GLINT AND GLARE ASSESSMENT

macroworks

Roofmounted PV,

Equinix DB8,

New Nangor Road,

Nangor,

Dublin 22.

Registered Landscape Architect

November 2021

1 INTRODUCTION

Macro Works Ltd. were commissioned to undertake a glint and glare assessment for a proposed roof-mounted photovoltaic (PV) panel installation on the roof of the proposed building adjacent to New Nangor Road, Nangor, Dublin 22. (Figure 1 refers). The application site boundary adjoins the New Nangor Road (R134 regional road) and Profile Park to the north and west, respectively. Details of the locations of the proposed PV panels are indicated on Drawing 'DB081-RKD-ZZ-ZZ-M3-A-ZZZZ-9001 - Floor Plan - 05 Overall Roof Level_Planning.dwg'. The PV panels will be attached to the surface of the roof and tilted 30 degrees to the horizontal in a southerly direction. The PV panels will remain in a fixed position throughout the day and year (i.e. they will not rotate to track the movement of the sun).

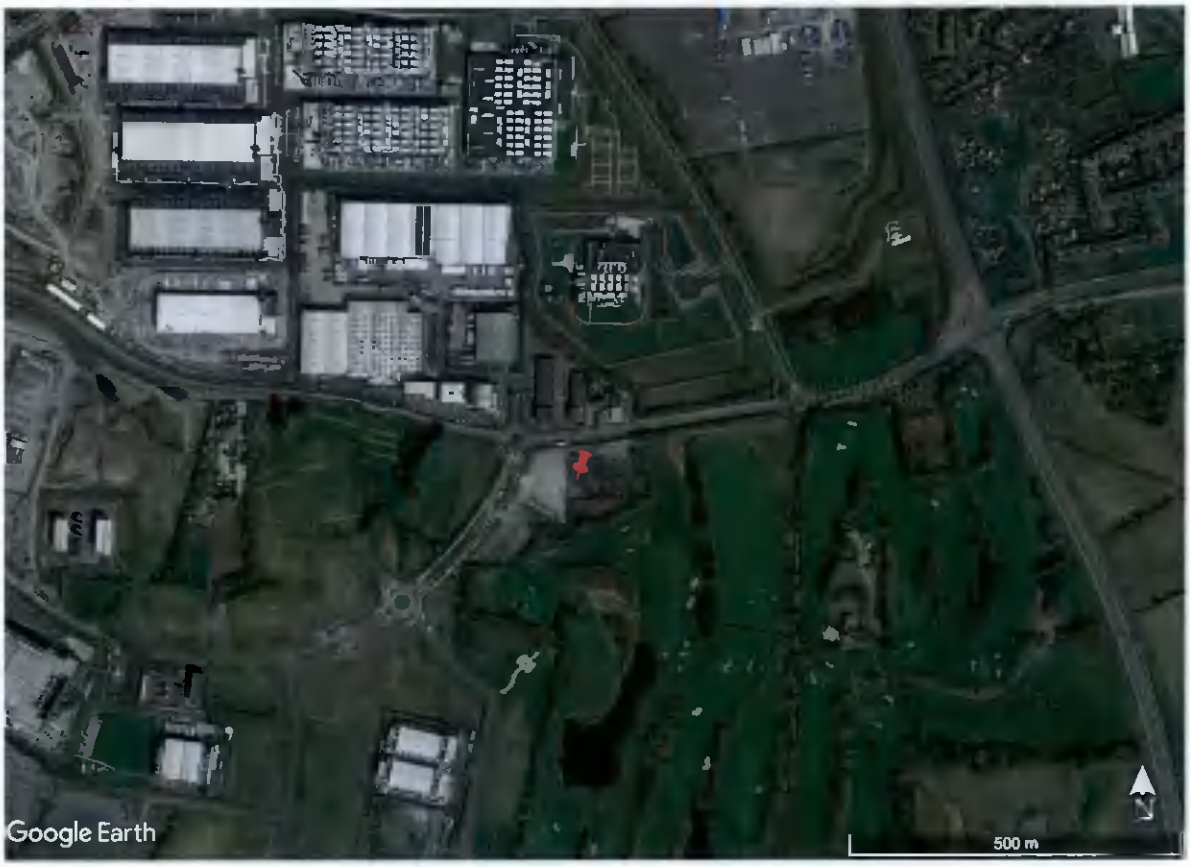


Figure 1: Aerial view (Google Earth Pro) indicating the location of the proposed PV panel layout (red pin) for analysis by SGHAT.

