Solar Photovoltaic Glint & Glare Study Aviation Specific

For roof mounted PV panels at a proposed SHD at Charlestown Place, Charlestown, Dublin 11

January 2021

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Executive Summary

This report assesses the potential for ocular impact of glare emanating from sunlight reflections from proposed rooftop solar PV panels and its potential to cause an impact to users of the nearby Dublin Airport. Receptors considered for assessment include the final approaches to existing Runways 16, 34, 10R, 28L, the proposed Runways 10L and 28R and the two Air Traffic Control Towers (ATCT) at Dublin Airport. The receptors and their position with respect to the proposed development are shown in Figure 1.

FIGURE 1: OVERVIEW OF PROPOSED SITE AND RECEPTORS

Using sun-path algorithms for every minute of the year, it was calculated if and when glare may theoretically occur at a particular receptor. If reflection was found geometrically possible at a particular location, further desk analysis was then carried out to ascertain if a view of the proposal (and thus potential for glare) would indeed be possible in reality.

The level of potential glare from solar PV panels is similar to that of water and much less than that of materials such as concrete and vegetation. Many common elements of the Irish landscape offer similar, if not higher levels of glare than that caused by solar PV systems such as shed roofs, poly tunnels and still lakes.

This is an aviation specific glint and glare report focusing only on the nearby Dublin Airport. It does not consider ground based receptors such as nearby roads, railway lines, residences or other aerodromes. However, due to the small scale of residential rooftop solar PV panels, it would not be deemed necessary to assess these receptors.

For the purpose of aviation analysis the US Federal Aviation Administration (FAA) recommend the use of the Solar Glare Hazard Plot (Figure 10) to measure the ocular impact of a solar array. Receptors with theoretical potential for glare can fall into one of three different areas: Green - “Low potential for after-image”, Yellow - “Potential for after-image” and Red - “Potential for Permanent Eye Damage (retinal burn)”.

The proposed development includes multiple arrays mounted on the roof-areas of several different blocks at various different elevations. A layout of the proposed development, as well as details of the solar arrays are shown in Figures 2, 3 and 4.

FIGURE 2: SITE DETAIL OF CHARLESTOWN DEVELOPMENT

FIGURE 3: PV ARRAYS WITH NUMBERING USED IN ANALYSIS FOR CHARLESTOWN DEVELOPMENT

Name	Orientation (degrees)	Pitch (degrees)	Height above ground (m)
Array 1	180	15	25.575
Array 2	180	15	22.81
Array 3	180	15	22.81
Array 4	180	15	22.81
Array 5	180	15	22.81
Array 6	180	15	25.885
Array 7	180	15	28.96
Array 8	180	15	32.035
Array 9	180	15	22.81
Array 10	180	15	22.81
Array 11	180	15	22.81
Array 12	180	15	13.275
Array 13	180	15	16.35
Array 14	180	15	16.35
Array 15	180	15	19.425
Array 16	180	15	22.5
Array 17	180	15	22.5
Array 18	180	15	22.8
Array 19	180	15	22.81
Array 20	180	15	22.81

FIGURE 4: PV ARRAY DETAILS

Figure 5 below gives a brief overview of the results of this glint and glare report; it can be seen that (based on the specified solar panel parameters) **none of the runways, nor any of the two ATC Towers at Dublin Airport will have the potential to experience glare**. It will be shown from the report and analyses herein that, based on the specified solar panel parameters, major nuisance or hazardous glare **can not** be expected for aircraft landing at any of the runways or the ATC Towers at Dublin Airport. This is due to the fact that there will be no geometric posibility for glare at any time of year for the ATC Towers or final approaches to runways 10R, 28L, 34, 16, 10L and 28R.

Name	No. of Assessed Arrays	No. with Theoretical Potential for Glare	No. with no Theoretical potential for Glare
Runway 10R	20	0	20
Runway 28L	20	0	20
Runway 34	20	0	20
Runway 16	20	0	20
Runway 10L	20	0	20
Runway 28R	20	0	20
ATC-Tower 1	20	0	20
ATC Tower 2	20	0	20

FIGURE 5: RESULTS AT A GLANCE (DUBLIN AIRPORT)

Introduction

Innovision has been appointed by Puddenhill Property Limited to carry out an aviation specific glint and glare study for roof mounted solar PV panels at a proposed residential development at Charlestown Place, Charlestown, Dublin 11. The subject site is located approximately 5 km east-south-east of Dublin Airport (Figure 1). The proposed development consists of several different blocks at various different elevations. It is proposed to mount solar PV panels on the majority of the structures (Figure 3).

Innovision is a leading visualisation, mapping & geographical information systems (GIS) analysis company. Our innovative team has over ten years' experience in the photomontage and 3D visualisation industry, working on a wide range of proposed commercial developments including numerous wind and solar farms, both in Ireland and abroad. Innovision is also a certified Forge Solar 'Glare Expert'. This is currently the only glint and glare assessor qualification available internationally.

Using desk-based analysis, this report has assessed the potential for glare on aircraft taking off and landing at Dublin Airport. Using sun-path algorithms for every minute of the year (assuming 100% sunshine for all daylight hours), it is determined if and when reflections may occur at these selected receptors. If reflection is found geometrically possible from a particular location, further analysis is then carried out. This further analysis determines the significance of the glare that could potentially be experienced and also if, in reality, these effects are likely to be experienced by an observer at that location. In certain cases, where glare is found to be significant and a likely source of hazard or nuisance, mitigation factors can then be discussed.

Proposed Solar PV Array Details

The proposed array is located on the rooftops of several blocks, with heights above ground ranging from 13 m to 32 m, on a site at the junction of St. Margaret's Road and Charlestown Place, Dublin 11 (Figures 2 and 3). Both the pitch angle and the orientation angle of the panels will be fixed so the panels will not track the sun throughout the day/year. The orientation of all the panels is due south (180°) and the pitch of the panels is 15°.

Glint and Glare Overview

What are Glint and Glare?

Glint and glare are phenomenon caused by many reflective materials, whereby light from the sun is reflected off such materials with a potential to cause hazard, nuisance or unwanted visual impact. Glint and glare have been best defined by the United States Federal Aviation Administration (FAA) in their "*Technical Guidance for Evaluating Selected Solar Technologies on Airports*"[1]:

Glint is a momentary flash of bright light.

Glare is a continuous source of bright light.

Glint and Glare are also commonly referred to as 'solar reflection'. To determine the impact that solar reflection could potentially have on members of the public, it is sometimes necessary to carry out a glint and glare assessment for proposed solar PV farms or roof mounted arrays.

When do Glint and Glare Occur?

The sun rises in the east and sets in the west and in the northern hemisphere, tracks a southerly arc across the sky (Figure 4). The elevation angle that the sun reaches varies depending on the time of year, with high angles in the summer months and much lower angles in winter.

Once the sun reaches a certain elevation in the sky, the incident angle of the sun will reflect off the solar panels at an opposing angle that will not impact on any ground-based receptors. As a result of this, for ground-based receptors, glint and glare from solar farms will generally only occur in the mornings and the evenings. At these times, the sun will also be shining from a similar direction as any potential glare. For aviation receptors however, glare can potentially occur at any time of day depending on the location of the aircraft.

[1] Federal Aviation Administration, November 2010: *Technical Guidance for Evaluating Selected Solar Technologies on Airports*

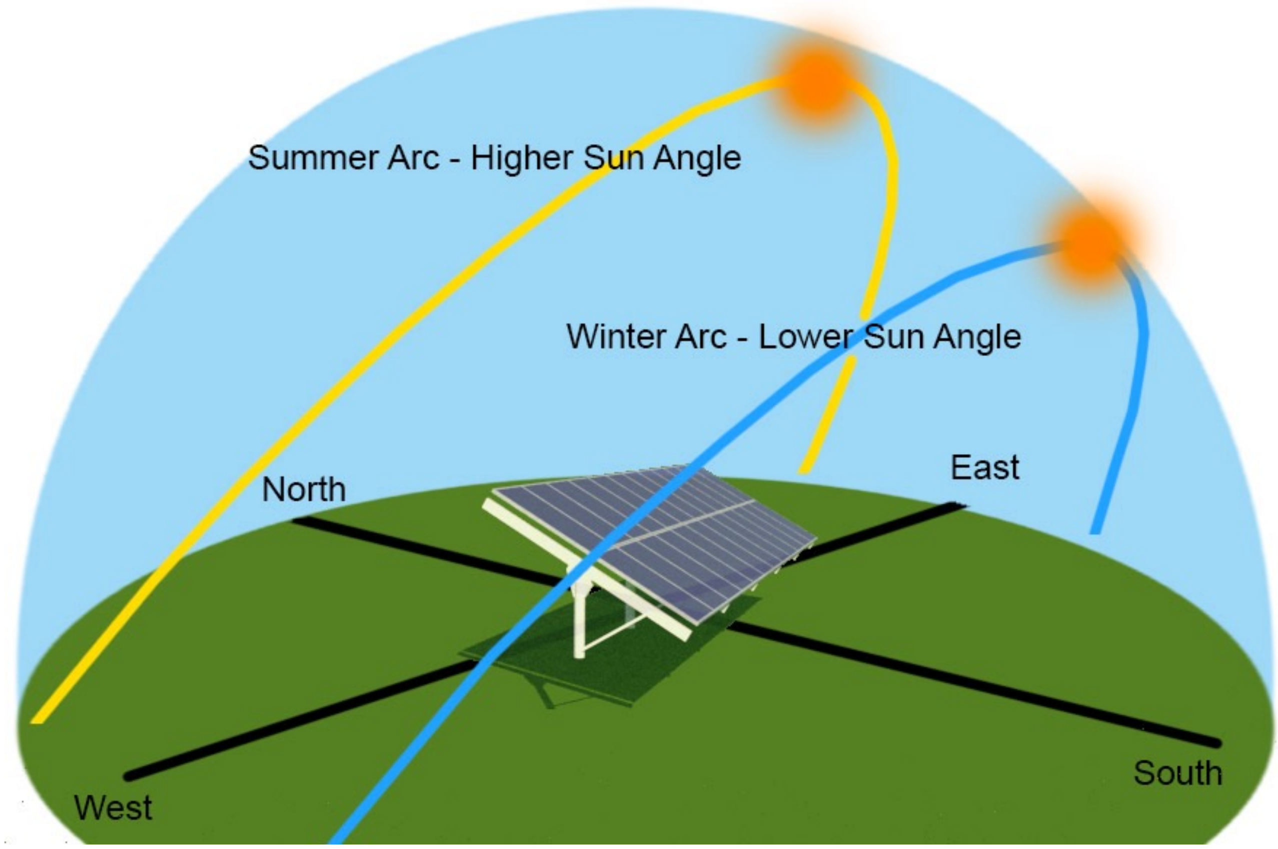

FIGURE 5: ARCS TRACKED BY SUN AT DIFFERENT TIMES OF YEAR

Meteorological & Atmospheric Conditions

It is also worth noting that glint and glare can only occur when there is direct sunlight reaching the solar panels. In overcast or rainy conditions, no glint or glare will occur. Met Éireann, Ireland's National Meteorological Service, suggests that due to Ireland's position off the northwest of Europe we are kept in humid, cloudy airflows for much of the time. *"Irish skies are completely covered by cloud for well over fifty percent of the time."*[2]

For this proposed development, historical sunshine duration data from 1981-2010, recorded at Dublin Airport has been analysed. Dublin Airport is the nearest Met Éireann weather station to the proposed development that records sunshine data. From looking at Figure 5 & Figure 6 below it can be seen that for this particular site, the number of days glare could potentially be experienced at each receptor could realistically be reduced by 70% and still offer an overstated prediciton of glare.

[2] Met Éireann "Sunshine and Solar Radiation" www.met.ie.

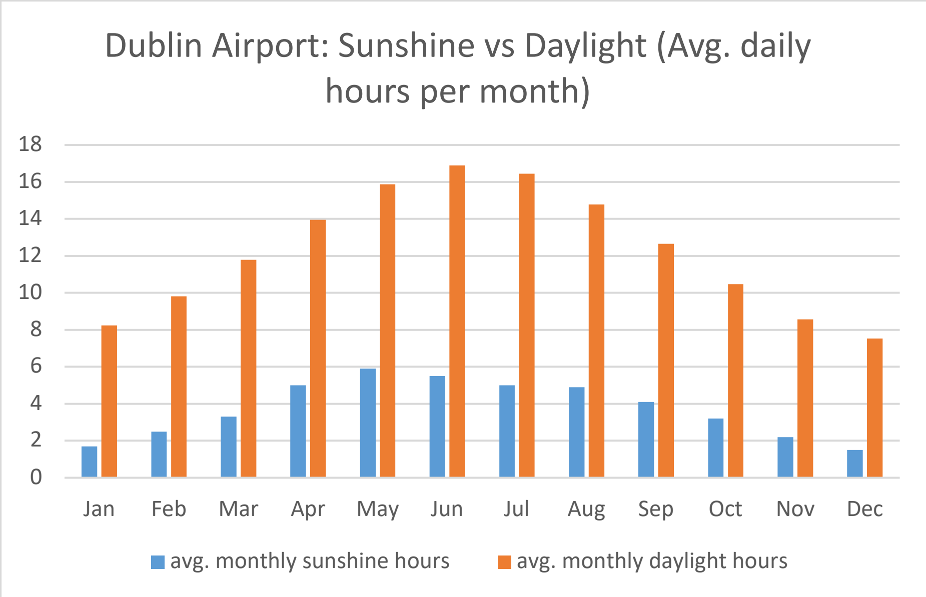

FIGURE 6: DUBLIN AIRPORT: SUNSHINE VS DAYLIGHT (AVG. DAILY HOURS PER MONTH)

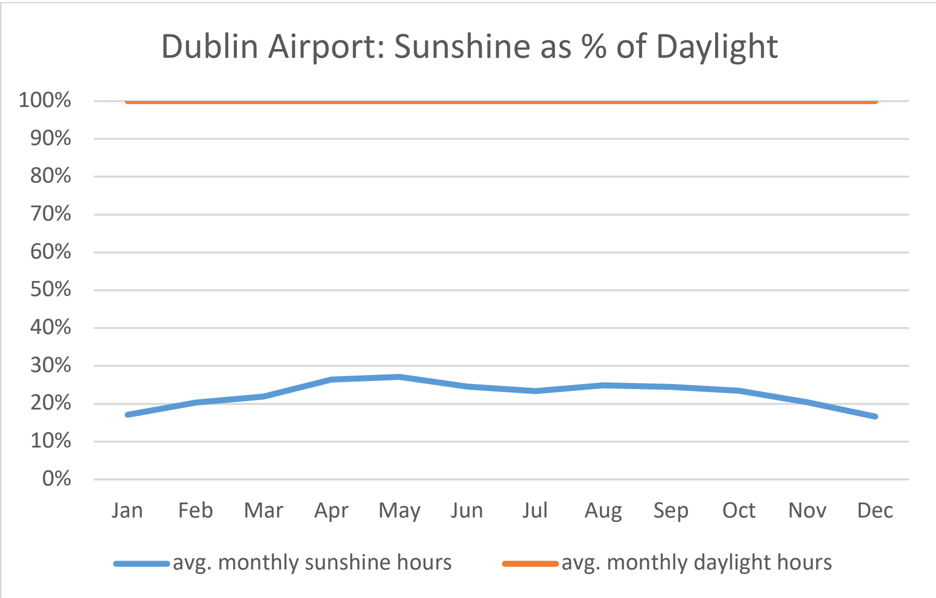

FIGURE 7: DUBLIN AIRPORT: SUNSHINE AS A PERCENTAGE OF DAYLIGHT

Solar Reflectance from PV Panels

Surface Reflectance

All surface types have different reflectivity characteristics. This results in varying degrees of sunlight reflection. Solar panels, by their nature, are designed to absorb as much sunlight as possible, thus converting the sun's energy to electricity. As a result, the amount of light reflected off these installations is far less than one might expect. The figure below (Figure 8) is taken from the FAA 2010 Solar Guidance and illustrates that the reflectance of solar PV panels is of a similar nature to water. Typical values for the reflectance levels of solar PV panels are far less than that of materials such as snow, concrete and even vegetation. It should be noted however, that at certain times of the day, generally early morning and late evening, with the sun low in the sky, the amount of light reflected off solar panels can increase, causing a potential for glare in certain directions.

