GLOBAL GREEN

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GLINT AND GLARE IMPACT ASSESSMENT

San Solar Proposed PV Power Plant

May 2022

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EXECUTIVE SUMMARY

Purpose of report

Global Green Environmental Consultants was appointed by Acciona Energia to conduct a glint and glare impact assessment for a proposed San Solar photovoltaic power (PV) plant in the Northern Cape Province, South Africa. As the proposed PV plant is near the Sishen Airport, this assessment pertains to the possible effects of glint and glare on aircraft and aviation activities.

Approach

As the assessment dealt specifically with the possible effects of glint and glare on activities at the Sishen Airport, the air traffic control (ATC) tower and the runway approaches (two possible approaches) were considered as receptors. This is in line with best practice guidelines, such as the '*Technical Guidance for Evaluation Selected Solar Technologies at Airports'* developed by the United States Federal Aviation Administration (FAA), which was used to inform this assessment. Glint and glare were simulated for the proposed PV plant configuration to determine possible glint and glare related impacts airport activities.

Findings

The glare analysis found no "yellow" glare (potential for after-image). Although some “green” glare was predicted, this was only for a configuration employing deeply textured glass. For configurations employing module surfaces with smooth or lightly textured glass, which is in line with the proposed configuration, no glint or glare was predicted.

Recommendation

The application can be approved for the proposed PV plant configuration as presented in the report.

ABBREVIATIONS

ARC	-	Anti-Reflective Coating
ATC	-	Air traffic control
CAA	-	Civil Aviation Authority
FAA	-	Federal Aviation Administration
PV	-	Photovoltaic

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1. Introduction and overview

Global Green was appointed by Acciona Energia to conduct a glint and glare assessment for a proposed photovoltaic power plant (PV) close to the Sishen Airport in the Northern Cape Province, South Africa. The South African Civil Aviation Authority (CAA) stipulates that such an assessment must be conducted for any solar project that is within three kilometres of an airport and located on the extended centreline of a runway (Obstacle Notice 3/2020). Obstacle Notice 3/2020 further states the assessment must focus specifically on aviation and aircraft activities related to the airport. This assessment, therefore, considers the glint and glare hazard associated with the proposed PV power plant and how it may impact on aviation and aircraft activities at the Sishen Airport. The glare impact can be defined as the potential hazards for pilots and air-traffic control personnel, which can range from discomfort to disability (Zhu, 2018). Impacts are identified, and possible mitigation measures proposed.

2. Glint and glare

According to Ho *et al*. (2011), 'Glint' can be defined as a monetary flash of light while 'Glare' is defined as a more continuous source of excessive brightness relative to the ambient lighting. Glint and glare, therefore, differ in terms of the temporal exposure to a hazard which can be caused by a variety of both manmade and natural features, such as lakes, ponds, buildings, and PV power plants (Hillesheim *et al.,* 2015). In extreme cases hazards from glint and glare can result in permanent eye injury (Ho *et al.,* 2011), however, a more likely effect, is only a temporary distraction (e.g. after image and flash blindness) which may impact on peoples activities, e.g. a pilot flying an aeroplane or an air traffic controller managing air traffic (Ho *et al.,* 2009; Saraswat *et al.*, 2020). In terms of glint and glare impacts related to airports, international best practice states that a PV power plant may cause no glare to an air traffic control tower and only glare with a low potential for after-image[1] to a standard landing approach (Hillesheim *et al.,* 2015). It is therefore important to understand the possible hazard during critical phases of flight, especially approach and landing (Zhu, 2018).

3. Project description

Acciona Energia is proposing the development of a PV solar power plant capable of producing total peak power of approximately 112 MW. The project proposes the use of a system which employs single-axis tracking technology.

3.1. Location

The proposed site is located to the east of the hamlet of Deben and to the north of the town of Kathu (Figure 3.1). The proposed solar modules will cover an area of approximately 196 ha and is directly adjacent to existing PV solar developments.

[1] After-image is what appears in one's vision after the exposure to the original image has ceased.

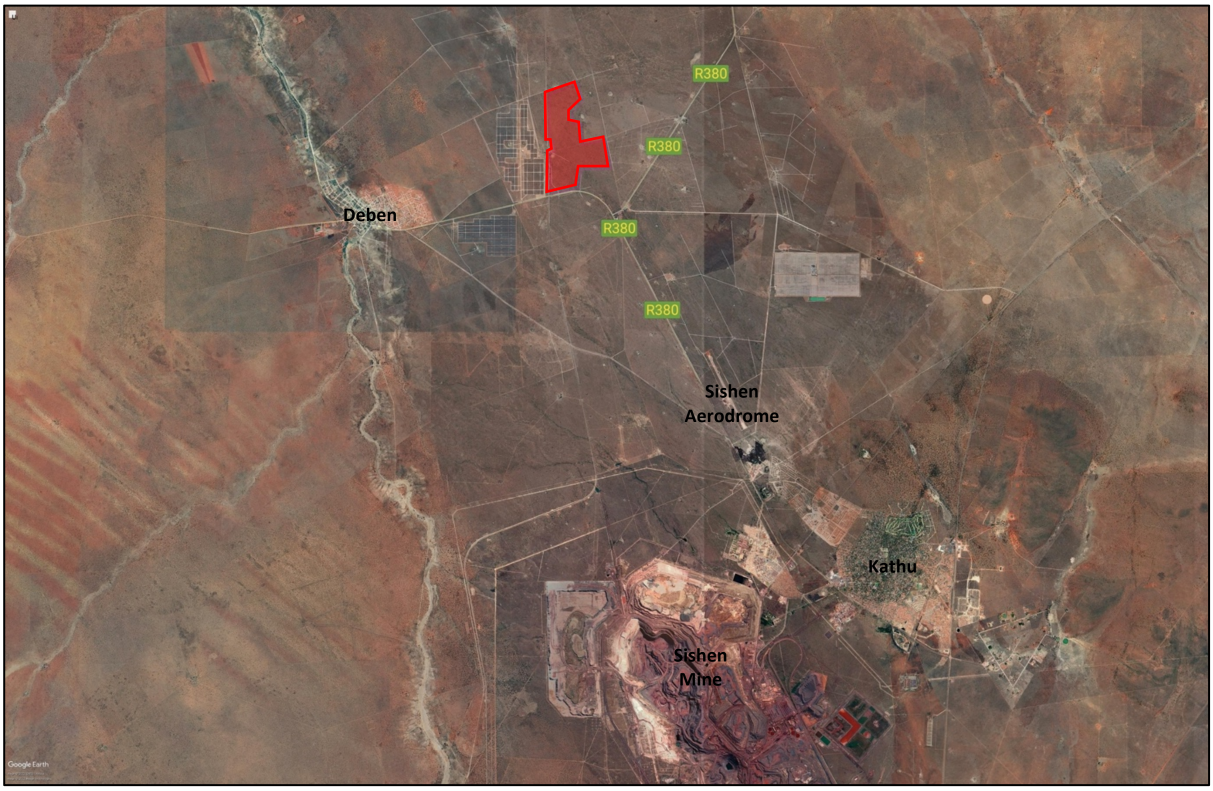


Figure 3.1 - Location of proposed PV power plant

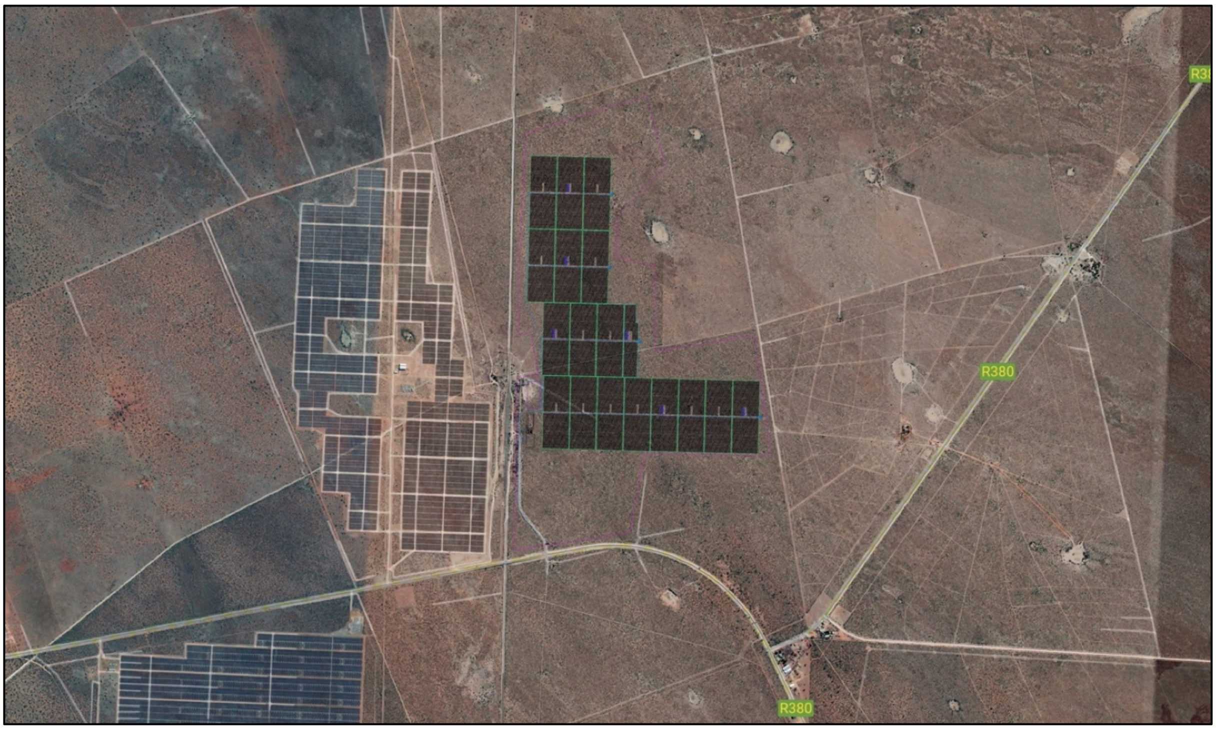


Figure 3.2 - Layout of proposed PV power plant

3.2. Layout

3.2.1. Proposed layout

The proposed PV power plant will include a total of approximately 202,000 modules[2]. Modules are to be installed on tables at a total height of approximately **2.5 metres** with a **0° tracking axis tilt** and at an **azimuthal orientation of 0°**, i.e., true north. The modules will have a **tracking range of 55°** in either direction resulting in a maximum tracking angle of 110°. The modules will either rest at a **0° resting angle** or at the maximum angle of **55°.** Examples of installed modules (not the exact technology that is planned for use) is shown in Figure 3.3, while Figure 3.4 illustrates the concepts of tracking axis tilt and tracking range.