2 STATEMENT OF AUTHORITY

Macro Works' relevant experience includes nineteen years of analysing the visual effects of a wide range of infrastructural and commercial development types. This experience includes numerous domestic and international wind and solar energy developments. Macro Works has assessed the effects of glint and glare for many solar development sites throughout Ireland to date.

3 METHODOLOGY

The process for dealing with aviation receptors is as follows:

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

4 GUIDANCE

Guidance has been prepared by the Federal Aviation Authority[1] to address the potential hazards that solar developments may pose to aviation activities, and this has been adopted for use by the Irish Aviation Authority. SGHAT was developed in conjunction with the FAA in harmony with this guidance and is commonly regarded as the accepted industry standard by aviation authorities internationally when considering the glint and glare effects upon aviation related receptors.

4.1 FEDERAL AVIATION AUTHORITY

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

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

- *No potential for glint or glare in the existing or planned Airport Traffic Control Tower (ATCT) cab, and*
- *No potential for glare or "low potential for after-image" (shown in green in Figure 1* [Figure 2 refers]*) along the final approach path for any existing landing threshold or future landing thresholds (including any planned interim phases of the landing thresholds) as shown on the current FAA-approved Airport Layout Plan (ALP). The*

---

[1] Harris, Miller, Miller & Hanson Inc.. (November 2010). Technical Guidance for Evaluating Selected Solar Technologies on Airports; 3.1.2 Reflectivity. *Technical Guidance for Evaluating Selected Solar Technologies on Airports.* Available at: https://www.faa.gov/airports/environmental/policy_guidance/media/airport-solar-guide.pdf

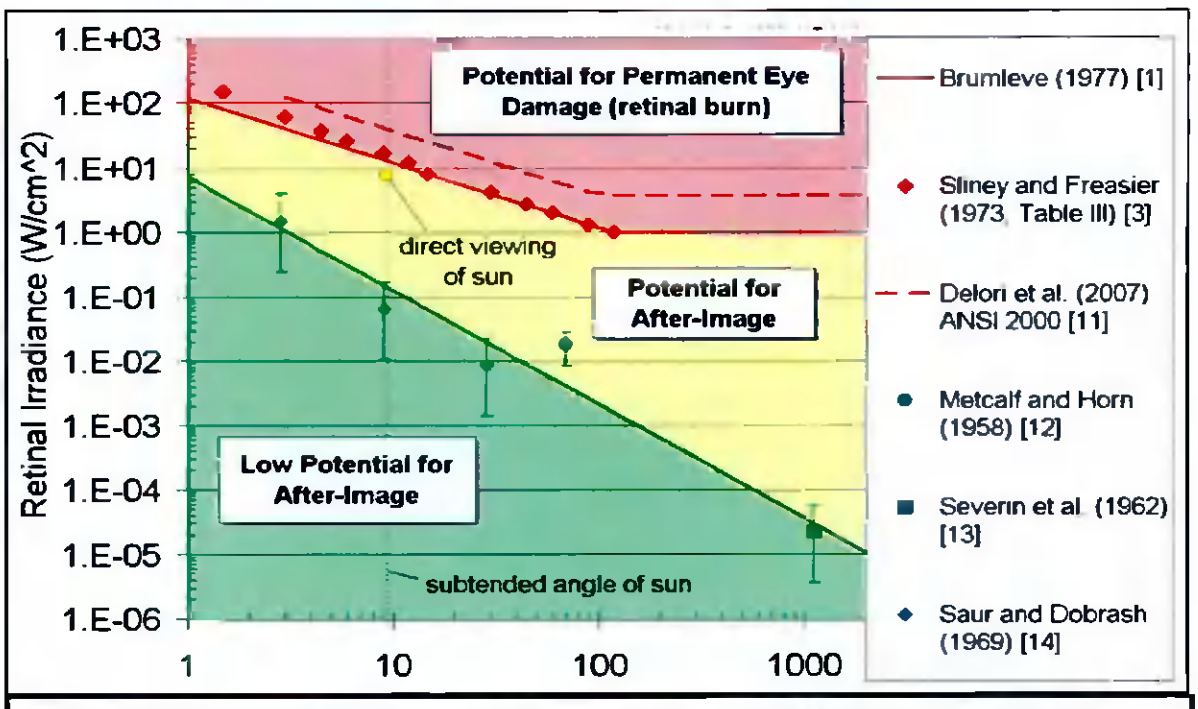
[2] Federal Aviation Administration (FAA). (2013). Department of Transportation - Federal Aviation Administration. *Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports.* Vol 78 (No 205), 63276-63279.