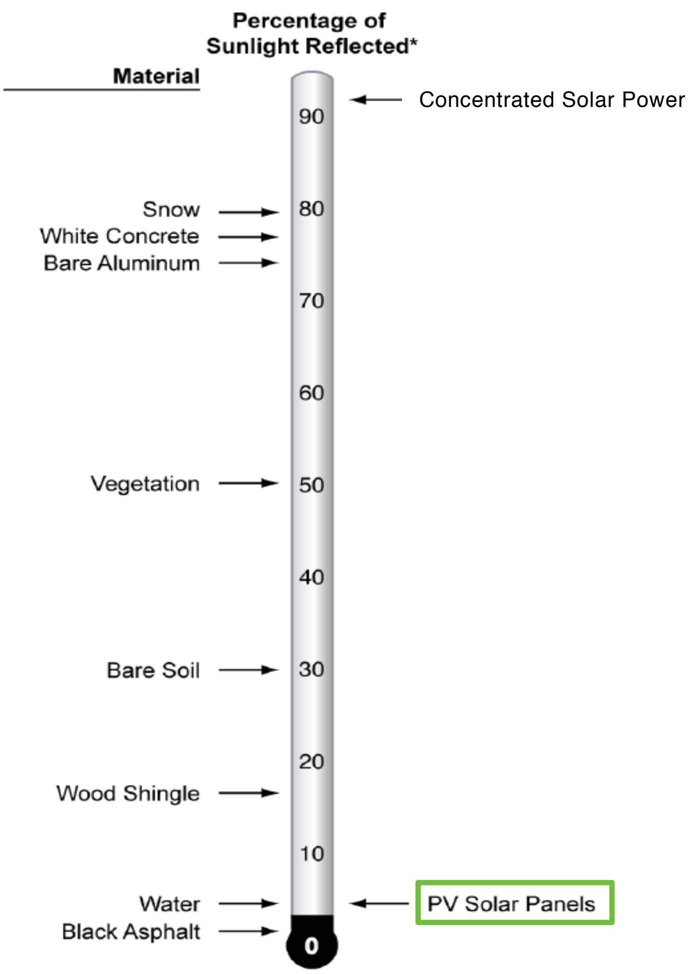

FIGURE 8: REFLECTIVITY PRODUCED BY DIFFERENT SURFACES (SOURCE: FAA)

Types of Reflection

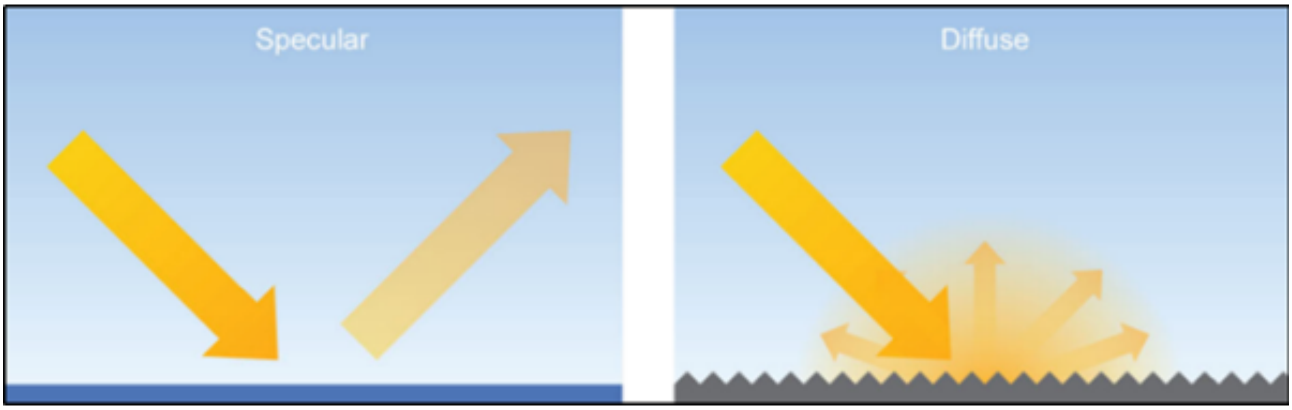

FIGURE 9: DIFFERENT TYPES OF REFLECTION (SOURCE: FAA)

There are two types of reflection which can occur on a surface; specular and diffuse. Specular reflection is a direct reflection which produces a more "focused" type of light. It occurs when light reflects off a smooth or polished surface like glass or still water. Diffuse reflection, on the other hand, produces a less "focused" type of light. Diffuse reflection occurs as a result of light reflecting off a rough surface such as vegetation, concrete or wavy water. Figure 9 helps to illustrate the difference between these two types of reflection. The main type of reflectance from solar PV panels is specular due to the glass like texture of the outer layer of the panels. However, in reality, like all surfaces, there will be a combination of both specular and diffuse reflection

As discussed earlier, the level of potential glare from solar PV panels is similar to that of water and much less than that of materials such as concrete and vegetation. Many common elements of the Irish landscape offer similar, if not higher levels of glare than that caused by solar PV systems such as shed roofs, still lakes and even the strips of plastic sheeting used on farms to produce maize (Figure 10).

FIGURE 10: PLASTIC MAIZE WRAP IN A FIELD WITH POTENTIAL TO CAUSE SIMILAR LEVELS OF GLARE AS SOLAR PV FARMS

Relevant Guidance & Studies

Republic of Ireland

In the Republic of Ireland (ROI), there is currently no guidance, policy or recommendations in relation to the assessment of glint and glare effects on aviation, road & rail users or residential buildings. Future Analytics in conjunction with the Sustainable Energy Authority of Ireland (SEAI) have produced planning and development guidance recommendations for utility scale solar photovoltaic schemes in Ireland [3]. While this is not formal guidance, it does set out recommended elements of the assessment based on international practice.

United Kingdom

In the United Kingdom (UK), where the development of large scale solar PV is more mature, certain studies have been carried out which help to establish an accepted best practice and planning guidance recommends the assessment of glint and glare effects. However, there is still no specific guidance by way of a prescriptive methodology document. In the absence of formal policy, the Civil Aviation Authority (CAA) have provided interim guidance in relation to the development of solar PV systems on, and in the vicinity (<15km) of aerodromes. This guidance recommends that solar PV developers should *"provide safety assurance documentation regarding the full potential impact of the SPV installation on aviation interests."* [4] The Building Research Establishment (BRE) have also issued several relevant papers, however neither the BRE nor the CAA have produced a methodology for assessing the effects of glint and glare on aviation, road & rail users or residential buildings.

Germany

In Germany, glare is considered an emission not unlike noise, odour or vibration. *"Licht-Leitlinie"* [5] or Light Guidelines produced by The Federal Ministry of the Environment defines acceptable levels of glare as being anything less than 30 minutes per day or 30 hours per year. The guidance also states that there is only additional impact to an observer as a result of glare from a solar array if the angle between the source of the glare and the sun is greater than ten degrees. These factors are taken into consideration at classification of impact stage in this report.

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[3] *Future Analytics. October 2016. Planning and Development Guidance Recommendations for Utility Scale Solar Photovoltaic Schemes in Ireland*

[4] Civil Aviation Authority. December 2010. *"Interim CAA Guidance - Solar Photovoltaic Systems".*

[5] Leitlinie des Ministeriums fur Umwelt. Gesundheit und Verbraucherschutz zur Messung und Beurteilung von Lichtimmissionen (Licht-Leitlinie). 2014 Available: http://www.mlul.brandenburg.de/media_fast/4055/licht_leitlinie.pdf

United States of America

The main form of guidance in assessing the likely effects of glint and glare (on aviation infrastructure) comes from the FAA in the United States. Their document, "*Technical Guidance for Evaluating Selected Solar Technologies on Airports*"[6] is accepted internationally as the most detailed methodology for assessing the effects of glint and glare. This document is currently under review and an interim policy document[7] was produced in October 2013. The 2013 interim policy further addresses glint and glare issues and recommends the use of a particular analysis tool, the Solar Glare Hazard Analysis Tool (SGHAT), when carrying out glint & glare assessments of solar PV systems. This is a tool that was developed by the US Department of Energy research laboratories, Sandia National Laboratories, to assess the ocular impact of proposed solar energy systems.

Innovision has created a methodology for assessing glint and glare taking all of the above studies and guidelines into consideration. Although SGHAT is a tool which was created to assess the impact of solar PV systems on aviation infrastructure, Innovision has employed this tool and prescribed methodology to all receptor types including road & rail users, aviation & residential buildings. This is currently the **only FAA approved tool** for measuring the ocular impact of solar PV systems on receptors. Until formal guidance is provided in Ireland, Innovision will continue to follow international guidelines and best practice.

Methodology

Innovision's methodology can be broken down into seven key stages:

1. Study Area Selection
2. Receptor Identification
3. Geometric Analysis
4. Examination of Screening and Receptor Orientation
5. Determination of Impact
6. Mitigation

[6] Federal Aviation Administration. November 2010. "*Technical Guidance for Evaluating Selected Solar Technologies on Airports*"

[7] Federal Aviation Administration. October 2013. *"Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports."*

1. Study Area Selection

The first stage of any glint and glare assessment is to identify the study area. In the case of this development the existing runways, proposed runways and both ATCT sites at Dublin Airport will be considered.

2. Receptor Identification

Once the study area has been defined, receptors can then be identified. For this site, the four existing runways, two proposed runways and two ATCT sites at Dublin Airport are being considered.

AIRPORTS & AIRSTRIPS

The two main receptors that need to be considered when assessing the glint and glare effects of solar PV farms on aerodromes are Air Traffic Control Towers (ATCT) and the final approach path to a runway. An ATCT is assessed much like any other receptor point using the correct altitude of the tower. For final runway approach paths, a line is extrapolated 2 miles back from the runway threshold (the point at which an aircraft enters the runway) at an angle of 3 degrees. This results in a continuous analysis of every point along the final approach to the runway. For utility scale solar PV systems any aerodromes within the vicinity of a proposed solar PV farm would be assessed. “Vicinity” in this case is within 15km as defined by the CAA interim guidance referred to earlier. It should also be noted that these calculations take the pilots field of view into consideration and thus limit the angle of view to 100 degrees in the horizontal and a downward viewing angle of 30 degrees.

3. Geometric Analysis

As discussed previously in this document, Innovision employs the use of the SGHAT in order to run the calculations for its glint and glare analysis. This is currently the only FAA approved tool for measuring the ocular impact of solar PV systems on receptors.

A number of parameters are considered in order to run these geometric analyses. These include, but are not limited to:

- The apparent position and height of the sun at a particular time of day and year (for every minute of the year).
- The position, height, orientation & pitch of the solar PV array.
- The position and height of the receptor.

The severity of the glare is influenced mainly by two factors:

- The distance of the observer from the glare spot, and
- The angle of the sunlight hitting the solar panels relevant to the observer

4. Examination of Screening and Receptor Orientation

The geometrical glare analysis does not consider screening from landform such as hills and mountains, or any vegetative or built environment elements of the landscape that may screen the development from view. For this reason, once the receptors that could potentially experience glare have been identified, their level of existing screening must be assessed. This is done through a combination of desk-based analysis of both Google StreetView and aerial photography and sometimes requires a site visit for further verification. Receptor orientation is also considered. Geometric analysis may suggest that a dwelling will experience glare, but the orientation of the dwelling also needs to be considered. If a dwelling is facing away from the solar array, any potential glare could have little or no impact. Similarly, a road may show up as having potential to experience glare, but unless the direction of travel is towards the source of glare, it is unlikely to cause significant impact.

5. Determination of Impact

Once all of the above steps are carried out, a determination of likely impacts can be made for each receptor. Results are collated into a comprehendable table with comments as to the likely glint and glare impact or otherwise, of the propsed solar PV panels on all assessed receptors. An initial determination is made using the table below, based purely on the theroetical amount of time a receptor may potentially experience glare.

Classification	Description
High	Potential for more than 45 mins of glare per day and/or more than 50 hours per year
Medium	Potential for no more than 45 mins of glare per day and/or no more than 50 hours per year
Low	Potential for 20 - 30 mins of glare per day and/or no more than 30 hours per year
Very Low	Potential for 10 - 20 mins of glare per day and/or no more than 20 hours per year
Negligible	Potential for less than 10 mins of glare per day and/or less than 10 hours per year
None	No geometric potential for glare / Any potential for glare fully screened by intervening landform, vegetation or the built environment

The above table is used as a guide only and final classification is based on a combination of additional factors including level of intervening screening (vegetative or otherwise), receptor orientation, position of sun in relation to source of glare, as well as professional judgement.

6. Mitigation

If it is determined that glare will be experienced at a particular receptor and there is no screening between the receptor and the solar array, mitigation may be recommended depending on the severity of the glare. Mitigating glare impact from a solar array can be achieved in a number of different ways. The most common method is to add vegetative screening to essentially form a visual barrier between the receptor and the development. This type of mitigation is often required for ecological and visual impact reasons also. Other forms of mitigation include changing the design of the solar array, such as a change in pitch and orientation of the panels.

Receptor Selection

As discussed, this report assesses the final approach at all existing and proposed runways and the two ATCT sites at Dublin Airport. These receptors have been analysed for glint and glare effects that may be experienced during take off and landing as a result of the propsed roof mounted solar PV arrays.

Results & Discussion

Tables 1 to 8 give an overview of the findings of this glint and glare report and can be used to assist in comprehension of the following discussion, along with the included maps (Maps 1 - 8). For more detailed information on the particulars of potential glare experienced at each receptor, please refer to the appendix of this report. The appendix contain graphs for any solar array showing the potential for glare. The date and time of potential glare, the potential duration of the glare, the hazard plot indicating the magnitude of the potential glare and also where along the final approach the glare might potentially be experienced.

Please note, all references to time herein refer to Irish Standard Time (IST) which equates to UTC/GMT +1 hour. Between mid-March and early November Ireland uses Daylight Savings Time (DST) and as a result, 1 hour needs to be subtracted from any results occuring outside this time period.

