# GLINT AND GLARE ASSESSMENT

macroworks

# Rooftop PV Solar Panels

## Unit Q2

Jordanstown Road
Aerodrome Business Park
Collegeland
Rathcoole
Co. Dublin

Registered Landscape Architect

August 2021

# GLINT AND GLARE STUDY


**Executive Summary**

The proposal for a roof mounted PV solar panel installation at Unit Q2 Jordanstown Road and Jordanstown Way, Collegeland, Aerodrome Business Park, Rathcoole, County Dublin, was assessed to determine whether it has the potential to cause any glint or glare impact upon aviation receptors, dwellings or transport routes located in the surrounding area.

Analysis of the roads and houses within a 1km defined study area has determined that there is no potential for adverse glint and glare impacts from this roof-mounted PV array. An in-depth study concentrating on aviation receptors at the adjacent Casement Aerodrome determined that there is no potential for hazardous glint and glare impacts.

# 1 INTRODUCTION

Macro Works Ltd. was commissioned to prepare this glint and glare report for a proposed rooftop PV solar installation atop the proposed office building of warehouse Q2 in the Aerodrome Business Park, just off the R120 regional road in Co. Dublin.

### 1.1.1 Statement of Authority

Macro Works' relevant experience includes twenty years of analysing the visual effects of a wide range of infrastructural and commercial development types. This experience includes numerous domestic and international wind and solar energy developments. The Glint and Glare analysis model used predominantly in this study was developed by Macro Works Ltd in conjunction with the National University of Ireland, (NUI) Maynooth. This model has successfully replicated results from the Federal Aviation Administration (FAA) approved Solar Glare Hazard Analysis Tool (SGHAT) - the internationally recognised standard for glare analysis for the aviation industry. The Macro Works Glint and Glare analysis model has been utilised to assess the effects of glint and glare for many solar development sites throughout Ireland to date.

### 1.1.2 Guidance and Best Practice

There is currently no specific guidance or standards for the assessment of photovoltaic glint and glare effects on residential and/or transport route (road and rail) receptors in Ireland. Guidance has been prepared, however, by the Federal Aviation Administration to address the potential hazards that solar developments may pose to aviation activities, and this has been adopted for use by the Irish Aviation Authority. The Solar Glare Hazard Analysis Tool (SGHAT) was developed in conjunction with the FAA in harmony with this guidance and has been made available as an online resource for use by international practitioners. Whilst in Ireland to date, this has typically been employed for the assessment of ground-based commercial solar installations of greater than 5MW in capacity (c. 11ha), it has also been used for a small number of roof-mounted installations that are considerably smaller. This guidance, concerned with hazard assessment, has relevance to the other receptor types mentioned, and coupled with numerous assessments already carried out across the UK, combine to establish a suitable best practice.

By virtue of their efficiency, the intensity of reflected light from modern PV solar panels is deliberately low and currently equates with that of the reflection from still water, however, studies generally agree that there is still a potential for hazard or nuisance upon surrounding receptors. Macro Works' glint and glare analysis methods and determination of effects are based on a combination of available studies and established best practice.

### 1.1.3 Definitions

The study is concerned with the potential nuisance and hazard effects of glint and glare in relation to receptors that include the occupants of surrounding dwellings as well as road users. In their "Technical Guidance for Evaluating Selected Solar Technologies on Airports"[1] the FAA have defined the terms 'Glint' and 'Glare' as meaning;

> ***Glint*** *– "A momentary flash of bright light"*

> ***Glare*** *– "A continuous source of bright light"*

Glint and glare are essentially the reflection of sunlight from reflective surfaces. This study uses a multi-step process of elimination to determine which receptors have the potential to experience the effects of glint and glare. It then examines, 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.

## 1.2 GENERAL NATURE OF REFLECTANCE FROM PHOTOVOLTAIC PANELS

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 emits 'specular' reflectance rather than a 'diffuse' reflectance, which would occur from a rough surface (**Figure 1** refers). 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 (**Figure 2** refers). Similar levels of reflectance can be found in common situations in rural environments from surfaces such as shed roofs, lines of plastic ground covering used in cropping and wet roads to name but a few (**Figure 3 - Figure 6** refer).