final approach path is defined as two (2) miles from fifty (50) feet above the landing threshold using a standard three (3) degree glidepath."

In summary, glare at an ATCT is not acceptable but glare with a *"low potential for after-image"* is acceptable along final approach paths to runways.

4.2 SOLAR GLARE HAZARD ANALYSIS TOOL

The SGHAT was designed to determine whether a proposed solar energy project would result in the potential for ocular impact as depicted on the Solar Glare Hazard Analysis Plot (Figure 2 refers). SGHAT analyses ocular impact over the entire calendar year in one minute intervals from when the sun rises above the horizon until the sun sets below the horizon. One of the principal outputs from the SGHAT report is a glare plot per receptor that indicates the time of day and days per year that glare has the potential to occur. SGHAT plot classifies the intensity of ocular impact as either Green Glare, Yellow Glare or Red Glare. These colour classifications are equivalent to the FAA's definitions regarding the level of ocular impact e.g. 'Green Glare' in the SGHAT is synonymous with the FAA's *"low potential for after-image','* and so forth. The various correlations are illustrated on the Solar Glare Hazard Analysis Plot.



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

Chart References: Ho, C.K., C.M. Ghanbari, and R.B. Diver, 2011, Methodology to Assess Potential Glint and Glare Hazards from Concentrating Solar Power Plants: Analytical Models and Experimental Validation. J. Solar Energy Engineering, August 2011, Vol. 133, 031021-1 – 031021-9.

Figure 2: Figure 1 from the FAA Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports

5 IDENTIFICATION OF STANDARD RECEPTORS

Casement Aerodrome is located approximately 1.1km southeast to the of the proposed PV panels and Weston Airport is located approximately 5.8km to the northwest thus warrant inclusion in this assessment (Figure 3 refers). There are four runway approaches at Casement Aerodrome; 04, 10, 22 and 28. The Air Traffic Control Tower (ATCT) at Casement Aerodrome is 9m Above Ground Level (AGL) and will be referenced as '1-ATCT' in this report. Weston Airport hosts just 1 operational runway with two potential approach paths; 07 and 25. The ATCT at Weston Airport has a structural elevation approximately 15m AGL and will be referenced as '2-ATCT' in this report.