Figure 3.3 – Examples of installed PV systems

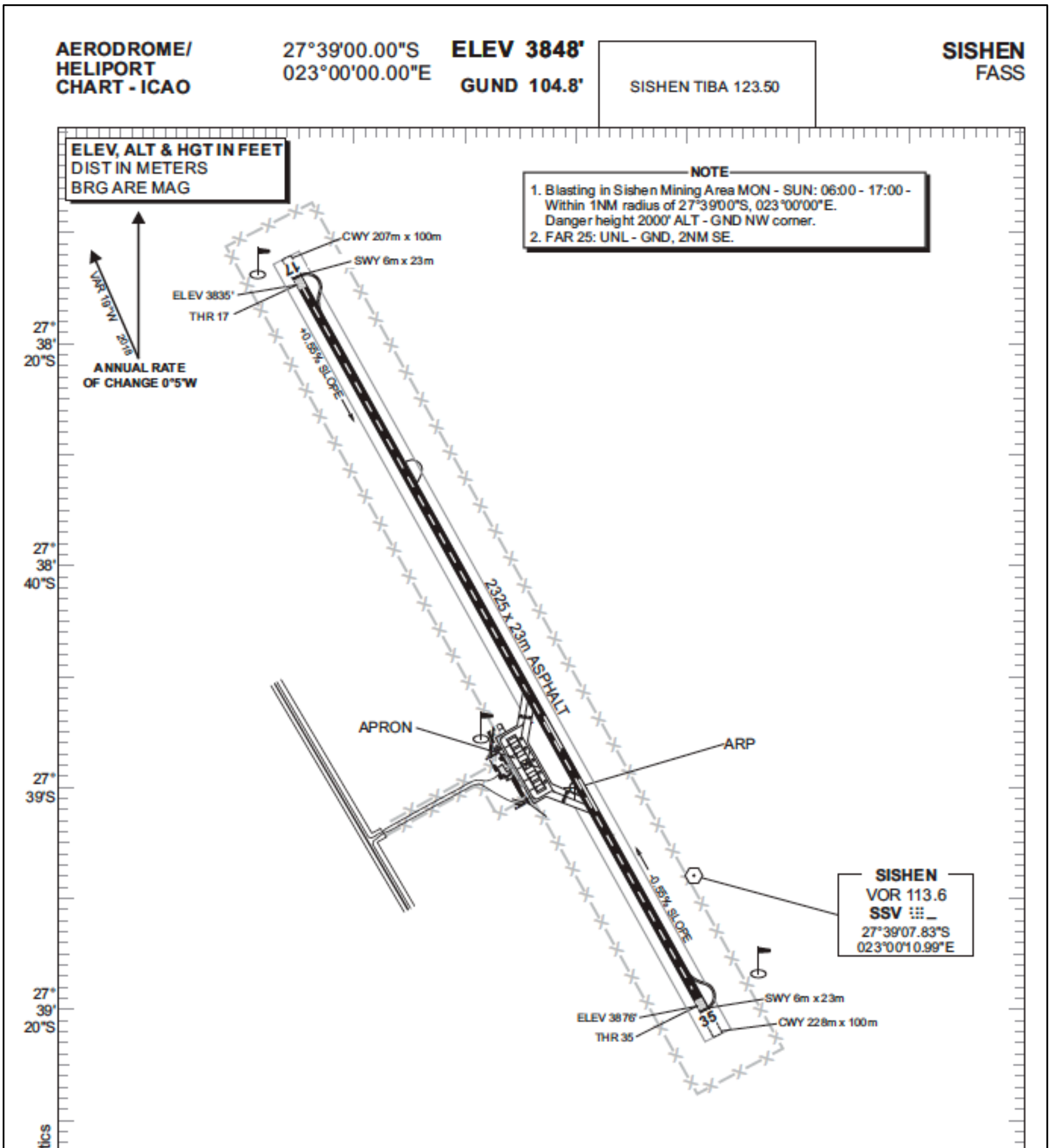
[2] Portioning of the site into smaller footprints is not required as the model used applies sophisticated glare spot location computation approach. This was, however, verified by running test simulations using smaller footprints through which it was indeed confirmed that the results were not affected (see Annexure C for an example).

Figure 3.4 – Axis tilt and tracking range

4. Airport description

The Sishen Airport (Figure 4.1) is located at an altitude of approximately 1,172 meters above mean sea level and has one asphalt runway (17/35) measuring 2,325 by 23 metres (Figure 4.2). The runway is at a slope of ± 0.55°. The ATC tower is located close to the terminal building. The airport offers weekly flights from centres such as Johannesburg, Capetown and Durban and mostly caters for domestic and regional airlines such as CemAir, Airlink and FlySafair.

Figure 4.1 – Sishen airport terminal building



RWY LIGHTING

RWY	ALS	PAPI	RTHL	REDL	RENL
17	NIL	NIL	GREEN	WHITE	RED
35	NIL	NIL	GREEN	WHITE	RED

OTHER: WDI, APRON, VOR & NDB

PHYSICAL CHARACTERISTICS

RWY	DIRECTION	THR COORDINATES	THR ELEVATION	TORA (m)	TODA (m)	ASDA (m)	LDA (m)	SWY (m)	CWY (m)	SLOPE	SURFACE	BEARING STRENGTH	CIRCUIT
17	154°(T)	27°38'13.03"S 022°59'34.03"E	3835'	2325	2553	2331	2325	6	228	0.0055U	ASPH	LCN 32	L
35	334°(T)	27°39'20.63"S 023°00'12.02"E	3876'	2325	2532	2331	2325	6	207	0.0055D	ASPH	LCN 32	R

Figure 4.2 – Airport layout

5. Methodology

To determine the potential glint and glare impact of the proposed PV powerplant on aviation and aircraft-related activities at the Sishen Airport, a methodological approach consisting of three phases, as illustrated in Figure 5.1, was applied. The software used for analysis is introduced, followed by a discussion of the three phases.

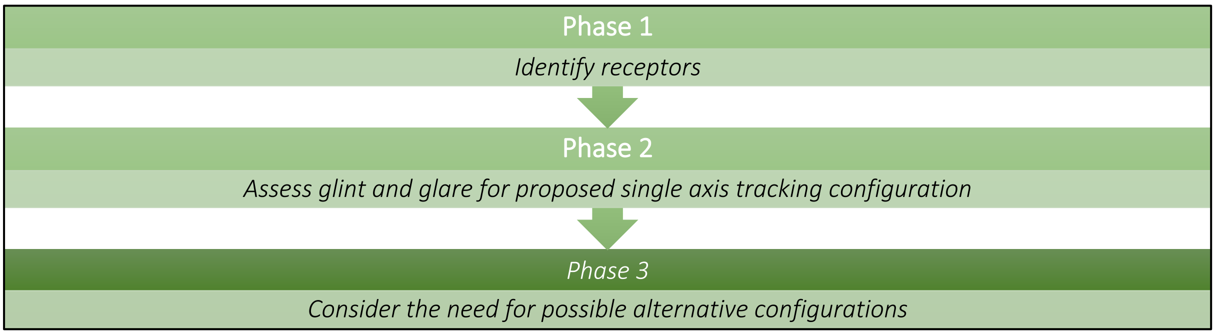


Figure 5.1 – Methodological workflow

5.1. Analysis software

All glint and glare analysis were conducted using ForgeSolar and more specifically, the GlareGauge module (v2). GlareGauge performs the annual glare hazard analysis of PV arrays on sensitive receptors. ForgeSolar was developed with the Solar Glare Hazard Analysis Tool technology (SGHAT), licensed from Sandia National Laboratories and, therefore, represents the international best practice standard. The approach has further been used in recent peer-reviewed publications in academic journals (Mostafa *et al.*, 2016; Sreenath *et al.*, 2020a; Sreenath *et al.*, 2020b; Sreenath *et al.*, 2020c) and therefore also represents the best available science. The general setting that was applied is shown in Table 5.1.

Table 5.1 – General settings

Parameter	Description	Setting
Time interval (min)	The time step, or sampling interval, for the annual glare hazard analysis. The sun position will be determined at each time step throughout the year. Regulatory authorities such as the FAA typically require a time step of 1 minute.	1
Sun angle (mrad)	The average subtended angle of the sun as viewed from earth is ~9.3 mrad or 0.5°.	9.3
Peak DNI (W/m2 or Wh/m2)	The maximum Direct Normal Irradiance at the given location at solar noon. DNI is the amount of solar radiation received in a collimated beam on a surface normal to the sun during a 60-minute period. On a clear sunny day at solar noon, a typical peak DNI is ~1,000 W/m2.	1000
Ocular transmission coefficient	Coefficient accounting for radiation that is absorbed in the eye before reaching the retina. A value of 0.5 is typical (Ho *et al.,* 2011)	0.5
Pupil diameter (m)	Defines the diameter of the pupil of the observer receiving predicted glare. The size impacts the amount of light entering the eye and reaching the retina. Typical values range from 0.002 m for daylight- adjusted eyes to 0.008 m for night-time vision (Ho, *2011*)	0.002
Eye focal length (m)	Distance between the nodal point (where rays intersect in the eye) and the retina. This value is used to determine the projected image size on the retina for a given subtended angle of the glare source. A typical eye focal length is 0.017 m (Ho, 2011)	0.017

5.2. Phase 1 - Identification of receptors

As the assessment explicitly dealt with the possible effects of glint and glare on the activities at the Sishen Airport, the air traffic control (ATC) tower and the runway approaches were considered as receptors. This is in line with best practice guidelines such as the '*Technical Guidance for Evaluation Selected Solar Technologies at Airports'* developed by the United States Federal Aviation Administration (FAA), which was used to inform this assessment (Lawrence & Magnotta, 2018).

5.2.1. Air traffic control (ATC) tower

The ATC tower is located close to the terminal building. To make provision for possible future development at the airport, a height range of 10 to 25 meters were used. This approach ensured an accurate assessment and allowed for testing height sensitivity. Simulations were, therefore, conducted for heights of **10m, 15m and 25m**.

5.2.2. Runways and approaches

The Sishen Airport has only one runway (17/35) resulting in two possible approaches that can potentially be used for landing at the airport (Figure 5.2). In terms of international best practice guidelines, a two-mile (4.2km) extended runway centreline originating at the runway threshold can be used to identify receptor points along the runway approach. The height of the aircraft along the line is calculated at a gliding slope of 3° relative to the runway threshold height of approximately 15m (50ft) above ground level (Figure 5.3). Two approach lines were subsequently mapped, and receptor points identified along them (Figure 5.4).