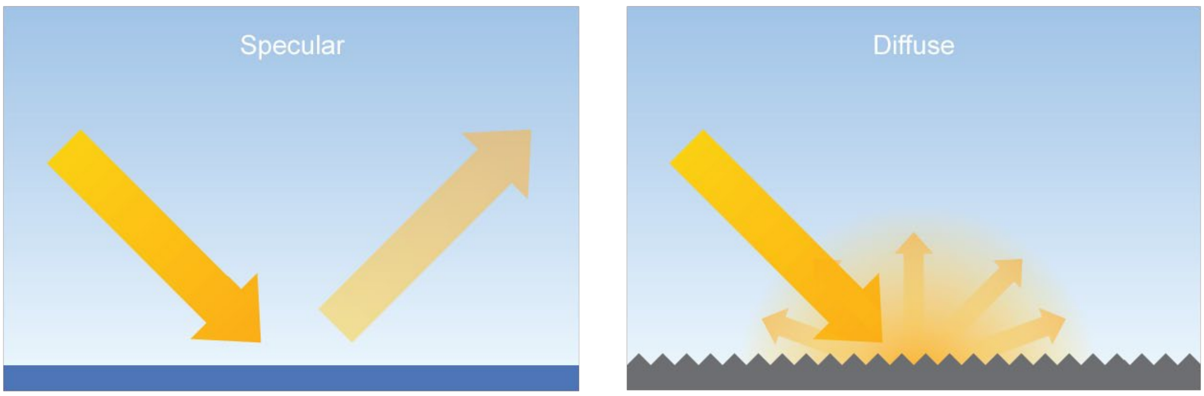



**Figure 1: Specular vs Diffuse reflection of light from polished and rough surfaces.**

[1] 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

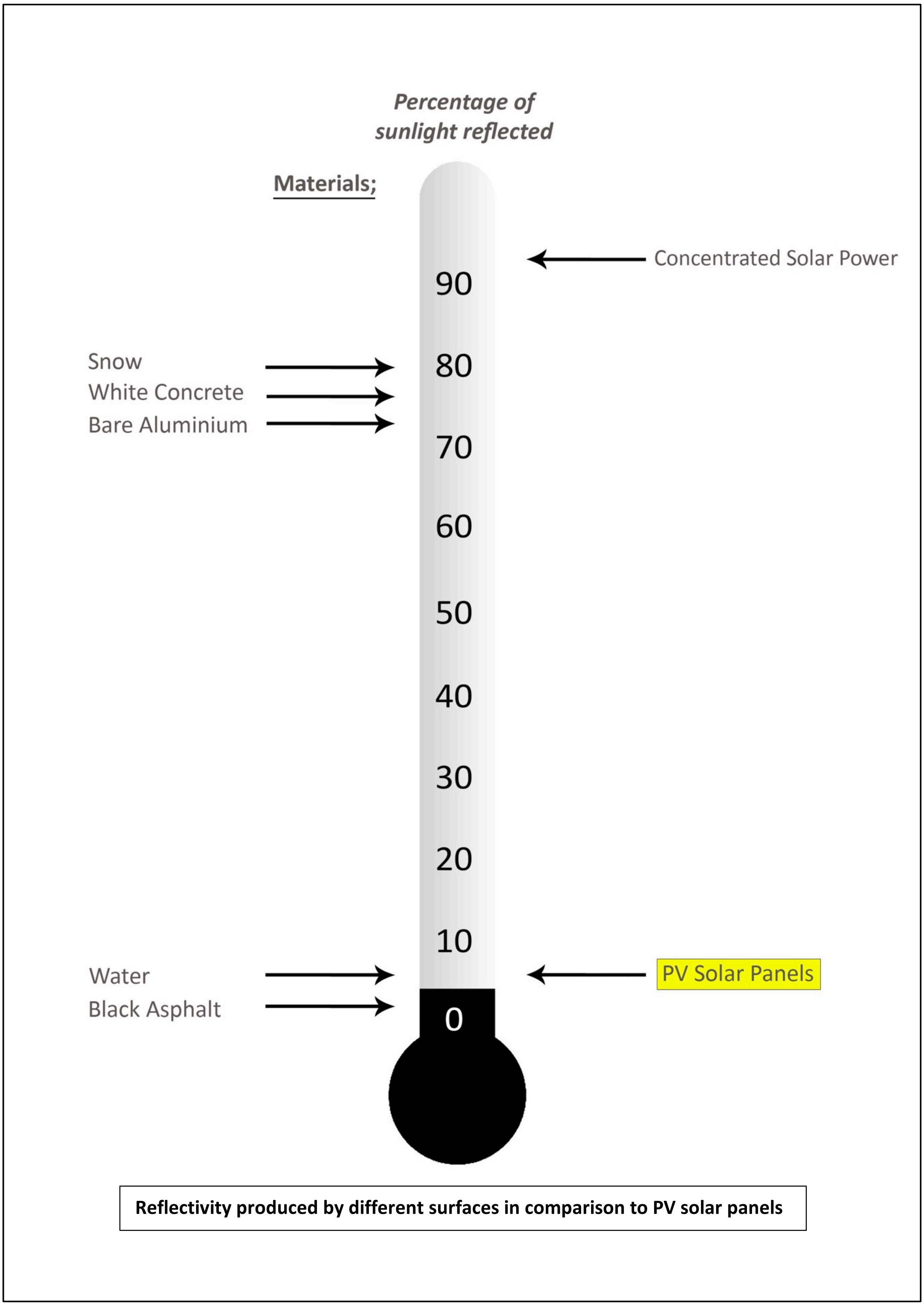



**Figure 2: Demonstrates that the amount of sunlight (measured in watts per meter -W/m2) reflected from the surface of a solar panel is very similar to that of still water and is far less than that of many surfaces commonly found in the environment, urban or rural**

**Figure 3: Similar level of