<table>
<tr><th>Array</th><th>Receptor</th><th colspan="2">Theoretical Potential for Glare</th><th>Mean Daily Duration</th><th>Max Daily Duration</th><th>Max Annual Duration</th><th colspan="2">Potential Times Affected</th><th colspan="4">Potential Dates Affected</th></tr>
<tr><th></th><th></th><th>am</th><th>pm</th><th></th><th></th><th></th><th>Earliest Start Time</th><th>Latest End Time</th><th>1st Start Date</th><th>1st End Date</th><th>2nd Start Date</th><th>2nd End Date</th></tr>
<tr><td>array_1</td><td>runway-10r</td><td rowspan="20" colspan="11">Glare Not Geometrically Possible for this Receptor</td></tr>
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<tr><td>array_3</td><td>runway-10r</td></tr>
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Table 1: Glint and Glare Analysis Results for Runway 10R

<table>
<tr><th>Array</th><th>Receptor</th><th colspan="2">Theoretical Potential for Glare</th><th>Mean Daily Duration</th><th>Max Daily Duration</th><th>Max Annual Duration</th><th colspan="2">Potential Times Affected</th><th colspan="4">Potential Dates Affected</th></tr>
<tr><th></th><th></th><th>am</th><th>pm</th><th></th><th></th><th></th><th>Earliest Start Time</th><th>Latest End Time</th><th>1st Start Date</th><th>1st End Date</th><th>2nd Start Date</th><th>2nd End Date</th></tr>
<tr><td>array_1</td><td>runway-28l</td><td rowspan="20" colspan="11">Glare Not Geometrically Possible for this Receptor</td></tr>
<tr><td>array_2</td><td>runway-28l</td></tr>
<tr><td>array_3</td><td>runway-28l</td></tr>
<tr><td>array_4</td><td>runway-28l</td></tr>
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Table 2: Glint and Glare Analysis Results for Runway 28L

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Table 3: Glint and Glare Analysis Results for Runway 34

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<tr><td>array_2</td><td>runway-16</td></tr>
<tr><td>array_3</td><td>runway-16</td></tr>
<tr><td>array_4</td><td>runway-16</td></tr>
<tr><td>array_5</td><td>runway-16</td></tr>
<tr><td>array_6</td><td>runway-16</td></tr>
<tr><td>array_7</td><td>runway-16</td></tr>
<tr><td>array_8</td><td>runway-16</td></tr>
<tr><td>array_9</td><td>runway-16</td></tr>
<tr><td>array_10</td><td>runway-16</td></tr>
<tr><td>array_11</td><td>runway-16</td></tr>
<tr><td>array_12</td><td>runway-16</td></tr>
<tr><td>array_13</td><td>runway-16</td></tr>
<tr><td>array_14</td><td>runway-16</td></tr>
<tr><td>array_15</td><td>runway-16</td></tr>
<tr><td>array_16</td><td>runway-16</td></tr>
<tr><td>array_17</td><td>runway-16</td></tr>
<tr><td>array_18</td><td>runway-16</td></tr>
<tr><td>array_19</td><td>runway-16</td></tr>
<tr><td>array_20</td><td>runway-16</td></tr>
</table>

Table 4: Glint and Glare Analysis Results for Runway 16

Array	Receptor	Theoretical Potential for Glare		Mean Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected			
		am	pm				Earliest Start Time	Latest End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date
array_1	runway-10l	Glare Not Geometrically Possible for this Receptor										
array_2	runway-10l											
array_3	runway-10l											
array_4	runway-10l											
array_5	runway-10l											
array_6	runway-10l											
array_7	runway-10l											
array_8	runway-10l											
array_9	runway-10l											
array_10	runway-10l											
array_11	runway-10l											
array_12	runway-10l											
array_13	runway-10l											
array_14	runway-10l											
array_15	runway-10l											
array_16	runway-10l											
array_17	runway-10l											
array_18	runway-10l											
array_19	runway-10l											
array_20	runway-10l											

Table 5: Glint and Glare Analysis Results for Runway 10L

Array	Receptor	Theoretical Potential for Glare		Mean Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected			
		am	pm				Earliest Start Time	Latest End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date
array_1	runway-28r	Glare Not Geometrically Possible for this Receptor										
array_2	runway-28r											
array_3	runway-28r											
array_4	runway-28r											
array_5	runway-28r											
array_6	runway-28r											
array_7	runway-28r											
array_8	runway-28r											
array_9	runway-28r											
array_10	runway-28r											
array_11	runway-28r											
array_12	runway-28r											
array_13	runway-28r											
array_14	runway-28r											
array_15	runway-28r											
array_16	runway-28r											
array_17	runway-28r											
array_18	runway-28r											
array_19	runway-28r											
array_20	runway-28r											

Table 6: Glint and Glare Analysis Results for Runway 28R

<table>
<tr><th rowspan="2">Array</th><th rowspan="2">Receptor</th><th colspan="2">Theoretical Potential for Glare</th><th>Mean Daily Duration</th><th>Max Daily Duration</th><th>Max Annual Duration</th><th colspan="2">Potential Times Affected</th><th colspan="4">Potential Dates Affected</th></tr>
<tr><th>am</th><th>pm</th><th></th><th></th><th></th><th>Earliest Start Time</th><th>Latest End Time</th><th>1st Start Date</th><th>1st End Date</th><th>2nd Start Date</th><th>2nd End Date</th></tr>
<tr><td>array_1</td><td>1-atct</td><td rowspan="20" colspan="11">Glare Not Geometrically Possible for this Receptor</td></tr>
<tr><td>array_2</td><td>1-atct</td></tr>
<tr><td>array_3</td><td>1-atct</td></tr>
<tr><td>array_4</td><td>1-atct</td></tr>
<tr><td>array_5</td><td>1-atct</td></tr>
<tr><td>array_6</td><td>1-atct</td></tr>
<tr><td>array_7</td><td>1-atct</td></tr>
<tr><td>array_8</td><td>1-atct</td></tr>
<tr><td>array_9</td><td>1-atct</td></tr>
<tr><td>array_10</td><td>1-atct</td></tr>
<tr><td>array_11</td><td>1-atct</td></tr>
<tr><td>array_12</td><td>1-atct</td></tr>
<tr><td>array_13</td><td>1-atct</td></tr>
<tr><td>array_14</td><td>1-atct</td></tr>
<tr><td>array_15</td><td>1-atct</td></tr>
<tr><td>array_16</td><td>1-atct</td></tr>
<tr><td>array_17</td><td>1-atct</td></tr>
<tr><td>array_18</td><td>1-atct</td></tr>
<tr><td>array_19</td><td>1-atct</td></tr>
<tr><td>array_20</td><td>1-atct</td></tr>
</table>

Table 7: Glint and Glare Analysis Results for ATCT-1

<table>
<tr><th rowspan="2">Array</th><th rowspan="2">Receptor</th><th colspan="2">Theoretical Potential for Glare</th><th>Mean Daily Duration</th><th>Max Daily Duration</th><th>Max Annual Duration</th><th colspan="2">Potential Times Affected</th><th colspan="4">Potential Dates Affected</th></tr>
<tr><th>am</th><th>pm</th><th></th><th></th><th></th><th>Earliest Start Time</th><th>Latest End Time</th><th>1st Start Date</th><th>1st End Date</th><th>2nd Start Date</th><th>2nd End Date</th></tr>
<tr><td>array_1</td><td>2-atct</td><td rowspan="20" colspan="11">Glare Not Geometrically Possible for this Receptor</td></tr>
<tr><td>array_2</td><td>2-atct</td></tr>
<tr><td>array_3</td><td>2-atct</td></tr>
<tr><td>array_4</td><td>2-atct</td></tr>
<tr><td>array_5</td><td>2-atct</td></tr>
<tr><td>array_6</td><td>2-atct</td></tr>
<tr><td>array_7</td><td>2-atct</td></tr>
<tr><td>array_8</td><td>2-atct</td></tr>
<tr><td>array_9</td><td>2-atct</td></tr>
<tr><td>array_10</td><td>2-atct</td></tr>
<tr><td>array_11</td><td>2-atct</td></tr>
<tr><td>array_12</td><td>2-atct</td></tr>
<tr><td>array_13</td><td>2-atct</td></tr>
<tr><td>array_14</td><td>2-atct</td></tr>
<tr><td>array_15</td><td>2-atct</td></tr>
<tr><td>array_16</td><td>2-atct</td></tr>
<tr><td>array_17</td><td>2-atct</td></tr>
<tr><td>array_18</td><td>2-atct</td></tr>
<tr><td>array_19</td><td>2-atct</td></tr>
<tr><td>array_20</td><td>2-atct</td></tr>
</table>

Table 8: Glint and Glare Analysis Results for ATCT-2

Interpreting the Results

For the purpose of aviation analysis, the methodology produced by SANDIA National Laboratories must be followed to comply with FAA guidance. This approach adopts the Solar Glare Hazard Plot (Figure 10) to measure the ocular impact of a solar array. Receptors with theoretical potential for glare can fall into one of three different areas: Green - "Low potential for after-image", Yellow - "Potential for after-image" and Red - "Potential for Permanent Eye Damage (retinal burn)".

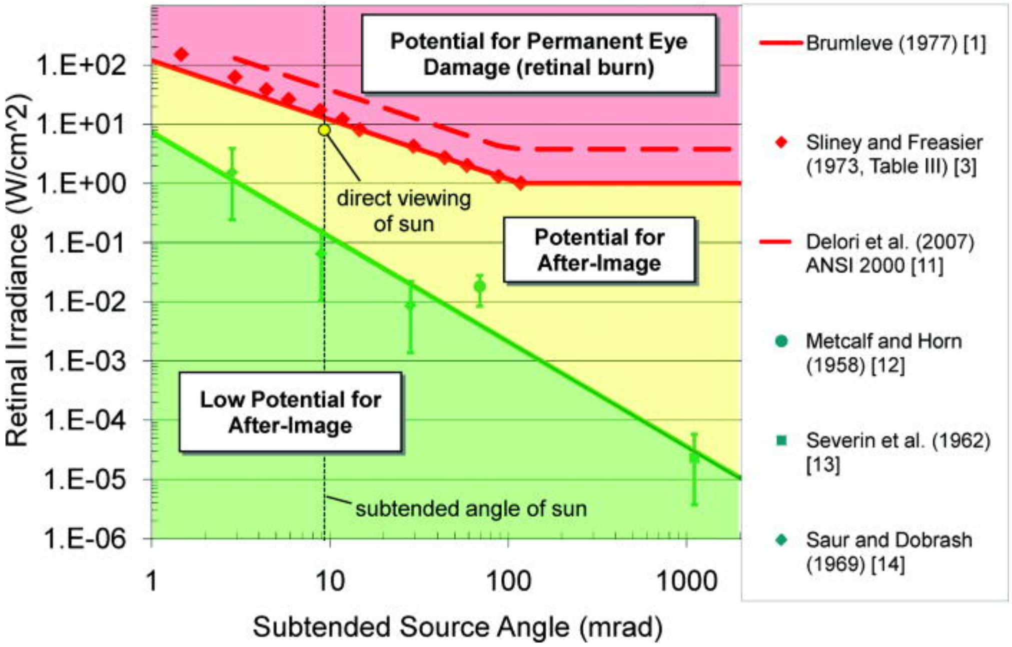


FIGURE 10: SOLAR GLARE HAZARD ANALYSIS PLOT (FIGURE 1 FROM FAA POLICY DOCUMENT)

The hazard plot above displays the ocular impact as a function of glare subtended source angle (the amount of an observer's field-of-view taken up by a glare spot) and retinal irradiance (the amount of light reaching the observer's retina). Each minute of potential glare is plotted on the chart. As a guide, a reference point which illustrates the hazard from viewing the sun without filtering is displayed on every graph.

From the 2013 FAA interim guidance, in order to obtain FAA approval for a proposed solar array the development must demonstrate that it meets the following standards:

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

2. No potential for glare or "low potential for after-image" (shown in green in Figure 1) 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."

Runway 10R

From Table 1 it can be seen that none of the proposed arrays have the potential to cause glare impact on this receptor.

Runway 28L

From Table 2 it can be seen that none of the proposed arrays have the potential to cause glare impact on this receptor.

Runway 34

From Table 3 it can be seen that none of the proposed arrays have the potential to cause glare impact on this receptor.

Runway 16

From Table 4 it can be seen that none of the proposed arrays have the potential to cause glare impact on this receptor.

Runway 10L (Under Construction)

From Table 5 it can be seen that none of the proposed arrays have the potential to cause glare impact on this receptor.

Runway 28R (Under Construction)

From Table 6 it can be seen that none of the proposed arrays have the potential to cause glare impact on this receptor.

Dublin Airport ATCT (ATCT-1 Recently Constructed)

From Table 7 it can be seen that none of the proposed arrays have the potential to cause glare impact on this receptor.

Dublin Airport ATCT (ATCT-2 Existing)

From Table 8 it can be seen that none of the proposed arrays have the potential to cause glare impact on this receptor.

Conclusion

In conclusion, it can be shown from the above analyses that, based on the specified solar panel parameters, major nuisance or hazardous glare **can not** be expected for aircraft landing at any of the runways or the ATCT at Dublin Airport. This is due to the fact that there will be no geometric posibility for glare at any time of year for the ATC towers or final approaches to runways 10L, 10R, 16, 28L, 28R and 34. These results achieve a pass by FAA standards based on the fact that no glare falls in the “yellow” area of the hazard plot.

The level of potential glare from solar PV panels is similar to that of water and much less than that of materials such as concrete and vegetation. Many common elements of the Irish landscape offer similar, if not higher levels of glare than that caused by solar PV panels.

In order for glare to be experienced by a pilot, there needs to be direct sunlight shining on the solar PV panels. From analysis of historical sunshine data near the proposed site, the number of days glare could potentially be experienced at each receptor could realistically be reduced by 70% and still offer an overstated prediciton of glare.

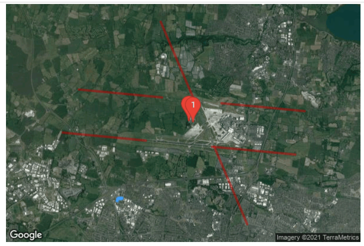
Appendix

Please note the following assumptions will apply to the following graphs:

- Please note, all references to time herein refer to Irish Standard Time (IST) which equates to UTC/GMT +1 hour. Between mid-March and early November Ireland uses Daylight Savings Time (DST) and as a result, 1 hour needs to be subtracted from any results occuring outside this time period.
- Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.

Site Configuration: charlestown

Project site configuration details and results.



Created **Jan. 5, 2021 11:05 a.m.**
Updated **Jan. 5, 2021 12:27 p.m.**
DNI **varies** and peaks at **1,000.0 W/m^2**
Analyze every **1** minute(s)
0.5 ocular transmission coefficient
0.002 m pupil diameter
0.017 m eye focal length
9.3 mrad sun subtended angle
Timezone **UTC1**
Site Configuration ID: 47596.3994

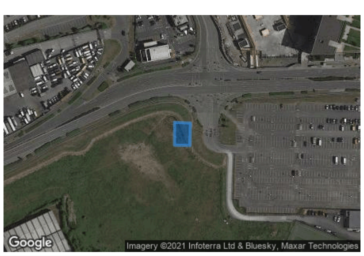
Summary of Results No glare predicted!