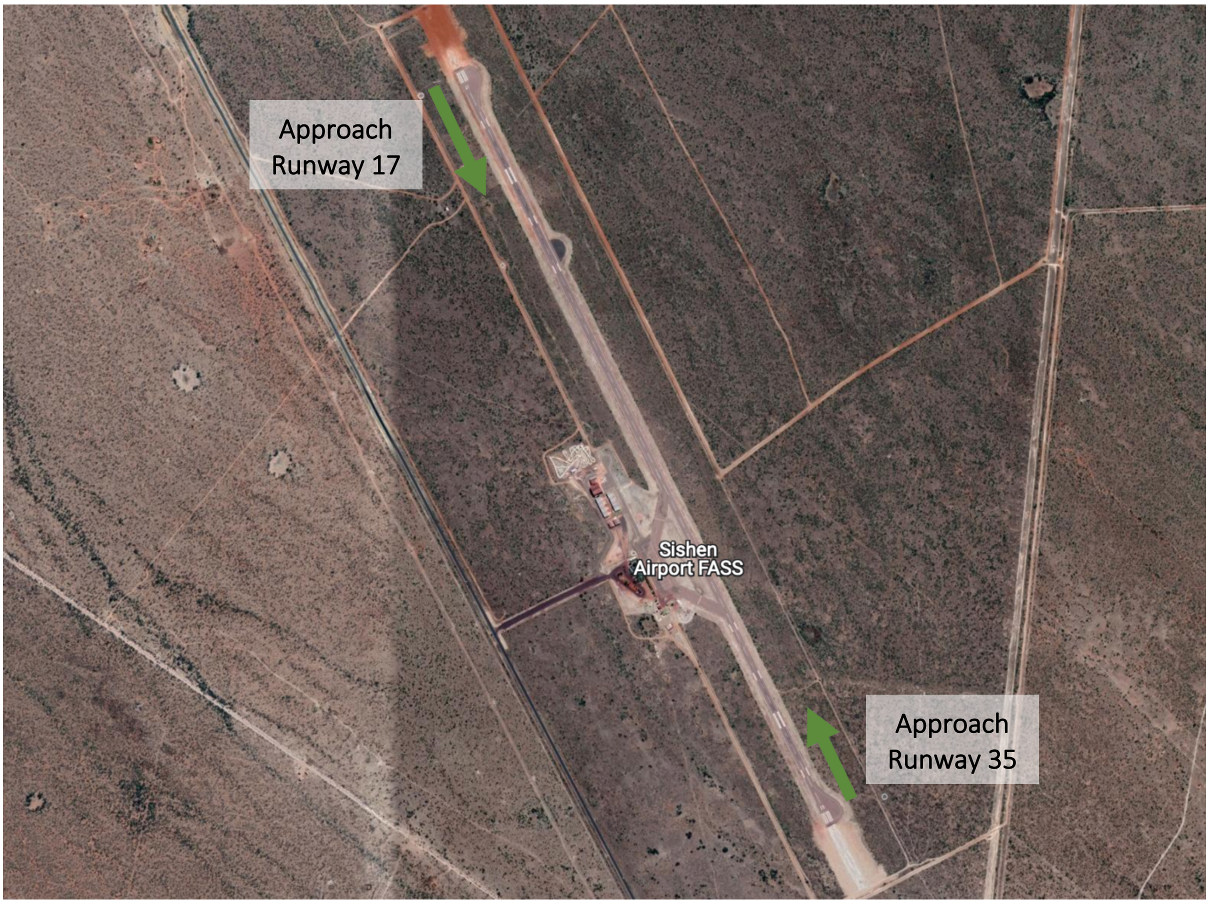


Figure 5.2 – Runways and approaches

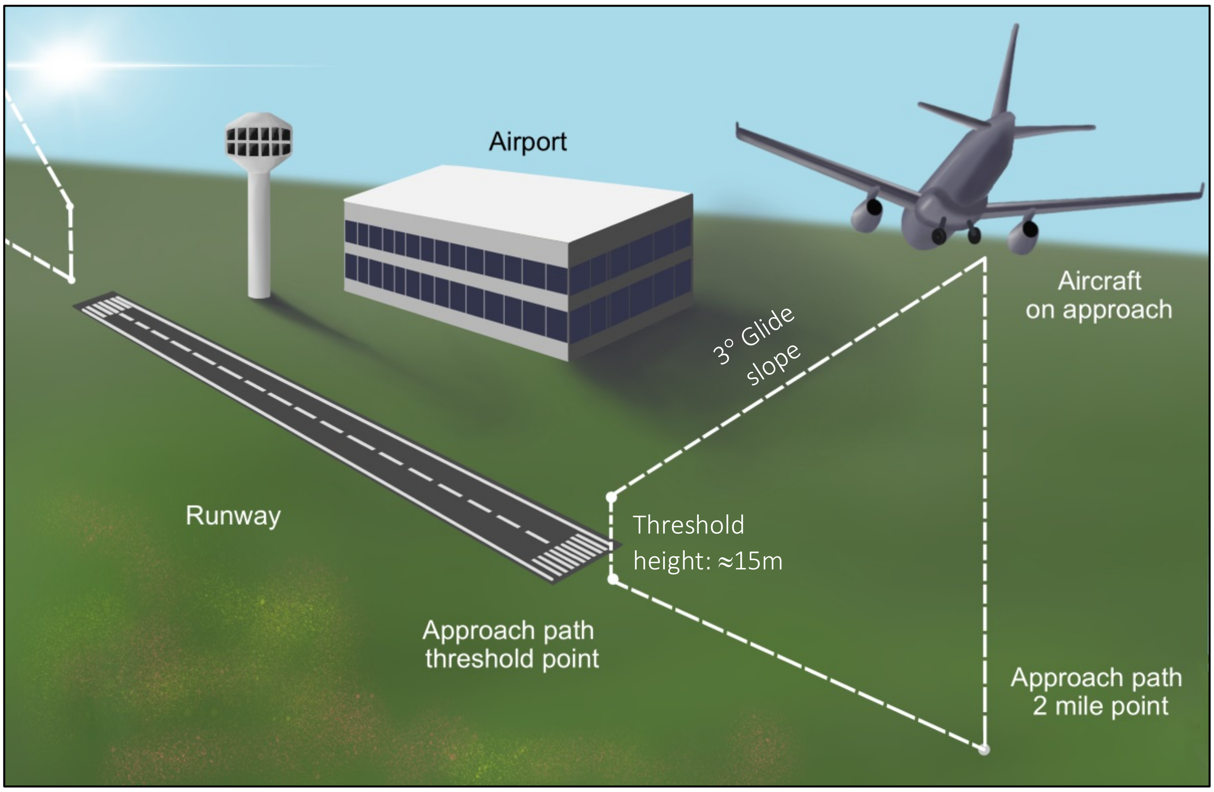


Figure 5.3 – Approach line, glide slope and threshold height.

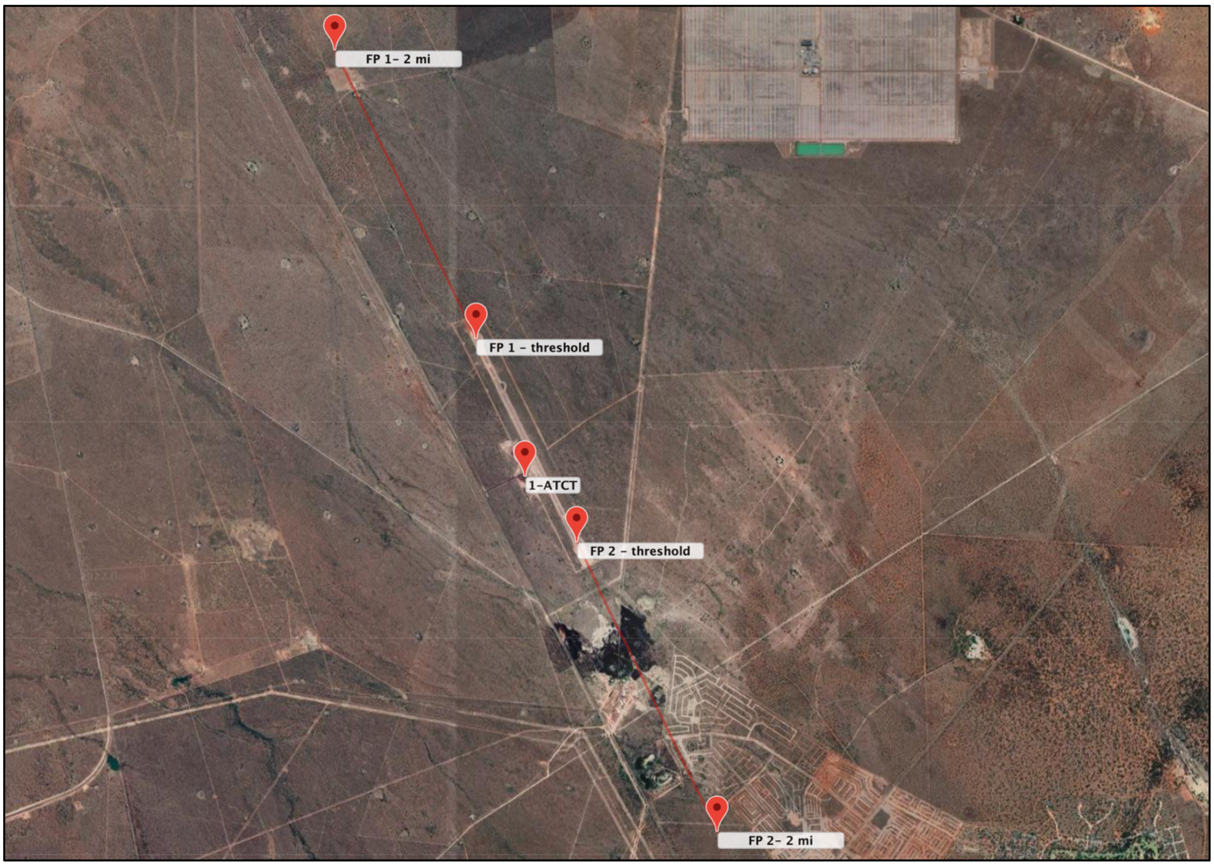


Figure 5.4 – Two approach lines.

5.3. Phase 2 - *Glint and glare assessment*

Phase 1 entailed a glint and glare assessment for the proposed PV power plant development based on the specifications received from Acciona Energia. The parameters listed in Table 5.2 were, therefore, used to model the impact of glint and glare on activities at the Sishen Airport. Eighteen (18) model runs were conducted with only the reflective surface type, the backtracking method, and the ATC tower height differing between runs (Table 5.2).

Table 5.2 – Phase two parameters

Parameter	Run nr																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Axis type	Singe axis tracking																	
Module reflective surface	Smooth glass without ARC						Light textured glass without ARC						Deeply textured glass					
ATC tower height	10m	15m	25m	10m	15m	25m	10m	15m	25m	10m	15m	25m	10m	15m	25m	10m	15m	25m
Tracking axis tilt (*the elevation angle of the tracking axis on which the panels rotate - 0 implies the axis is on level flat ground*)	0°																	
Tracking axis orientation (*Azimuthal position clockwise from true North*)	0°																	
Module offset angle (*additional tilt between tacking axis and the actual panel*)	0°																	
Max tracking angle (*rotation limit of panels in either direction*)	± 55°																	
Backtracking	Revert to 0°			Rest at 55°			Revert to 0°			Rest at 55°			Revert to 0°			Rest at 55°		
Table height above ground	2.5m																	

5.4. Phase 3 – *Consider the need for alternative configurations*

As the simulations predicted no glint and glare other than some 'green glare' for panels with deeply textured glass (see Section 6), no alternatives had to be assessed.

5.5. Assumptions and limitations

Reality can never be represented with 100% accuracy in any computerised model or system. It can, therefore, be expected that any process where reality is simulated will be subject to some limitations. The models used are, therefore, based on certain assumptions and acknowledges certain limitations but are nonetheless aligned with industry standards applied for the purpose of glint and glare assessment internationally. For a detailed list of assumptions and limitations, please see: https://www.forgesolar.com/help/ #assumptions

6. Findings

6.1. Interpretation of results

The results from glint and glare analysis can be interpreted using the glare hazard plot illustrated in Figure 6.1. As the difference between glint and glare is duration, industry-standard glare analysis tools evaluate the occurrence of glare on a minute-by-minute basis (as done here). Accordingly, they generally refer to solar hazards as 'glare'. The ocular impact of solar glare is quantified into three categories (Ho, 2011):

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

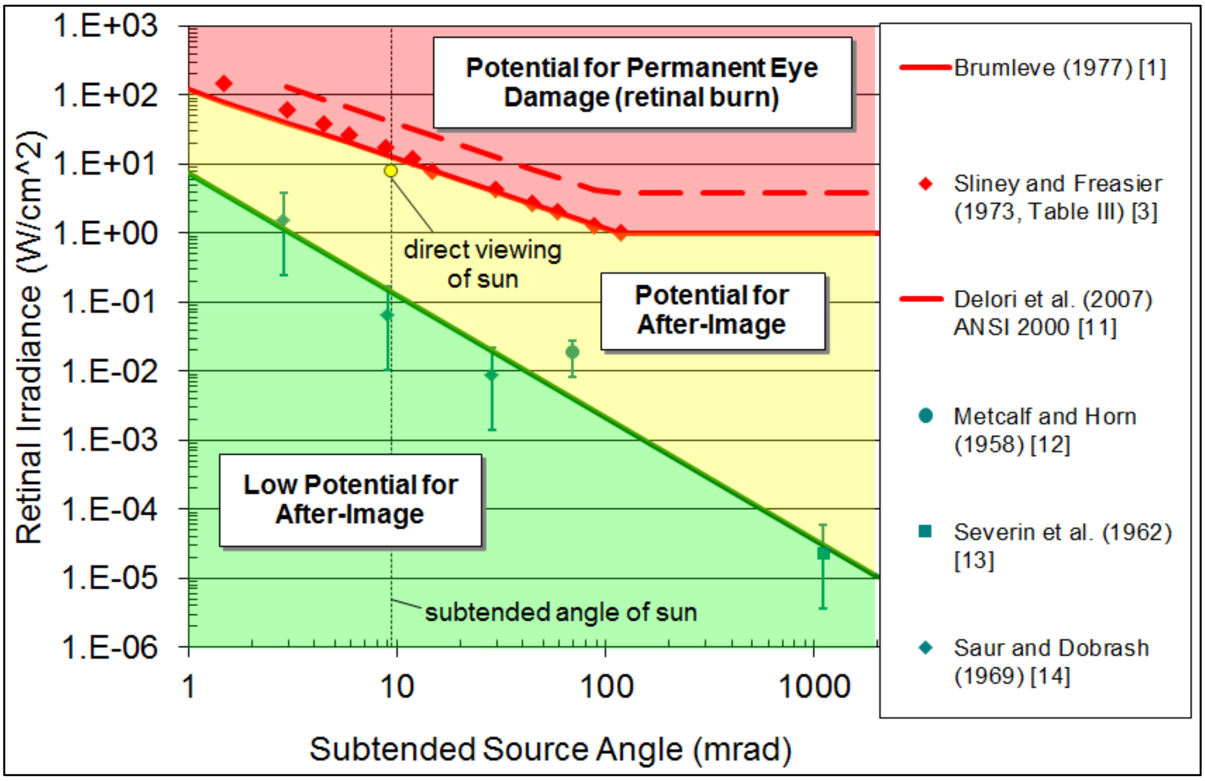


Figure 6.1 – Glare hazard plot

These categories assume a typical blink response in the observer. Note that retinal burn (red) is typically not possible for PV glare since PV modules do not focus reflected sunlight. The ocular impact of glare, as visualised with the glare hazard plot (Figure 6.1), is displayed 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 context, a reference point is provided, which illustrates the hazard from viewing the sun without filtering, i.e., staring at the sun.

