

Independent House PBSA, Abbey Street, Dublin

Glint & Glare Assessment Report



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	Kevin Fitzgerald	Kevin Fitzgerald	Minor amendments
Role:	Senior Energy & Sustainability Engineer	Senior Energy & Sustainability Engineer	
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R1	30/10/2024	Kevin Fitzgerald	Kevin Fitzgerald	First Revision
R2	11/11/2024	Kevin Fitzgerald	Kevin Fitzgerald	Removed South PV Array.
R3	03/03/2025	Kevin Fitzgerald	Kevin Fitzgerald	Updated Site Plan and Description of Development

Executive Summary

Lawler Sustainability conducted an analysis on the risk of glint and glare for the proposed rooftop solar Photovoltaic (PV) array of the proposed Independent House PBSA, Abbey Street, Dublin. This report assesses the potential for ocular impact of glare which would emanate from sunlight reflections of the PV array and its possibility to cause an impact to air traffic controllers in Air Traffic Control Towers (ATCT) and/or pilots approaching each direction on runways at nearby airports, and to pilots landing or taking-off from nearby helipads. The development is located within several Solar Safeguarding Zones as identified by The Planning and Development (Solar Safeguarding Zone) Regulations 2022 of which is required to undergo a Glint and Glare assessment.

An initial “baseline” assessment was undertaken whereby the wall parapet feature was omitted to represent an unobstructed view from the PV panels towards all receptors studied. This assessment revealed that all but one receptor (Baldonnel Air Traffic Control Tower) passed the 2021 U.S. Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally Obligated Airports. Bearing in mind that the distance between Baldonnel Aerodrome and the proposed development is approximately 13 km, and the simulation software does not take account of any opaque objects in between, it is plausible that the effects of glint and glare will not be seen from the Aerodrome. Nonetheless, a second assessment put in place the parapet feature around the PV locations as described in the Architectural drawings, thus shielding the PV panels from nearby receptors. This resulted in all surrounding receptors passing the criteria and no visible glare occurring within the simulation model.

An optimisation assessment was undertaken modifying the tilt of the PV panels from 0° (flat to the roof) to 45° in steps of 5° increments and azimuth angles between 0° (North) to 315°, in steps of 45° increments. The results all demonstrated a pass and no visible glare occurring on any of the receptors studied within this report. It is recommended that the proposed PV be fixed in place at roof level orientated towards the South direction, have no sun tracking, and have low-texture glass with anti-reflective coating. The PV panels can be tilted anywhere between 0° (flat to the roof) and 45° provided that the parapet feature is constructed as per the Architectural drawings.

The table below demonstrates the policy adherence of this glare analysis according to the 2021 U.S. Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports. The policy may require the following criteria be met for solar energy systems on airport property:

- No glare of any kind for ATCT(s) at cab height
- Default analysis and observer characteristics, including 1-minute time step

The above policy has been used as a guide in relation to glint and glare assessments performed in Ireland for consideration by the Planning Authority, the Irish Aviation Association (IAA), and Dublin Airport Authority (DAA).

Table 1. Summary of results

Component	Status	Description
Analysis parameters	PASS	Analysis time interval and eye characteristics used are acceptable
ATCT(s)	PASS	Receptor(s) marked as ATCT do not receive glare

Introduction

Summix IHD Developments Limited and Mitchell McDermott have requested Lawler Sustainability to conduct a Glint & Glare analysis on the proposed Photovoltaic (PV) installation at the proposed Independent House PBSA, Abbey Street, Dublin.

The development is located within several Solar Safeguarding Zones as identified by The Planning and Development (Solar Safeguarding Zone) Regulations 2022 of which is required to undergo a Glint and Glare assessment. This report has assessed the potential for glare towards the following airports, aerodromes, and helipads near the proposed Independent House PBSA, Abbey Street, Dublin:

- Dublin Airport
 - 6 No. runway approaches
 - 2 No. Air Traffic Control Towers (ATCT)
- Beaumont Hospital
 - Nearby green space for helicopter landing
- Royal Hospital of Kilmainham
 - Nearby green space for helicopter landing
- Phoenix Park
 - Nearby green space for helicopter landing
- Cathal Brugha Barracks
 - Nearby green space for helicopter landing
- Tallaght University Hospital
 - Nearby helipad
- Baldonnell Aerodrome
 - 4 No. runway approaches
 - 1 No. Air Traffic Control Tower (ATCT)

The glint and glare assessment was conducted using the ForgeSolar toolset. ForgeSolar uses GlareGauge which is the leading solar glare analysis tool used globally to satisfy local standards and policies. The tool uses the Solar Glare Hazard Analysis Tool (SGHAT) developed by Sandia National Laboratories which uses a sun-path algorithm for every minute of the year (assuming 100% sunshine for all daylight hours) to determine if and when reflections may occur at selected receptors. If reflection is found to be present, further analysis is then conducted to determine the significance of the potential glare that could be experienced and whether if these effects are likely to be experienced by an observer in that location. In some cases, where there is significant glare found in the analysis, mitigation factors can then be discussed and assessed further.

Description of Development

Summix IHD Developments Limited intend to apply to Dublin City Council for a permission for a large-scale residential development principally comprising student accommodation at a c. 0.29 Ha site at Nos. 87-93 Middle Abbey Street, Dublin 1, D01 NH70 (known collectively as 'Independent House'). The site is generally bound by Prince's Street North to the north, William's Lane and Nos. 94-96 Middle Abbey Street to the west, Middle Abbey Street to the south, and Nos. 35-39 O'Connell Street Lower (known as 'Penneys') to the east. The site comprises 6 No. interconnecting, long-standing vacant structures as follows: (a) a principally part 5 No. to part 6 No. storey above basement level building fronting Middle Abbey Street, known as Independent House, with a single storey workshop building to the rear; (b) a 5 No. storey (above basement level) building at the corner of Middle Abbey Street and William's Lane, known as Emerald Chambers; (c) a triple height (at basement level) structure towards the centre of the site, known as the 'Printing Hall'; (d) a 2 No. storey (above basement level) warehouse and office fronting William's Lane; (e) a part 3 No. to part 4 No. storey (above basement level) loading bay and office fronting Prince's Street North; and (f) a 3 No. storey (above basement level) office in the eastern portion of the site, bounded by Penneys. The site includes 2 No. Protected Structures (RPS Ref. Nos. 18 & 8797).

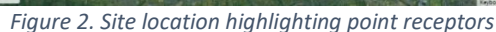
The development's surface water and foul water drainage network shall discharge from the site into the existing combined sewer located along Prince's Street North to the north-west of the site. A new pedestrian crossing and upgrade works to the footpath and kerb along Prince's Street North are proposed. Public realm improvements are also proposed to William's Lane. The development site area, drainage works, road works and public realm improvements will provide a total application site area of c. 0.324 Ha.

The development will principally consist of: the retention and refurbishment of part of the building façade along Prince's Street North; the demolition of the 3 No. former warehouses and offices (c. 5,270 sq m) and the lowering of part of the basement level thereat; the partial demolition of the Printing Hall (c. 457 sq m) and the rear of Emerald Chambers (c. 150 sq m) and Independent House (c. 100 sq m); the removal of the existing concrete roof slab at Emerald Chambers to facilitate an increase in floor to ceiling height at fourth floor level; the lowering of part of the ground floor level in Independent House and Emerald Chambers for universal access; refurbishment works to the Protected Structures including general internal and external works for conservation repairs, maintenance, change of use and upgrading of the buildings; and the construction of a part 1 No. to part 9 No. storey over basement building connecting into the retained structures and principally comprising 316 No. Student Accommodation bedspaces (267 No. standard rooms, 5 No. accessible rooms, 2 No. twin studios (4 No. bedspaces), 10 No. accessible studios and 30 No. single studios). The 272 No. standard and accessible rooms are provided in 42 No. clusters ranging in size from 5 No. bedspaces to 8 No. bedspaces, and all clusters are served by a communal living/kitchen/dining room.

The development also provides: ancillary internal and external communal student amenity spaces and support facilities; cultural and community floor space (c. 644 sq m); 3 No. retail units (c. 216 sq m); a café (c. 254 sq m); bicycle stores at basement and ground floor levels; visitor cycle parking spaces; bin stores; ESB substation; hard and soft landscaping; green/blue roofs; new telecommunications infrastructure at roof level, together with all associated equipment; boundary treatments; PV panels; plant; lift overruns; and all associated works above and below ground.

The gross floor area of the development is c. 15,413 sq m comprising c. 12,751 sq m above basement level.

The proposed solar photovoltaic (PV) array will be mounted on the roof of the proposed Independent House PBSA, Abbey Street, Dublin. There are two proposed locations for the PV panels: East PV array situated on the roof above Cluster C 07 01, and North PV array situated above Cluster A 07 02. A PV optimisation assessment will be carried out to determine the optimal PV positioning in terms of orientation and tilt considering the nearby developments and mitigating the risk of glint and/or glare.



About Glint and Glare

What are Glint and Glare?

The United States Federal Aviation Administration (FAA) have best defined glint and glare as¹:

- Glint is a momentary flash of bright light, and
- Glare is a continuous source of bright light.

The difference between glint and glare is duration. Glint is often caused by a reflection off a moving source, whereas glare is generally associated with stationary objects that reflect sunlight.

The ocular impact of solar glare is split into three categories²:

- Green – low potential to cause after-image (flash blindness)
- Yellow – potential to cause temporary after-image
- Red – potential to cause retinal burn (permanent eye damage)

These categories assume a typical blink response in the observer. Note that retinal burn is generally not possible for PV glare since PV modules do not focus reflected sunlight.

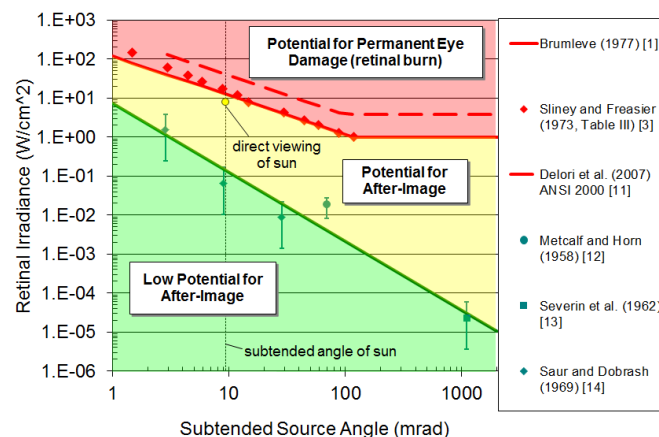


Figure 3. Sample glare hazard plot defining ocular impact as function of retinal irradiance and subtended source angle³

The ocular impact of glare is visualised with the Glare Hazard Plot (Figure 3). This chart displays the ocular impact as a function of glare subtended source angle and retinal irradiance. Each minute of glare is displayed on the chart as a small circle in its respective hazard zone. For convenience, a reference point is highlighted which illustrates the hazard from viewing the sun without filtering, i.e., looking at the sun. Each plot includes predicted glare for one PV array and one receptor.

¹ Federal Aviation Administration, November 2010: Technical Guidance for Evaluating Selected Solar Technologies on Airports October 2019.

² Ho, C. K., Ghanbari, C. M., and Diver, R. B., 2011, "Methodology to Assess Potential Glint and Glare Hazards from Concentrating Solar Power Plants: Analytical Models and Experimental Validation", ASME J. Sol. Energy Eng., 133.

³ Federal Aviation Administration, November 2010: Technical Guidance for Evaluating Selected Solar Technologies on Airports October 2019.

Solar Reflectance of PV Panels

PV panels have low reflectivity characteristics, as sunlight is used to induce electrical generation in the PV panels, the panels' function is to absorb the light, not to reflect it. The material used for this function is therefore black or dark blue. Figure 4 below displays that the reflectance of PV panels is remarkably like that of water. However, the amount of light reflected off solar PV panels can increase during certain times of the day, generally early morning, or late evening, which can have the potential for glare in certain directions.