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
array 1	15.0	180.0	0	0	-
array 10	15.0	180.0	0	0	-
array 11	15.0	180.0	0	0	-
array 12	15.0	180.0	0	0	-
array 13	15.0	180.0	0	0	-
array 14	15.0	180.0	0	0	-
array 15	15.0	180.0	0	0	-
array 16	15.0	180.0	0	0	-
array 17	15.0	180.0	0	0	-
array 18	15.0	180.0	0	0	-
array 19	15.0	180.0	0	0	-
array 2	15.0	180.0	0	0	-
array 20	15.0	180.0	0	0	-
array 3	15.0	180.0	0	0	-
array 4	15.0	180.0	0	0	-
array 5	15.0	180.0	0	0	-
array 6	15.0	180.0	0	0	-
array 7	15.0	180.0	0	0	-
array 8	15.0	180.0	0	0	-
array 9	15.0	180.0	0	0	-

Component Data

PV Array(s)

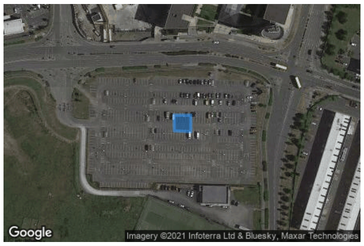
Name: array 1
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad
Approx. area: 288 sq-m



Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	53.402639	-6.306164	70.74	25.89	96.63
2	53.402453	-6.306164	70.79	25.89	96.67
3	53.402450	-6.305955	70.74	25.89	96.63
4	53.402632	-6.305949	70.33	25.89	96.21

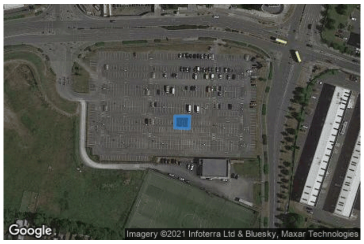
Name: array 10
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad
Approx. area: 221 sq-m

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	53.402495	-6.304184	69.22	22.81	92.03
2	53.402495	-6.303954	69.08	22.81	91.89
3	53.402360	-6.303954	69.02	22.81	91.83
4	53.402367	-6.304179	69.04	22.81	91.85



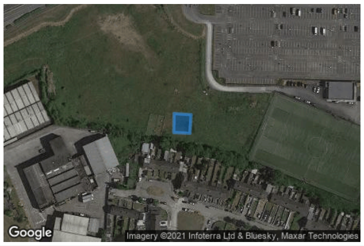
Name: array 11
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad
Approx. area: 145 sq-m

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	53.402271	-6.304174	69.03	22.81	91.84
2	53.402271	-6.303970	69.06	22.81	91.87
3	53.402169	-6.303981	69.06	22.81	91.87
4	53.402175	-6.304174	69.01	22.81	91.82



Name: array 12
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad
Approx. area: 253 sq-m

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	53.401666	-6.305885	68.87	13.28	82.15
2	53.401657	-6.305654	68.89	13.28	82.16
3	53.401506	-6.305670	68.80	13.28	82.07
4	53.401513	-6.305890	68.82	13.28	82.10



Name: array 13
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad
Approx. area: 39 sq-m

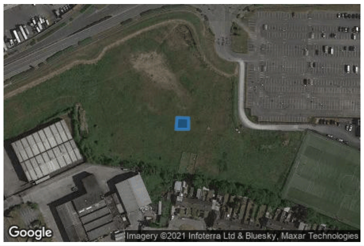
Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	53.401638	-6.306539	69.22	16.35	85.57
2	53.401689	-6.306502	69.26	16.35	85.61
3	53.401673	-6.306427	69.19	16.35	85.54
4	53.401606	-6.306464	69.15	16.35	85.50

Name: array 14
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad
Approx. area: 104 sq-m

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	53.401861	-6.306378	69.46	16.35	85.81
2	53.401829	-6.306287	69.40	16.35	85.75
3	53.401714	-6.306373	69.19	16.35	85.54
4	53.401734	-6.306475	69.30	16.35	85.65

Name: array 15
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad
Approx. area: 116 sq-m

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	53.401945	-6.306293	69.66	19.43	89.08
2	53.401941	-6.306132	69.72	19.43	89.14
3	53.401849	-6.306132	69.41	19.43	88.83
4	53.401849	-6.306303	69.45	19.43	88.87

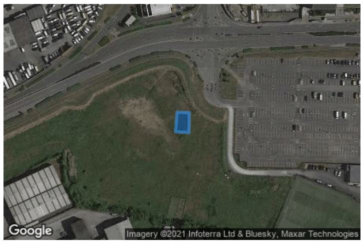


Name: array 16
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad
Approx. area: 30 sq-m

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	53.402325	-6.306346	70.76	22.50	93.26
2	53.402325	-6.306234	70.77	22.50	93.27
3	53.402290	-6.306234	70.73	22.50	93.23
4	53.402290	-6.306357	70.71	22.50	93.21

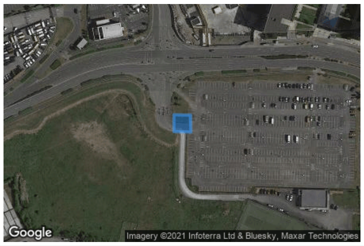
Name: array 17
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad
Approx. area: 207 sq-m

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	53.402357	-6.306137	70.79	22.50	93.29
2	53.402354	-6.305971	70.80	22.50	93.30
3	53.402191	-6.305976	70.68	22.50	93.18
4	53.402197	-6.306158	70.55	22.50	93.05



Name: array 18
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad
Approx. area: 231 sq-m

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	53.402530	-6.305525	69.81	22.80	92.61
2	53.402392	-6.305525	69.99	22.80	92.79
3	53.402389	-6.305295	69.84	22.80	92.64
4	53.402527	-6.305300	69.82	22.80	92.62

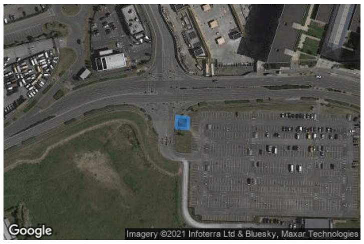


Name: array 19
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad
Approx. area: 229 sq-m

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	53.402511	-6.304855	69.51	22.80	92.31
2	53.402501	-6.304614	69.19	22.80	91.99
3	53.402376	-6.304624	69.13	22.80	91.93
4	53.402383	-6.304871	69.54	22.80	92.34

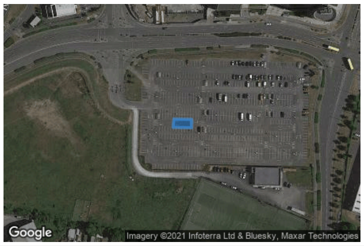
Name: array 2
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad
Approx. area: 111 sq-m

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	53.402757	-6.305525	69.61	22.81	92.42
2	53.402661	-6.305536	69.76	22.81	92.57
3	53.402655	-6.305375	69.78	22.81	92.59
4	53.402744	-6.305365	69.69	22.81	92.50



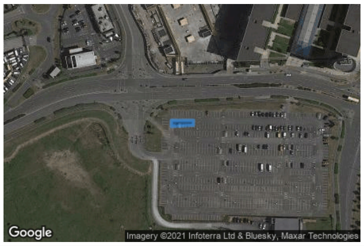
Name: array 20
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad
Approx. area: 122 sq-m

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	53.402312	-6.304892	69.54	22.80	92.34
2	53.402309	-6.304651	69.17	22.80	91.97
3	53.402242	-6.304651	69.39	22.80	92.19
4	53.402245	-6.304903	69.51	22.80	92.31



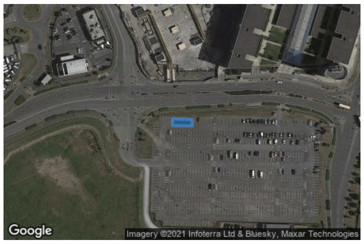
Name: array 3
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad
Approx. area: 103 sq-m

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	53.402712	-6.305193	69.82	22.81	92.63
2	53.402712	-6.304892	69.74	22.81	92.55
3	53.402671	-6.304892	69.74	22.81	92.55
4	53.402661	-6.305193	69.82	22.81	92.63



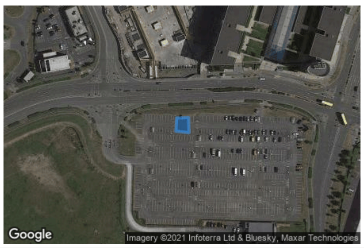
Name: array 4
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad
Approx. area: 103 sq-m

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	53.402725	-6.304791	69.56	22.81	92.37
2	53.402728	-6.305059	69.81	22.81	92.62
3	53.402783	-6.305059	69.66	22.81	92.47
4	53.402776	-6.304796	69.39	22.81	92.20



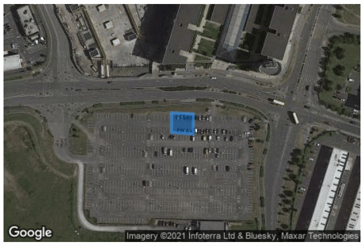
Name: array 5
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad
Approx. area: 142 sq-m

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	53.402661	-6.304785	69.65	22.81	92.46
2	53.402767	-6.304774	69.35	22.81	92.16
3	53.402770	-6.304614	69.01	22.81	91.82
4	53.402648	-6.304608	69.33	22.81	92.14



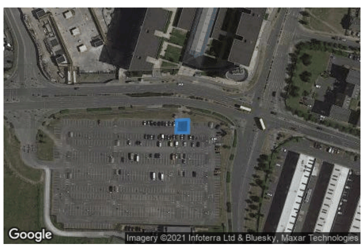
Name: array 6
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad
Approx. area: 351 sq-m

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	53.402799	-6.304184	69.33	25.89	95.21
2	53.402789	-6.303889	69.38	25.89	95.26
3	53.402626	-6.303889	69.18	25.89	95.06
4	53.402639	-6.304184	69.16	25.89	95.05



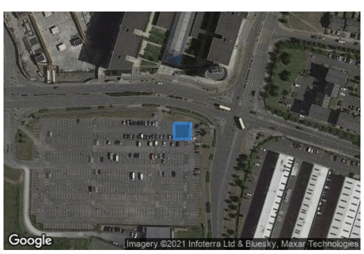
Name: array 7
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad
Approx. area: 138 sq-m

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	53.402792	-6.303669	69.39	28.96	98.35
2	53.402799	-6.303498	69.24	28.96	98.20
3	53.402687	-6.303503	69.14	28.96	98.10
4	53.402687	-6.303675	69.19	28.96	98.15



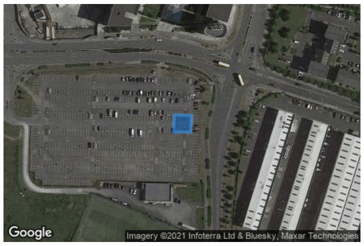
Name: array 8
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad
Approx. area: 212 sq-m

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	53.402757	-6.303417	69.13	32.03	101.16
2	53.402757	-6.303192	68.99	32.03	101.03
3	53.402629	-6.303203	69.00	32.03	101.04
4	53.402629	-6.303423	69.06	32.03	101.09



Name: array 9
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad
Approx. area: 238 sq-m

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	53.402479	-6.303407	69.09	22.81	91.90
2	53.402472	-6.303176	68.81	22.81	91.62
3	53.402338	-6.303187	68.89	22.81	91.70
4	53.402338	-6.303423	68.95	22.81	91.76



2-Mile Flight Path Receptor(s)

Name: Runway 10L
Description:
Threshold height : 15 m
Direction: 95.4 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	53.437241	-6.280170	71.95	15.24	87.19
2-mile point	53.439962	-6.328547	75.52	180.36	255.87

Name: Runway 10R
Description:
Threshold height : 15 m
Direction: 95.4 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	53.422405	-6.289531	74.02	15.24	89.26
2-mile point	53.425146	-6.337888	80.37	177.58	257.95

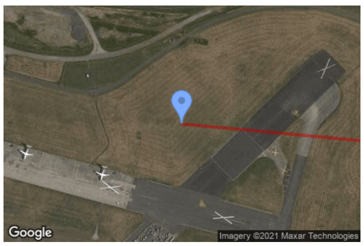
Name: Runway 16
Description:
Threshold height : 15 m
Direction: 156.7 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	53.436695	-6.261765	66.48	15.24	81.72
2-mile point	53.463248	-6.280993	69.95	180.45	250.40

Name: Runway 28L
Description:
Threshold height : 15 m
Direction: 275.4 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

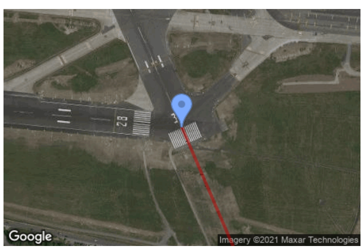
Point	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
Threshold	53.420291	-6.251115	62.01	15.24	77.25
2-mile point	53.417596	-6.202754	41.73	204.21	245.94

Name: Runway 28R
Description:
Threshold height : 15 m
Direction: 275.4 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg



Point	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
Threshold	53.435248	-6.245649	63.27	15.24	78.51
2-mile point	53.432527	-6.197275	30.99	216.20	247.19

Name: Runway 34
Description:
Threshold height : 15 m
Direction: 336.8 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

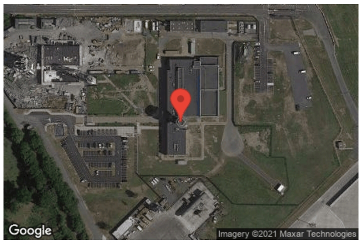


Point	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
Threshold	53.420207	-6.249810	62.21	15.24	77.45
2-mile point	53.393632	-6.230675	49.36	196.78	246.14

Discrete Observation Receptors

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	m	m	m
1-ATCT	53.428491	-6.262204	65.73	22.00	87.73
2-ATCT	53.428920	-6.264277	65.54	80.50	146.04

1-ATCT map image



2-ATCT map image

PV Array Results

Summary of PV Glare Analysis PV configuration and predicted glare

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced	Data File
	deg	deg	min	min	kWh	
array 1	15.0	180.0	0	0	-	-
array 10	15.0	180.0	0	0	-	-
array 11	15.0	180.0	0	0	-	-
array 12	15.0	180.0	0	0	-	-
array 13	15.0	180.0	0	0	-	-
array 14	15.0	180.0	0	0	-	-
array 15	15.0	180.0	0	0	-	-
array 16	15.0	180.0	0	0	-	-
array 17	15.0	180.0	0	0	-	-
array 18	15.0	180.0	0	0	-	-
array 19	15.0	180.0	0	0	-	-
array 2	15.0	180.0	0	0	-	-
array 20	15.0	180.0	0	0	-	-
array 3	15.0	180.0	0	0	-	-
array 4	15.0	180.0	0	0	-	-
array 5	15.0	180.0	0	0	-	-
array 6	15.0	180.0	0	0	-	-
array 7	15.0	180.0	0	0	-	-
array 8	15.0	180.0	0	0	-	-
array 9	15.0	180.0	0	0	-	-

Click the name of the PV array to scroll to its results

PV & Receptor Analysis Results detailed results for each PV array and receptor

array 1 no glare found

Component	Green glare (min)	Yellow glare (min)
FP: Runway 10L	0	0
FP: Runway 10R	0	0
FP: Runway 16	0	0
FP: Runway 28L	0	0
FP: Runway 28R	0	0
FP: Runway 34	0	0
OP: 1-ATCT	0	0
OP: 2-ATCT	0	0

No glare found

array 10 no glare found

Component	Green glare (min)	Yellow glare (min)
FP: Runway 10L	0	0
FP: Runway 10R	0	0
FP: Runway 16	0	0
FP: Runway 28L	0	0
FP: Runway 28R	0	0
FP: Runway 34	0	0
OP: 1-ATCT	0	0
OP: 2-ATCT	0	0