reflectance (to photovoltaic panels) emanating from plastic ground covering in an Irish rural scenario.**

**Figure 4: Similar levels of reflectance (to photovoltaic panels) emanating from various agricultural structures in an Irish rural scenario.**

**Figure 5: Similar levels of reflectance (to photovoltaic panels) emanating from wet road surfaces.**

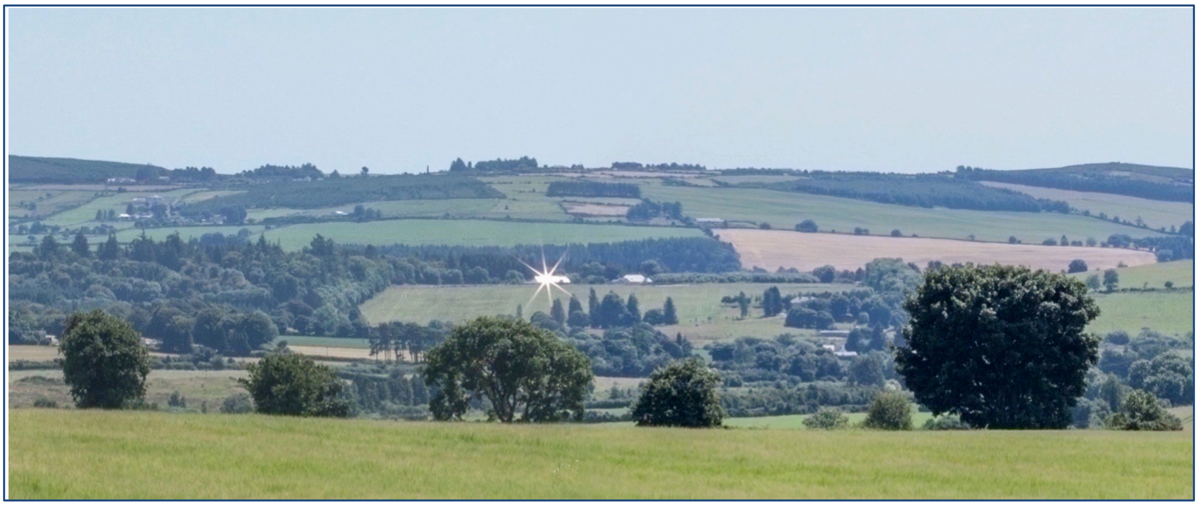


**Figure 6: Higher levels of reflectance (to photovoltaic panels) emanating from metallic roof surfaces in and Irish rural scenario.**

