential Receptors

| Receptor | Magnitude of Impact | | |
|---|---|---|---|
| | Theoretical Visibility | Actual Visibility (No Mitigation) | Actual Visibility with Mitigation |
| 1 | None | None | None |
| 2 (1) | None | None | None |
| 3 (1) | None | None | None |
| 4 (1) | None | None | None |
| 5 (1) | None | None | None |
| 6 (1) | None | None | None |
| 7 (1) | None | None | None |
| 8 (1) | None | None | None |
| 9 (1) | Low | None | None |
| 10 | Medium | None | None |
| 11 | Medium | None | None |
| 12 (2) | Medium | None | None |
| 13 (2) | Medium | None | None |
| 14 | Low | None | None |
| 15 | Low | None | None |
| 16 | Low | None | None |
| 17 (3) | None | None | None |
| 18 (3) | None | None | None |
| 19 | None | None | None |

| Receptor | Magnitude of Impact | | |
|---|---|---|---|
| | Theoretical Visibility | Actual Visibility (No Mitigation) | Actual Visibility with Mitigation |
| 20 (4) | None | None | None |
| 21 (4) | None | None | None |
| 22 (4) | None | None | None |
| 23 (4) | None | None | None |
| 24 | None | None | None |
| 25 | None | None | None |
| 26 | None | None | None |
| 27 | None | None | None |
| 28 | None | None | None |
| 29 | Low | None | None |
| 30 | None | None | None |
| 31 | None | None | None |
| 32 | None | None | None |
| 33 | Low | None | None |

Table 6 - 11: Potential Residual Glint and Glare Impacts on Road Receptors

| Receptor | Magnitude of Impact | | |
|---|---|---|---|
| | Theoretical Visibility | Actual Visibility (No Mitigation) | Actual Visibility with Mitigation |
| 1 | None | None | None |
| 2 | None | None | None |
| 3 | Low | None | None |
| 4 | Low | None | None |
| 5 | Low | None | None |
| 6 | Low | None | None |
| 7 | Low | None | None |

| Receptor | Magnitude of Impact | | |
|---|---|---|---|
| | Theoretical Visibility | Actual Visibility (No Mitigation) | Actual Visibility with Mitigation |
| 8 | Low | None | None |
| 9 | Low | None | None |
| 10 | Low | None | None |
| 11 | Low | None | None |
| 12 | Low | None | None |

6.134 **Table 6 - 12 and Table 6 - 13** show the overall impacts for all residential and road receptors.

Table 6 - 12: Solar Reflections: Residential Receptors

| Magnitude | Theoretical Visibility | Actual Visibility (No Mitigation) | Actual Visibility with Mitigation |
|---|---|---|---|
| High | 0 | 0 | 0 |
| Medium | 4 | 0 | 0 |
| Low | 6 | 0 | 0 |
| None | 23 | 33 | 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 6 - 13: Solar Reflections: Road Receptors

| Magnitude | Theoretical Visibility | Actual Visibility (No Mitigation) | Actual Visibility with Mitigation |
|---|---|---|---|
| High | 0 | 0 | 0 |
| Low | 10 | 0 | 0 |
| None | 2 | 12 | 12 |

- **High -** Solar reflections impacts with yellow glare (potential for after-image).
- **Low -** Solar reflections impacts with only green glare (low potential for after-image)
- **None -** Effects not geometrically possible or no visibility of reflective surfaces likely due to high levels of intervening screening or being outside the drivers field of view

# SUMMARY

6.135 There is no guidance or policy available across Ireland in relation to the assessment of glint and glare from a Proposed Development. However, as identified by UK policy, it is recognised as a potential impact which needs to be considered for a proposed solar development.

6.136 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 1km of the Application Site, there are 53 residential receptors, including six residential areas, and 21 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 the glint and glare analysis 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 included in the glint and glare analysis with some context to all receptors given in the visual analysis. 20 residential receptors, including two residential area, and nine road receptors were dismissed as they are located within the no reflection zones and therefore, will not be impacted upon by the Proposed Development. The Grand Canal has been considered for a visibility assessment due to its proximity to the Proposed Development. Four aerodromes are located within 30km of the Proposed Development: Ballyduff Airfield, Clonbullogue Airfield, Limetree Airfield and Eyne Airfield. One aerodrome, Clonbullogue Airfield, requires a detailed assessment due to its size and orientation in relation to the Proposed Development.

6.137 The solar panels will face south and will be inclined at an angle of between 10 and 20 degrees. The maximum above ground level height of the panels is 2.5m and points at the top of the panels are used to determine the potential for glint and glare generation.

6.138 Geometric analysis was conducted for 33 individual residential receptors, including four residential areas, and 12 road receptors as well as two runway approach paths.

6.139 Following an initial assessment, rail receptors were scoped out as assets that will be impacted upon from the Proposed Development as no rail receptors fell within the 1km study area. The assessment concludes that:

- Solar reflections are possible at 10 of the 33 residential receptors assessed within the 1km study area. Initial impacts were **Medium** at four receptors, including one residential area, **Low** at six receptors and **None** at the remaining 23 receptors, including three residential areas. Upon reviewing the actual visibility of the receptors, glint and glare impacts reduce to **None** at all receptors, including four residential areas.

- Solar reflections are possible at 10 of the 12 road receptors assessed within the 1km study area. Initial impacts were **Low** at 10 receptors and **None** at the remaining two receptors. Upon reviewing the actual visibility of the receptors, glint and glare impacts reduce to **None** at all receptors.

- **No impact** on train drivers or railway infrastructure is predicted.
- **No impact** on the Grand Canal boat drivers is predicted.
- Only green glare is predicted to impact upon the Runway 27 approach path at Clonbullogue Airfield. Green glare is an **acceptable impact** when pilots are approaching runways/helipads, according to FAA guidance. No glare impacts are predicted upon the Runway 09 approach path at Clonbullogue Airfield. Therefore, the impact on aviation assets is **Low** and **Not Significant**.

6.140 Mitigation measures are not required due to all impacts upon ground-based receptors being **None**.

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

# APPENDICES

## Appendix 6A: Figures

- Figure 6.1: Residential Receptors
- Figure 6.2: Road Based Receptors

## Appendix 6B: Residential Receptor Results (10 degrees)

## Appendix 6C: Residential Receptor Results (20 degrees)

## Appendix 6D: Road Receptor Results (10 degrees)

## Appendix 6E: Road Receptor Results (20 degrees)

## Appendix 6F: Aviation Receptor Results (10 degrees)

## Appendix 6G: Aviation Receptor Results (20 degrees)

## Appendix 6H: Visibility Assessment Evidence

## Appendix 6I: Solar Module Glare and Reflectance Technical Memo

NEO ENVIRONMENTAL

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