No glare found

array 11 no glare found

Component	Green glare (min)	Yellow glare (min)
FP: Runway 10L	0	0
FP: Runway 10R	0	0
FP: Runway 16	0	0
FP: Runway 28L	0	0
FP: Runway 28R	0	0
FP: Runway 34	0	0
OP: 1-ATCT	0	0
OP: 2-ATCT	0	0

No glare found

array 12 no glare found

Component	Green glare (min)	Yellow glare (min)
FP: Runway 10L	0	0
FP: Runway 10R	0	0
FP: Runway 16	0	0
FP: Runway 28L	0	0
FP: Runway 28R	0	0
FP: Runway 34	0	0
OP: 1-ATCT	0	0
OP: 2-ATCT	0	0

No glare found

array 13 no glare found

Component	Green glare (min)	Yellow glare (min)
FP: Runway 10L	0	0
FP: Runway 10R	0	0
FP: Runway 16	0	0
FP: Runway 28L	0	0
FP: Runway 28R	0	0
FP: Runway 34	0	0
OP: 1-ATCT	0	0
OP: 2-ATCT	0	0

No glare found

array 14 no glare found

Component	Green glare (min)	Yellow glare (min)
FP: Runway 10L	0	0
FP: Runway 10R	0	0
FP: Runway 16	0	0
FP: Runway 28L	0	0
FP: Runway 28R	0	0
FP: Runway 34	0	0
OP: 1-ATCT	0	0
OP: 2-ATCT	0	0

No glare found

array 15 no glare found

Component	Green glare (min)	Yellow glare (min)
FP: Runway 10L	0	0
FP: Runway 10R	0	0
FP: Runway 16	0	0
FP: Runway 28L	0	0
FP: Runway 28R	0	0
FP: Runway 34	0	0
OP: 1-ATCT	0	0
OP: 2-ATCT	0	0

No glare found

array 16 no glare found

Component	Green glare (min)	Yellow glare (min)
FP: Runway 10L	0	0
FP: Runway 10R	0	0
FP: Runway 16	0	0
FP: Runway 28L	0	0
FP: Runway 28R	0	0
FP: Runway 34	0	0
OP: 1-ATCT	0	0
OP: 2-ATCT	0	0

No glare found

array 17 no glare found

Component	Green glare (min)	Yellow glare (min)
FP: Runway 10L	0	0
FP: Runway 10R	0	0
FP: Runway 16	0	0
FP: Runway 28L	0	0
FP: Runway 28R	0	0
FP: Runway 34	0	0
OP: 1-ATCT	0	0
OP: 2-ATCT	0	0

No glare found

array 18 no glare found

Component	Green glare (min)	Yellow glare (min)
FP: Runway 10L	0	0
FP: Runway 10R	0	0
FP: Runway 16	0	0
FP: Runway 28L	0	0
FP: Runway 28R	0	0
FP: Runway 34	0	0
OP: 1-ATCT	0	0
OP: 2-ATCT	0	0

No glare found

array 19 no glare found

Component	Green glare (min)	Yellow glare (min)
FP: Runway 10L	0	0
FP: Runway 10R	0	0
FP: Runway 16	0	0
FP: Runway 28L	0	0
FP: Runway 28R	0	0
FP: Runway 34	0	0
OP: 1-ATCT	0	0
OP: 2-ATCT	0	0

No glare found

array 2 no glare found

Component	Green glare (min)	Yellow glare (min)
FP: Runway 10L	0	0
FP: Runway 10R	0	0
FP: Runway 16	0	0
FP: Runway 28L	0	0
FP: Runway 28R	0	0
FP: Runway 34	0	0
OP: 1-ATCT	0	0
OP: 2-ATCT	0	0

No glare found

array 20 no glare found

Component	Green glare (min)	Yellow glare (min)
FP: Runway 10L	0	0
FP: Runway 10R	0	0
FP: Runway 16	0	0
FP: Runway 28L	0	0
FP: Runway 28R	0	0
FP: Runway 34	0	0
OP: 1-ATCT	0	0
OP: 2-ATCT	0	0

No glare found

array 3 no glare found

Component	Green glare (min)	Yellow glare (min)
FP: Runway 10L	0	0
FP: Runway 10R	0	0
FP: Runway 16	0	0
FP: Runway 28L	0	0
FP: Runway 28R	0	0
FP: Runway 34	0	0
OP: 1-ATCT	0	0
OP: 2-ATCT	0	0

No glare found

array 4 no glare found

Component	Green glare (min)	Yellow glare (min)
FP: Runway 10L	0	0
FP: Runway 10R	0	0
FP: Runway 16	0	0
FP: Runway 28L	0	0
FP: Runway 28R	0	0
FP: Runway 34	0	0
OP: 1-ATCT	0	0
OP: 2-ATCT	0	0

No glare found

array 5 no glare found

Component	Green glare (min)	Yellow glare (min)
FP: Runway 10L	0	0
FP: Runway 10R	0	0
FP: Runway 16	0	0
FP: Runway 28L	0	0
FP: Runway 28R	0	0
FP: Runway 34	0	0
OP: 1-ATCT	0	0
OP: 2-ATCT	0	0

No glare found

array 6 no glare found

Component	Green glare (min)	Yellow glare (min)
FP: Runway 10L	0	0
FP: Runway 10R	0	0
FP: Runway 16	0	0
FP: Runway 28L	0	0
FP: Runway 28R	0	0
FP: Runway 34	0	0
OP: 1-ATCT	0	0
OP: 2-ATCT	0	0

No glare found

array 7 no glare found

Component	Green glare (min)	Yellow glare (min)
FP: Runway 10L	0	0
FP: Runway 10R	0	0
FP: Runway 16	0	0
FP: Runway 28L	0	0
FP: Runway 28R	0	0
FP: Runway 34	0	0
OP: 1-ATCT	0	0
OP: 2-ATCT	0	0

No glare found

array 8 no glare found

Component	Green glare (min)	Yellow glare (min)
FP: Runway 10L	0	0
FP: Runway 10R	0	0
FP: Runway 16	0	0
FP: Runway 28L	0	0
FP: Runway 28R	0	0
FP: Runway 34	0	0
OP: 1-ATCT	0	0
OP: 2-ATCT	0	0

No glare found

array 9 no glare found

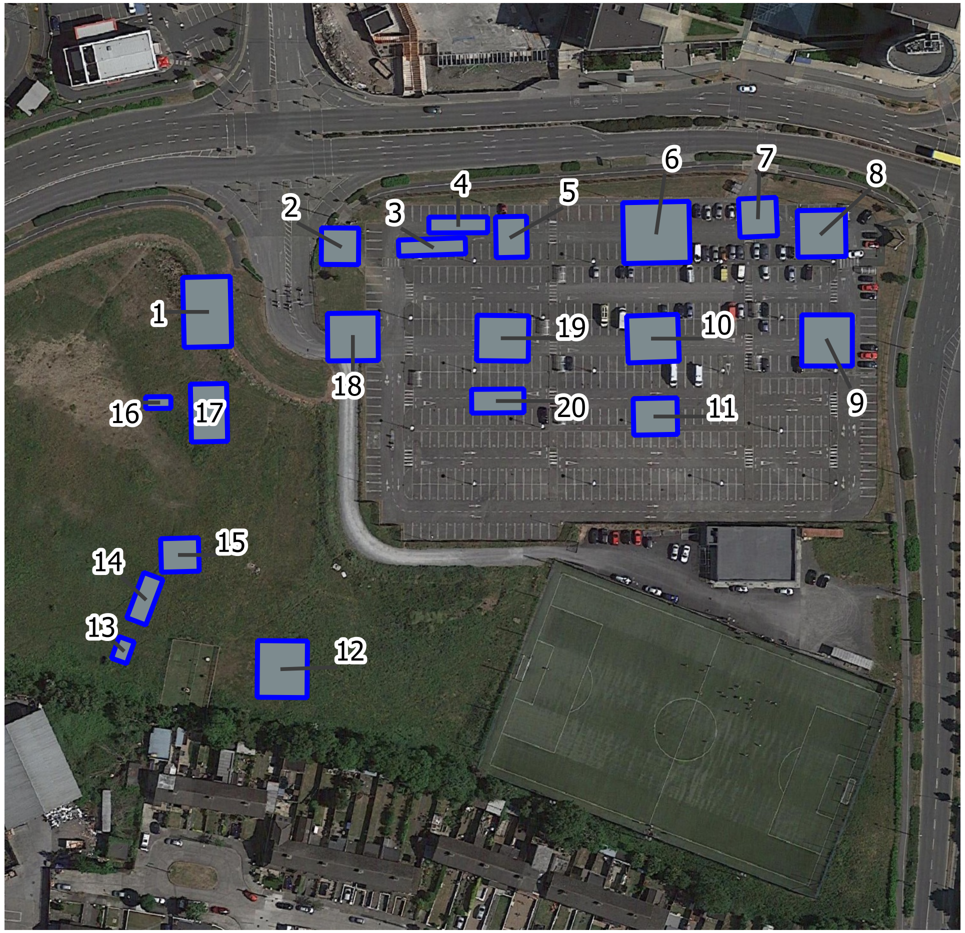
Component	Green glare (min)	Yellow glare (min)
FP: Runway 10L	0	0
FP: Runway 10R	0	0
FP: Runway 16	0	0
FP: Runway 28L	0	0
FP: Runway 28R	0	0
FP: Runway 34	0	0
OP: 1-ATCT	0	0
OP: 2-ATCT	0	0

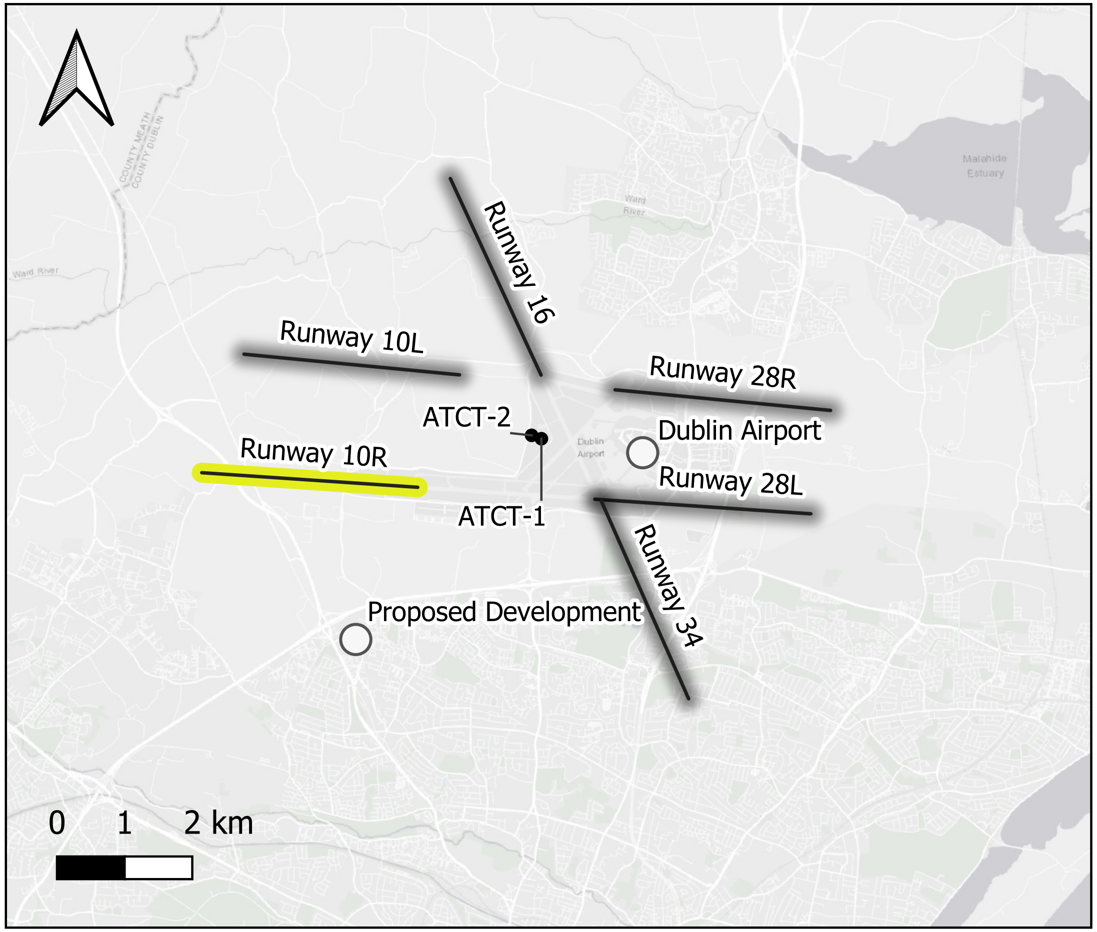
No glare found

Assumptions

- Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
- Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
- Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub sections can provide additional information on expected glare.
- The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potential impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (Se previous point on related limitations.)
- Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
- Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
- Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
- Glare analysis methods used: OP V1, FP V1, Route V1
- Refer to the **Help page** for assumptions and limitations not listed here.