The outputs from the modelling process were further used to conduct a risk assessment. Risk assessment can be defined as the process of evaluating and analysing a hazard and its consequences by identifying the hazard probability and severity (Mostafa *et al.*, 2016). Probability can be understood as the frequency or likelihood of occurrence of an event and can be classified into five classes: frequent, occasional, remote, improbable, and extremely improbable. Severity can be defined as the extent of harm that might be expected to occur (Mostafa *et al.*, 2016). Mostafa *et al*. (2016) proposed a risk index matrix (Figure 6.2) for use when determining risk related to PV power plants. The model output for the different receptors was interpreted in terms of probability and severity (Table 6.1) and mapped on a risk matrix (Figure 6.2).

Table 6.1 – Risk probability and severity

Risk probability		
Likelihood	Meaning	Rating
Frequent	Likely to occur many times	5
Occasional	Likely to occur sometimes	4
Remote	Unlikely to occur, but possible	3
Improbable	Very unlikely to occur	2
Extremely improbable	Almost inconceivable to occur	1
Risk severity		
Severity	**Consequences**	**Rating**
Catastrophic	Equipment destroyed; Multiple deaths	A
Hazardous	Large reduction in safety margins; Operators cannot be relied upon to complete their tasks accurately or completely	B
Major	Significant reduction in safety margins; Decrease in the ability of operators to cope with operating conditions	C
Minor	Nuisance; Operating limitations	D
Negligible	Few consequences	E

Risk probabilities and their values		Risk Severity				
		Catastrophic A	Hazardous B	Major C	Minor D	Negligible E
Frequent	5	5A	5B	5C	5D	5E
Occasional	4	4A	4B	4C	4D	4E
Remote	3	3A	3B	3C	3D	3E
Improbable	2	2A	2B	2C	2D	2E
Extremely improbable	1	1A	1B	1C	1D	1E

Red – Intolerable region	Unacceptable under the existing circumstances
Yellow – Tolerable region	Acceptable based on risk mitigation
Green – Acceptable region	Acceptable

Figure 6.2 – Risk assessment matrix and risk tolerability (Mostafa et al., 2016; Sreenath *et al.*, 2020b*)*

6.2. *Glint and glare analysis for original assessment*

Table 6.2 provides a summary of the results for the glint and glare assessment for the proposed PV power plant development based on the specifications as received from Acciona Energia. No glare with potential for temporary after-image was predicated. The findings will now be discussed per receptor.

Table 6.2 – Summary of results

Receptor	Green glare (min)	Yellow glare (min)	Glare potential	Detailed results
Run 1	0	0	No glare detected	Annexure – Run 1
Run 2	0	0	No glare detected	Annexure – Run 2
Run 3	0	0	No glare detected	Annexure – Run 3
Run 4	0	0	No glare detected	Annexure – Run 4
Run 5	0	0	No glare detected	Annexure – Run 5
Run 6	0	0	No glare detected	Annexure – Run 6
Run 7	0	0	No glare detected	Annexure – Run 7
Run 8	0	0	No glare detected	Annexure – Run 8
Run 9	0	0	No glare detected	Annexure – Run 9
Run 10	0	0	No glare detected	Annexure – Run 10
Run 11	0	0	No glare detected	Annexure – Run 11
Run 12	0	0	No glare detected	Annexure – Run 12
Run 13	4,324	0	Low potential	Annexure – Run 13
Run 14	4,578	0	Low potential	Annexure – Run 14
Run 15	5,136	0	Low potential	Annexure – Run 15
Run 16	1,537	0	Low potential	Annexure – Run 16
Run 17	1,621	0	Low potential	Annexure – Run 17
Run 18	1,793	0	Low potential	Annexure – Run 18

6.2.1. ATC tower

The simulation predicted no glint and glare associated risks pertaining to the ATC tower for module surfaces with smooth glass or lightly textured glass. The model did, however, predict 'green' glare for module surfaces of deeply textured glass. This is because module surface reflectivity is a function of incidence angle and will vary between module surface types (Figure 6.2). In terms of best practice guidelines as contained in the 2013 U.S. Federal Aviation Administration (FAA) policy on Solar Energy System Projects on Federal Obligated Airports (78 FR 63276), "no glare of any kind" should be allowed for ATC towers. The PV plant (when using a deeply textured glass) is expected to produce some 'green' glare with a low potential to cause temporary after-image. This glare is expected to be observable mostly between May and August and during the morning (09:00 – 11:00) and afternoons (14:00 – 18:00) (e.g. Figure 6.3).

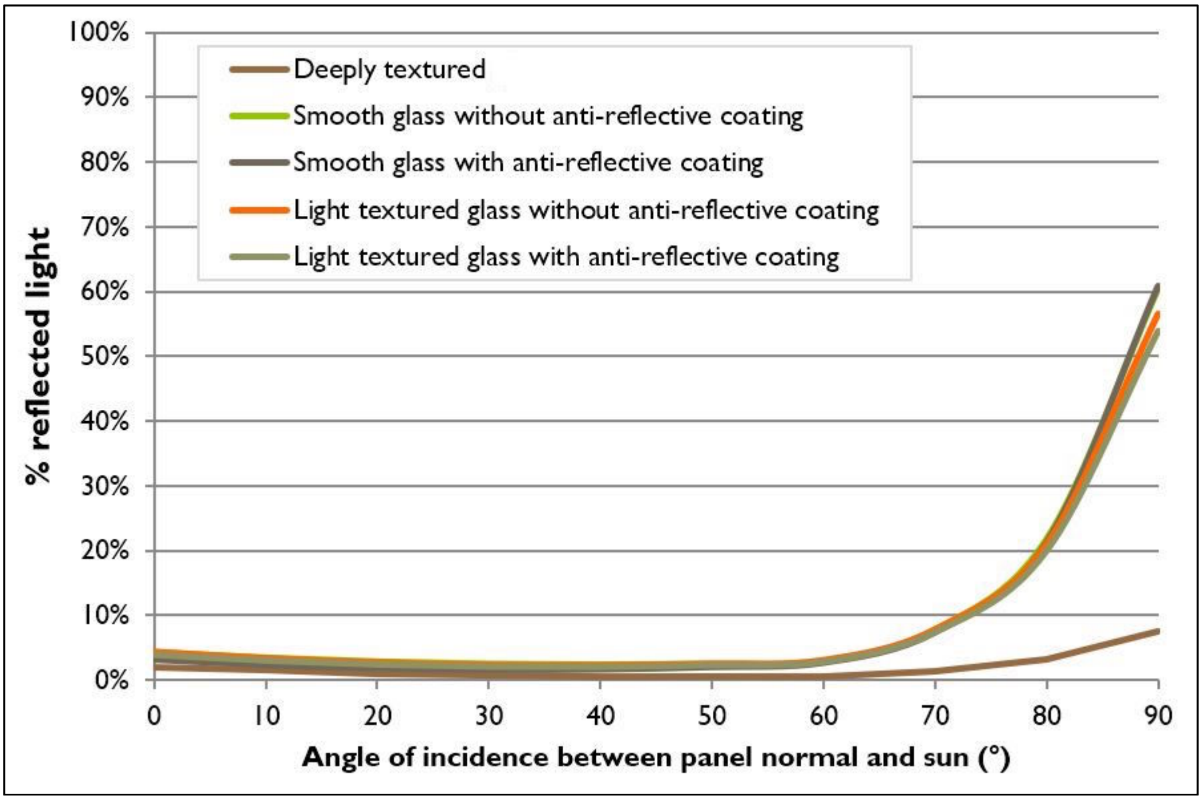


Figure 6.2 Reflectance profiles of typical PV module materials (Yellowhair, 2015).

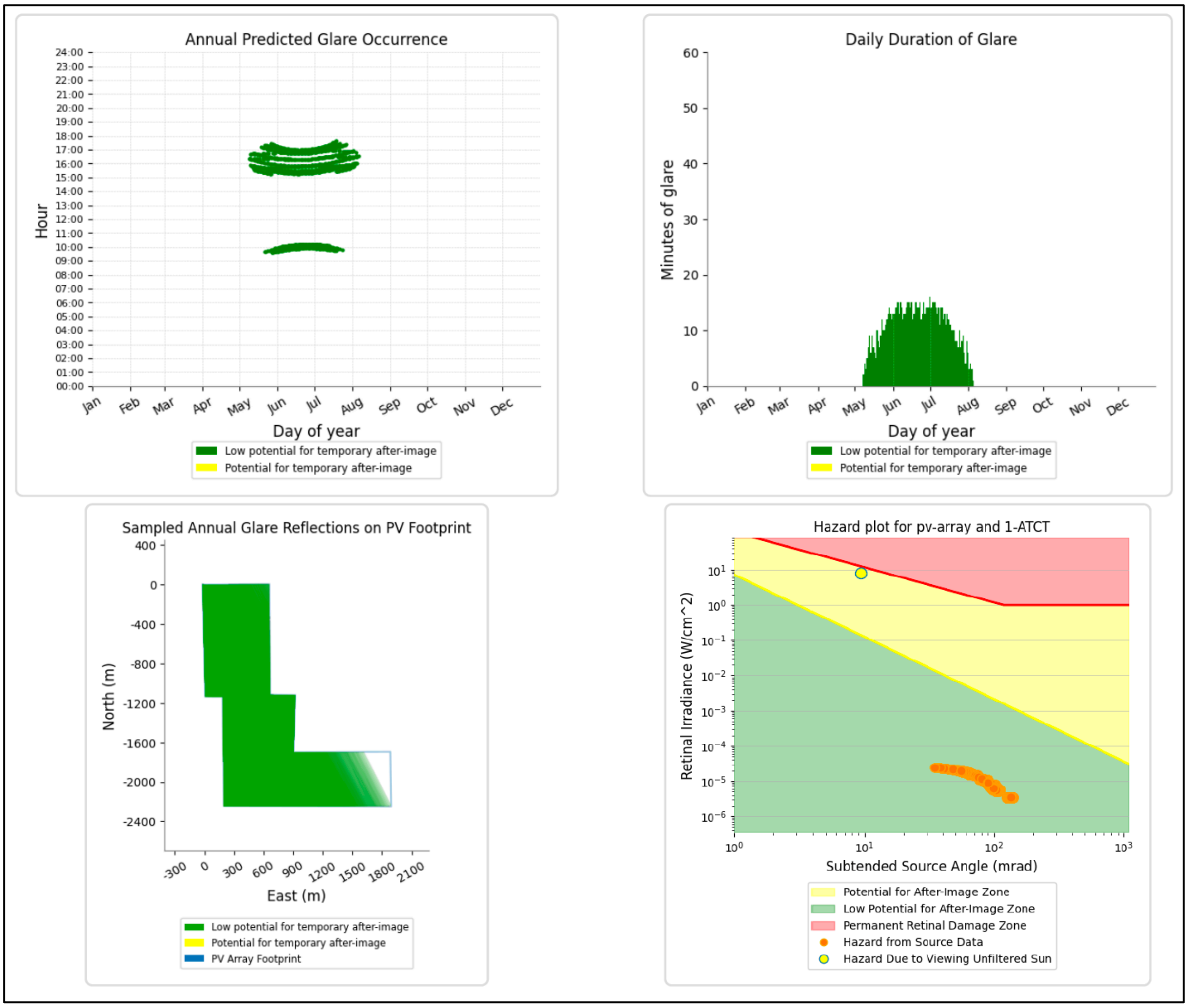


Figure 6.3 – Glare hazard plot, and glare characteristics for ATC (deeply textured glass).

6.2.2. Approach – Runway 17

The simulations predicted no glint and glare with potential for after image pertaining to the approach for runway 17 for any of the module surface materials modelled. The proposed PV plant is therefore not expected to produce any glare that will affect pilots approaching the runway, regardless of the module surface materials used.

6.2.3. Approach – Runway 35

The simulation also predicted no glint and glare with potential for after image pertaining to the approach for runway 35 for any of the module surface materials modelled. The proposed PV plant is therefore not expected to produce any glare that will affect pilots approaching the runway, regardless of the module surface materials used.