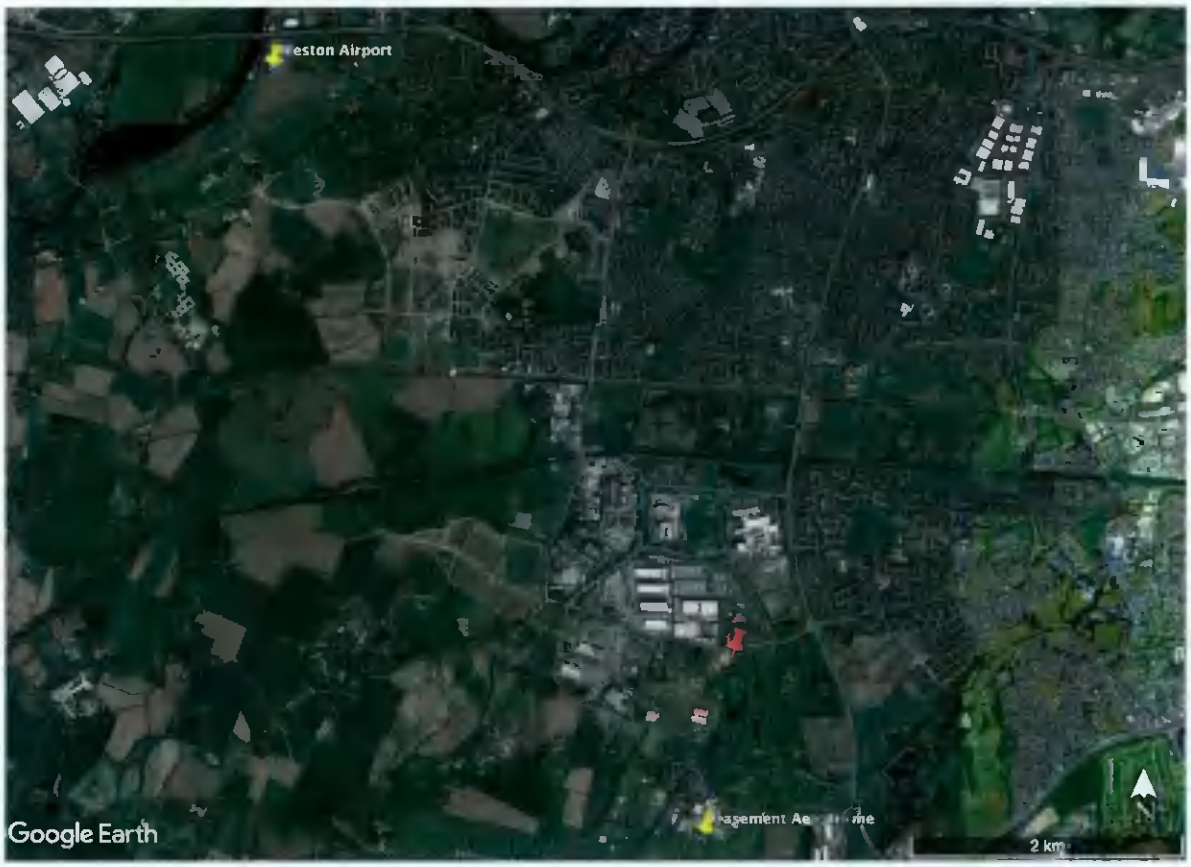


Figure 3: Aerial view (Google Earth Pro) showing the location of the PV panels (red pin) relative to Casement Aerodrome and Weston Airport (yellow pins).

6 RESULTS

6.1 RUNWAY APPROACHES

The SGHAT results are contained in Appendix A and show that of the six runway approaches analysed, runway approaches 10 and 22 at Casement Aerodrome have the theoretical potential to receive glare. In this instance, SGHAT calculated the potential glare to be *'Green Glare'*. SGHATs *'Green Glare'* classification regarding the intensity of the potential glare is synonymous with FAA's *'low potential for temporary after image'*. *'Green Glare' /* glare with a *'low potential for temporary after image,'* regardless of the number of minutes per year, is considered by the FAA to be an **acceptable level of reflectance effect for runway approaches.**

6.2 AIR TRAFFIC CONTROL TOWERS

The SGHAT results are contained in Appendix A and show that there is **no potential for glint and glare to occur at the ATCT in Casement Aerodrome or Weston Airport**.

7 OVERALL CONCLUSION

From the analysis and discussions contained herein, it is considered that there will not be any hazardous glint and glare effects upon the aviation receptors identified as a result of the proposed roof-mounted solar PV panels.

APPENDIX A:

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

FORGESOLAR GLARE ANALYSIS

Project: **SGHAT**
Site configuration: **Eqinix DB8**
Analysis conducted by Luis Dominguez (luis@macroworks.ie) at 15:37 on 17 Nov, 2021.

U.S. FAA 2013 Policy Adherence

The following table summarizes the policy adherence of the glare analysis based on the 2013 U.S. Federal Aviation Administration Interim Policy 78 FR 63276. This policy requires the following criteria be met for solar energy systems on airport property:

- No "yellow" glare (potential for after-image) for any flight path from threshold to 2 miles
- No glare of any kind for Air Traffic Control Tower(s) ("ATCT") at cab height.
- Default analysis and observer characteristics (see list below)

ForgeSolar does not represent or speak officially for the FAA and cannot approve or deny projects. Results are informational only.