**Figure 7: Higher levels of reflectance (to photovoltaic panels) emanating from powder coated corrugated metal roof surfaces in an Irish rural scenario.**

## 1.3 ASSESSMENT METHODOLOGY – GROUND BASED RECEPTORS

Macro Works' glint and glare assessment methodology follows a rational sequence of steps to identify receptors that might potentially be affected by glint and glare. These are then further filtered to yield those receptors to those that *are likely* to actually experience such effects. These steps are set out below;

1. Identify study area within which to assess the potential for glint and glare effects. The potential for nuisance or hazardous impacts are greatest in close proximity to the source of reflectance and the potential for adverse impacts reduces with increased distances therefore to balance these factors a buffer extent of 1km from the site boundary is used as standard on all solar developments.
2. Undertake a Zone of Theoretical Visibility analysis to determine if there are any ground-based receptors within the study area that may require a detailed analysis.
3. Pre-analyse the study area for potential glare effects by populating the study area with a regular grid of receptor points (100m spacing). This analysis ($1^{st}$ analysis) allows us to determine those areas theoretically exposed to glint and glare effects that might warrant further investigation. This pre-analysis is based on a 3D model of the development superimposed onto a Digital Terrain Model (DTM) of the study area. **Note:** This DTM accurately replicates the profile of the terrain but does not account for screening by the vegetation or buildings that are present – in this sense the results are somewhat theoretical but they do offer a representation of a bare-earth, worst-case scenario.
4. Identify relevant receptors (dwellings and transport routes) that fall within the theoretically affected zones of the study area. Dwelling identification utilises a combination of up to date aerial photography and the Eircode Finder tool which locates and identifies buildings classed as residential. Routes receptors are defined by regularly spaced points along roads and rail lines (50m spacing). The height of the road Receptor Points are set to 1.7m above ground level, broadly equivalent to the eye level a person walking or a driver of a 4x4 / SUV type vehicle.
5. Execute the glint and glare analysis on the DTM-based 3-D model ($2^{nd}$ analysis), in respect of each of the theoretically affected receptors. This identifies the times of the day and months of the year that glint and glare could potentially affect receptors in the absence of screening. Such screening includes vegetation and buildings that may exist in the area between the receptors and the proposed PV panels. In this instance the parapet that encloses the office roof space has been included for in the model.
6. Where instances of glint and glare remain, assess whether they are likely to cause a hazard / nuisance. For dwellings, this is achieved by comparing the periods of glare potential with our 'Magnitude of Glint and Glare Effects' table, while roads are examined in further detail for potential for hazardous impacts.
7. If hazard / substantial nuisance is likely to occur, mitigation measures are proposed where possible. This might relate to the re-orienting or re-siting of particular panels and / or the provision of additional screening.

8. If necessary, re-run the glint and glare calculations to verify the effectiveness of the proposed mitigation measures and determine if there are any residual glare impacts.

### 1.3.1 Magnitude of Impact for Dwelling Receptors

Although there is currently no regulation or guidance as to acceptable levels of glint and glare effects at receptors in Ireland, it is considered necessary to provide a gauge for determining relative levels of impact across a range of development types. Macro Works has established the following indicative textual categories of effect, which are used herein to determine the relative impact levels (Table 1 refers). The percentage figures provided are intended as a relative guide only. The final category of assessment is determined on the basis of professional judgement, and accounts for mitigating factors where relevant and the careful consideration of a range of circumstantial variables that may act to intensify or reduce the effect upon a particular receptor.