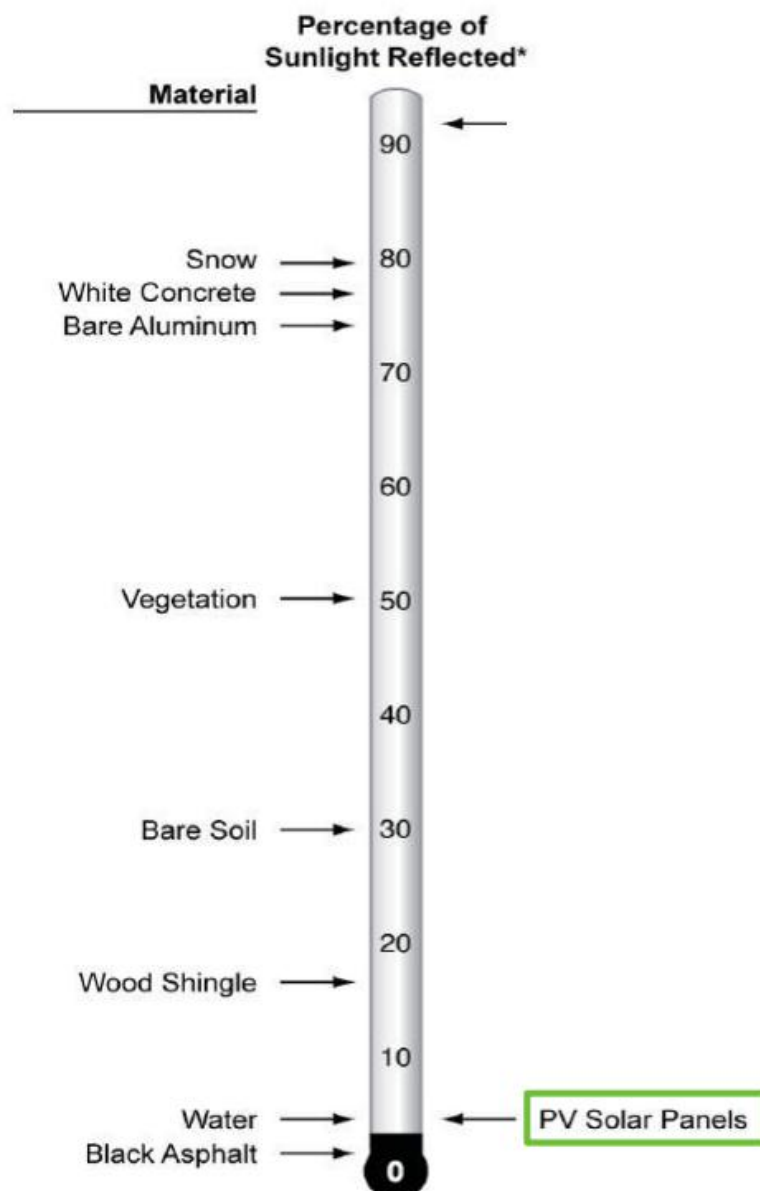


Figure 4. Reflectivity produced by different surfaces⁴

⁴ FAA 2010 Solar Guidance

Sandia National Laboratories developed five generic PV module material reflectance profiles by analysing over twenty PV module samples. These profiles are available in ForgeSolar and allow for customizing the material properties of the PV array during analysis. It is known from the current PV supplier that the reflectivity of their PV modules, which will be used for the proposed development, are light textured glass with anti-reflective coating. Figure 5 below highlights the reflectance of each material profile as a function of incidence angle, where an angle of 0° implies the panels are directly facing the sun.

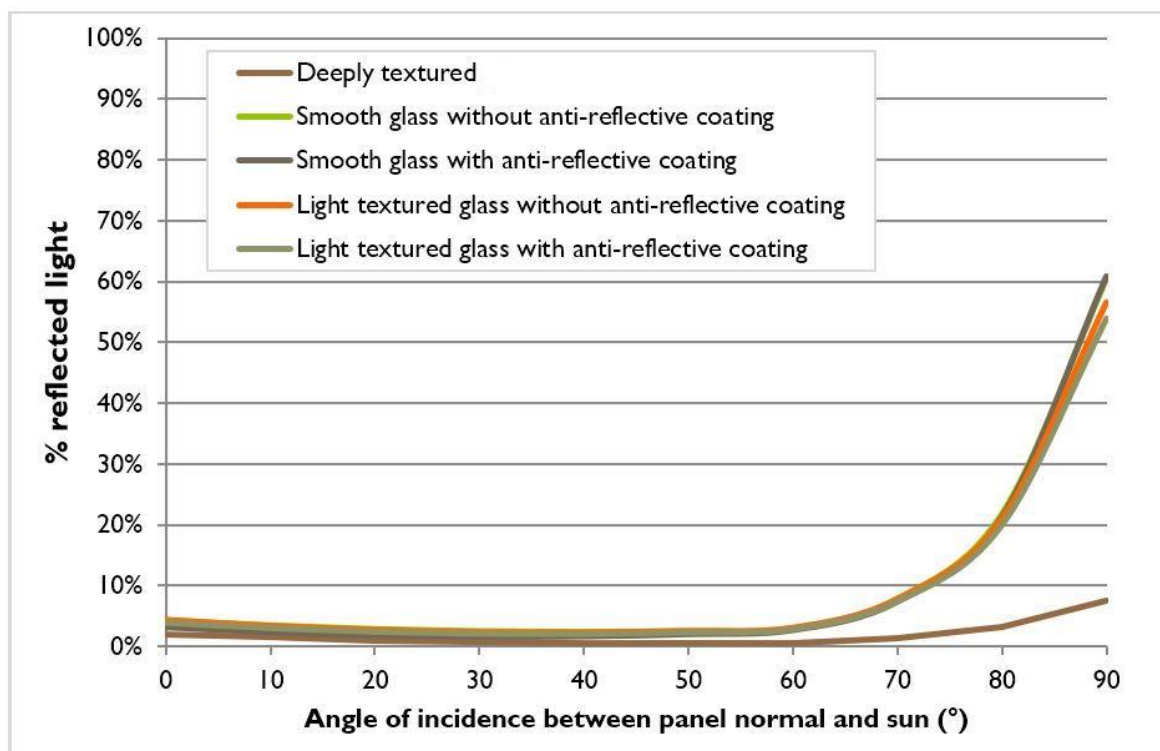


Figure 5. Reflectance profiles of typical PV module materials⁵

Studies have found that 7 W/m² is enough to cause an after-image lasting 4 to 12 seconds⁶. This represents a reflection of only 1-2% of typical solar irradiance for a given location, which generally ranges between 800-1000 W/m². A panel that absorbs 90% of direct sunlight may reflect up to 60% when not directly facing the sun. This is common for low-tilt panels during sunrise and sunset. The claim that PV panels reflect less than 5% of sunlight only holds true when the panels are directly facing the sun, which for fixed-mount panels, only applies for a few minutes of the day at most.

⁵ Yellowhair, J. and C.K. Ho. "Assessment of Photovoltaic Surface Texturing on Transmittance Effects and Glint/Glare Impacts". ASME 2015 9th International Conference on Energy Sustainability collocated with the ASME 2015 Power Conference, the ASME 2015 13th International Conference on Fuel Cell Science, Engineering and Technology, and the ASME 2015 Nuclear Forum. 2015. American Society of Mechanical Engineers.

⁶ Ho, C. K., Ghanbari, C. M., and Diver, R. B., 2009, "Hazard Analyses of Glint and Glare from Concentrating Solar Power Plants", SAND2009-4131C, in proceedings of SolarPACES 2009, Berlin, Germany, Sept. 15-18.

Sunshine Hours in Ireland

According to Met Eireann⁷, Ireland normally gets between 1100 and 1600 hours of sunshine each year with the sunniest months being May and June. Also, Irish skies are estimated to be completely covered by cloud for well over 50% of the time. The graph below represents the amount of average monthly sunshine hours that Ireland receives which is based on data from Dublin Airport and world data website⁸.

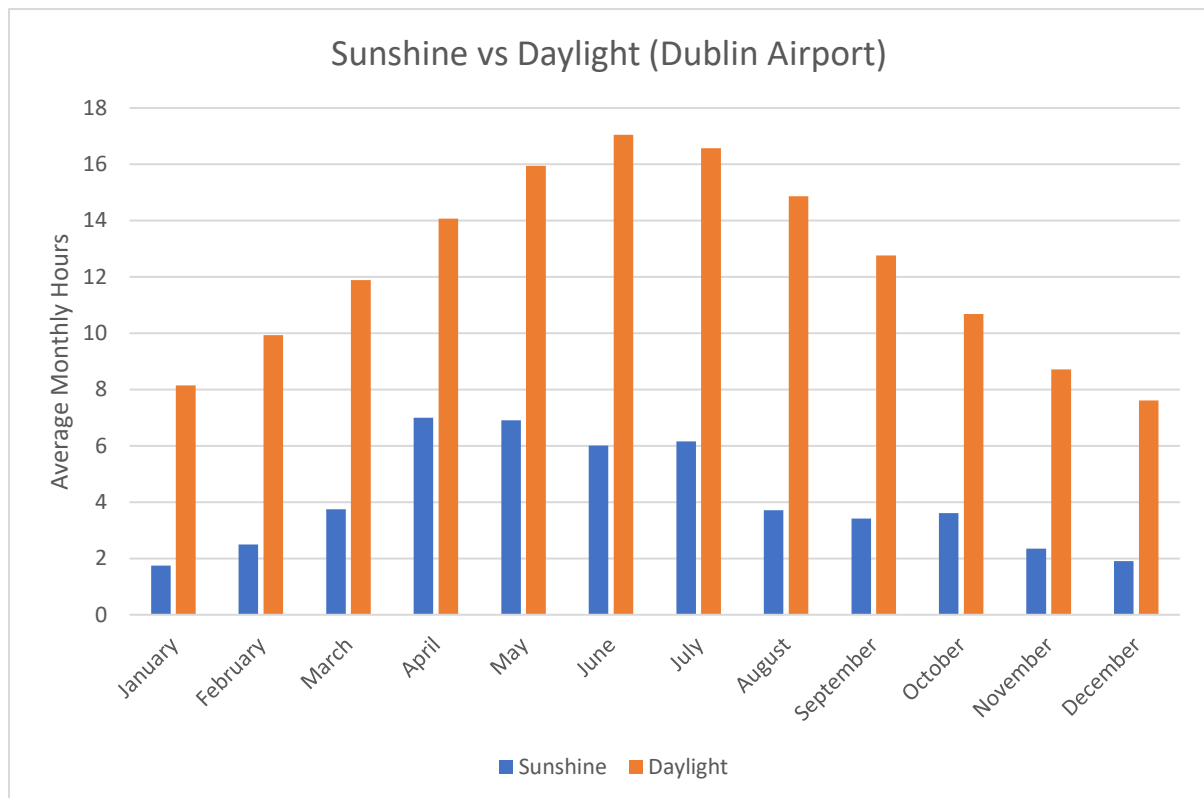


Figure 6. Sunshine vs Daylight (Dublin Airport)

⁷ <https://www.met.ie/climate/what-we-measure/sunshine>

⁸ <https://www.worlddata.info/europe/ireland/sunset.php>

Relevant Guidance and Studies

Ireland

There is currently no policy, guidance, or recommendations in Ireland in relation to the assessment of glint and glare effects on residential buildings, road and rail users, and aviation. A report produced by Future Analytics, in conjunction with the Sustainable Energy Authority of Ireland (SEAI), contains a set of planning policy and development guidance recommendations for utility scale solar PV schemes in Ireland⁹. This is not a formal guidance document, but it sets out recommended elements of the assessment based on international practice.

United Kingdom (UK)

Studies have been conducted in the UK which helps to establish an accepted best practice and planning guidance recommends the assessment of glint and glare effects. However, there currently is no specific guidance by way of a prescriptive methodology document. The Civil Aviation Authority (CAA) have produced an interim guidance document¹⁰ in relation to the development of solar PV systems on, and in the vicinity (<15 km) of aerodromes. The Building Research Establishment (BRE) have also developed several relevant papers, however neither the BRE or the CAA have produced a methodology for assessing the effects of glint and glare on rail and road users, aviation, or residential buildings.

Germany

The Light Guidelines¹¹ 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 stipulates that there is only additional impact to an observer because of glare from a solar PV array if the angle between the source of the glare and the sun is greater than ten degrees.

United States of America (USA)

The FAA in the USA have produced a document called the “Technical Guidance for Evaluating Selected Solar Technologies on Airports”¹² which is accepted internationally as the most detailed methodology for assessing the effects of glint and glare. This document recommends the use of a particular analysis tool, the Solar Glare Hazard Analysis Tool (SGHAT), when conducting glint and glare assessments of solar PV systems.

⁹ Future Analytics. October 2016. Planning and Development Guidance Recommendations for Utility Scale Solar Photovoltaic Schemes in Ireland

¹⁰ Civil Aviation Authority. December 2010. “Interim CAA Guidance - Solar Photovoltaic Systems”.

¹¹ Leitlinie des Ministeriums für Umwelt, Gesundheit und Verbraucherschutz zur Messung und Beurteilung von Lichtimmissionen (LichtLeitlinie). 2014 Available :

http://www.mlul.brandenburg.de/media_fast/4055/licht_leitlinie.pdf

¹² Federal Aviation Administration. November 2010. “Technical Guidance for Evaluating Selected Solar Technologies on Airports”

Methodology

Lawler Sustainability, considering all the studies and guidelines mentioned in the previous section, have created a methodology for assessing the effects of glint and glare. The ForgeSolar tool has been used to satisfy aviation policy throughout the world, including that of the FAA, hence, this is the tool that Lawler Sustainability has employed and prescribed a methodology to all receptor types including road and rail, aviation, and residential buildings. Until formal guidance is provided in Ireland, the methodology that is described in this section will be used and is broken down into the following seven key stages:

1. Study area assessment
2. Solar PV array layout
3. Identifying receptors to suit analysis
4. Geometric evaluation
5. Glare analysis
6. Interpretation of results
7. Mitigation measures

1. Study area assessment

In the first stage of the glint and glare assessment, the area of the proposed development is identified along with any high-risk areas that could be susceptible to glare e.g., airport runways and air traffic control towers.

2. Solar PV array layout

The next stage identifies the size of the proposed solar PV array and its assumed area. Consideration is also given to the PV system if it is fixed mount or on a tracking system, and if it is roof mounted or mounted on the ground. Where possible, the characteristics of the proposed PV modules to be installed are determined e.g., if the panel has anti-reflective coating.

3. Identifying receptors to suit analysis

Once the study area and solar PV system have been defined, the location of potential receptors can be identified in the surrounding area which may include, but is not limited to, roads, railways, residential buildings, commercial buildings, runways, and air traffic control towers. The potential receptors undergo a geometrical analysis to consider if landform such as mountains, vegetative, hills, or built environment elements of the landscape may screen the development from view. This is accomplished using desk-based analysis of Google Street view and Google Earth. The orientation of the receptors is also considered as it may dictate whether the receptors are in direct line of sight of the solar PV array. For example, a dwelling may be located within the surrounding area of the solar PV array, but the orientation of the dwelling's glazing may be facing away from the panels which would receive little or no impact of glare.