6.2.4. Risk assessment

Figure 6.3 shows the risk assessment for the proposed configuration thresholds as modelled and discussed in the previous sections. The proposed configuration when employing modules of smooth or lightly textured surface types poses no to very little predicted risk to aircraft and aviation activities at the Sishen Airport. Modules with deeply textured surface types might pose some risk to ATC activities.

Risk probabilities and their values		Risk Severity				
		Catastrophic A	Hazardous B	Major C	Minor D	Negligible E
Frequent	5					
Occasional	4			Single axis-tracking, 0° orientation, Maximum tacking angle ±55°, DT		
Remote	3					
Improbable	2					Single axis-tracking, 0° orientation, Maximum tacking angle ±55°, SG/LT
Extremely improbable	1					

Red – Intolerable region	Unacceptable under the existing circumstances
Yellow – Tolerable region	Acceptable based on risk mitigation
Green – Acceptable region	Acceptable
SG = Smooth Glass; LT = Lightly Textured Glass; DT = Deeply Textured Glass	

Figure 6.3 – Risk assessment for the proposed layout configuration.

7. Recommendation

The configuration proposed by Acciona Energia when eploying smooth or lightly textured glass is predicted to adhere to safety standards, both locally (SACAA) and internationally (FAA), as they pertain to glint and glare hazards. An anti-reflective coating could be considered to further minimise any possible glint and glare effects. It is recommended that the application **be approved** for the configurations presented in this report.

8. Conclusion

Solar systems can safely coexist in and around airports provided that remedial/preventive measures are undertaken if needed. It is believed that if the PV plant is developed within the proposed configurations and layout criteria the aforementioned will be achieved.

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ANNEXURES

FORGESOLAR GLARE ANALYSIS

Project: **Sansol**
Site configuration: **Original-temp-1**

Client: Acciona

Created 18 May, 2022
Updated 18 May, 2022
Time-step 1 minute
Timezone offset UTC2
Site ID 69258.12207
Category 100 MW to 1 GW
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
Methodology V2

Summary of Results No glare predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array	SA tracking	SA tracking	0	0.0	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

Component Data

PV Arrays

Name: PV array
Axis tracking: Single-axis rotation
Backtracking: Instant
Tracking axis orientation: 0.0°
Tracking axis tilt: 0.0°
Tracking axis panel offset: 0.0°
Max tracking angle: 55.0°
Resting angle: 0.0°
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	-27.562174	22.940655	1134.77	2.50	1137.27
2	-27.562136	22.947328	1137.47	2.50	1139.97
3	-27.572242	22.947407	1139.75	2.50	1142.25
4	-27.572280	22.949982	1140.75	2.50	1143.25
5	-27.577504	22.949824	1141.26	2.50	1143.76
6	-27.577466	22.959737	1144.54	2.50	1147.04
7	-27.582465	22.959818	1145.27	2.50	1147.77
8	-27.582427	22.942652	1140.25	2.50	1142.75
9	-27.572430	22.942512	1138.25	2.50	1140.75
10	-27.572418	22.940728	1137.75	2.50	1140.25
11	-27.562146	22.940456	1134.75	2.50	1137.25

Flight Path Receptors

Name: 17
Description:
Threshold height: 15 m
Direction: 154.0°
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	-27.637172	22.993009	1167.25	15.00	1182.25
Two-mile	-27.611186	22.978685	1156.11	194.82	1350.93

Name: 35
Description:
Threshold height: 15 m
Direction: 334.0°
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	-27.655499	23.003189	1179.25	15.00	1194.25
Two-mile	-27.681486	23.017515	1199.91	163.02	1362.94

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	-27.649551	22.997970	1175.04	10.00

Map image of 1-ATCT

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	SA tracking	SA tracking	0	0.0	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV: PV array no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV array and 17

Receptor type: 2-mile Flight Path

No glare found

PV array and 35

Receptor type: 2-mile Flight Path

No glare found

PV array and 1-ATCT

Receptor type: Observation Point

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

FORGESOLAR GLARE ANALYSIS

Project: **Sansol**
Site configuration: **Original-temp-2**

Client: Acciona

Created 18 May, 2022
Updated 18 May, 2022
Time-step 1 minute
Timezone offset UTC2
Site ID 69259.12207
Category 100 MW to 1 GW
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
Methodology V2

Summary of Results No glare predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array	SA tracking	SA tracking	0	0.0	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

Component Data

PV Arrays

Name: PV array
Axis tracking: Single-axis rotation
Backtracking: Instant
Tracking axis orientation: 0.0°
Tracking axis tilt: 0.0°
Tracking axis panel offset: 0.0°
Max tracking angle: 55.0°
Resting angle: 0.0°
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	-27.562174	22.940655	1134.77	2.50	1137.27
2	-27.562136	22.947328	1137.47	2.50	1139.97
3	-27.572242	22.947407	1139.75	2.50	1142.25
4	-27.572280	22.949982	1140.75	2.50	1143.25
5	-27.577504	22.949824	1141.26	2.50	1143.76
6	-27.577466	22.959737	1144.54	2.50	1147.04
7	-27.582465	22.959818	1145.27	2.50	1147.77
8	-27.582427	22.942652	1140.25	2.50	1142.75
9	-27.572430	22.942512	1138.25	2.50	1140.75
10	-27.572418	22.940728	1137.75	2.50	1140.25
11	-27.562146	22.940456	1134.75	2.50	1137.25

Flight Path Receptors

Name: 17
Description:
Threshold height: 15 m
Direction: 154.0°
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	-27.637172	22.993009	1167.25	15.00	1182.25
Two-mile	-27.611186	22.978685	1156.11	194.82	1350.93

Name: 35
Description:
Threshold height: 15 m
Direction: 334.0°
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	-27.655499	23.003189	1179.25	15.00	1194.25
Two-mile	-27.681486	23.017515	1199.91	163.02	1362.94

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	-27.649551	22.997970	1175.04	15.00

Map image of 1-ATCT

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	SA tracking	SA tracking	0	0.0	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV: PV array no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV array and 17

Receptor type: 2-mile Flight Path

No glare found

PV array and 35

Receptor type: 2-mile Flight Path

No glare found

PV array and 1-ATCT

Receptor type: Observation Point

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

FORGESOLAR GLARE ANALYSIS

Project: **Sansol**
Site configuration: **Original-temp-3**

Client: Acciona

Created 18 May, 2022
Updated 18 May, 2022
Time-step 1 minute
Timezone offset UTC2
Site ID 69260.12207
Category 100 MW to 1 GW
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
Methodology V2

Summary of Results No glare predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array	SA tracking	SA tracking	0	0.0	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

Component Data

PV Arrays

Name: PV array
Axis tracking: Single-axis rotation
Backtracking: Instant
Tracking axis orientation: 0.0°
Tracking axis tilt: 0.0°
Tracking axis panel offset: 0.0°
Max tracking angle: 55.0°
Resting angle: 0.0°
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	-27.562174	22.940655	1134.77	2.50	1137.27
2	-27.562136	22.947328	1137.47	2.50	1139.97
3	-27.572242	22.947407	1139.75	2.50	1142.25
4	-27.572280	22.949982	1140.75	2.50	1143.25
5	-27.577504	22.949824	1141.26	2.50	1143.76
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7	-27.582465	22.959818	1145.27	2.50	1147.77
8	-27.582427	22.942652	1140.25	2.50	1142.75
9	-27.572430	22.942512	1138.25	2.50	1140.75
10	-27.572418	22.940728	1137.75	2.50	1140.25
11	-27.562146	22.940456	1134.75	2.50	1137.25

Flight Path Receptors

Name: 17
Description:
Threshold height: 15 m
Direction: 154.0°
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	-27.637172	22.993009	1167.25	15.00	1182.25
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Name: 35
Description:
Threshold height: 15 m
Direction: 334.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
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Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-27.655499	23.003189	1179.25	15.00	1194.25
Two-mile	-27.681486	23.017515	1199.91	163.02	1362.94

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	-27.649551	22.997970	1175.04	25.00

Map image of 1-ATCT

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	SA tracking	SA tracking	0	0.0	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV: PV array no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV array and 17

Receptor type: 2-mile Flight Path

No glare found

PV array and 35

Receptor type: 2-mile Flight Path

No glare found

PV array and 1-ATCT

Receptor type: Observation Point

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.
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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

FORGESOLAR GLARE ANALYSIS

Project: **Sansol**
Site configuration: **Original-temp-4**

Client: Acciona

Created 18 May, 2022
Updated 18 May, 2022
Time-step 1 minute
Timezone offset UTC2
Site ID 69261.12207
Category 100 MW to 1 GW
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
Methodology V2

Summary of Results No glare predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array	SA tracking	SA tracking	0	0.0	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

Component Data

PV Arrays

Name: PV array
Axis tracking: Single-axis rotation
Backtracking: None
Tracking axis orientation: 0.0°
Tracking axis tilt: 0.0°
Tracking axis panel offset: 0.0°
Max tracking angle: 55.0°
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	-27.562174	22.940655	1134.77	2.50	1137.27
2	-27.562136	22.947328	1137.47	2.50	1139.97
3	-27.572242	22.947407	1139.75	2.50	1142.25
4	-27.572280	22.949982	1140.75	2.50	1143.25
5	-27.577504	22.949824	1141.26	2.50	1143.76
6	-27.577466	22.959737	1144.54	2.50	1147.04
7	-27.582465	22.959818	1145.27	2.50	1147.77
8	-27.582427	22.942652	1140.25	2.50	1142.75
9	-27.572430	22.942512	1138.25	2.50	1140.75
10	-27.572418	22.940728	1137.75	2.50	1140.25
11	-27.562146	22.940456	1134.75	2.50	1137.25

Flight Path Receptors

Name: 17
Description:
Threshold height: 15 m
Direction: 154.0°
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	-27.637172	22.993009	1167.25	15.00	1182.25
Two-mile	-27.611186	22.978685	1156.11	194.82	1350.93

Name: 35
Description:
Threshold height: 15 m
Direction: 334.0°
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	-27.655499	23.003189	1179.25	15.00	1194.25
Two-mile	-27.681486	23.017515	1199.91	163.02	1362.94

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	-27.649551	22.997970	1175.04	10.00

Map image of 1-ATCT

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	SA tracking	SA tracking	0	0.0	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV: PV array no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV array and 17

Receptor type: 2-mile Flight Path

No glare found

PV array and 35

Receptor type: 2-mile Flight Path

No glare found

PV array and 1-ATCT

Receptor type: Observation Point

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.
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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 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

FORGESOLAR GLARE ANALYSIS

Project: **Sansol**
Site configuration: **Original-temp-5**

Client: Acciona

Created 18 May, 2022
Updated 18 May, 2022
Time-step 1 minute
Timezone offset UTC2
Site ID 69262.12207
Category 100 MW to 1 GW
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
Methodology V2

Summary of Results No glare predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array	SA tracking	SA tracking	0	0.0	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

Component Data

PV Arrays

Name: PV array
Axis tracking: Single-axis rotation
Backtracking: None
Tracking axis orientation: 0.0°
Tracking axis tilt: 0.0°
Tracking axis panel offset: 0.0°
Max tracking angle: 55.0°
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	-27.562174	22.940655	1134.77	2.50	1137.27
2	-27.562136	22.947328	1137.47	2.50	1139.97
3	-27.572242	22.947407	1139.75	2.50	1142.25
4	-27.572280	22.949982	1140.75	2.50	1143.25
5	-27.577504	22.949824	1141.26	2.50	1143.76
6	-27.577466	22.959737	1144.54	2.50	1147.04
7	-27.582465	22.959818	1145.27	2.50	1147.77
8	-27.582427	22.942652	1140.25	2.50	1142.75
9	-27.572430	22.942512	1138.25	2.50	1140.75
10	-27.572418	22.940728	1137.75	2.50	1140.25
11	-27.562146	22.940456	1134.75	2.50	1137.25

Flight Path Receptors

Name: 17
Description:
Threshold height: 15 m
Direction: 154.0°
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	-27.637172	22.993009	1167.25	15.00	1182.25
Two-mile	-27.611186	22.978685	1156.11	194.82	1350.93

Name: 35
Description:
Threshold height: 15 m
Direction: 334.0°
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	-27.655499	23.003189	1179.25	15.00	1194.25
Two-mile	-27.681486	23.017515	1199.91	163.02	1362.94

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	-27.649551	22.997970	1175.04	15.00

Map image of 1-ATCT

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	SA tracking	SA tracking	0	0.0	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV: PV array no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV array and 17