COMPONENT	STATUS	DESCRIPTION
Analysis parameters	PASS	Analysis time interval and eye characteristics used are acceptable
2-mile flight path(s)	PASS	Flight path receptor(s) do not receive yellow glare
ATCT(s)	PASS	Receptor(s) marked as ATCT do not receive glare

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

FAA Policy 78 FR 63276 can be read at https://www.federalregister.gov/d/2013-24729

SITE CONFIGURATION

Analysis Parameters

DNI: peaks at 1,000.0 W/m^2
Time interval: 1 min
Ocular transmission coefficient: 0.5
Pupil diameter: 0.002 m
Eye focal length: 0.017 m
Sun subtended angle: 9.3 mrad
Site Config ID: 61274.9717

PV Array(s)

Name: Area 1
Axis tracking: Fixed (no rotation)
Tilt: 30.0°
Orientation: 180.0°
Rated power: -
Panel material: Smooth glass without 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	53.317363	-6.438779	74.30	19.76	94.06
2	53.317392	-6.438423	74.30	19.76	94.06
3	53.317495	-6.438447	74.30	19.76	94.06
4	53.317466	-6.438803	74.30	19.76	94.06
5	53.317363	-6.438779	74.30	19.76	94.06

Flight Path Receptor(s)

Name: Casement 04 Runway
Description: None
Threshold height: 15 m
Direction: 41.3°
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	53.293830	-6.453465	98.30	15.20	113.50
Two-mile	53.272113	-6.485435	154.40	127.80	282.20

Name: Casement 10 Runway
Description: None
Threshold height: 15 m
Direction: 101.8°
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	53.304622	-6.468287	86.30	15.30	101.60
Two-mile	53.310549	-6.515700	73.60	196.60	270.20

Name: Casement 22 Runway
Description: None
Threshold height: 15 m
Direction: 220.9°
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	53.303267	-6.439788	93.40	15.20	108.60
Two-mile	53.325107	-6.408047	62.50	214.80	277.30

Name: Casement 28 Runway
Description: None
Threshold height: 15 m
Direction: 281.8°
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	53.301696	-6.445153	96.10	15.20	111.30
Two-mile	53.295759	-6.397747	106.20	173.80	280.00

Name: Weston 07 Runway
Description: None
Threshold height: 15 m
Direction: 63.0°
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	53.350770	-6.493330	47.50	15.20	62.70
Two-mile	53.337644	-6.536538	56.30	175.10	231.40

Name: Weston 25 Runway
Description: None
Threshold height: 15 m
Direction: 243.0°
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	53.354037	-6.482623	46.80	15.20	62.00
Two-mile	53.367163	-6.439411	31.60	199.10	230.70

Discrete Observation Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	53.305496	-6.441790	93.50	9.00
2-ATCT	2	53.355640	-6.489488	49.40	15.00

Map image of 1-ATCT

Map image of 2-ATCT

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt	Orient	"Green" Glare	"Yellow" Glare	Energy
	(°)	(°)	min	min	kWh
Area 1	30.0	180.0	3,102	0	-

Total annual glare received by each receptor

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
Casement 04 Runway	0	0
Casement 10 Runway	2431	0
Casement 22 Runway	671	0
Casement 28 Runway	0	0
Weston 07 Runway	0	0
Weston 25 Runway	0	0
1-ATCT	0	0
2-ATCT	0	0

Results for: Area 1

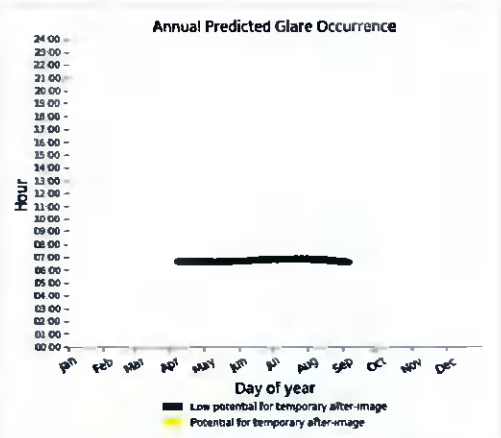
Receptor	Green Glare (min)	Yellow Glare (min)
Casement 04 Runway	0	0
Casement 10 Runway	2431	0
Casement 22 Runway	671	0
Casement 28 Runway	0	0
Weston 07 Runway	0	0
Weston 25 Runway	0	0
1-ATCT	0	0
2-ATCT	0	0