4. Geometric Evaluation

As mentioned previously in this report, Lawler Sustainability use the ForgeSolar tool to perform calculations for glint and glare analysis. A number of parameters are considered to run these calculations which include, but are not limited to:

- The time zone for the proposed development.
- The apparent height and position of the sun at a particular moment in time of day and year.
- The orientation, height, and pitch of the solar PV array.
- The height and location of each receptor.

5. Glare analysis

Once all parameters and receptors are set within the ForgeSolar tool, the glare analysis can commence. The software performs an annual analysis of the proposed development to determine expected glare from PV arrays towards receptors. Another tool within ForgeSolar that is called GlaReduce Optimisation Tool can be used to conduct a module optimisation analysis. This evaluates a single PV array over a range of tilts and orientations to aid in identifying the optimal module configuration.

6. Interpretation of results

The results from the ForgeSolar tool are collated into a comprehensible table and graph with comments as to the likely impact of glint and glare of the proposed solar PV array on all assessed receptors. Based on the theoretical amount of time a receptor may potentially experience glare, a determination of the classification of glare is made using the table below. This table has been inspired by the German light guidelines as mentioned previously.

Table 2. Classification of Glare based on theoretical amount of time of glare from results

Glare Classification	Description
High	Potential for more than 30 mins of glare per day and/or more than 30 hours per year.
Low	Potential for less than 30 mins of glare per day and/or less than 30 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 a guide only as additional factors such as intervening screening (vegetative, built environment elements, and hills) and receptor orientation may better determine a more realistic classification of glare.

7. Mitigation measures

Depending on the severity of the glare experienced at any of the receptors, mitigation measures may be recommended to reduce the impact of glare. This can be achieved in a number of ways such as recommending that vegetative screening be added to form a visual barrier between the solar PV array and the receptor or suggesting that the PV modules be orientated or positioned differently to reduce the effect of glare. Tracking systems can also be installed on PV systems which can help to reduce the impact of glare.

Glint & Glare Model Setup

Site Plan

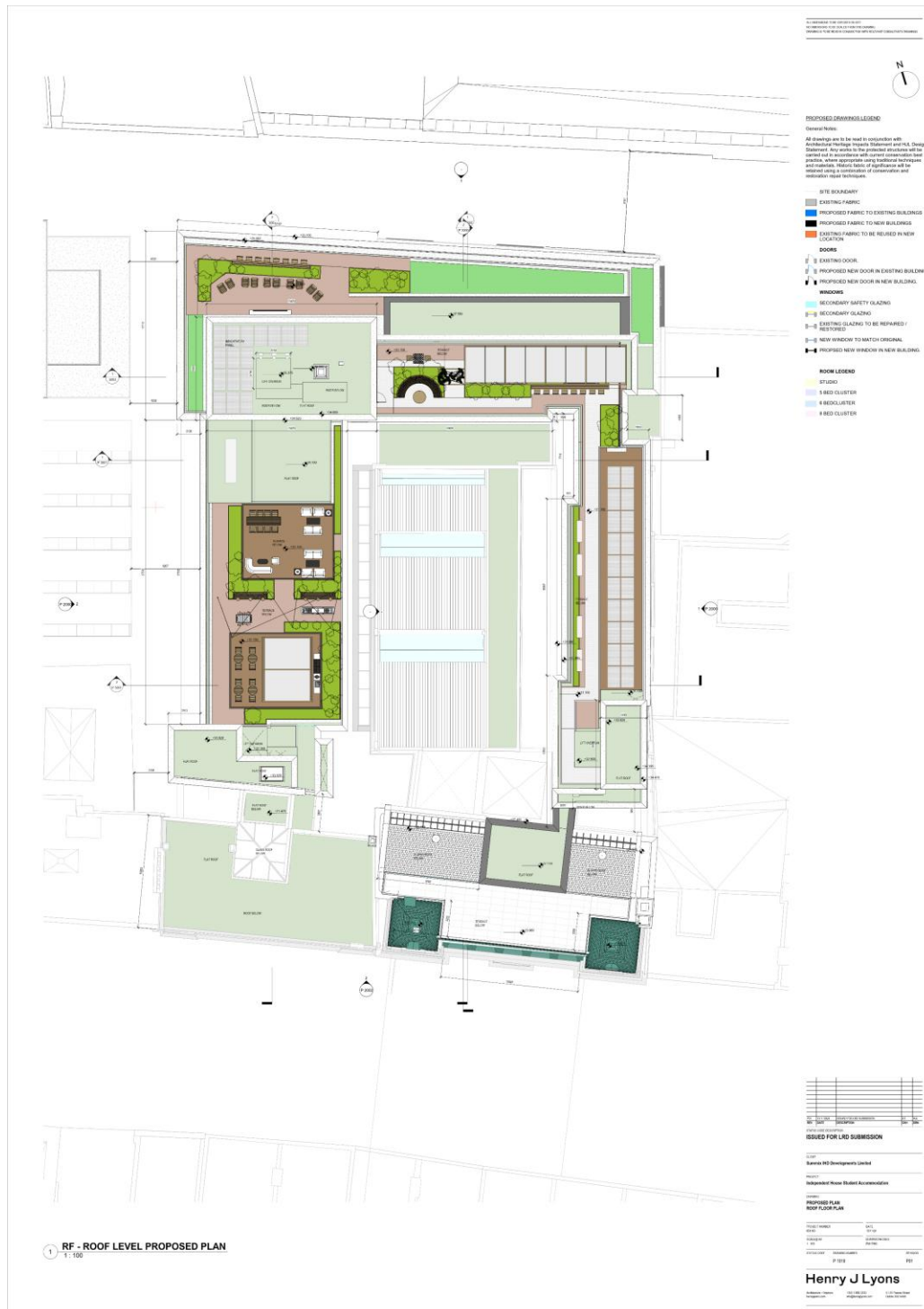


Figure 7. Site Plan for proposed Independent House PBSA, Abbey Street, Dublin [Source: Henry J. Lyon] (Not to Scale)

Solar PV Array Description and Parameters

Table 3. Proposed PV details

Name:	PV array 1 - East
Footprint area:	~95 m ²
Axis tracking:	Fixed (no rotation)
Tilt:	0.0°
Orientation:	197.0°
Rated power:	-
Panel material:	Light textured glass with AR coating
Vary reflectivity with sun position?	Yes
Correlate slope error with surface type?	Yes
Slope error:	9.16 mrad

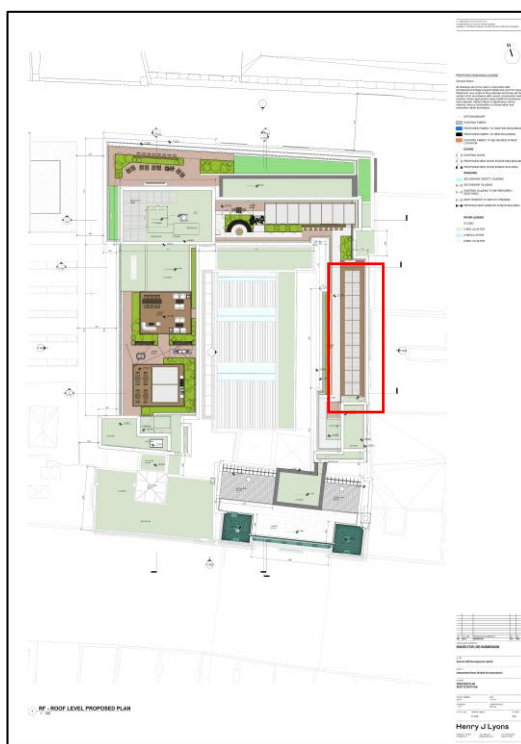


Figure 8. Proposed PV array 2 - East

Table 4. Proposed PV positioning

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	53.348786	-6.261342	4.44	26.66	31.10
2	53.348613	-6.261270	4.48	26.62	31.10
3	53.348623	-6.261201	4.46	26.64	31.10
4	53.348797	-6.261273	4.45	26.65	31.10

Table 5. Proposed PV details

Name:	PV array 2 - North
Footprint area:	~53 m ²
Axis tracking:	Fixed (no rotation)
Tilt:	0.0°
Orientation:	197.0°
Rated power:	-
Panel material:	Light textured glass with AR coating
Vary reflectivity with sun position?	Yes
Correlate slope error with surface type?	Yes
Slope error:	9.16 mrad

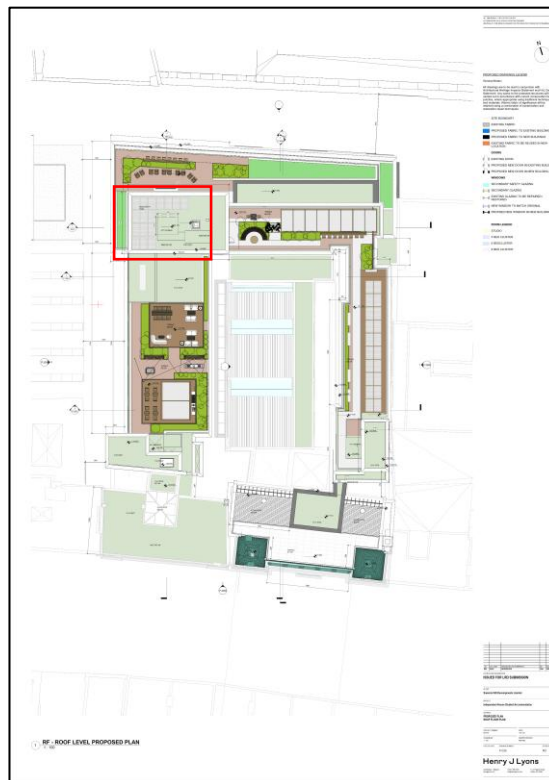


Figure 9. Proposed PV array 3 - North

Table 6. Proposed PV positioning

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	53.348739	-6.261858	4.39	29.67	34.05
2	53.348759	-6.261726	4.36	29.70	34.05
3	53.348729	-6.261713	4.40	29.65	34.05
4	53.348719	-6.261779	4.42	29.64	34.05
5	53.348676	-6.261759	4.47	29.59	34.05
6	53.348667	-6.261822	4.49	29.56	34.05

Dublin Airport 2-mile flight path receptors

Table 7. 2-mile flight path receptor FP 10 details

Name	FP 10
Threshold height	15 m
Direction	94.7°
Glide Slope	3.0°
Pilot view restricted?	Yes
Vertical view restriction	30.0°
Azimuthal view restriction	50.0°



Figure 10. 2-mile flight path receptor FP 10

Table 8. 2-mile flight path receptor FP 10 details

Point	Latitude	Longitude	Ground Elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	53.422422	-6.289750	74.08	15.24	89.32
2-mile point	53.424791	-6.338161	81.31	176.70	258.01

Table 9. 2-mile flight path receptor FP 10L details

Name	FP 10L
Threshold height	15 m
Direction	94.7°
Glide Slope	3.0°
Pilot view restricted?	Yes
Vertical view restriction	30.0°
Azimuthal view restriction	50.0°



Figure 11. 2-mile flight path receptor FP 10L

Table 10. 2-mile flight path receptor FP 10L details

Point	Latitude deg	Longitude deg	Ground Elevation m	Height above ground m	Total elevation m
Threshold	53.437380	-6.284410	72.98	15.24	88.22
2-mile point	53.439749	-6.332839	77.59	179.32	256.91

Table 11. 2-mile flight path receptor FP 16 details

Name	FP 16
Threshold height	15 m
Direction	156.7°
Glide Slope	3.0°
Pilot view restricted?	Yes
Vertical view restriction	30.0°
Azimuthal view restriction	50.0°



Figure 12. 2-mile flight path receptor FP 16

Table 12. 2-mile flight path receptor FP 16 details

Point	Latitude deg	Longitude deg	Ground Elevation m	Height above ground m	Total elevation m
Threshold	53.436800	-6.261850	66.50	15.24	81.74
2-mile point	53.463355	-6.281070	69.90	180.53	250.43

Table 13. 2-mile flight path receptor FP 28 details

Name	FP 28
Threshold height	15 m
Direction	275.3°
Glide Slope	3.0°
Pilot view restricted?	Yes
Vertical view restriction	30.0°
Azimuthal view restriction	50.0°



Figure 13. 2-mile flight path receptor FP 28

Table 14. 2-mile flight path receptor FP 28 details

Point	Latitude deg	Longitude deg	Ground Elevation m	Height above ground m	Total elevation m
Threshold	53.420286	-6.250877	61.99	15.24	77.23
2-mile point	53.417615	-6.202512	41.17	204.75	245.92

Table 15. 2-mile flight path receptor FP 28R details

Name	FP 28R
Threshold height	15 m
Direction	274.7°
Glide Slope	3.0°
Pilot view restricted?	Yes
Vertical view restriction	30.0°
Azimuthal view restriction	50.0°



Figure 14. 2-mile flight path receptor FP 28R

Table 16. 2-mile flight path receptor FP 28 details

Point	Latitude deg	Longitude deg	Ground Elevation m	Height above ground m	Total elevation m
Threshold	53.434847	-6.238503	67.75	15.24	82.99
2-mile point	53.432478	-6.190077	32.67	219.01	251.67

Table 17. 2-mile flight path receptor FP 34 details

Name	FP 34
Threshold height	15 m
Direction	336.7°
Glide Slope	3.0°
Pilot view restricted?	Yes
Vertical view restriction	30.0°
Azimuthal view restriction	50.0°



Figure 15. 2-mile flight path receptor FP 34

Table 18. 2-mile flight path receptor FP 34 details

Point	Latitude deg	Longitude deg	Ground Elevation m	Height above ground m	Total elevation m
Threshold	53.420099	-6.249719	62.26	15.24	77.50
2-mile point	53.393545	-6.230507	49.02	197.17	246.18