Receptor type: 2-mile Flight Path

No glare found

PV array and 35

Receptor type: 2-mile Flight Path

No glare found

PV array and 1-ATCT

Receptor type: Observation Point

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.
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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

FORGESOLAR GLARE ANALYSIS

Project: **Sansol**
Site configuration: **Original-temp-6**

Client: Acciona

Created 18 May, 2022
Updated 18 May, 2022
Time-step 1 minute
Timezone offset UTC2
Site ID 69263.12207
Category 100 MW to 1 GW
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
Methodology V2

Summary of Results No glare predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array	SA tracking	SA tracking	0	0.0	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

Component Data

PV Arrays

Name: PV array
Axis tracking: Single-axis rotation
Backtracking: None
Tracking axis orientation: 0.0°
Tracking axis tilt: 0.0°
Tracking axis panel offset: 0.0°
Max tracking angle: 55.0°
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	-27.562174	22.940655	1134.77	2.50	1137.27
2	-27.562136	22.947328	1137.47	2.50	1139.97
3	-27.572242	22.947407	1139.75	2.50	1142.25
4	-27.572280	22.949982	1140.75	2.50	1143.25
5	-27.577504	22.949824	1141.26	2.50	1143.76
6	-27.577466	22.959737	1144.54	2.50	1147.04
7	-27.582465	22.959818	1145.27	2.50	1147.77
8	-27.582427	22.942652	1140.25	2.50	1142.75
9	-27.572430	22.942512	1138.25	2.50	1140.75
10	-27.572418	22.940728	1137.75	2.50	1140.25
11	-27.562146	22.940456	1134.75	2.50	1137.25

Flight Path Receptors

Name: 17
Description:
Threshold height: 15 m
Direction: 154.0°
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	-27.637172	22.993009	1167.25	15.00	1182.25
Two-mile	-27.611186	22.978685	1156.11	194.82	1350.93

Name: 35
Description:
Threshold height: 15 m
Direction: 334.0°
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	-27.655499	23.003189	1179.25	15.00	1194.25
Two-mile	-27.681486	23.017515	1199.91	163.02	1362.94

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	-27.649551	22.997970	1175.04	25.00

Map image of 1-ATCT

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	SA tracking	SA tracking	0	0.0	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV: PV array no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV array and 17

Receptor type: 2-mile Flight Path

No glare found

PV array and 35

Receptor type: 2-mile Flight Path

No glare found

PV array and 1-ATCT

Receptor type: Observation Point

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.
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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.
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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

FORGESOLAR GLARE ANALYSIS

Project: **Sansol**
Site configuration: **Original-temp-7**

Client: Acciona

Created 18 May, 2022
Updated 18 May, 2022
Time-step 1 minute
Timezone offset UTC2
Site ID 69264.12207
Category 100 MW to 1 GW
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
Methodology V2

Summary of Results No glare predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array	SA tracking	SA tracking	0	0.0	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

Component Data

PV Arrays

Name: PV array
Axis tracking: Single-axis rotation
Backtracking: Instant
Tracking axis orientation: 0.0°
Tracking axis tilt: 0.0°
Tracking axis panel offset: 0.0°
Max tracking angle: 55.0°
Resting angle: 0.0°
Rated power: -
Panel material: Light textured 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	-27.562174	22.940655	1134.77	2.50	1137.27
2	-27.562136	22.947328	1137.47	2.50	1139.97
3	-27.572242	22.947407	1139.75	2.50	1142.25
4	-27.572280	22.949982	1140.75	2.50	1143.25
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6	-27.577466	22.959737	1144.54	2.50	1147.04
7	-27.582465	22.959818	1145.27	2.50	1147.77
8	-27.582427	22.942652	1140.25	2.50	1142.75
9	-27.572430	22.942512	1138.25	2.50	1140.75
10	-27.572418	22.940728	1137.75	2.50	1140.25
11	-27.562146	22.940456	1134.75	2.50	1137.25

Flight Path Receptors

Name: 17
Description:
Threshold height: 15 m
Direction: 154.0°
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	-27.637172	22.993009	1167.25	15.00	1182.25
Two-mile	-27.611186	22.978685	1156.11	194.82	1350.93

Name: 35
Description:
Threshold height: 15 m
Direction: 334.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
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Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-27.655499	23.003189	1179.25	15.00	1194.25
Two-mile	-27.681486	23.017515	1199.91	163.02	1362.94

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	-27.649551	22.997970	1175.04	10.00

Map image of 1-ATCT

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	SA tracking	SA tracking	0	0.0	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV: PV array no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV array and 17

Receptor type: 2-mile Flight Path

No glare found

PV array and 35

Receptor type: 2-mile Flight Path

No glare found

PV array and 1-ATCT

Receptor type: Observation Point

No glare found

Assumptions

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

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- 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

FORGESOLAR GLARE ANALYSIS

Project: **Sansol**
Site configuration: **Original-temp-8**

Client: Acciona

Created 18 May, 2022
Updated 18 May, 2022
Time-step 1 minute
Timezone offset UTC2
Site ID 69265.12207
Category 100 MW to 1 GW
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
Methodology V2

Summary of Results No glare predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array	SA tracking	SA tracking	0	0.0	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

Component Data

PV Arrays

Name: PV array
Axis tracking: Single-axis rotation
Backtracking: Instant
Tracking axis orientation: 0.0°
Tracking axis tilt: 0.0°
Tracking axis panel offset: 0.0°
Max tracking angle: 55.0°
Resting angle: 0.0°
Rated power: -
Panel material: Light textured 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	-27.562174	22.940655	1134.77	2.50	1137.27
2	-27.562136	22.947328	1137.47	2.50	1139.97
3	-27.572242	22.947407	1139.75	2.50	1142.25
4	-27.572280	22.949982	1140.75	2.50	1143.25
5	-27.577504	22.949824	1141.26	2.50	1143.76
6	-27.577466	22.959737	1144.54	2.50	1147.04
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8	-27.582427	22.942652	1140.25	2.50	1142.75
9	-27.572430	22.942512	1138.25	2.50	1140.75
10	-27.572418	22.940728	1137.75	2.50	1140.25
11	-27.562146	22.940456	1134.75	2.50	1137.25

Flight Path Receptors

Name: 17
Description:
Threshold height: 15 m
Direction: 154.0°
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	-27.637172	22.993009	1167.25	15.00	1182.25
Two-mile	-27.611186	22.978685	1156.11	194.82	1350.93

Name: 35
Description:
Threshold height: 15 m
Direction: 334.0°
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	-27.655499	23.003189	1179.25	15.00	1194.25
Two-mile	-27.681486	23.017515	1199.91	163.02	1362.94

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	-27.649551	22.997970	1175.04	15.00

Map image of 1-ATCT

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	SA tracking	SA tracking	0	0.0	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV: PV array no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV array and 17

Receptor type: 2-mile Flight Path

No glare found

PV array and 35

Receptor type: 2-mile Flight Path

No glare found

PV array and 1-ATCT

Receptor type: Observation Point

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

FORGESOLAR GLARE ANALYSIS

Project: **Sansol**
Site configuration: **Original-temp-9**

Client: Acciona

Created 18 May, 2022
Updated 18 May, 2022
Time-step 1 minute
Timezone offset UTC2
Site ID 69266.12207
Category 100 MW to 1 GW
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
Methodology V2

Summary of Results No glare predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array	SA tracking	SA tracking	0	0.0	0	0.0	-

Total annual 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
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35	0	0.0	0	0.0
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Component Data

PV Arrays

Name: PV array
Axis tracking: Single-axis rotation
Backtracking: Instant
Tracking axis orientation: 0.0°
Tracking axis tilt: 0.0°
Tracking axis panel offset: 0.0°
Max tracking angle: 55.0°
Resting angle: 0.0°
Rated power: -
Panel material: Light textured glass without AR coating
Reflectivity: Vary with sun
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Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
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11	-27.562146	22.940456	1134.75	2.50	1137.25

Flight Path Receptors

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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)
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Description:
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Direction: 334.0°
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Pilot view restricted? Yes
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Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
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Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	-27.649551	22.997970	1175.04	25.00

Map image of 1-ATCT

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	SA tracking	SA tracking	0	0.0	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV: PV array no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV array and 17

Receptor type: 2-mile Flight Path

No glare found

PV array and 35

Receptor type: 2-mile Flight Path

No glare found

PV array and 1-ATCT

Receptor type: Observation Point

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

FORGESOLAR GLARE ANALYSIS

Project: **Sansol**
Site configuration: **Original-temp-10**

Client: Acciona

Created 18 May, 2022
Updated 18 May, 2022
Time-step 1 minute
Timezone offset UTC2
Site ID 69267.12207
Category 100 MW to 1 GW
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
Methodology V2

Summary of Results No glare predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array	SA tracking	SA tracking	0	0.0	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

Component Data

PV Arrays

Name: PV array
Axis tracking: Single-axis rotation
Backtracking: None
Tracking axis orientation: 0.0°
Tracking axis tilt: 0.0°
Tracking axis panel offset: 0.0°
Max tracking angle: 55.0°
Rated power: -
Panel material: Light textured 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	-27.562174	22.940655	1134.77	2.50	1137.27
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3	-27.572242	22.947407	1139.75	2.50	1142.25
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10	-27.572418	22.940728	1137.75	2.50	1140.25
11	-27.562146	22.940456	1134.75	2.50	1137.25

Flight Path Receptors

Name: 17
Description:
Threshold height: 15 m
Direction: 154.0°
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	-27.637172	22.993009	1167.25	15.00	1182.25
Two-mile	-27.611186	22.978685	1156.11	194.82	1350.93

Name: 35
Description:
Threshold height: 15 m
Direction: 334.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
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Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-27.655499	23.003189	1179.25	15.00	1194.25
Two-mile	-27.681486	23.017515	1199.91	163.02	1362.94

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	-27.649551	22.997970	1175.04	10.00

Map image of 1-ATCT

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	SA tracking	SA tracking	0	0.0	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV: PV array no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV array and 17

Receptor type: 2-mile Flight Path

No glare found

PV array and 35

Receptor type: 2-mile Flight Path

No glare found

PV array and 1-ATCT

Receptor type: Observation Point

No glare found

Assumptions

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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

FORGESOLAR GLARE ANALYSIS

Project: **Sansol**
Site configuration: **Original-temp-11**

Client: Acciona

Created 18 May, 2022
Updated 18 May, 2022
Time-step 1 minute
Timezone offset UTC2
Site ID 69268.12207
Category 100 MW to 1 GW
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
Methodology V2

Summary of Results No glare predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
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PV array	SA tracking	SA tracking	0	0.0	0	0.0	-

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

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Glide slope: 3.0°
Pilot view restricted? Yes
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Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
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Two-mile	-27.611186	22.978685	1156.11	194.82	1350.93

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Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
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Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	-27.649551	22.997970	1175.04	15.00

Map image of 1-ATCT

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	SA tracking	SA tracking	0	0.0	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV: PV array no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV array and 17

Receptor type: 2-mile Flight Path

No glare found

PV array and 35

Receptor type: 2-mile Flight Path

No glare found

PV array and 1-ATCT

Receptor type: Observation Point

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 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

FORGESOLAR GLARE ANALYSIS

Project: **Sansol**
Site configuration: **Original-temp-12**

Client: Acciona

Created 18 May, 2022
Updated 18 May, 2022
Time-step 1 minute
Timezone offset UTC2
Site ID 69269.12207
Category 100 MW to 1 GW
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
Methodology V2

Summary of Results No glare predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array	SA tracking	SA tracking	0	0.0	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

Component Data

PV Arrays

Name: PV array
Axis tracking: Single-axis rotation
Backtracking: None
Tracking axis orientation: 0.0°
Tracking axis tilt: 0.0°
Tracking axis panel offset: 0.0°
Max tracking angle: 55.0°
Rated power: -
Panel material: Light textured 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	-27.562174	22.940655	1134.77	2.50	1137.27
2	-27.562136	22.947328	1137.47	2.50	1139.97
3	-27.572242	22.947407	1139.75	2.50	1142.25
4	-27.572280	22.949982	1140.75	2.50	1143.25
5	-27.577504	22.949824	1141.26	2.50	1143.76
6	-27.577466	22.959737	1144.54	2.50	1147.04
7	-27.582465	22.959818	1145.27	2.50	1147.77
8	-27.582427	22.942652	1140.25	2.50	1142.75
9	-27.572430	22.942512	1138.25	2.50	1140.75
10	-27.572418	22.940728	1137.75	2.50	1140.25
11	-27.562146	22.940456	1134.75	2.50	1137.25