Map 1 Potential Glint and Glare Impact on Runway 10R as a result of Roof Mounted PV Arrays at the proposed residential development at Charlestown Place, Charlestown, Dublin 11





Array Impact

No Potential for Glare

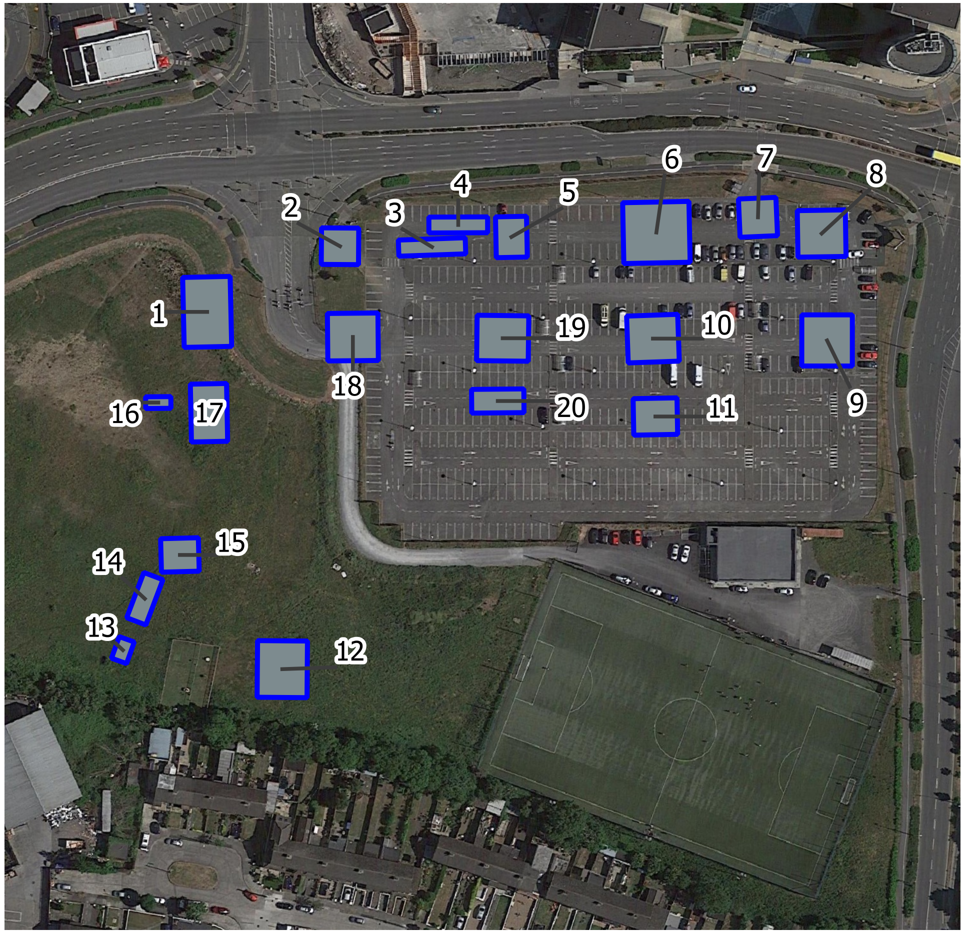
Distance from approach threshold to Proposed Development:	2430 metres
Bearing from approach threshold to Proposed Development:	202 degrees

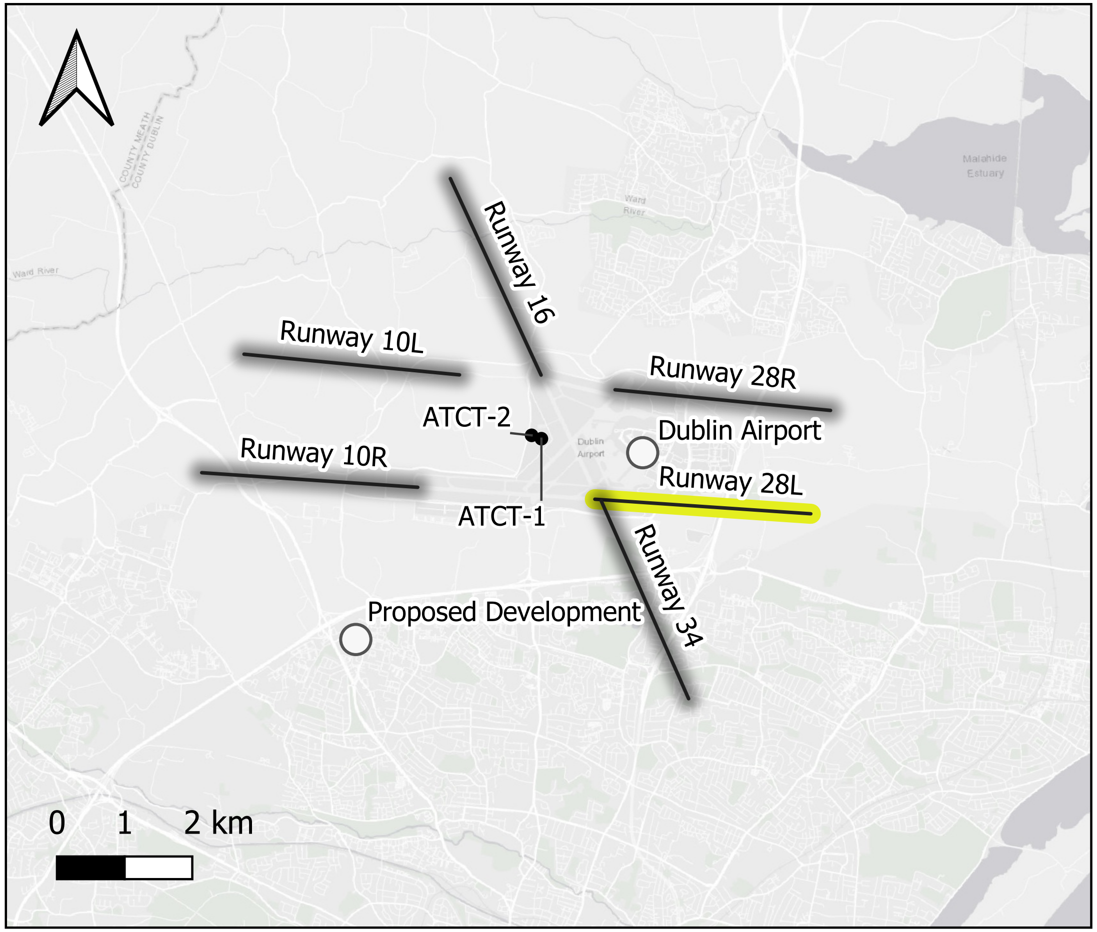
Glare Potential at Proposed Site for:

Runway 10R

Max Daily Duration:	No Glare Geometrically Possible
Average Daily Duration:	No Glare Geometrically Possible
Max Annual Duration:	No Glare Geometrically Possible

Map 2 Potential Glint and Glare Impact on Runway 28L as a result of Roof Mounted PV Arrays at the proposed residential development at Charlestown Place, Charlestown, Dublin 11





Array Impact

No Potential for Glare

Distance from approach threshold to Proposed Development: 4098 metres

Bearing from approach threshold to Proposed Development: 240 degrees

Glare Potential at Proposed Site for:

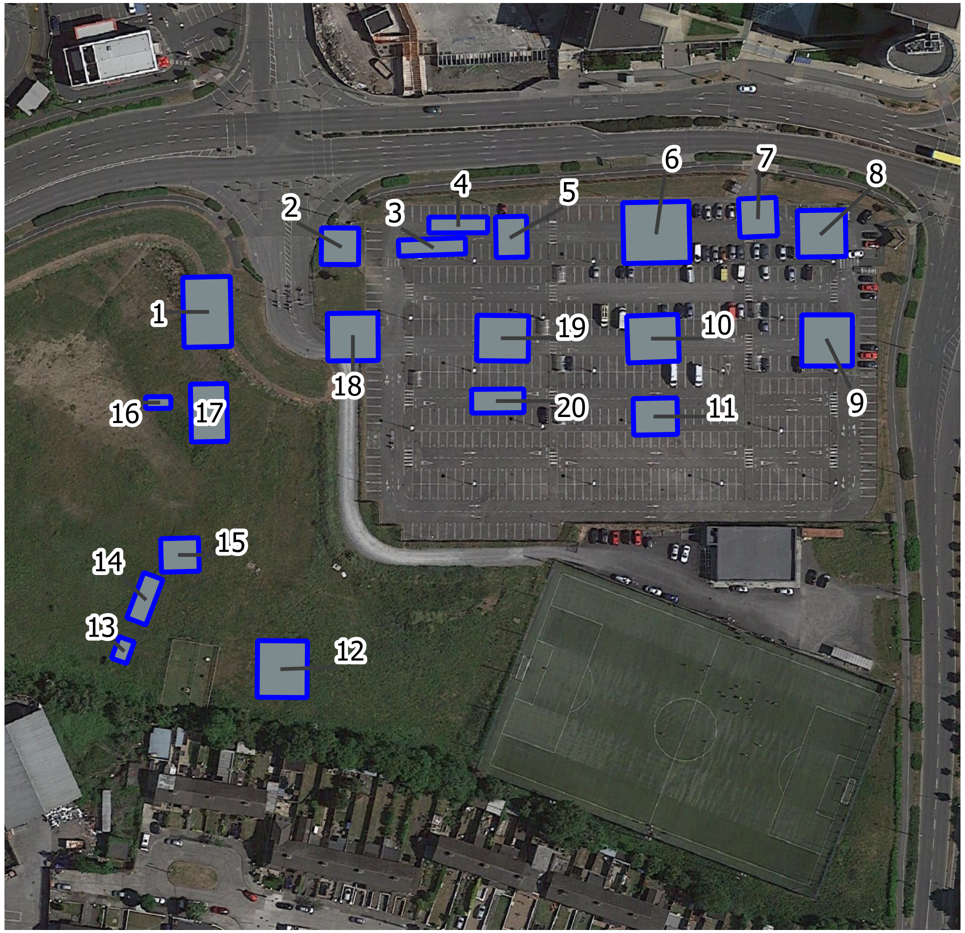
Runway 28L

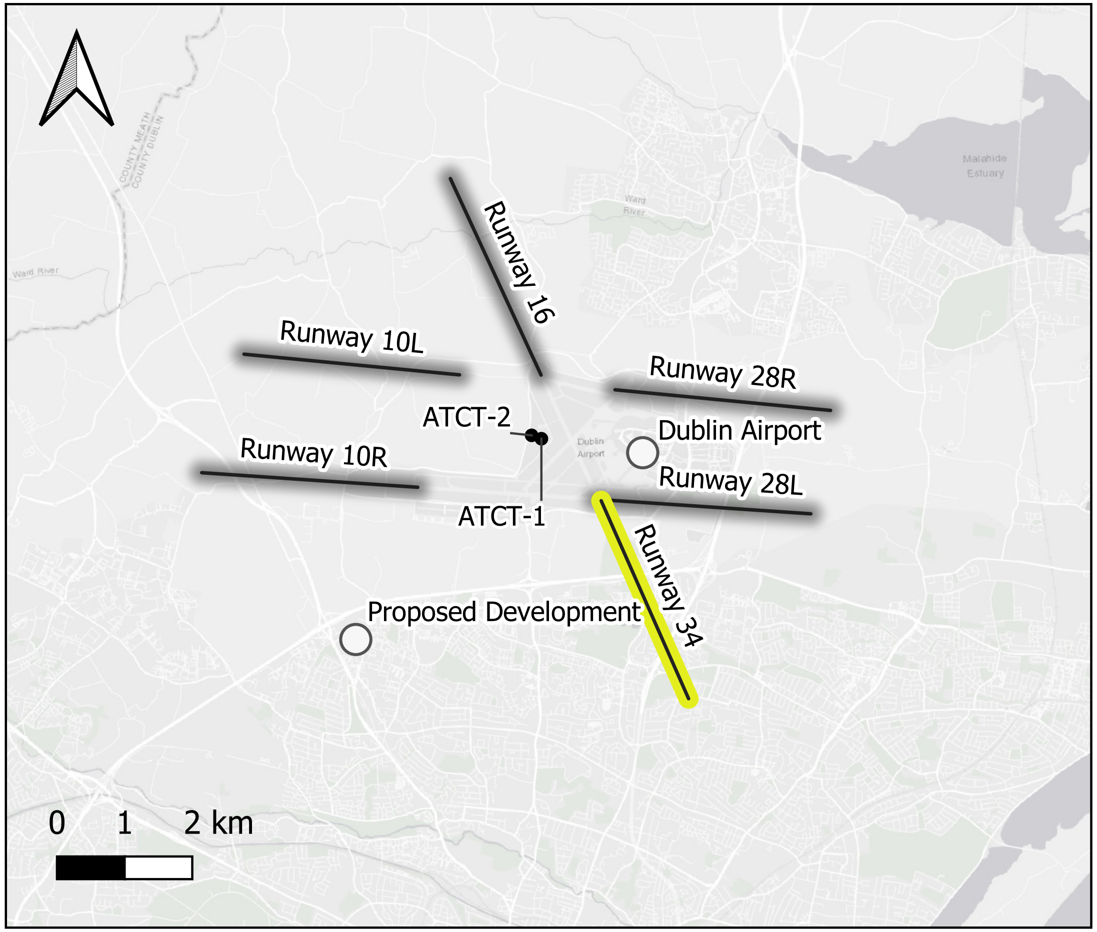
Max Daily Duration: No Glare Geometrically Possible

Average Daily Duration: No Glare Geometrically Possible

Max Annual Duration: No Glare Geometrically Possible

Map 3 Potential Glint and Glare Impact on Runway 34 as a result of Roof Mounted PV Arrays at the proposed residential development at Charlestown Place, Charlestown, Dublin 11





Array Impact

No Potential for Glare

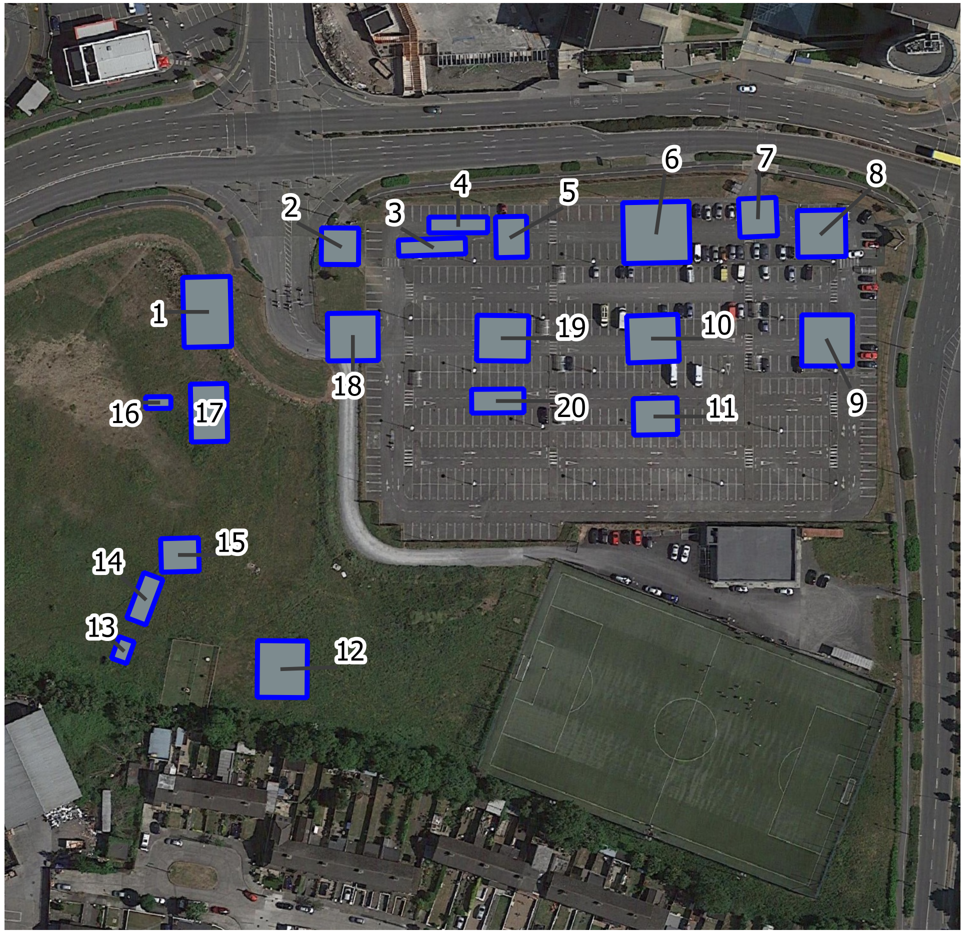
Distance from approach threshold to Proposed Development:	4168 metres
Bearing from approach threshold to Proposed Development:	241 degrees