**Table 1: Magnitude of Glint and Glare Effects**

| Magnitude of Impact | Description |
|---|---|
| **Very High** | Hazard / nuisance effects emanating from highly reflective surfaces (>50% sunlight reflection) for most of the year (>70% / 255 days) and for significant periods of each day (>45 mins). |
| **High** | Hazard / nuisance effects emanating from moderately reflective surfaces (>30% sunlight reflection) for the majority of days in a year (>50% / 182 days) and for substantial periods of each day (>30 mins). |
| **Medium** | Nuisance effects emanating from moderately/low reflective surfaces (>10% sunlight reflection) for a substantial number of days in a year (>30% / 109 days) and for substantial periods of each day (>20 mins). |
| **Low** | Nuisance effects emanating from low reflective surfaces (>5% sunlight reflection) for a modest number of days in a year (>10% / 36 days) and for notable periods of each day (>15 mins). |
| **Very low*** | Nuisance effects emanating from low reflective surfaces (>5% sunlight reflection) for a small number of days in a year (≤10% / 36 days) and for short periods of each day (<15 mins). |
| **None*** | Effects not geometrically possible. |

*Note: In some instances, a precautionary reflectance impact level of 'Very low / None' is attributed where a very minor degree of reflectance cannot be categorically excluded from occurring. This could occur in respect of a second storey window where it is difficult to ascertain the precise level of screening.

**Note:** The positioning of points has been done such that it broadly represents each dwelling. There is the potential that micro-siting to a particular window or door might result in a marginally different outcome but attempts are made to try to avoid this scenario. In the case of road points the positioning is simply at 50m intervals along the line of the road. This may result in a point that is positioned behind a tall tree, however, it may conversely result in it being positioned at an open gateway. On balance the analysis should deliver a non-biased result that is representative of the road section as a whole.

## 1.4 ASSESSMENT METHODOLOGY – AVIATION

There is no guidance in Ireland as yet to specifically address the effects of solar panel reflections upon surrounding receptors, however, the Solar Glare Hazard Analysis Tool (SGHAT) produced by Sandia National Laboratories in the US is endorsed by the Federal Aviation Administration (FAA) and is commonly regarded as the accepted industry standard by aviation authorities internationally when considering the glint and glare effects upon aviation related receptors. For this reason, SGHAT has been used as the default tool for glint and glare of aviation receptors. The process for dealing with aviation receptors differs from that used for ground based receptors and is as follows:

1. Identify aviation receptors such as runway approaches and air traffic control towers associated with airports, aerodromes and airfields relevant to the proposed solar development.
2. The Federal Aviation Administration (FAA) approved Solar Glare Hazard Analysis Tool (SGHAT) is used to determine if any of these aviation receptors has the potential to theoretically experience glint or glare. This tool also calculates the intensity of such reflectance and whether it is acceptable by FAA standards.
3. SGHAT does not account for terrain screening or screening provided by surface elements such as existing vegetation or buildings, therefore the results of the SGHAT are considered, in conjunction with an assessment of existing intervening screening that may be present, to establish if reflectance can actually be experienced at the receptors.
4. Finally, if necessary, additional assessment is undertaken using Macro Works' bespoke model which takes into account any screening provided by any proposed mitigation measures.

### 1.4.1 Magnitude of Impact for Aviation Receptors

Within the FAA's interim policy, a 'Review of Solar Energy System Projects on Federally Obligated Airports'[2] it states that:

[2] Federal Aviation Administration (FAA). (2013). Department of Transportation - Federal Aviation Administration. *Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports*. Vol 78 (No 205), 63276-63279.