Flight Path Receptors

Name: 17
Description:
Threshold height: 15 m
Direction: 154.0°
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	-27.637172	22.993009	1167.25	15.00	1182.25
Two-mile	-27.611186	22.978685	1156.11	194.82	1350.93

Name: 35
Description:
Threshold height: 15 m
Direction: 334.0°
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	-27.655499	23.003189	1179.25	15.00	1194.25
Two-mile	-27.681486	23.017515	1199.91	163.02	1362.94

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	-27.649551	22.997970	1175.04	25.00

Map image of 1-ATCT

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	SA tracking	SA tracking	0	0.0	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV: PV array no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
17	0	0.0	0	0.0
35	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV array and 17

Receptor type: 2-mile Flight Path

No glare found

PV array and 35

Receptor type: 2-mile Flight Path

No glare found

PV array and 1-ATCT

Receptor type: Observation Point

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.
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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

FORGESOLAR GLARE ANALYSIS

Project: **Sansol**
Site configuration: **Original-temp-13**

Client: Acciona

Created 18 May, 2022
Updated 18 May, 2022
Time-step 1 minute
Timezone offset UTC2
Site ID 69270.12207
Category 100 MW to 1 GW
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
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
	°	°	min	hr	min	hr	kWh
PV array	SA tracking	SA tracking	4,324	72.1	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	3,345	55.8	0	0.0
1-ATCT	979	16.3	0	0.0

Component Data

PV Arrays

Name: PV array
Axis tracking: Single-axis rotation
Backtracking: Instant
Tracking axis orientation: 0.0°
Tracking axis tilt: 0.0°
Tracking axis panel offset: 0.0°
Max tracking angle: 55.0°
Resting angle: 0.0°
Rated power: -
Panel material: Deeply textured glass
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-27.562174	22.940655	1134.77	2.50	1137.27
2	-27.562136	22.947328	1137.47	2.50	1139.97
3	-27.572242	22.947407	1139.75	2.50	1142.25
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5	-27.577504	22.949824	1141.26	2.50	1143.76
6	-27.577466	22.959737	1144.54	2.50	1147.04
7	-27.582465	22.959818	1145.27	2.50	1147.77
8	-27.582427	22.942652	1140.25	2.50	1142.75
9	-27.572430	22.942512	1138.25	2.50	1140.75
10	-27.572418	22.940728	1137.75	2.50	1140.25
11	-27.562146	22.940456	1134.75	2.50	1137.25

Flight Path Receptors

Name: 17
Description:
Threshold height: 15 m
Direction: 154.0°
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	-27.637172	22.993009	1167.25	15.00	1182.25
Two-mile	-27.611186	22.978685	1156.11	194.82	1350.93

Name: 35
Description:
Threshold height: 15 m
Direction: 334.0°
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	-27.655499	23.003189	1179.25	15.00	1194.25
Two-mile	-27.681486	23.017515	1199.91	163.02	1362.94

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	-27.649551	22.997970	1175.04	10.00

Map image of 1-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	SA tracking	SA tracking	4,324	72.1	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	3,345	55.8	0	0.0
1-ATCT	979	16.3	0	0.0

PV: PV array low potential for temporary after-image

Receptor results ordered by category of glare

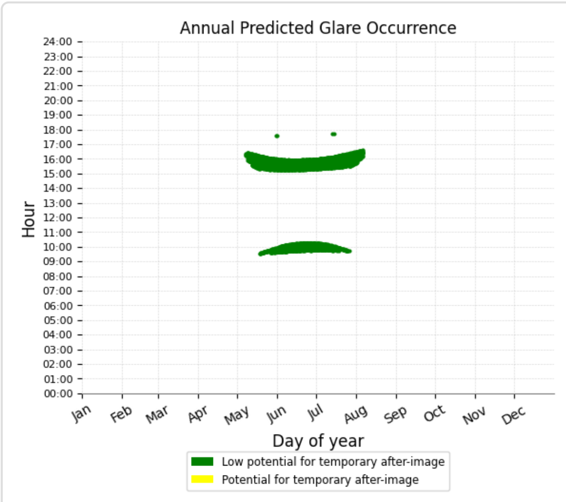
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
35	3,345	55.8	0	0.0
17	0	0.0	0	0.0
1-ATCT	979	16.3	0	0.0

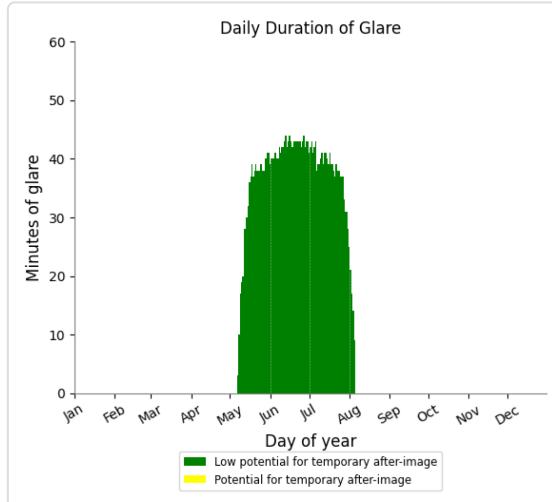
PV array and 35

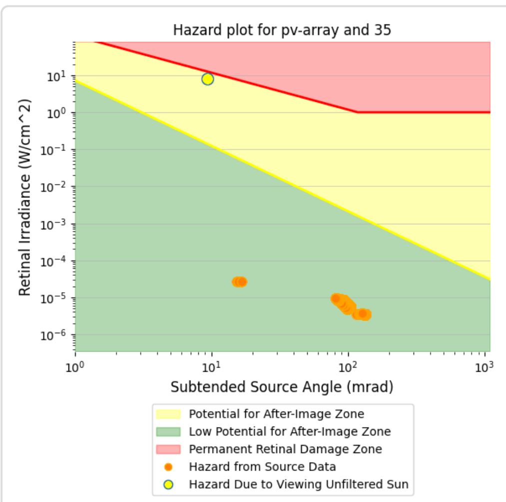
Receptor type: 2-mile Flight Path

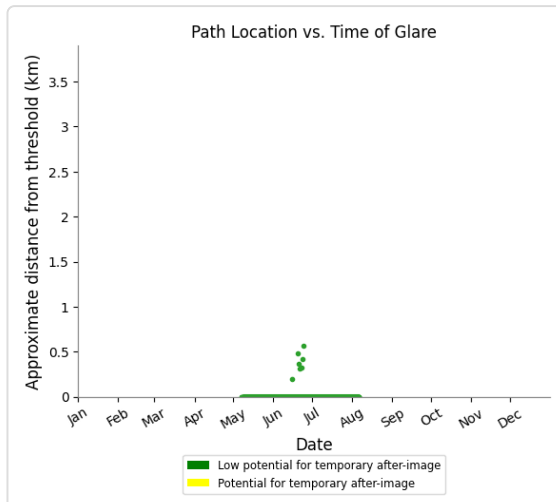
0 minutes of yellow glare

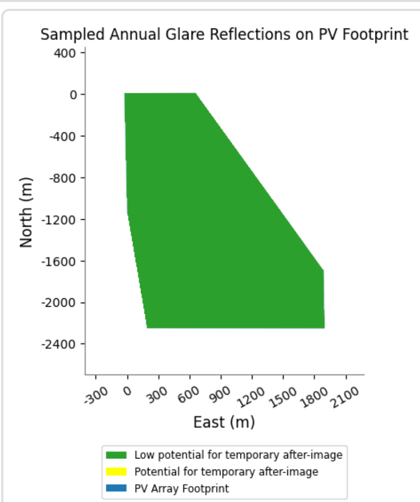
3,345 minutes of green glare

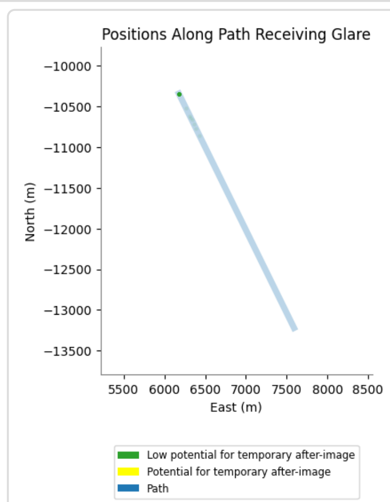












PV array and 17

Receptor type: 2-mile Flight Path

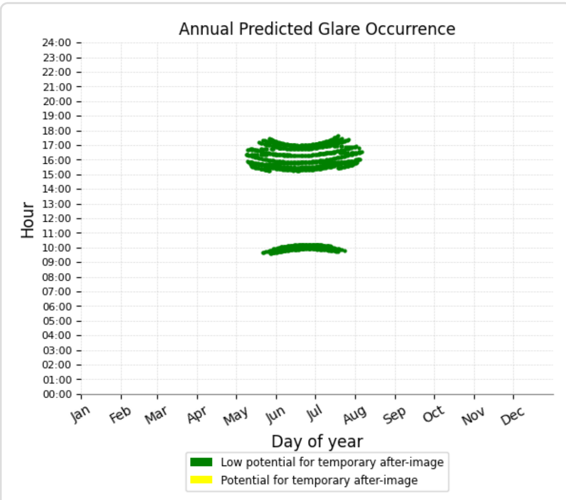
No glare found

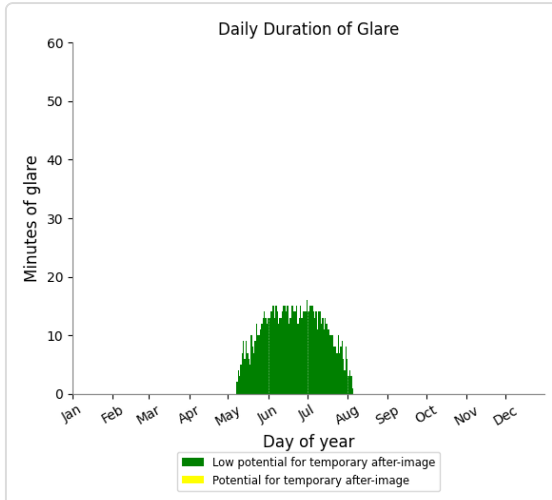
PV array and 1-ATCT

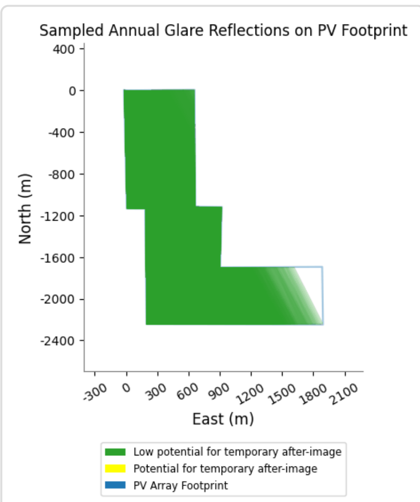
Receptor type: Observation Point

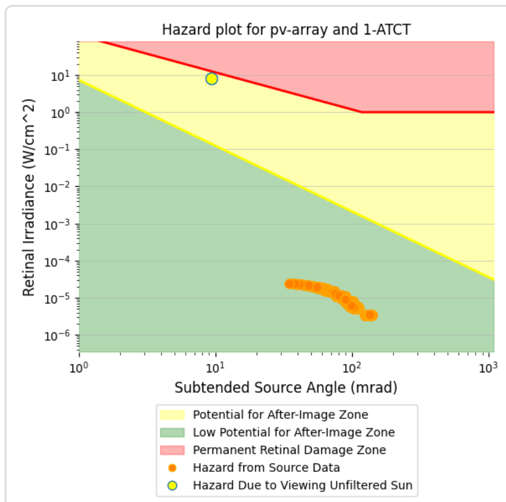
0 minutes of yellow glare

979 minutes of green glare









Assumptions

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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.
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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

FORGESOLAR GLARE ANALYSIS

Project: **Sansol**
Site configuration: **Original-temp-14**

Client: Acciona

Created 18 May, 2022
Updated 18 May, 2022
Time-step 1 minute
Timezone offset UTC2
Site ID 69271.12207
Category 100 MW to 1 GW
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
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
	°	°	min	hr	min	hr	kWh
PV array	SA tracking	SA tracking	4,578	76.3	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	3,345	55.8	0	0.0
1-ATCT	1,233	20.6	0	0.0