Baldonnell Airport 2-mile flight path receptors

Table 19. 2-mile flight path receptor FP 04 details

Name	FP 04
Threshold height	15 m
Direction	40.8°
Glide Slope	3.0°
Pilot view restricted?	Yes
Vertical view restriction	30.0°
Azimuthal view restriction	50.0°



Figure 16. 2-mile flight path receptor FP 04

Table 20. 2-mile flight path receptor FP 04 details

Point	Latitude	Longitude	Ground Elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	53.293734	-6.453598	98.43	15.24	113.67
2-mile point	53.271847	-6.485242	154.25	128.10	282.36

Table 21. 2-mile flight path receptor FP 10 details

Name	FP 10
Threshold height	15 m
Direction	101.0°
Glide Slope	3.0°
Pilot view restricted?	Yes
Vertical view restriction	30.0°
Azimuthal view restriction	50.0°



Figure 17. 2-mile flight path receptor FP 10

Table 22. 2-mile flight path receptor FP 10 details

Point	Latitude deg	Longitude deg	Ground Elevation m	Height above ground m	Total elevation m
Threshold	53.304657	-6.468508	86.24	15.24	101.48
2-mile point	53.310174	-6.516059	73.44	196.72	270.16

Table 23. 2-mile flight path receptor FP 22 details

Name	FP 22
Threshold height	15 m
Direction	220.8°
Glide Slope	3.0°
Pilot view restricted?	Yes
Vertical view restriction	30.0°
Azimuthal view restriction	50.0°



Figure 18. 2-mile flight path receptor FP 22

Table 24. 2-mile flight path receptor FP 22 details

Point	Latitude deg	Longitude deg	Ground Elevation m	Height above ground m	Total elevation m
Threshold	53.303367	-6.439656	93.37	15.24	108.61
2-mile point	53.325253	-6.408004	62.63	214.66	277.29

Table 25. 2-mile flight path receptor FP 28 details

Name	FP 28
Threshold height	15 m
Direction	281.9°
Glide Slope	3.0°
Pilot view restricted?	Yes
Vertical view restriction	30.0°
Azimuthal view restriction	50.0°



Figure 19. 2-mile flight path receptor FP 28

Table 26. 2-mile flight path receptor FP 28 details

Point	Latitude deg	Longitude deg	Ground Elevation m	Height above ground m	Total elevation m
Threshold	53.301675	-6.444952	96.04	15.24	111.28
2-mile point	53.295713	-6.397555	106.18	173.79	279.97

Discrete Observation Receptors

Table 27. Discrete Observation Receptors

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	m	m	m
1-ATCT	53.428936	-6.264267	65.46	89.90	155.36
2-ATCT	53.428508	-6.262158	65.59	30.00	95.59
OP 3	53.388256	-6.229919	47.27	49.00	96.27
OP 4	53.343161	-6.301995	19.46	50.00	69.46
OP 5	53.350156	-6.309584	27.73	50.00	77.73
OP 6	53.328549	-6.270103	22.41	50.00	72.41
OP 7	53.289504	-6.376775	103.75	50.00	153.75
8-ATCT	53.305499	-6.441760	93.62	29.00	122.62

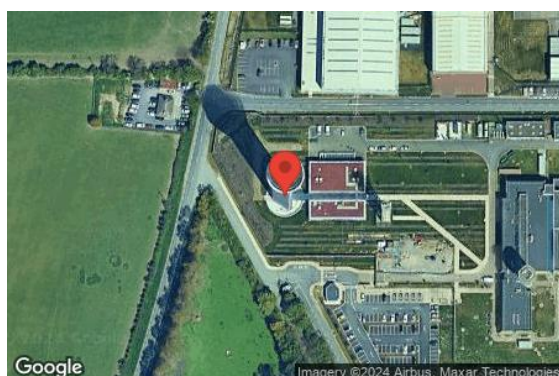


Figure 20. 1-ATCT Dublin ATCT (new)



Figure 21. 2-ATCT Dublin ATCT (old)



Figure 22. OP3 Beaumont Hospital



Figure 23. OP4 Royal Hospital Kilmainham



Figure 24. OP5 Phoenix Park



Figure 25. OP6 Cathal Burgha Barracks



Figure 26. OP7 Tallaght University Hospital



Figure 27. 8-ATCT Baldonnel ATCT

Glint and Glare Analysis

The analysis simulated ten 2-mile flight path receptors (six from Dublin Airport and four from Baldonnel Airport), three Air Traffic Control Towers (two at Dublin Airport and one at Baldonnel Airport), as well as five nearby known helipad/locations for helicopter landings.

The current ATCT at Baldonnel Airport was given a height of 15 metres. The old ATCT at Dublin Airport was given a height of 30 metres and the new ATCT at Dublin Airport was given a height of 89.90 metres. All helicopter locations/helipads were given a height of 50 metres from ground level to indicate the critical stage during helicopter take-off and landing.

An initial “baseline” assessment was undertaken whereby the wall parapet feature was omitted to represent an unobstructed view from the PV panels towards all receptors studied.

Subsequent assessments included for the parapet feature (Figure 28) and were undertaken to identify optimal PV positioning to reduce the impact of ocular glare emanating from the PV panels.

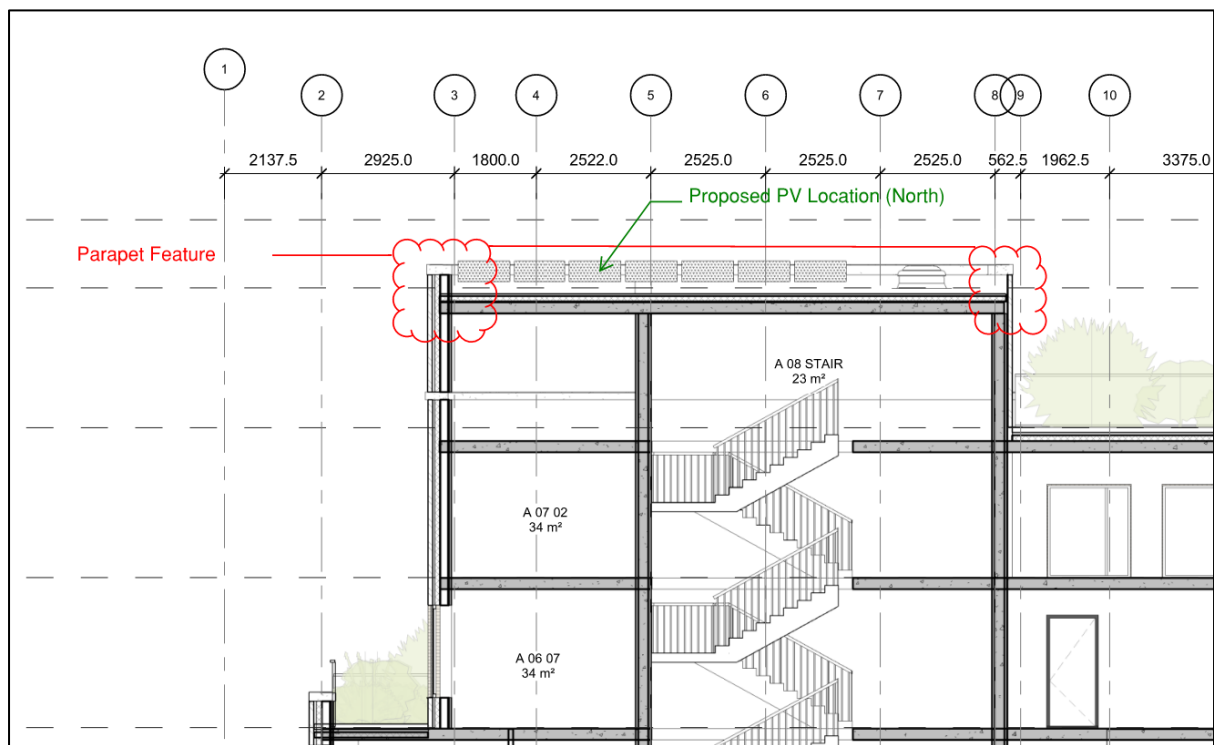


Figure 28. Snip of sectional drawing showing parapet feature on roof (Source: Henry J. Lyons)[Not to scale]

Glint and Glare Results

Baseline with no parapet

The results indicated in the following tables highlight potential for green and yellow hazard glare from the solar PV arrays at the development.

Table 28. Summary of results

PV Name	Tilt	Orientation	Annual "Green" Glare	Annual "Yellow" Glare	Annual Energy Produced*
	deg	deg	min	min	kWh
PV array 1 - East	0.0	197.0	3,729	0	-
PV array 2 - North	0.0	197.0	3,479	0	-

*Please note that the value listed here is an approximate of the potential yield from the proposed solar PV array. Please refer to more specialised software for estimating solar energy yields.

Table 29. Receptor analysis annual results

Component	Annual Green glare (min)	Annual Green glare (hours)	Annual Yellow glare (min)	Annual Yellow glare (hours)
FP 04 Baldonnell Airport	2,210	36.8	0	0
FP 10 Baldonnell Airport	1,463	24.4	0	0
FP 10 Dublin Airport	0	0	0	0
FP 10L Dublin Airport	0	0	0	0
FP 16 Dublin Airport	0	0	0	0
FP 22 Baldonnell Airport	0	0	0	0
FP 28 Baldonnell Airport	0	0	0	0
FP 28 Dublin Airport	0	0	0	0
FP 28R Dublin Airport	0	0	0	0
FP 34 Dublin Airport	0	0	0	0
1-ATCT	0	0	0	0
2-ATCT	0	0	0	0
OP 3	0	0	0	0
OP 4	904	15.1	0	0
OP 5	837	13.9	0	0
OP 6	0	0	0	0
OP 7	1,035	17.2	0	0
8-ATCT	759	12.7	0	0

Parapet included in model

The results indicated in the following tables highlight potential for green and yellow hazard glare from the solar PV arrays at the development.

Table 30. Summary of results

PV Name	Tilt	Orientation	Annual "Green" Glare	Annual "Yellow" Glare	Annual Energy Produced*
	deg	deg	min	min	kWh
PV array 1 - East	0.0	197.0	0	0	-
PV array 2 - North	0.0	197.0	0	0	-

*Please note that the value listed here is an approximate of the potential yield from the proposed solar PV array. Please refer to more specialised software for estimating solar energy yields.

Table 31. Receptor analysis annual results

Component	Annual Green glare (min)	Annual Green glare (hours)	Annual Yellow glare (min)	Annual Yellow glare (hours)
FP 04 Baldonnell Airport	0	0	0	0
FP 10 Baldonnell Airport	0	0	0	0
FP 10 Dublin Airport	0	0	0	0
FP 10L Dublin Airport	0	0	0	0
FP 16 Dublin Airport	0	0	0	0
FP 22 Baldonnell Airport	0	0	0	0
FP 28 Baldonnell Airport	0	0	0	0
FP 28 Dublin Airport	0	0	0	0
FP 28R Dublin Airport	0	0	0	0
FP 34 Dublin Airport	0	0	0	0
1-ATCT	0	0	0	0
2-ATCT	0	0	0	0
OP 3	0	0	0	0
OP 4	0	0	0	0
OP 5	0	0	0	0
OP 6	0	0	0	0
OP 7	0	0	0	0
8-ATCT	0	0	0	0

PV Tilt Optimisation

The tilt of the PV panels were analysed from 0° (flat to the roof) to 45° in steps of 5° increments, and azimuth angle 0° (North) to 315° in increments of 45° to establish an optimal solution for the positioning of PV. This solution allows for optimal performance of the PV panels whilst also minimizing the amount of potential glare. It was found that the PV panels can be tilted to any degree between 0° and 45° and within any orientation without risking negative effects of glint and/or glare.

Blue: adheres to FAA Policy (No glare found)

Green: glare with low potential for after-image

Yellow: glare with potential for after-image

Red: Fails FAA Policy

Table 32. Solar PV array 1 - East

Tilt -> Orient ↓	0°	5°	10°	15°	20°	25°	30°	35°	40°	45°
0°										
45°										
90°										
135°										
180°										
225°										
270°										
315°										

Table 33. Solar PV array 2 - North

Tilt -> Orient ↓	0°	5°	10°	15°	20°	25°	30°	35°	40°	45°
0°										
45°										
90°										
135°										
180°										
225°										
270°										
315°										

Conclusion

A glint and glare analysis was completed for the proposed Solar PV installation at the proposed Independent House PBSA, Abbey Street, Dublin. The development is located within several Solar Safeguarding Zones as identified by The Planning and Development (Solar Safeguarding Zone) Regulations 2022. The report has assessed the required nearby airports, aerodromes, and helipad receptors.

No glare was found within the study provided that the parapet wall feature is constructed as demonstrated in the Architectural drawings with an edge height of at least 400mm and that the PV panels are positioned at roof level with a tilt degree between 0° and 45°. The parapet wall acts as a shield which obstructs the effect of glare emanating from the PV panels and is an important factor in this assessment. It is recommended that the proposed PV be fixed in place at roof level orientated towards the South direction, have no sun tracking, and have low-texture glass with anti-reflective coating.