*"To obtain FAA approval to revise an airport layout plan to depict a solar installation and/or a ''no objection'' to a Notice of Proposed Construction Form 7460–1, the airport sponsor will be required to demonstrate that the proposed solar energy system meets the following standards:*

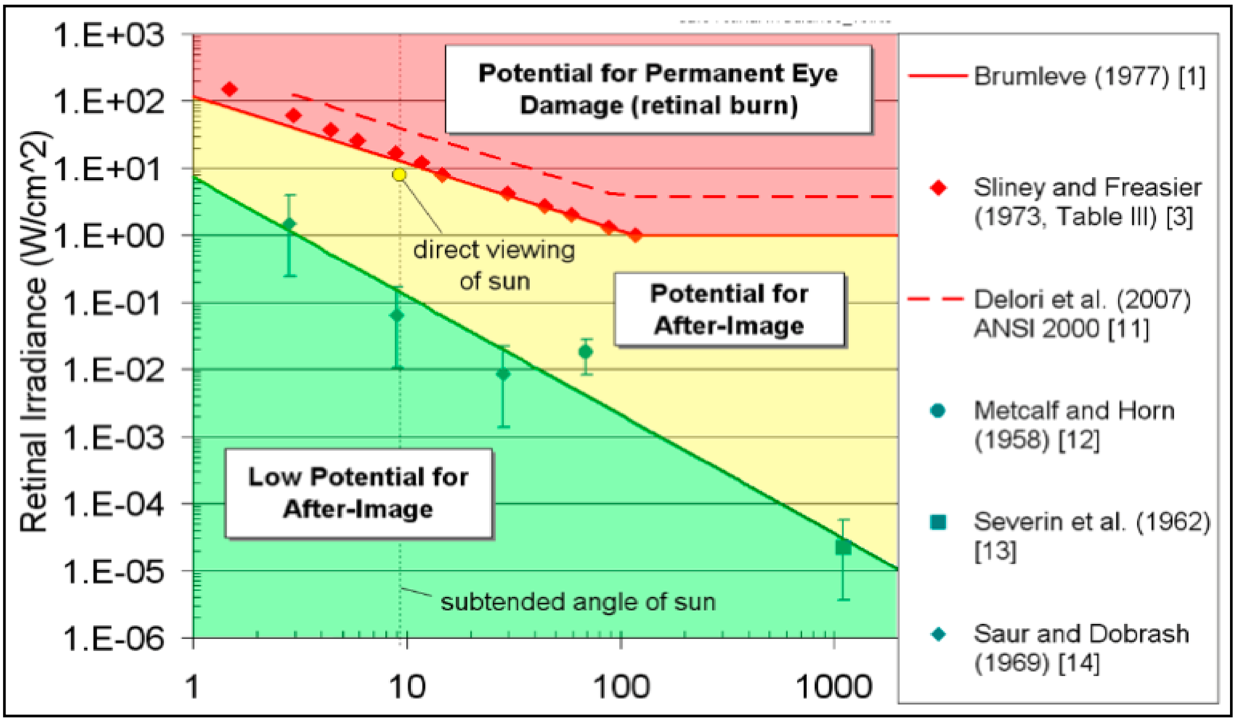
- *No potential for glint or glare in the existing or planned Airport Traffic Control Tower (ATCT) cab, and*

- *No potential for glare or ''**low potential for after-image**'' (shown in green in Figure 1* [**Figure 8** below refers]*) along the final approach path for any existing landing threshold or future landing thresholds (including any planned interim phases of the landing thresholds) as shown on the current FAA-approved Airport Layout Plan (ALP). The final approach path is defined as two (2) miles from fifty (50) feet above the landing threshold using a standard three (3) degree glidepath."*

The SGHAT was designed to determine whether a proposed solar energy project would result in the potential for ocular impact as depicted on the Solar Glare Hazard Analysis Plot (**Figure 8** refers). The SGHAT website describes the tool as follows:

> *"This tool determines when and where solar glare can occur throughout the year from a user-specified PV array as viewed from user-prescribed observation points. The potential ocular impact from the observed glare is also determined..."*

SGHAT analyses ocular impact over the entire calendar year in one (1) minute intervals from when the sun rises above the horizon until the sun sets below the horizon. One of the principal outputs from the SGHAT report is a glare plot per receptor that indicates the time of day and days per year that glare has the potential to occur. SGHAT plot classifies the intensity of ocular impact as either Green Glare, Yellow Glare or Red Glare. These colour classifications are equivalent to the FAA's definitions regarding the level of ocular impact (**Figure 8** refers) e.g. 'Green Glare' in the SGHAT is synonymous to the FAA's *''low potential for after-image',*' and so forth. These correlations are illustrated on the Solar Glare Hazard Analysis Plot in **Figure 8.**




Solar Glare Ocular Hazard Plot: The potential ocular hazard from solar glare is a function of retinal irradiance and the subtended angle (size/distance) of the glare source. It should be noted that the ratio of spectrally weighted solar illuminance to solar irradiance at the earth's surface yields a conversion factor of ~100 lumens/W. Plot adapted from Ho et al., 2011.