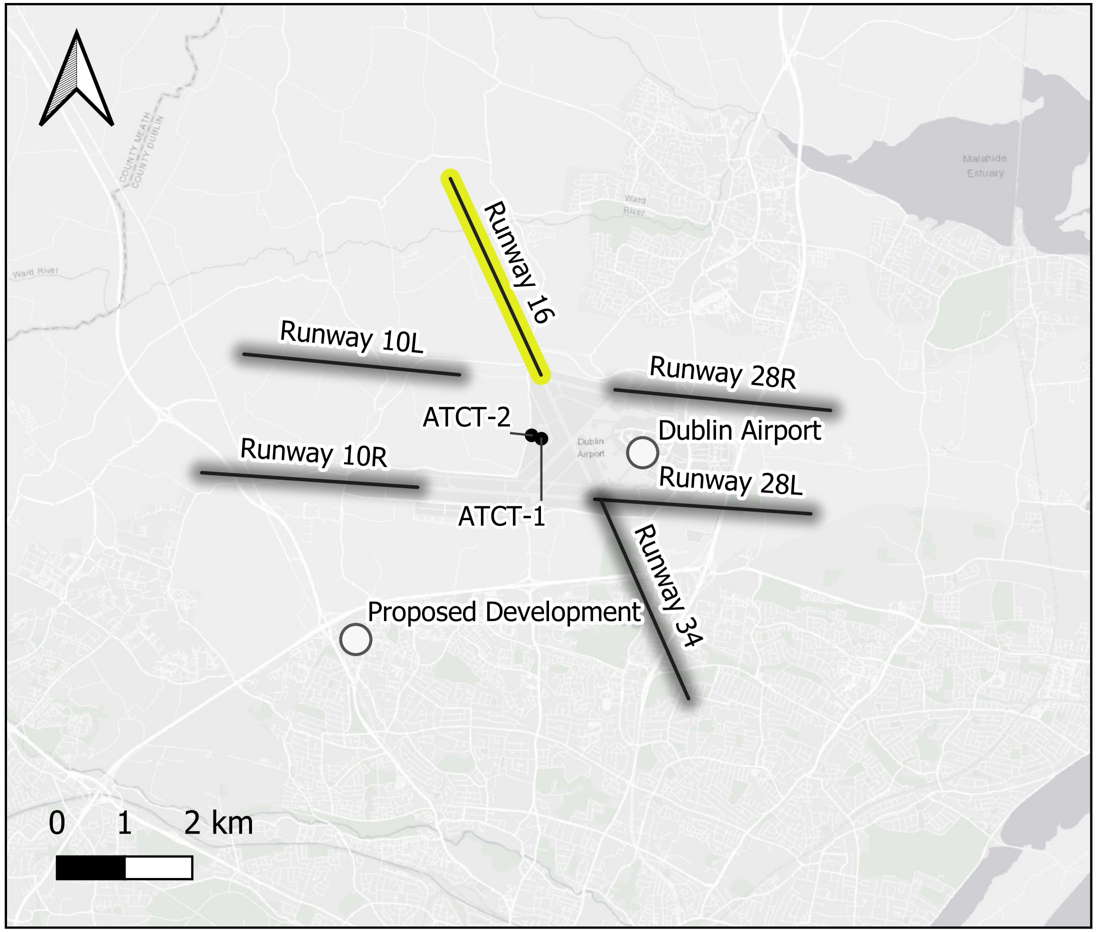
Glare Potential at Proposed Site for:

Runway 34

Max Daily Duration:	No Glare Geometrically Possible
Average Daily Duration:	No Glare Geometrically Possible
Max Annual Duration:	No Glare Geometrically Possible

Map 4 Potential Glint and Glare Impact on Runway 16 as a result of Roof Mounted PV Arrays at the proposed residential development at Charlestown Place, Charlestown, Dublin 11





Array Impact

No Potential for Glare

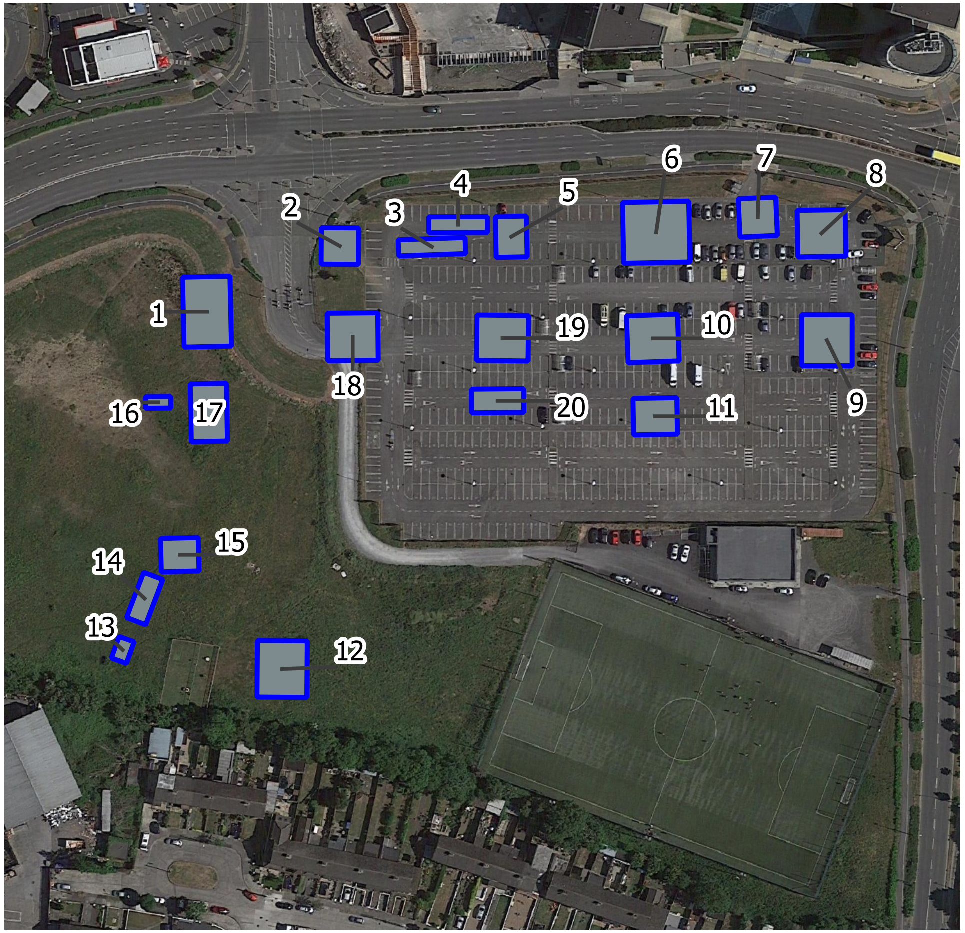
Distance from approach threshold to Proposed Development:	6959 metres
Bearing from approach threshold to Proposed Development:	192 degrees

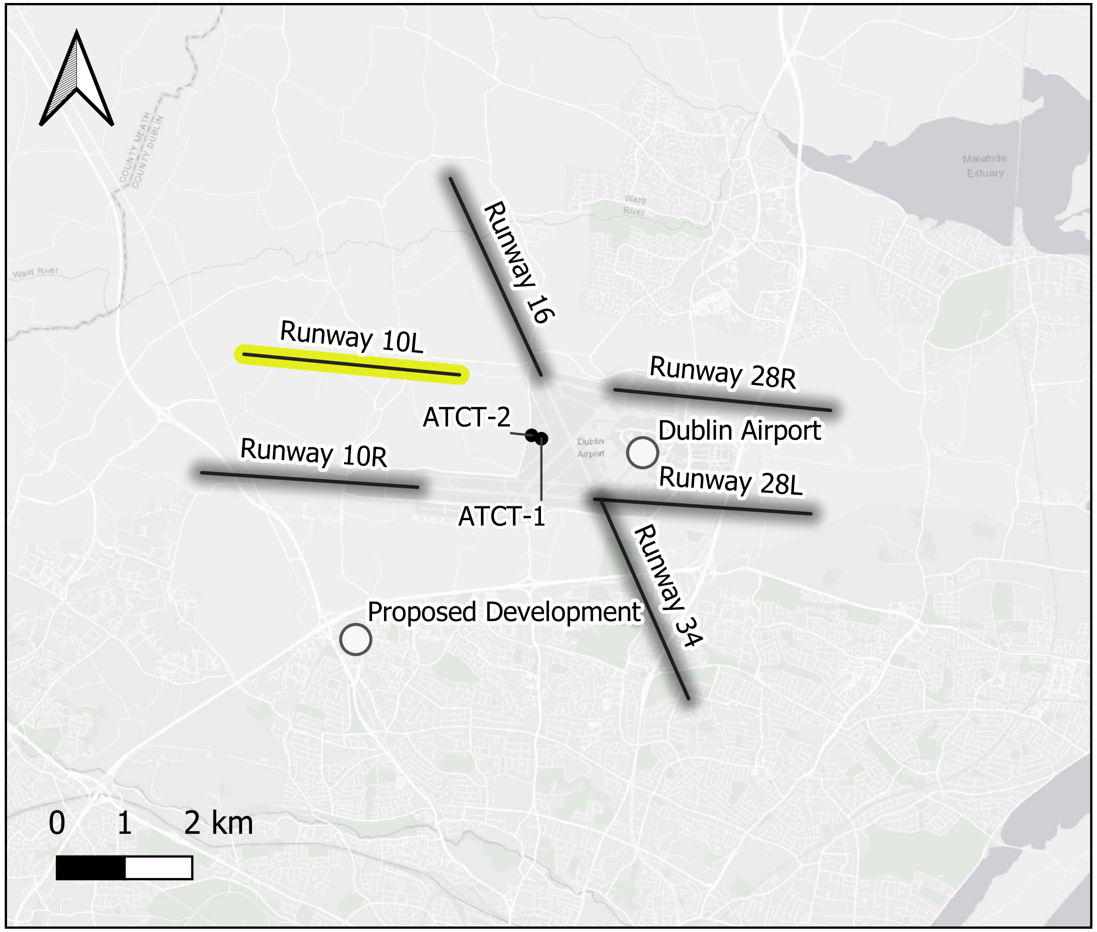
Glare Potential at Proposed Site for:

Runway 16

Max Daily Duration:	No Glare Geometrically Possible
Average Daily Duration:	No Glare Geometrically Possible
Max Annual Duration:	No Glare Geometrically Possible

Map 5 Potential Glint and Glare Impact on Runway 10L as a result of Roof Mounted PV Arrays at the proposed residential development at Charlestown Place, Charlestown, Dublin 11





Array Impact

No Potential for Glare

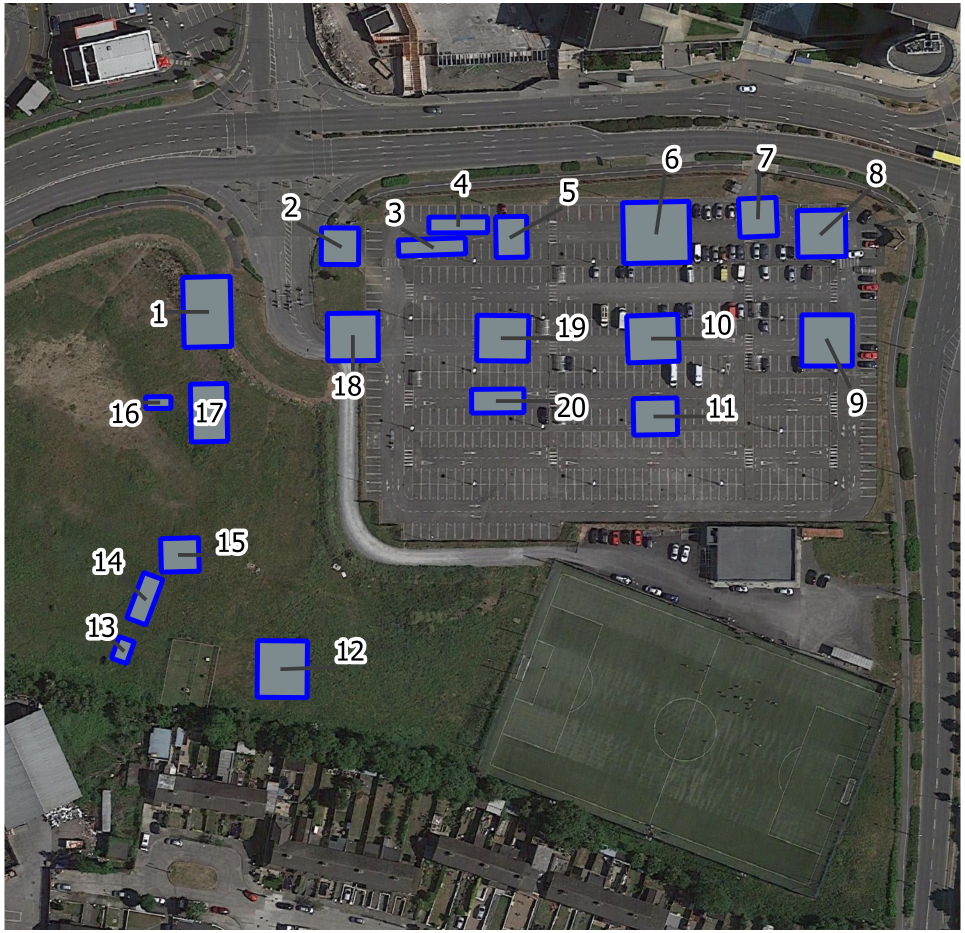
Distance from approach threshold to Proposed Development:	4531 metres
Bearing from approach threshold to Proposed Development:	159 degrees

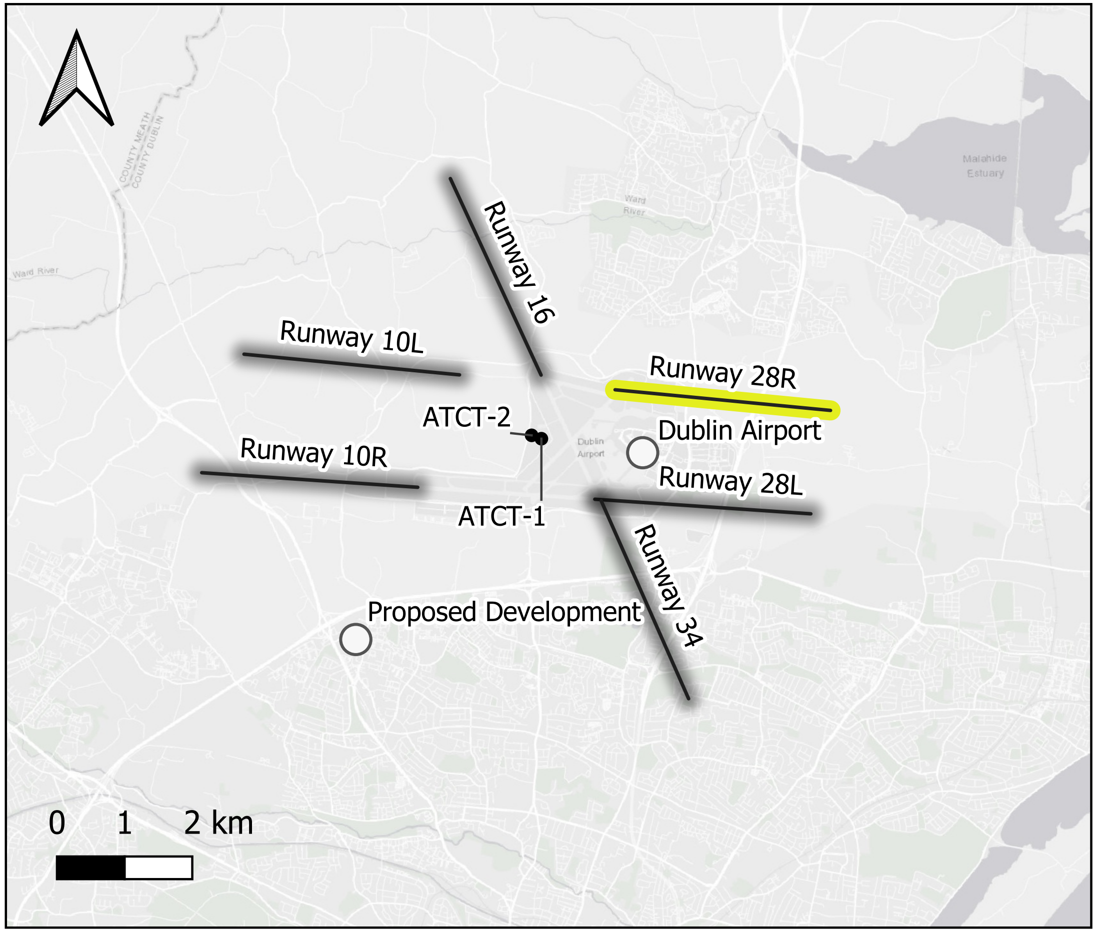
Glare Potential at Proposed Site for:

Runway 10L

Max Daily Duration:	No Glare Geometrically Possible
Average Daily Duration:	No Glare Geometrically Possible
Max Annual Duration:	No Glare Geometrically Possible

Map 6 Potential Glint and Glare Impact on Runway 28R as a result of Roof Mounted PV Arrays at the proposed residential development at Charlestown Place, Charlestown, Dublin 11





Array Impact

No Potential for Glare

Distance from approach threshold to Proposed Development: 5323 metres

Bearing from approach threshold to Proposed Development: 226 degrees

Glare Potential at Proposed Site for:

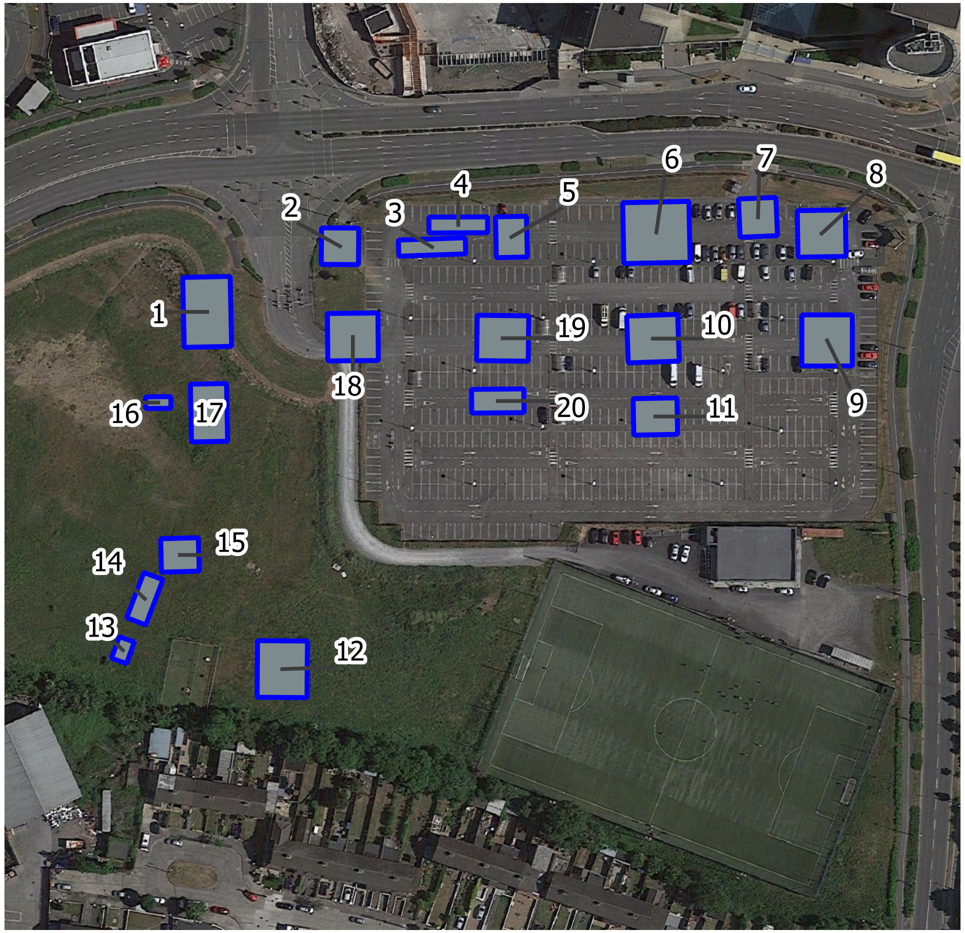
Runway 28R

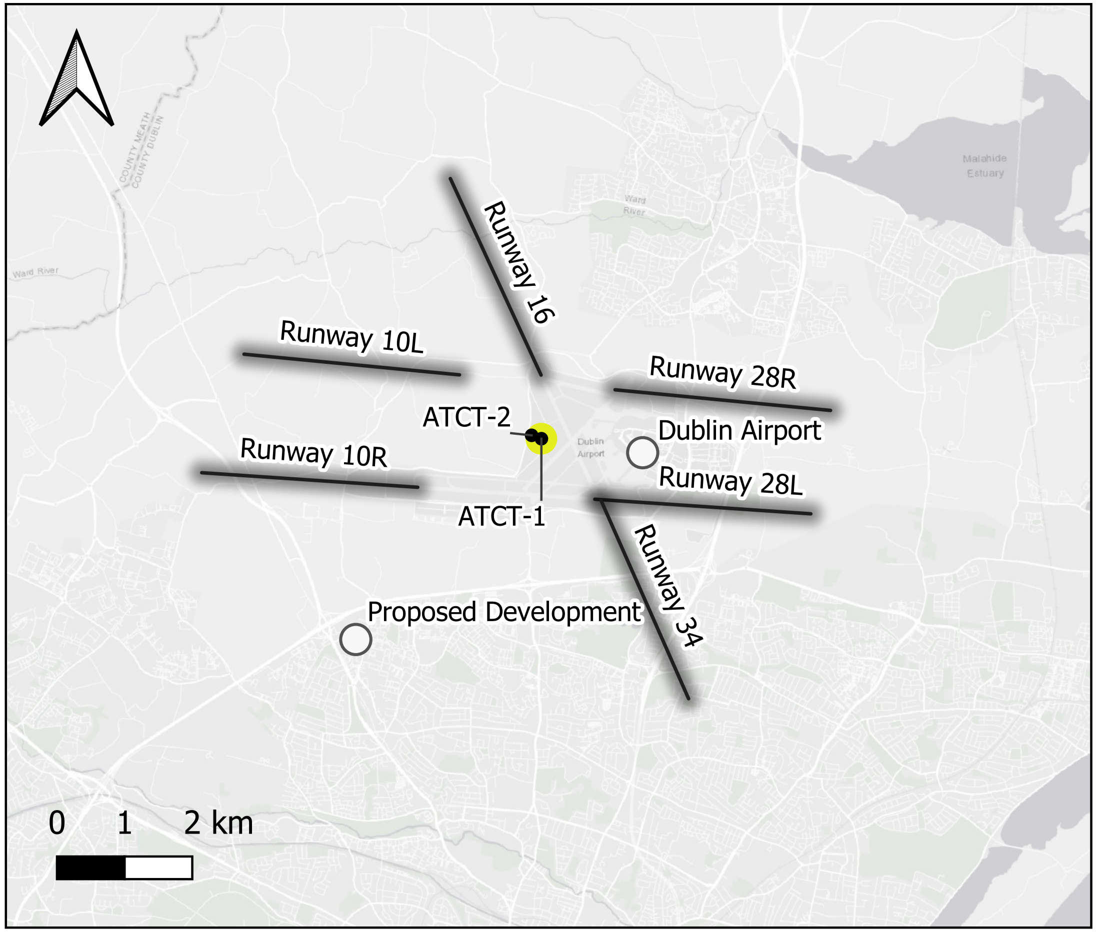
Max Daily Duration: No Glare Geometrically Possible

Average Daily Duration: No Glare Geometrically Possible

Max Annual Duration: No Glare Geometrically Possible

Map 7 Potential Glint and Glare Impact on ATCT-1 as a result of Roof Mounted PV Arrays at the proposed residential development at Charlestown Place, Charlestown, Dublin 11





Array Impact

No Potential for Glare

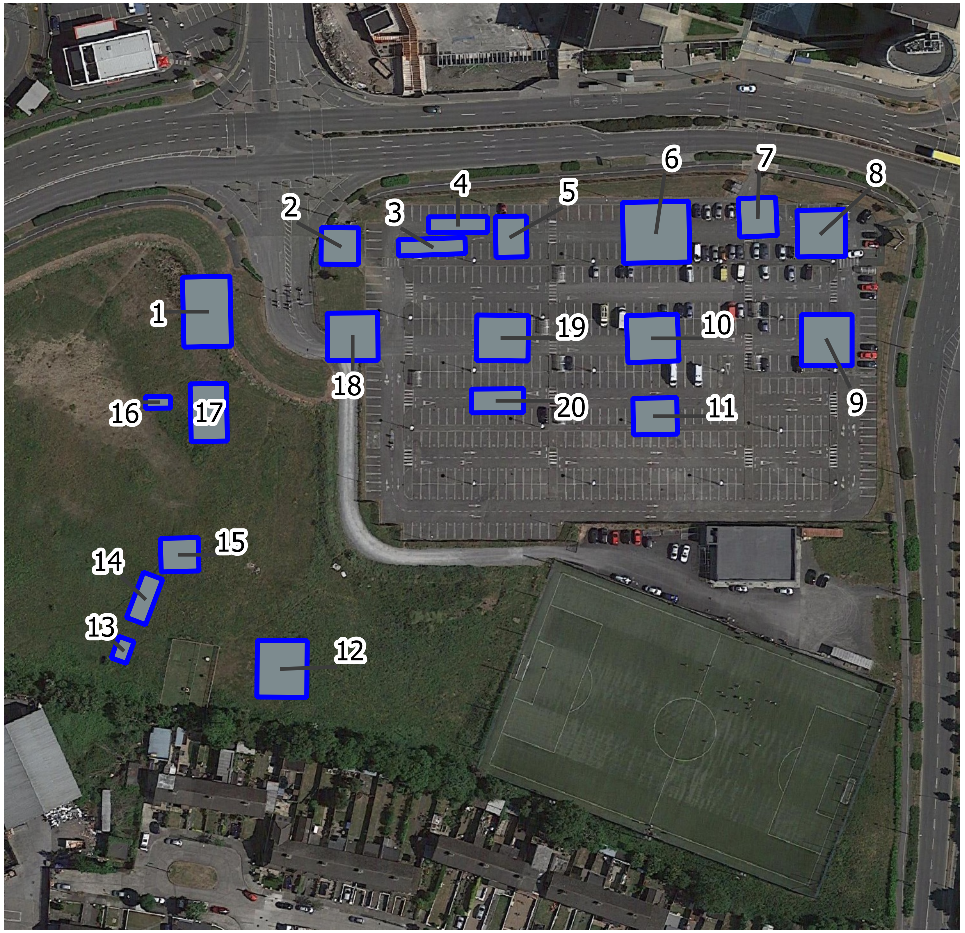
Distance from approach threshold to Proposed Development:	4043 metres
Bearing from approach threshold to Proposed Development:	223 degrees

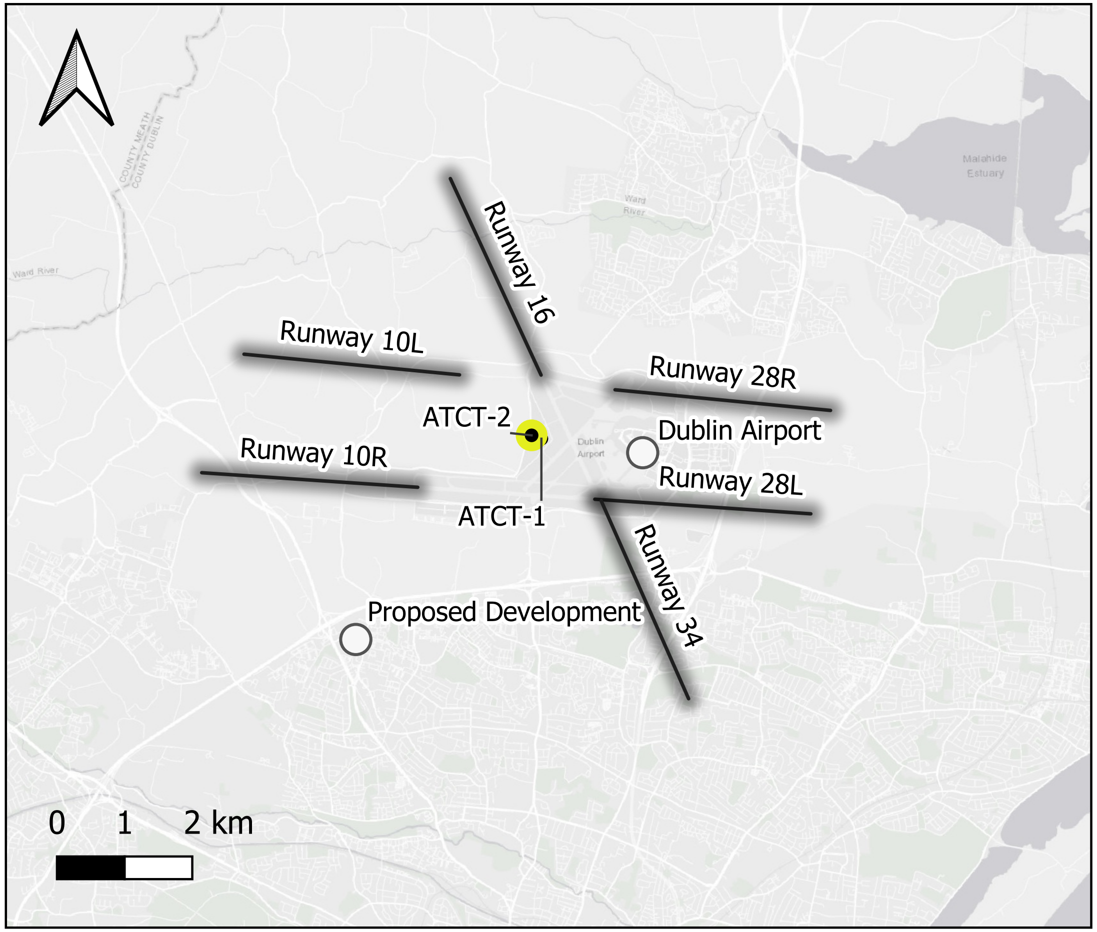
Glare Potential at Proposed Site for:

ATCT-1

Max Daily Duration:	No Glare Geometrically Possible
Average Daily Duration:	No Glare Geometrically Possible
Max Annual Duration:	No Glare Geometrically Possible

Map 8 Potential Glint and Glare Impact on ATCT-2 as a result of Roof Mounted PV Arrays at the proposed residential development at Charlestown Place, Charlestown, Dublin 11





Array Impact

No Potential for Glare

Distance from approach threshold to Proposed Development:	3984 metres
Bearing from approach threshold to Proposed Development:	221 degrees

Glare Potential at Proposed Site for:

ATCT-2

Max Daily Duration:	No Glare Geometrically Possible
Average Daily Duration:	No Glare Geometrically Possible
Max Annual Duration:	No Glare Geometrically Possible