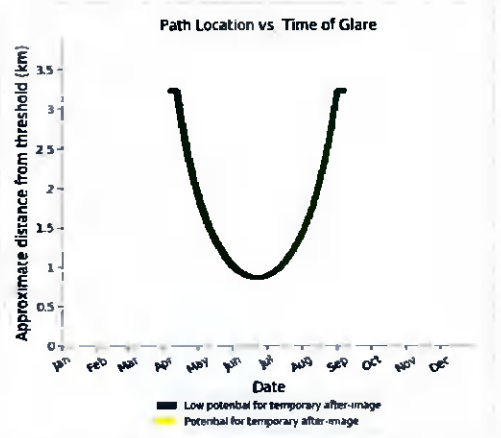
Flight Path: Casement 04 Runway

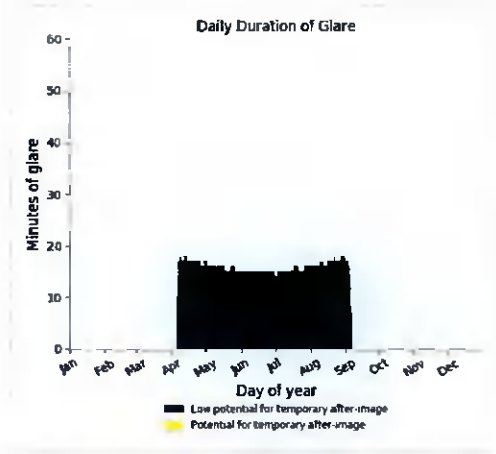
0 minutes of yellow glare
0 minutes of green glare

Flight Path: Casement 10 Runway

0 minutes of yellow glare
2431 minutes of green glare



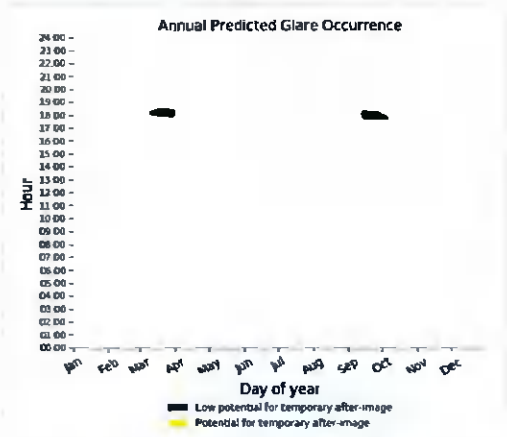


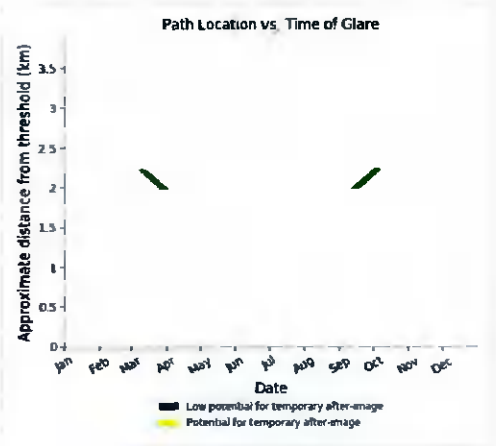


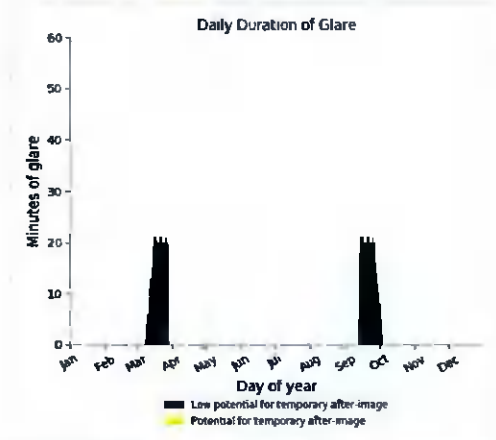
Flight Path: Casement 22 Runway

0 minutes of yellow glare

671 minutes of green glare







Flight Path: Casement 28 Runway

0 minutes of yellow glare

0 minutes of green glare

Flight Path: Weston 07 Runway

0 minutes of yellow glare
0 minutes of green glare

Flight Path: Weston 25 Runway

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: 1-ATCT

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: 2-ATCT

0 minutes of yellow glare
0 minutes of green glare

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.
Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.
Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to V1 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.)
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.
The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual results and glare occurrence may differ.
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.
Refer to the Help page at **www.forgesolar.com/help/** for assumptions and limitations not listed here.