Chart References: 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, J. Solar Energy Engineering, August 2011, Vol. 133, 031021-1 – 031021-9.

**Figure 8: Figure 1 from the FAA Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports**

**Important Note**

It must be emphasised at this point that all results, whether from FAA endorsed SGHAT software or our own bespoke software, are theoretical by default in that they assume that the sun is always shining and at full intensity. The results do not account for climate and inherent weather patterns that occur across the island of Ireland.

Records from the nearest meteorological station of Dublin Airport for the years 2010 - 2017 indicate a mean daily duration of sunshine of 4.1 hours, or approximately 33% of daylight hours. If we consider only those months where glare is likely to occur (March-September) this figure increases to 5.3 hours, or approximately 45% of daylight hours[3].

While we cannot correlate the historic random periods of sunshine with our predicted periods of glare, we can state with a high level of confidence that the weather, more precisely cloud cover, will account for a substantial reduction in all figures quoted in this report i.e. frequency and duration of glare periods.

[3] https://www2.metweb.ie/climate/available-data/historical-data

In addition, atmospheric conditions such as haze, mist, fog and precipitation will all have the effect of both reducing the visibility of the site overall and reducing the intensity of any glare emanating from the proposed PV array.

## 1.5 RELEVANT PARAMETERS OF THE PROPOSED DEVELOPMENT

The site is located just off the northern side of the R120 regional road. The site lies in a relatively flat landscape that ranges between c.90 and c.110m Above Ordinance Datum (AOD). The surrounding area is urban fringe characterised by a mixture of commercial and industrial land uses adjoined by agricultural fields (**Figure 9** refers).

The PV panel installation is proposed of the roof of the Unit Q2 building in the Aerodrome Business Park (**Figure 9** refers). As indicated on drawing 'ABPUQ2-Z-L05-DR-TOT-AR-2002', the proposed PV Panels will occupy just the south-eastern facing roof pitches of the building. The PV panels will be installed parallel to the roof surface which slopes to the southeast at 6 degrees. The PV panels will be mounted with an offset distance of approximately 35mm.


**Figure 9: Aerial view (Google Earth Pro) showing the building footprint of Unit Q2 (red outline) and the 1km study area (blue circle).**

## 2 IDENTIFICATION OF RELEVANT RECEPTORS

### 2.1 GROUND BASED RECEPTORS

Given, on this particular development, a parapet is proposed which surrounds the roof of the building, a Zone of Theoretical Visibility (ZTV) analysis was undertaken to determine where in the surrounding landscape it might be possible for views of the surface of the PV panels to be obtained. The result of this analysis are presented in **Figure 10**. This ZTV analysis shows that there are no dwellings, roads or railways that will have the potential to see the proposed PV panels. Therefore, none of these receptors have any potential to be impacted by the effects of glint and glare as a result of the proposed PV panels.


**Figure 10: Parts of the study area it may be possible to see the proposed PV panels. The results are based on 3D terrain data that does not account for screening by vegetation or man-made structures. This is calculated for 1.7m above ground level which is indicative of eye-level of a person standing or a 4x4 vehicle driver.**

## 2.2 AVIATION RECEPTORS

Casement Aerodrome is located immediately northeast of the proposed PV development. There are four runway approaches at Casement Aerodrome, 04, 10, 22 and 28. There is one existing Air Traffic Control Tower (ATCT). This existing ATCT will be referenced as 1-ATCT in this report. Additionally there two potential locations for a potential future new Air Traffic Control Tower. These will be referred to as 2-ATCT and 3-ATCT (**Figure 11** refers). 2-ATCT (with a height of 28m) would be situated adjacent to the existing 1-ATCT. The location of 3-ATCT (with a height of 25m) would be situated just over 1km to the southwest of 1-ATCT. The existing and the both potential future ATCTs have been examined using SGHAT.