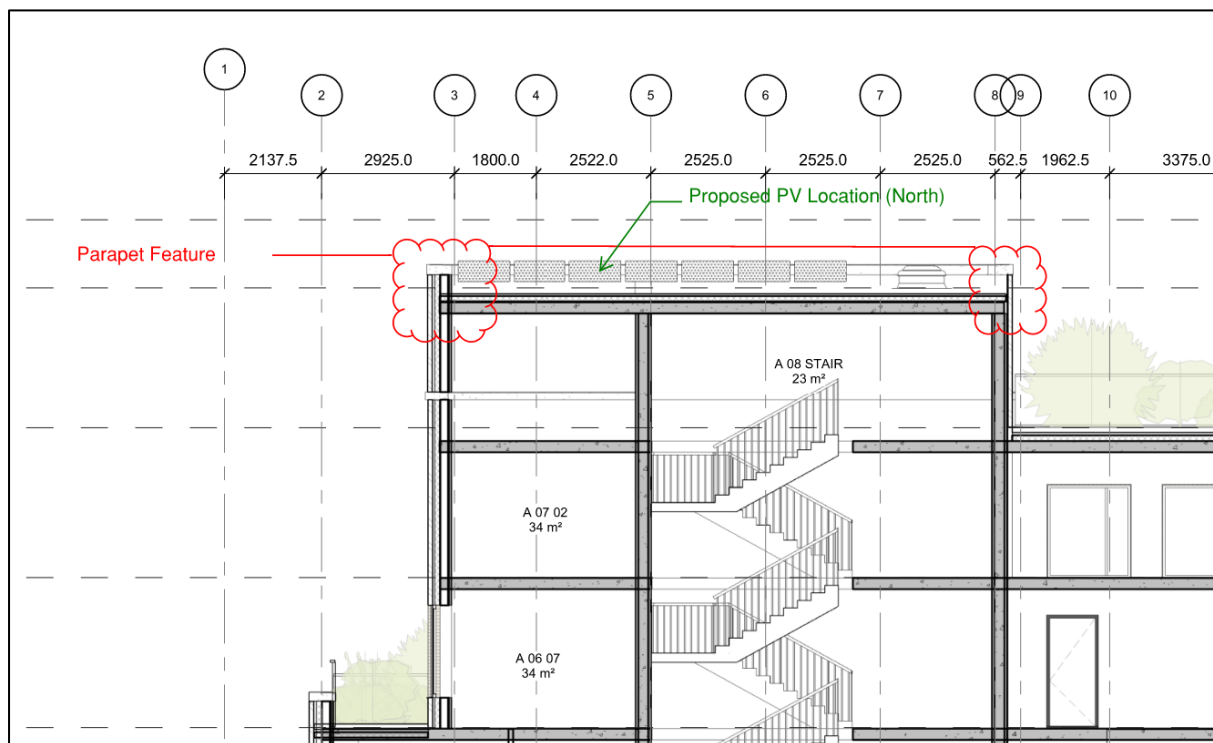


Figure 29. Snip of sectional drawing showing parapet feature on roof (Source: Henry J. Lyons)[Not to scale]

Appendix

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

- 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 modelling methods.
- Several V1 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, potentially 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. (See 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.

Baseline with no parapet

FORGESOLAR GLARE ANALYSIS

Project: **Independent House**

Proposed Solar PV installation on the roof of the proposed Independent House, Abbey Street Lower, Dublin

Site configuration: **No Parapet Feature**

Created 16 Oct, 2024

Updated 11 Nov, 2024

Time-step 1 minute

Timezone offset UTC0

Minimum sun altitude 0.0 deg

DNI peaks at 1,000.0 W/m²

Category 10 to 100 kW

(1,000 kW / 32,400 m² limit)

Site ID 131414.22372

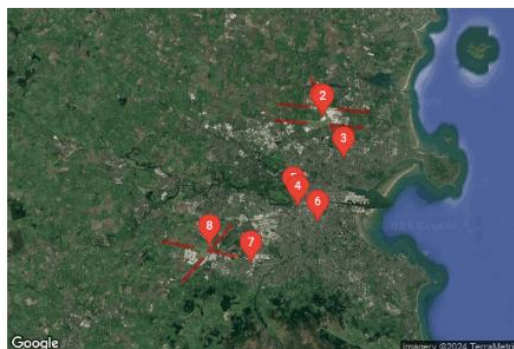
Ocular transmission coefficient 0.5

Pupil diameter 0.002 m

Eye focal length 0.017 m

Sun subtended angle 9.3 mrad

PV analysis methodology V2



Summary of Results Glare with low potential for temporary after-image predicted

PV Array	Tilt °	Orient °	Annual Green Glare		Annual Yellow Glare		Energy kWh
			min	hr	min	hr	
PV array 1 - East	0.0	197.0	3,729	62.1	0	0.0	-
PV array 2 - North	0.0	197.0	3,479	58.0	0	0.0	-

Total glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
FP 04	2,210	36.8	0	0.0
FP 10	0	0.0	0	0.0
FP 10	1,463	24.4	0	0.0
FP 10L	0	0.0	0	0.0
FP 16	0	0.0	0	0.0
FP 22	0	0.0	0	0.0
FP 28	0	0.0	0	0.0
FP 28	0	0.0	0	0.0
FP 28R	0	0.0	0	0.0
FP 34	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0
2-ATCT	0	0.0	0	0.0
OP 3	0	0.0	0	0.0



Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 4	904	15.1	0	0.0
OP 5	837	13.9	0	0.0
OP 6	0	0.0	0	0.0
OP 7	1,035	17.2	0	0.0
8-ATCT	759	12.7	0	0.0



Component Data

PV Arrays

Name: PV array 1 - East
Description: Located above C 07 01
Axis tracking: Fixed (no rotation)
Tilt: 0.0°
Orientation: 197.0°
Rated power: -
Panel material: Light textured glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.348786	-6.261342	4.44	26.66	31.10
2	53.348613	-6.261270	4.48	26.62	31.10
3	53.348623	-6.261201	4.46	26.64	31.10
4	53.348797	-6.261273	4.45	26.65	31.10

Name: PV array 2 - North
Description: Located above A 07 02
Axis tracking: Fixed (no rotation)
Tilt: 0.0°
Orientation: 197.0°
Rated power: -
Panel material: Light textured glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.348739	-6.261858	4.39	29.67	34.05
2	53.348759	-6.261726	4.36	29.70	34.05
3	53.348729	-6.261713	4.40	29.65	34.05
4	53.348719	-6.261779	4.42	29.64	34.05
5	53.348676	-6.261759	4.47	29.59	34.05
6	53.348667	-6.261822	4.49	29.56	34.05



Flight Path Receptors

Name: FP 04
Description:
Threshold height: 15 m
Direction: 40.8°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.293734	-6.453598	98.43	15.24	113.67
Two-mile	53.271847	-6.485242	154.25	128.10	282.36

Name: FP 10
Description:
Threshold height: 15 m
Direction: 94.7°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.422422	-6.289750	74.08	15.24	89.32
Two-mile	53.424791	-6.338161	81.31	176.70	258.01



Name: FP 10
Description:
Threshold height: 15 m
Direction: 101.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.304657	-6.468508	86.24	15.24	101.48
Two-mile	53.310174	-6.516059	73.44	196.72	270.16

Name: FP 10L
Description:
Threshold height: 15 m
Direction: 94.7°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.437380	-6.284410	72.98	15.24	88.22
Two-mile	53.439749	-6.332839	77.59	179.32	256.91

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



Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.436800	-6.261850	66.50	15.24	81.74
Two-mile	53.463355	-6.281070	69.90	180.53	250.43



Name: FP 22
Description:
Threshold height: 15 m
Direction: 220.8°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.303367	-6.439656	93.37	15.24	108.61
Two-mile	53.325253	-6.408004	62.63	214.66	277.29

Name: FP 28
Description:
Threshold height: 15 m
Direction: 281.9°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.301675	-6.444952	96.04	15.24	111.28
Two-mile	53.295713	-6.397555	106.18	173.79	279.97

Name: FP 28
Description:
Threshold height: 15 m
Direction: 275.3°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.420286	-6.250877	61.99	15.24	77.23
Two-mile	53.417615	-6.202512	41.17	204.75	245.92



Name: FP 28R

Description:

Threshold height: 15 m

Direction: 274.7°

Glide slope: 3.0°

Pilot view restricted? Yes

Vertical view: 30.0°

Azimuthal view: 50.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.434847	-6.238503	67.75	15.24	82.99
Two-mile	53.432478	-6.190077	32.67	219.01	251.67

Name: FP 34

Description:

Threshold height: 15 m

Direction: 336.7°

Glide slope: 3.0°

Pilot view restricted? Yes

Vertical view: 30.0°

Azimuthal view: 50.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.420099	-6.249719	62.26	15.24	77.50
Two-mile	53.393545	-6.230507	49.02	197.17	246.18



Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	53.428936	-6.264267	65.46	89.90
2-ATCT	2	53.428508	-6.262158	65.59	30.00
OP 3	3	53.388256	-6.229919	47.27	49.00
OP 4	4	53.343161	-6.301995	19.46	50.00
OP 5	5	53.350156	-6.309584	27.73	50.00
OP 6	6	53.328549	-6.270103	22.41	50.00
OP 7	7	53.289504	-6.376775	103.75	50.00
8-ATCT	8	53.305499	-6.441760	93.62	29.00

Map image of 1-ATCT



Map image of 2-ATCT



Map image of 8-ATCT



Glare Analysis Results

Summary of Results Glare with low potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1 - East	0.0	197.0	3,729	62.1	0	0.0	-
PV array 2 - North	0.0	197.0	3,479	58.0	0	0.0	-

Total glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
FP 04	2,210	36.8	0	0.0
FP 10	0	0.0	0	0.0
FP 10	1,463	24.4	0	0.0
FP 10L	0	0.0	0	0.0
FP 16	0	0.0	0	0.0
FP 22	0	0.0	0	0.0
FP 28	0	0.0	0	0.0
FP 28	0	0.0	0	0.0
FP 28R	0	0.0	0	0.0
FP 34	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0
2-ATCT	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	904	15.1	0	0.0
OP 5	837	13.9	0	0.0
OP 6	0	0.0	0	0.0
OP 7	1,035	17.2	0	0.0
8-ATCT	759	12.7	0	0.0

PV: PV array 1 - East low potential for temporary after-image

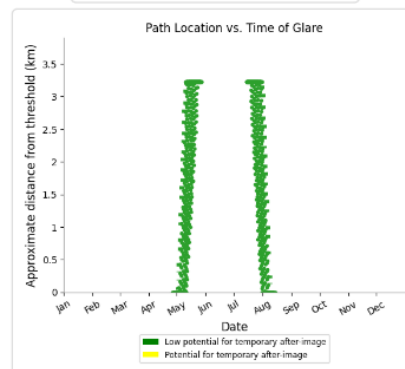
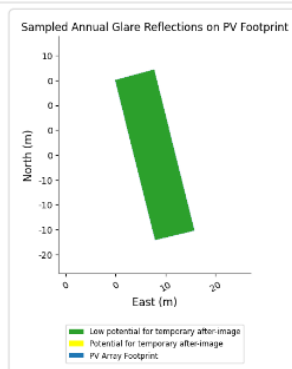
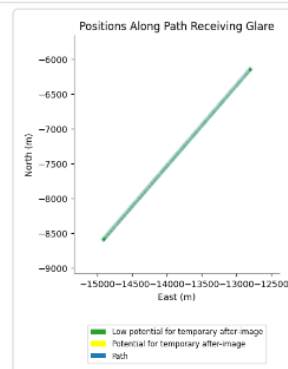
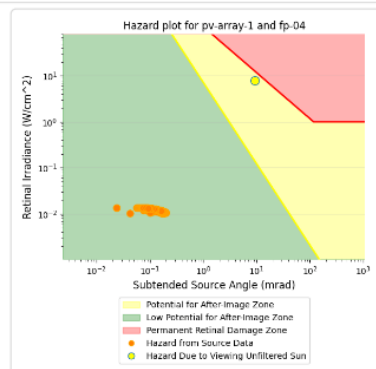
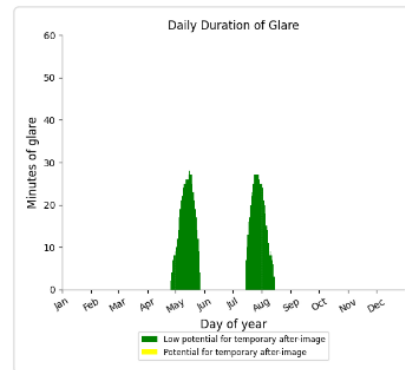
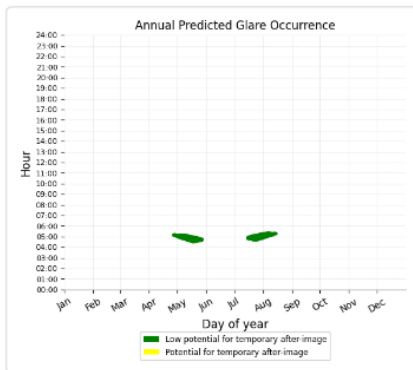
Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
FP 04	1,111	18.5	0	0.0
FP 10	823	13.7	0	0.0
FP 10	0	0.0	0	0.0
FP 10L	0	0.0	0	0.0
FP 16	0	0.0	0	0.0
FP 22	0	0.0	0	0.0
FP 28	0	0.0	0	0.0
FP 28	0	0.0	0	0.0
FP 28R	0	0.0	0	0.0
FP 34	0	0.0	0	0.0
OP 4	472	7.9	0	0.0
OP 5	424	7.1	0	0.0
OP 7	539	9.0	0	0.0
8-ATCT	360	6.0	0	0.0
1-ATCT	0	0.0	0	0.0
2-ATCT	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 6	0	0.0	0	0.0

PV array 1 - East and FP: FP 04

Yellow glare: none

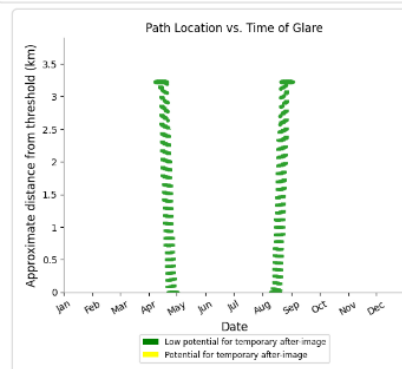
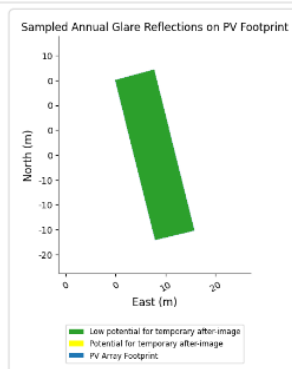
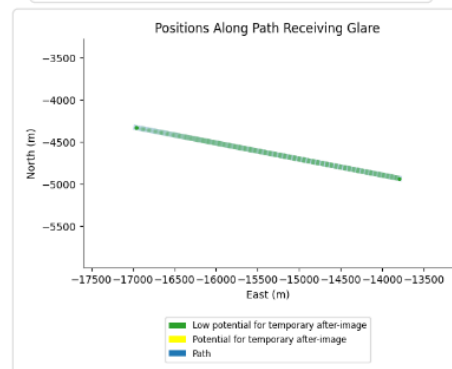
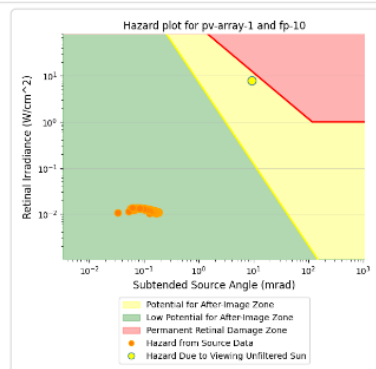
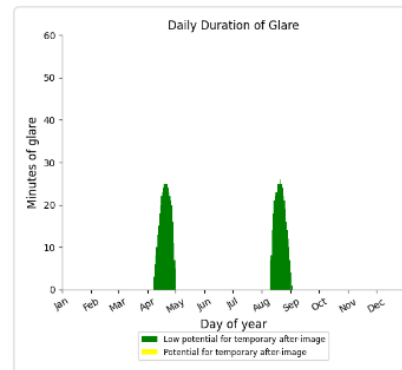
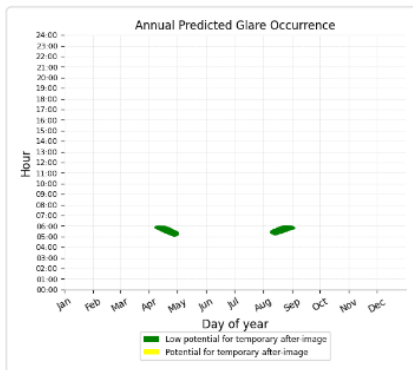
Green glare: 1,111 min.



PV array 1 - East and FP: FP 10

Yellow glare: none

Green glare: 823 min.



PV array 1 - East and FP: FP 10

No glare found



PV array 1 - East and FP: FP 10L

No glare found

PV array 1 - East and FP: FP 16

No glare found

PV array 1 - East and FP: FP 22

No glare found

PV array 1 - East and FP: FP 28

No glare found

PV array 1 - East and FP: FP 28

No glare found

PV array 1 - East and FP: FP 28R

No glare found

PV array 1 - East and FP: FP 34

No glare found

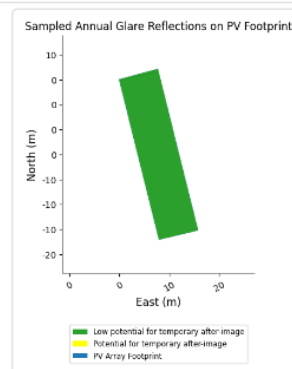
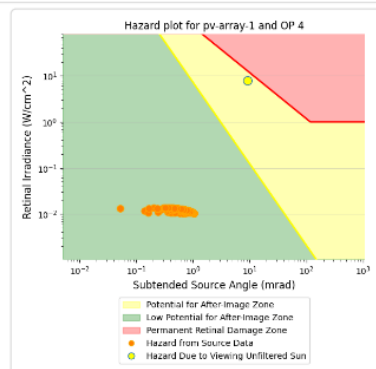
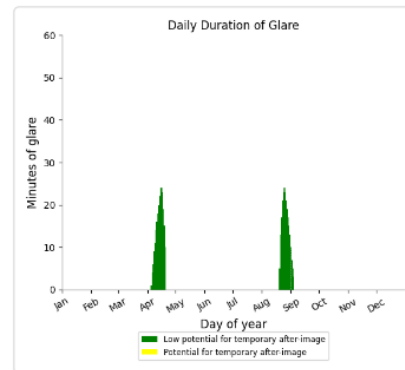
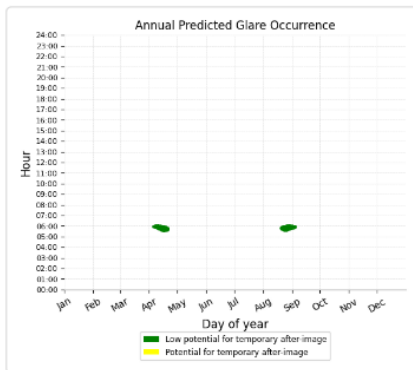


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PV array 1 - East and OP 4

Yellow glare: none

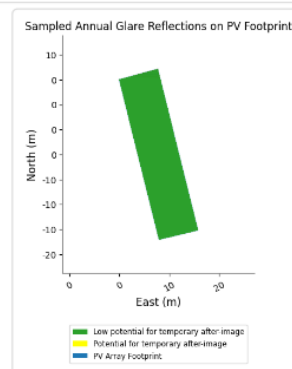
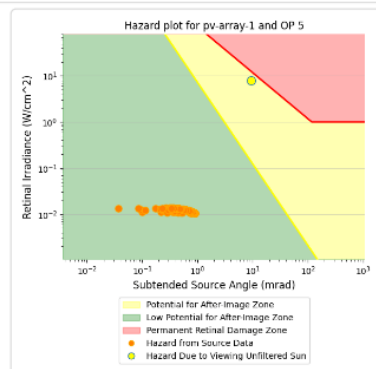
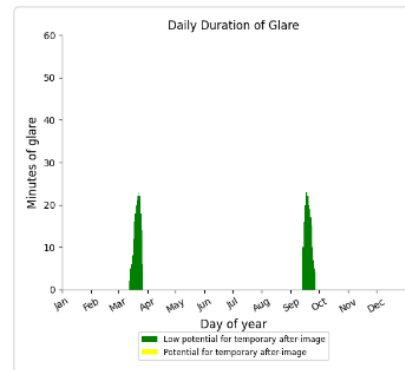
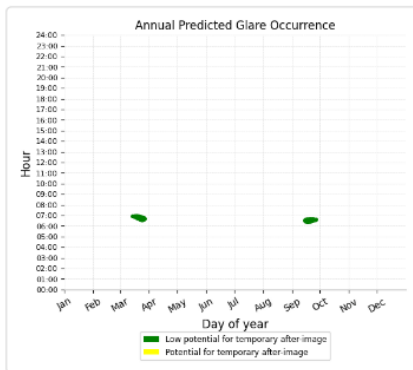
Green glare: 472 min.



PV array 1 - East and OP 5

Yellow glare: none

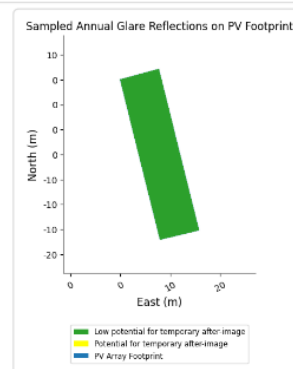
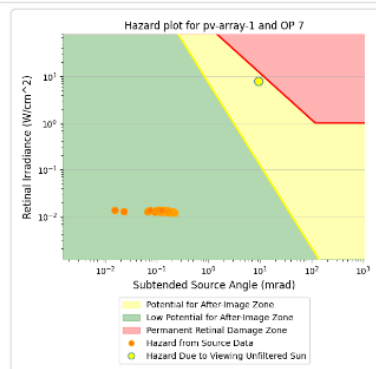
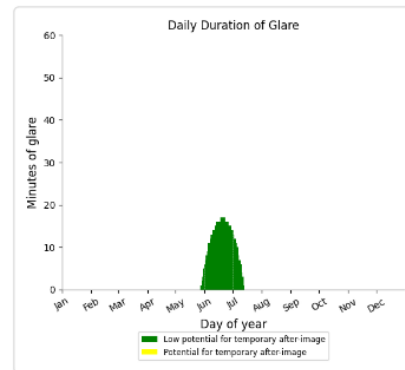
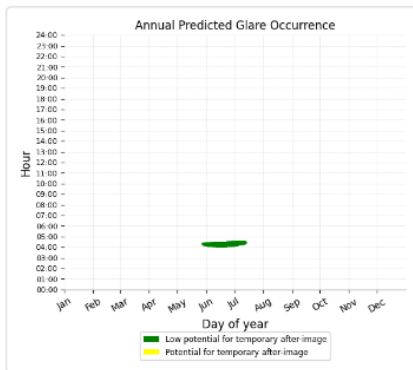
Green glare: 424 min.



PV array 1 - East and OP 7

Yellow glare: none

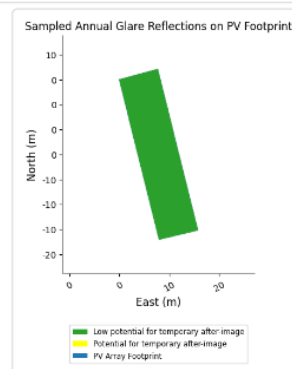
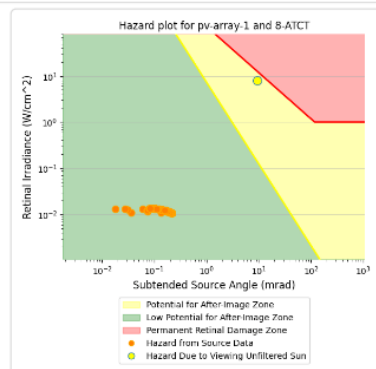
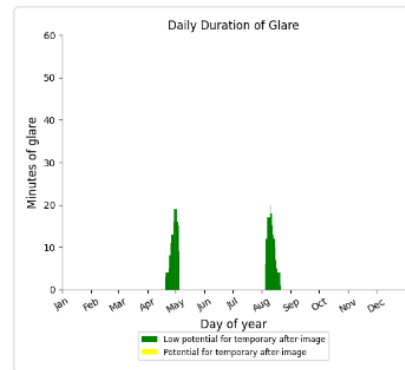
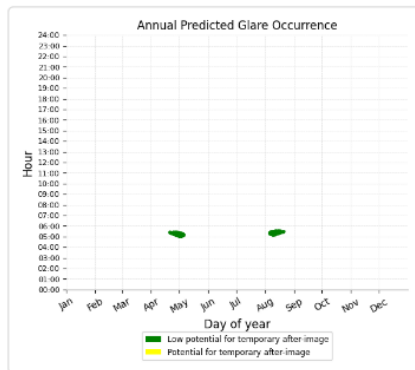
Green glare: 539 min.



PV array 1 - East and 8-ATCT

Yellow glare: none

Green glare: 360 min.



PV array 1 - East and 1-ATCT

No glare found

PV array 1 - East and 2-ATCT

No glare found

PV array 1 - East and OP 3

No glare found

PV array 1 - East and OP 6

No glare found



PV: PV array 2 - North low potential for temporary after-image

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
FP 04	1,099	18.3	0	0.0
FP 10	640	10.7	0	0.0
FP 10	0	0.0	0	0.0
FP 10L	0	0.0	0	0.0
FP 16	0	0.0	0	0.0
FP 22	0	0.0	0	0.0
FP 28	0	0.0	0	0.0
FP 28	0	0.0	0	0.0
FP 28R	0	0.0	0	0.0
FP 34	0	0.0	0	0.0
OP 4	432	7.2	0	0.0
OP 5	413	6.9	0	0.0
OP 7	496	8.3	0	0.0
8-ATCT	399	6.7	0	0.0
1-ATCT	0	0.0	0	0.0
2-ATCT	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 6	0	0.0	0	0.0