**Figure 11: Showing the locations of the existing (1-ATCT) and the two potential future Air Traffic Control Towers (2-ATCT and 3-ATCT) at Casement Aerodrome.**

# 3 RESULTS OUTPUTS OF GLINT AND GLARE ASSESSMENT

## 3.1 GROUND-BASED RECEPTORS

The result of the ZTV analysis (**Figure 10** refers) showed that there are no residential and transport route receptors within the Study Area that have any potential to be impacted by glint and glare.

**For this reason, it has been determined that there will be no adverse effects generated from glint and glare at the surrounding dwellings or transport routes (roads) as a result of the proposed solar development.**

## 3.2 AVIATION RECEPTORS

The SGHAT analysis results for Casement Aerodrome are set out in Appendix A. An assessment of glint and glare effects is provided below and presents a summary of the data provided in Appendix A.

All receptors and analysis parameters for Casement Aerodrome resulted in a 'PASS' score from the Solar Glare Hazard Analysis Tool (SGHAT). Approaching aircraft to runway 22 and 28 at Casement Aerodrome have the potential to experience glare over short periods during the year (Jan/Feb and again in Oct/Dev). With regard to the 'Retinal Irradiance' chart (**Figure 8**), this is of a low 'Green' intensity and is deemed fully acceptable by the FAA standards, and by default the IAA standards.

The SGHAT results are contained in Appendix A show that there is the theoretical potential to result in glare at the existing ATCT and the two potential future ATCTs in Casement Aerodrome. SGHAT calculated the potential glare up to 1487 minutes of '*Green Glare*' per annum at 1-ATCT, 1646 minutes at 2-ATCT and 1917 minutes at 3-ATCT. SGHATs '*Green Glare*' classification regarding the intensity of the potential glare is synonymous with FAA's *'low potential for temporary after image'*. *'Green Glare'* / glare with a *'low potential for temporary after image,'* regardless of the number of minutes per year, is considered by the FAA to be an unacceptable level of reflectance effect for an ATCT. This result is not unexpected or uncommon as SGHAT does not account for screening as a result of intervening terrain, buildings or vegetation. With the eye height within 1-ATCT at 102.5m OD, and with respect to the parapet and the top of panels proposed at 109.5m OD, it is not geometrically possible for glare to occur at 1-ATCT. A 3D visibility analysis was undertaken in relation to the two, potentially closer, future ATCTs (2-ATCT and 3-ATCT), to assess the effectiveness of the screening provided by the parapet that surrounds the roof the proposed building.

### 3.2.1 Visibility Analysis

A Zone of Theoretical Visibility (ZTV) analysis was undertaken from the future potential (P)ATCTS at Casement Aerodrome. The results of the ZTV analysis are presented in **Figure 6**. (In this Figure, 2-ATCT and 3-ATCT are labelled as PATCT 1 and PATCT 2.) This Figures shows there is no potential for visibility of the roof or the proposed PV panels from either of the future potential ATCTs at Casement Aerodrome therefore, there will be no potential for glint and glare to occur.

**For the reasons outlined above, it has been determined that the proposed solar installation will not impact local aviation activities in any way.**


**Figure 12: Output of results of ZTV analysis showing areas that are theoretically visible from the future potential ATCT at Casement Aerodrome.**

# 4 OVERALL CONCLUSION

**From the analysis and discussions contained herein, it is considered that there will not be any nuisance effects from glint and glare at dwellings surrounding this proposed PV array. Furthermore, it is considered highly unlikely that there will be any hazardous glint and glare effects upon either road receptors or aviation receptors resulting from the proposed PV array.**

# APPENDIX A:

## SGHAT RESULTS – RUNWAYS APPROACHES AND AIR TRAFFIC CONTROL TOWERS (ATCT)