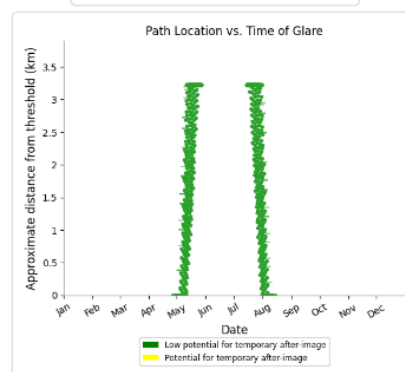
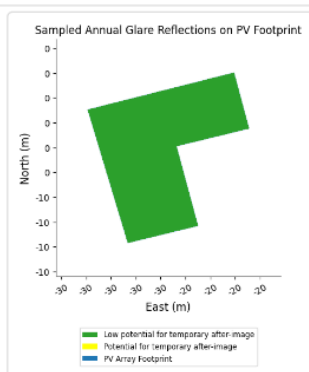
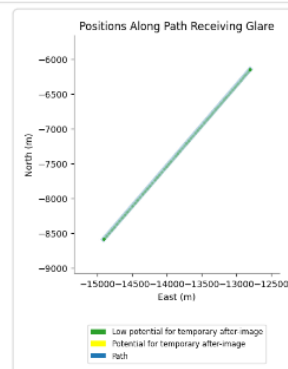
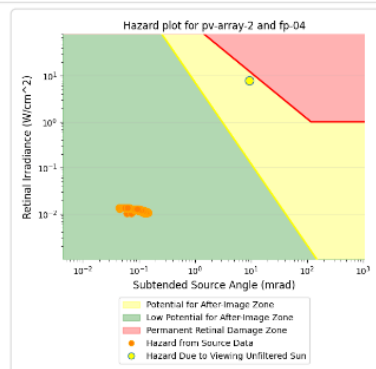
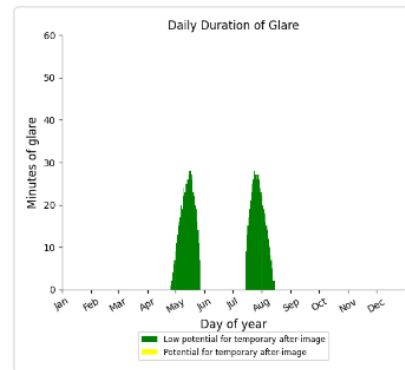
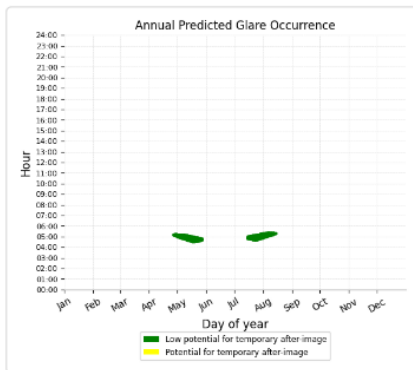


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PV array 2 - North and FP: FP 04

Yellow glare: none

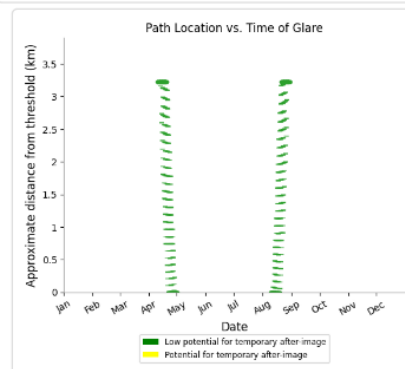
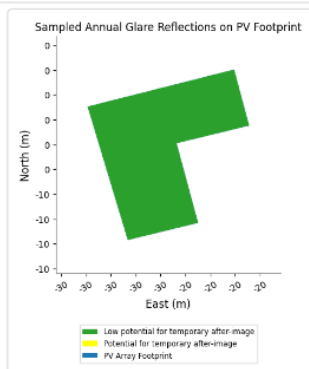
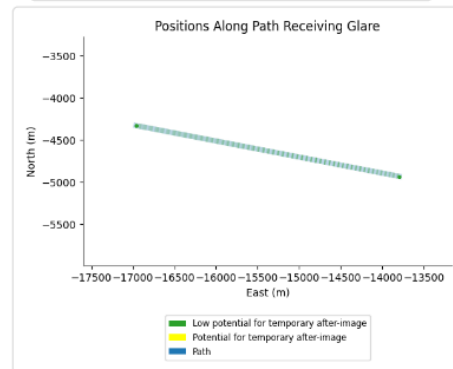
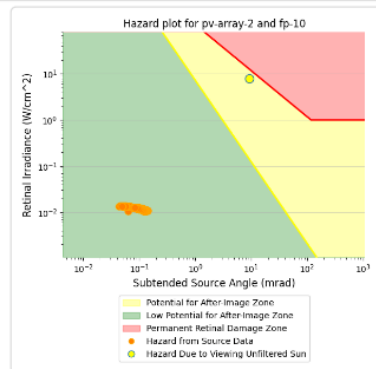
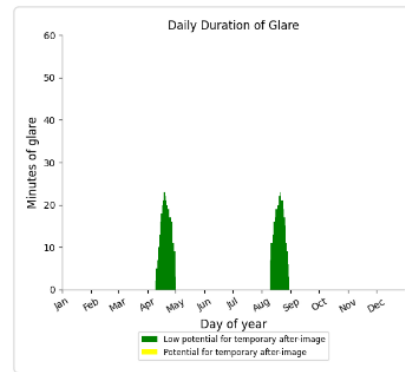
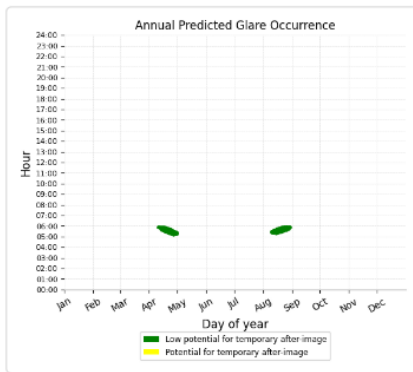
Green glare: 1,099 min.



PV array 2 - North and FP: FP 10

Yellow glare: none

Green glare: 640 min.



PV array 2 - North and FP: FP 10

No glare found



PV array 2 - North and FP: FP 10L

No glare found

PV array 2 - North and FP: FP 16

No glare found

PV array 2 - North and FP: FP 22

No glare found

PV array 2 - North and FP: FP 28

No glare found

PV array 2 - North and FP: FP 28

No glare found

PV array 2 - North and FP: FP 28R

No glare found

PV array 2 - North and FP: FP 34

No glare found

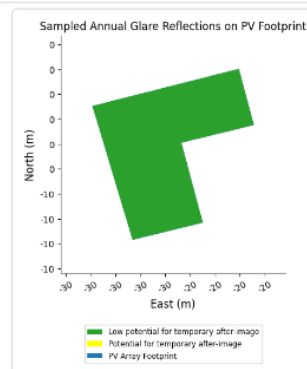
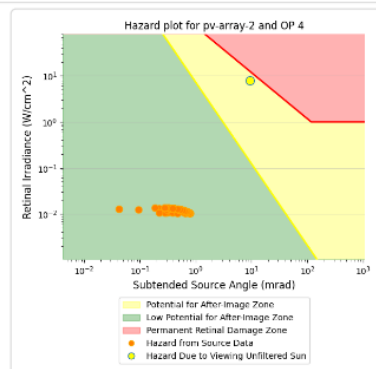
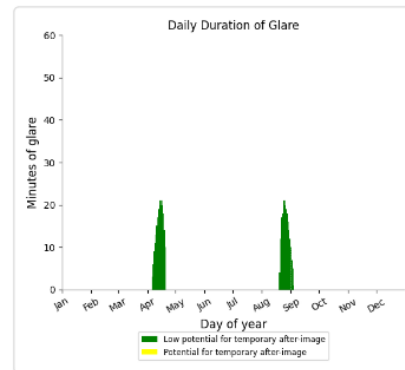
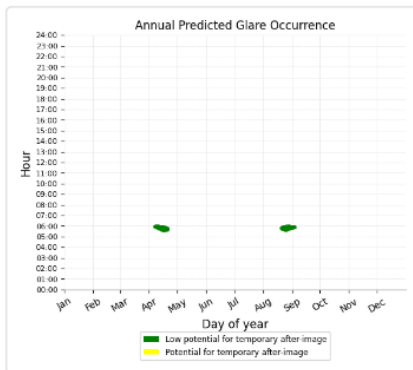


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PV array 2 - North and OP 4

Yellow glare: none

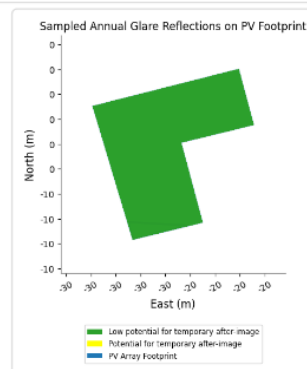
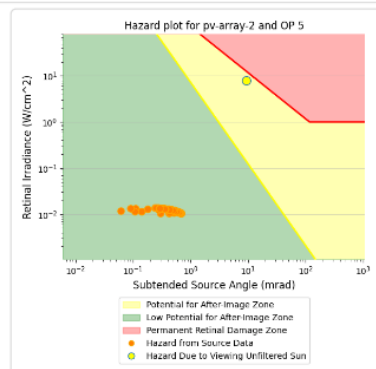
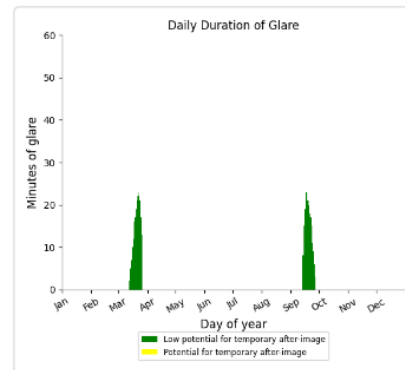
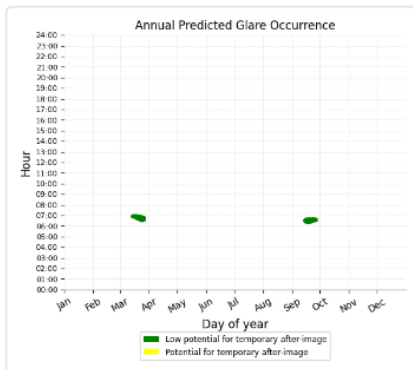
Green glare: 432 min.



PV array 2 - North and OP 5

Yellow glare: none

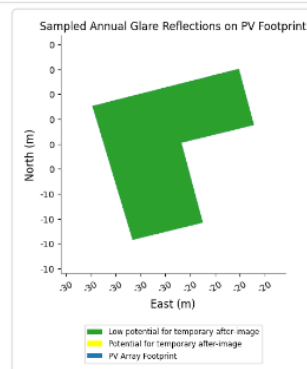
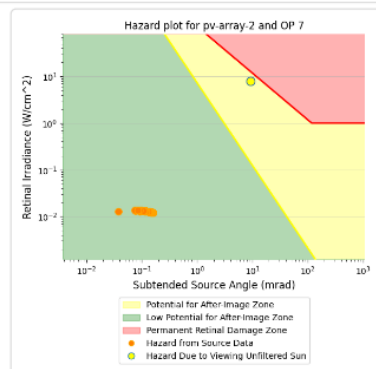
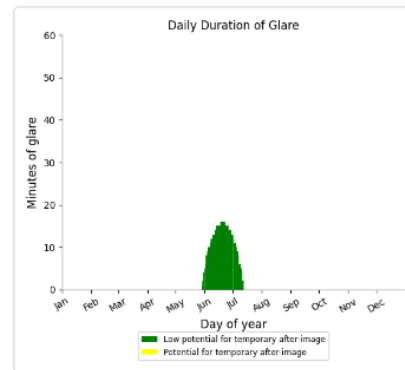
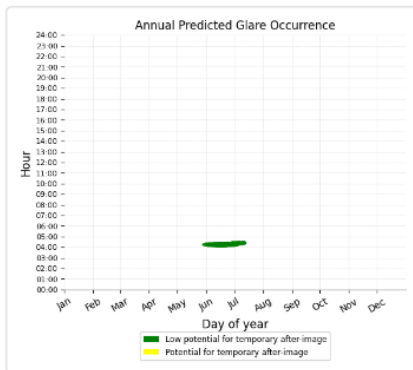
Green glare: 413 min.



PV array 2 - North and OP 7

Yellow glare: none

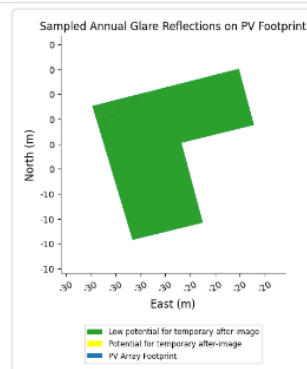
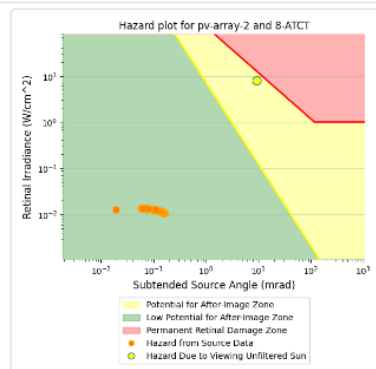
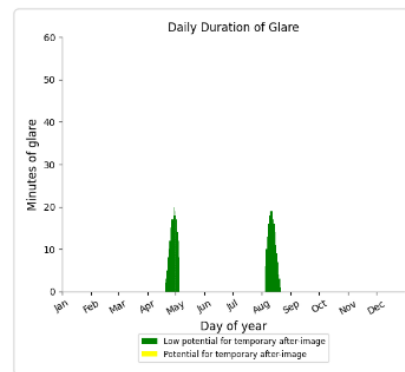
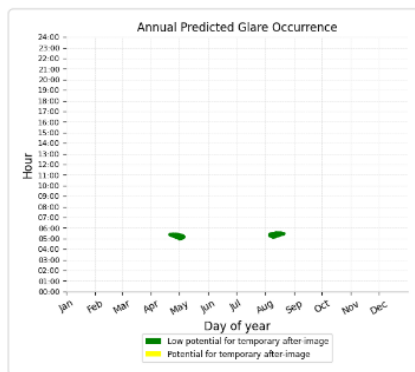
Green glare: 496 min.



PV array 2 - North and 8-ATCT

Yellow glare: none

Green glare: 399 min.



PV array 2 - North and 1-ATCT

No glare found

PV array 2 - North and 2-ATCT

No glare found

PV array 2 - North and OP 3

No glare found

PV array 2 - North and OP 6

No glare found



Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.

"Yellow" glare is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.

Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.

The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. However, we have validated our models against several systems, including a PV array causing glare to the air-traffic control tower at Manchester-Boston Regional Airport and several sites in Albuquerque, and the tool accurately predicted the occurrence and intensity of glare at different times and days of the year.

Several V1 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. This primarily affects V1 analyses of path receptors.

Random number computations are utilized by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result. This limitation primarily affects analyses of Observation Point receptors, including ATCTs. Note that the SGHAT/ ForgeSolar methodology has always relied on an analytical, qualitative approach to accurately determine the overall hazard (i.e. green vs. yellow) of expected glare on an annual basis.

The analysis does not automatically consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc.

The 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, potentially 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. (See previous point on related limitations.)

The variable direct normal irradiance (DNI) feature (if selected) scales the user-prescribed peak DNI using a typical clear-day irradiance profile. This profile has a lower DNI in the mornings and evenings and a maximum at solar noon. The scaling uses a clear-day irradiance profile based on a normalized time relative to sunrise, solar noon, and sunset, which are prescribed by a sun-position algorithm and the latitude and longitude obtained from Google maps. The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors.

The ocular hazard predicted by the tool depends on a number of environmental, optical, and human factors, which can be uncertain. We provide input fields and typical ranges of values for these factors so that the user can vary these parameters to see if they have an impact on the results. The speed of SGHAT allows expedited sensitivity and parametric analyses.

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.

Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid based on aggregated research data. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.

Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.

Refer to the Help page at www.forgesolar.com/help/ for assumptions and limitations not listed here.

Default glare analysis parameters and observer eye characteristics (for reference only):

- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

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Parapet Feature Included

FORGESOLAR GLARE ANALYSIS

Project: **Independent House**

Proposed Solar PV installation on the roof of the proposed Independent House, Abbey Street Lower, Dublin

Site configuration: **Parapets**

Created 12 Oct, 2024

Updated 11 Nov, 2024

Time-step 1 minute

Timezone offset UTC0

Minimum sun altitude 0.0 deg

DNI peaks at 1,000.0 W/m²

Category 10 to 100 kW

(1,000 kW / 32,400 m² limit)

Site ID 131163.22372

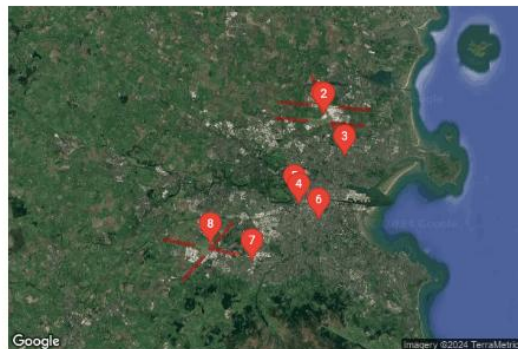
Ocular transmission coefficient 0.5

Pupil diameter 0.002 m

Eye focal length 0.017 m

Sun subtended angle 9.3 mrad

PV analysis methodology V2



Summary of Results No glare predicted

PV Array	Tilt °	Orient °	Annual Green Glare		Annual Yellow Glare		Energy kWh
			min	hr	min	hr	
PV array 1 - East	0.0	197.0	0	0.0	0	0.0	-
PV array 2 - North	0.0	197.0	0	0.0	0	0.0	-

Total glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
FP 04	0	0.0	0	0.0
FP 10	0	0.0	0	0.0
FP 10	0	0.0	0	0.0
FP 10L	0	0.0	0	0.0
FP 16	0	0.0	0	0.0
FP 22	0	0.0	0	0.0
FP 28	0	0.0	0	0.0
FP 28	0	0.0	0	0.0
FP 28R	0	0.0	0	0.0
FP 34	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0
2-ATCT	0	0.0	0	0.0
OP 3	0	0.0	0	0.0



Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 4	0	0.0	0	0.0
OP 5	0	0.0	0	0.0
OP 6	0	0.0	0	0.0
OP 7	0	0.0	0	0.0
8-ATCT	0	0.0	0	0.0



Component Data

PV Arrays

Name: PV array 1 - East
Description: Located above C 07 01
Axis tracking: Fixed (no rotation)
Tilt: 0.0°
Orientation: 197.0°
Rated power: -
Panel material: Light textured glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.348786	-6.261342	4.44	26.66	31.10
2	53.348613	-6.261270	4.48	26.62	31.10
3	53.348623	-6.261201	4.46	26.64	31.10
4	53.348797	-6.261273	4.45	26.65	31.10

Name: PV array 2 - North
Description: Located above A 07 02
Axis tracking: Fixed (no rotation)
Tilt: 0.0°
Orientation: 197.0°
Rated power: -
Panel material: Light textured glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.348739	-6.261858	4.39	29.67	34.05
2	53.348759	-6.261726	4.36	29.70	34.05
3	53.348729	-6.261713	4.40	29.65	34.05
4	53.348719	-6.261779	4.42	29.64	34.05
5	53.348676	-6.261759	4.47	29.59	34.05
6	53.348667	-6.261822	4.49	29.56	34.05



Flight Path Receptors

Name: FP 04
Description:
Threshold height: 15 m
Direction: 40.8°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.293734	-6.453598	98.43	15.24	113.67
Two-mile	53.271847	-6.485242	154.25	128.10	282.36

Name: FP 10
Description:
Threshold height: 15 m
Direction: 94.7°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.422422	-6.289750	74.08	15.24	89.32
Two-mile	53.424791	-6.338161	81.31	176.70	258.01



Name: FP 10
Description:
Threshold height: 15 m
Direction: 101.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.304657	-6.468508	86.24	15.24	101.48
Two-mile	53.310174	-6.516059	73.44	196.72	270.16

Name: FP 10L
Description:
Threshold height: 15 m
Direction: 94.7°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.437380	-6.284410	72.98	15.24	88.22
Two-mile	53.439749	-6.332839	77.59	179.32	256.91

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



Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.436800	-6.261850	66.50	15.24	81.74
Two-mile	53.463355	-6.281070	69.90	180.53	250.43



Name: FP 22
Description:
Threshold height: 15 m
Direction: 220.8°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.303367	-6.439656	93.37	15.24	108.61
Two-mile	53.325253	-6.408004	62.63	214.66	277.29

Name: FP 28
Description:
Threshold height: 15 m
Direction: 281.9°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.301675	-6.444952	96.04	15.24	111.28
Two-mile	53.295713	-6.397555	106.18	173.79	279.97

Name: FP 28
Description:
Threshold height: 15 m
Direction: 275.3°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.420286	-6.250877	61.99	15.24	77.23
Two-mile	53.417615	-6.202512	41.17	204.75	245.92



Name: FP 28R

Description:

Threshold height: 15 m

Direction: 274.7°

Glide slope: 3.0°

Pilot view restricted? Yes

Vertical view: 30.0°

Azimuthal view: 50.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.434847	-6.238503	67.75	15.24	82.99
Two-mile	53.432478	-6.190077	32.67	219.01	251.67

Name: FP 34

Description:

Threshold height: 15 m

Direction: 336.7°

Glide slope: 3.0°

Pilot view restricted? Yes

Vertical view: 30.0°

Azimuthal view: 50.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.420099	-6.249719	62.26	15.24	77.50
Two-mile	53.393545	-6.230507	49.02	197.17	246.18



Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	53.428936	-6.264267	65.46	89.90
2-ATCT	2	53.428508	-6.262158	65.59	30.00
OP 3	3	53.388256	-6.229919	47.27	49.00
OP 4	4	53.343161	-6.301995	19.46	50.00
OP 5	5	53.350156	-6.309584	27.73	50.00
OP 6	6	53.328549	-6.270103	22.41	50.00
OP 7	7	53.289504	-6.376775	103.75	50.00
8-ATCT	8	53.305499	-6.441760	93.62	29.00

Map image of 1-ATCT



Map image of 2-ATCT



Map image of 8-ATCT



Obstruction Components

Name: Obstruction 1 - East Parapet
Top height: 31.7 m



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	53.348585	-6.261309	4.49
2	53.348608	-6.261165	4.46
3	53.348815	-6.261252	4.46
4	53.348794	-6.261391	4.42
5	53.348586	-6.261305	4.49

Name: Obstruction 2 - North Parapet
Top height: 34.8 m



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	53.348742	-6.261864	4.39
2	53.348776	-6.261636	4.35
3	53.348695	-6.261599	4.44
4	53.348663	-6.261825	4.51
5	53.348742	-6.261864	4.39



Glare Analysis Results

Summary of Results No glare predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1 - East	0.0	197.0	0	0.0	0	0.0	-
PV array 2 - North	0.0	197.0	0	0.0	0	0.0	-

Total glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
FP 04	0	0.0	0	0.0
FP 10	0	0.0	0	0.0
FP 10	0	0.0	0	0.0
FP 10L	0	0.0	0	0.0
FP 16	0	0.0	0	0.0
FP 22	0	0.0	0	0.0
FP 28	0	0.0	0	0.0
FP 28	0	0.0	0	0.0
FP 28R	0	0.0	0	0.0
FP 34	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0
2-ATCT	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 5	0	0.0	0	0.0
OP 6	0	0.0	0	0.0
OP 7	0	0.0	0	0.0
8-ATCT	0	0.0	0	0.0



PV: PV array 1 - East no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
FP 04	0	0.0	0	0.0
FP 10	0	0.0	0	0.0
FP 10	0	0.0	0	0.0
FP 10L	0	0.0	0	0.0
FP 16	0	0.0	0	0.0
FP 22	0	0.0	0	0.0
FP 28	0	0.0	0	0.0
FP 28	0	0.0	0	0.0
FP 28R	0	0.0	0	0.0
FP 34	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0
2-ATCT	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 5	0	0.0	0	0.0
OP 6	0	0.0	0	0.0
OP 7	0	0.0	0	0.0
8-ATCT	0	0.0	0	0.0

PV array 1 - East and FP: FP 04

No glare found

PV array 1 - East and FP: FP 10

No glare found

PV array 1 - East and FP: FP 10

No glare found

PV array 1 - East and FP: FP 10L

No glare found

PV array 1 - East and FP: FP 16

No glare found



PV array 1 - East and FP: FP 22

No glare found

PV array 1 - East and FP: FP 28

No glare found

PV array 1 - East and FP: FP 28

No glare found

PV array 1 - East and FP: FP 28R

No glare found

PV array 1 - East and FP: FP 34

No glare found

PV array 1 - East and 1-ATCT

No glare found

PV array 1 - East and 2-ATCT

No glare found

PV array 1 - East and OP 3

No glare found

PV array 1 - East and OP 4

No glare found

PV array 1 - East and OP 5

No glare found

PV array 1 - East and OP 6

No glare found

PV array 1 - East and OP 7

No glare found

PV array 1 - East and 8-ATCT

No glare found



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PV: PV array 2 - North no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
FP 04	0	0.0	0	0.0
FP 10	0	0.0	0	0.0
FP 10	0	0.0	0	0.0
FP 10L	0	0.0	0	0.0
FP 16	0	0.0	0	0.0
FP 22	0	0.0	0	0.0
FP 28	0	0.0	0	0.0
FP 28	0	0.0	0	0.0
FP 28R	0	0.0	0	0.0
FP 34	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0
2-ATCT	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 5	0	0.0	0	0.0
OP 6	0	0.0	0	0.0
OP 7	0	0.0	0	0.0
8-ATCT	0	0.0	0	0.0

PV array 2 - North and FP: FP 04

No glare found

PV array 2 - North and FP: FP 10

No glare found

PV array 2 - North and FP: FP 10

No glare found

PV array 2 - North and FP: FP 10L

No glare found

PV array 2 - North and FP: FP 16

No glare found

PV array 2 - North and FP: FP 22

No glare found



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PV array 2 - North and FP: FP 28

No glare found

PV array 2 - North and FP: FP 28

No glare found

PV array 2 - North and FP: FP 28R

No glare found

PV array 2 - North and FP: FP 34

No glare found

PV array 2 - North and 1-ATCT

No glare found

PV array 2 - North and 2-ATCT

No glare found

PV array 2 - North and OP 3

No glare found

PV array 2 - North and OP 4

No glare found

PV array 2 - North and OP 5

No glare found

PV array 2 - North and OP 6

No glare found

PV array 2 - North and OP 7

No glare found

PV array 2 - North and 8-ATCT

No glare found



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Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.

"Yellow" glare is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.

Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.

The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. However, we have validated our models against several systems, including a PV array causing glare to the air-traffic control tower at Manchester-Boston Regional Airport and several sites in Albuquerque, and the tool accurately predicted the occurrence and intensity of glare at different times and days of the year.

Several V1 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. This primarily affects V1 analyses of path receptors.

Random number computations are utilized by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result. This limitation primarily affects analyses of Observation Point receptors, including ATCTs. Note that the SGHAT/ ForgeSolar methodology has always relied on an analytical, qualitative approach to accurately determine the overall hazard (i.e. green vs. yellow) of expected glare on an annual basis.

The analysis does not automatically consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc.

The 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, potentially 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. (See previous point on related limitations.)

The variable direct normal irradiance (DNI) feature (if selected) scales the user-prescribed peak DNI using a typical clear-day irradiance profile. This profile has a lower DNI in the mornings and evenings and a maximum at solar noon. The scaling uses a clear-day irradiance profile based on a normalized time relative to sunrise, solar noon, and sunset, which are prescribed by a sun-position algorithm and the latitude and longitude obtained from Google maps. The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors.

The ocular hazard predicted by the tool depends on a number of environmental, optical, and human factors, which can be uncertain. We provide input fields and typical ranges of values for these factors so that the user can vary these parameters to see if they have an impact on the results. The speed of SGHAT allows expedited sensitivity and parametric analyses.

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.

Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid based on aggregated research data. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.

Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.

Refer to the Help page at www.forgesolar.com/help/ for assumptions and limitations not listed here.

Default glare analysis parameters and observer eye characteristics (for reference only):

- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

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