Component Data

PV Arrays

Name: PV array
Axis tracking: Single-axis rotation
Backtracking: Instant
Tracking axis orientation: 0.0°
Tracking axis tilt: 0.0°
Tracking axis panel offset: 0.0°
Max tracking angle: 55.0°
Resting angle: 0.0°
Rated power: -
Panel material: Deeply textured glass
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
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8	-27.582427	22.942652	1140.25	2.50	1142.75
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Flight Path Receptors

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Description:
Threshold height: 15 m
Direction: 154.0°
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	-27.637172	22.993009	1167.25	15.00	1182.25
Two-mile	-27.611186	22.978685	1156.11	194.82	1350.93

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Description:
Threshold height: 15 m
Direction: 334.0°
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	-27.655499	23.003189	1179.25	15.00	1194.25
Two-mile	-27.681486	23.017515	1199.91	163.02	1362.94

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	-27.649551	22.997970	1175.04	15.00

Map image of 1-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	SA tracking	SA tracking	4,578	76.3	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	3,345	55.8	0	0.0
1-ATCT	1,233	20.6	0	0.0

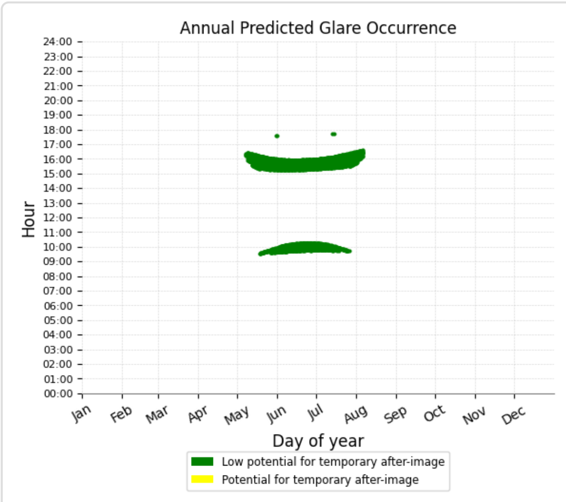
PV: PV array **low potential for temporary after-image**

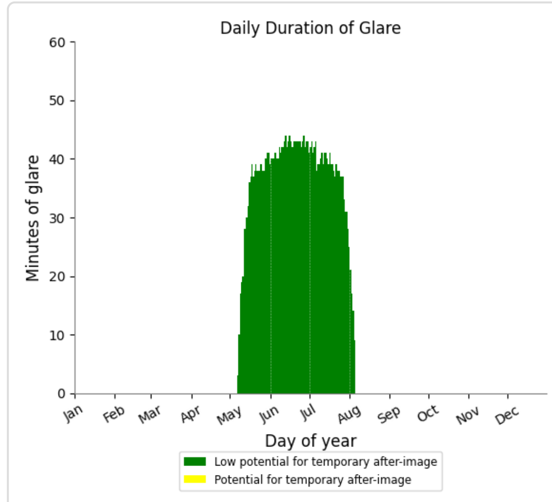
Receptor results ordered by category of glare

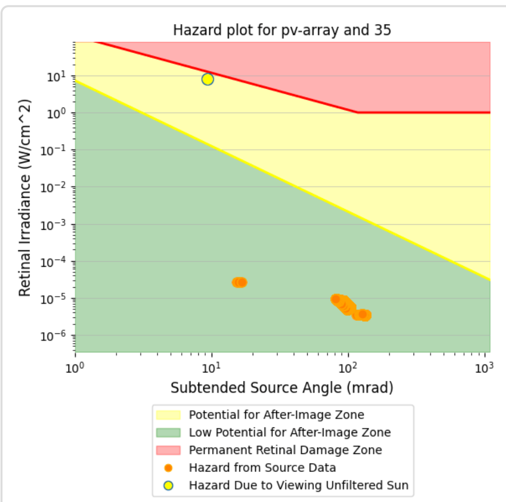
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
35	3,345	55.8	0	0.0
17	0	0.0	0	0.0
1-ATCT	1,233	20.6	0	0.0

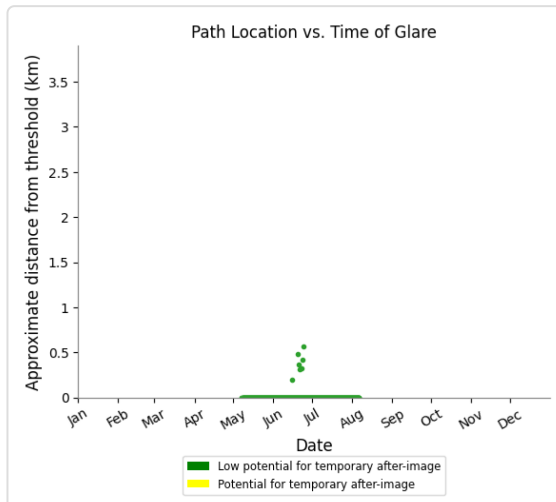
PV array and 35

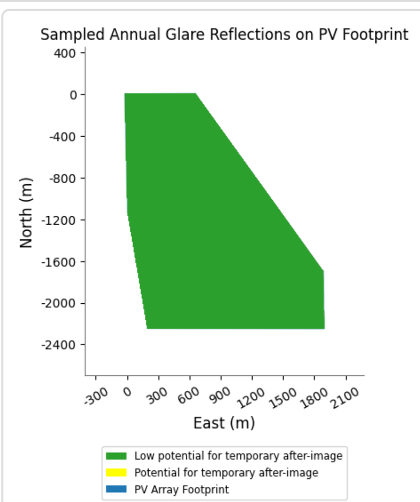
Receptor type: 2-mile Flight Path
0 minutes of yellow glare
3,345 minutes of green glare

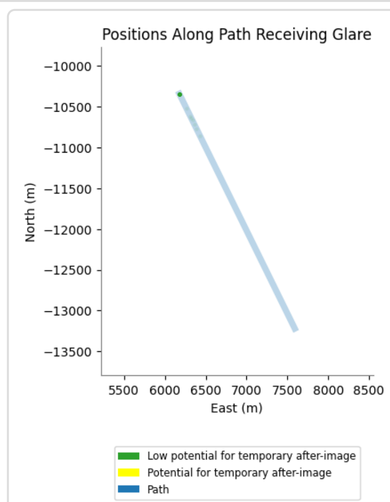












ForgeSolar

PV array and 17

Receptor type: 2-mile Flight Path

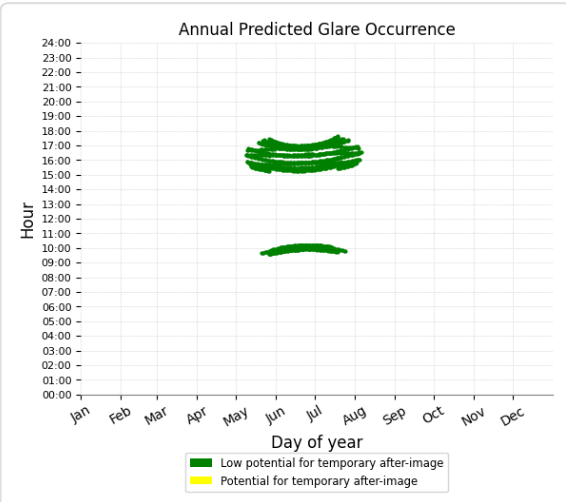
No glare found

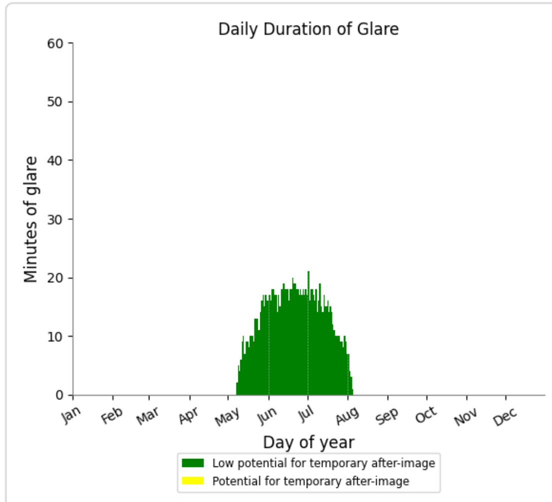
PV array and 1-ATCT

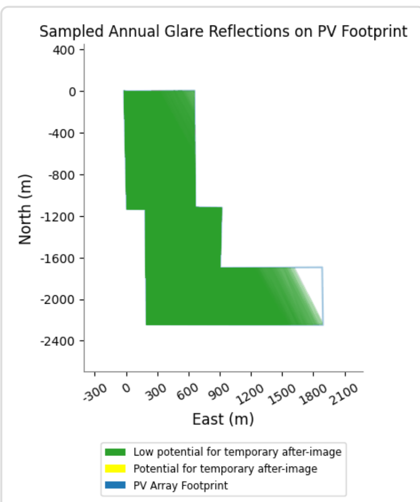
Receptor type: Observation Point

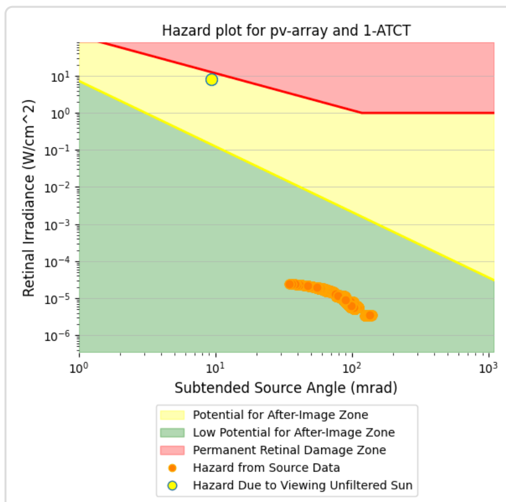
0 minutes of yellow glare

1,233 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.
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 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

FORGESOLAR GLARE ANALYSIS

Project: **Sansol**
Site configuration: **Original-temp-15**

Client: Acciona

Created 18 May, 2022
Updated 18 May, 2022
Time-step 1 minute
Timezone offset UTC2
Site ID 69272.12207
Category 100 MW to 1 GW
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
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
	°	°	min	hr	min	hr	kWh
PV array	SA tracking	SA tracking	5,136	85.6	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	3,345	55.8	0	0.0
1-ATCT	1,791	29.9	0	0.0

Component Data

PV Arrays

Name: PV array
Axis tracking: Single-axis rotation
Backtracking: Instant
Tracking axis orientation: 0.0°
Tracking axis tilt: 0.0°
Tracking axis panel offset: 0.0°
Max tracking angle: 55.0°
Resting angle: 0.0°
Rated power: -
Panel material: Deeply textured glass
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-27.562174	22.940655	1134.77	2.50	1137.27
2	-27.562136	22.947328	1137.47	2.50	1139.97
3	-27.572242	22.947407	1139.75	2.50	1142.25
4	-27.572280	22.949982	1140.75	2.50	1143.25
5	-27.577504	22.949824	1141.26	2.50	1143.76
6	-27.577466	22.959737	1144.54	2.50	1147.04
7	-27.582465	22.959818	1145.27	2.50	1147.77
8	-27.582427	22.942652	1140.25	2.50	1142.75
9	-27.572430	22.942512	1138.25	2.50	1140.75
10	-27.572418	22.940728	1137.75	2.50	1140.25
11	-27.562146	22.940456	1134.75	2.50	1137.25

Flight Path Receptors

Name: 17
Description:
Threshold height: 15 m
Direction: 154.0°
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	-27.637172	22.993009	1167.25	15.00	1182.25
Two-mile	-27.611186	22.978685	1156.11	194.82	1350.93

Name: 35
Description:
Threshold height: 15 m
Direction: 334.0°
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	-27.655499	23.003189	1179.25	15.00	1194.25
Two-mile	-27.681486	23.017515	1199.91	163.02	1362.94

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	-27.649551	22.997970	1175.04	25.00

Map image of 1-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	SA tracking	SA tracking	5,136	85.6	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	3,345	55.8	0	0.0
1-ATCT	1,791	29.9	0	0.0

PV: PV array low potential for temporary after-image

Receptor results ordered by category of glare

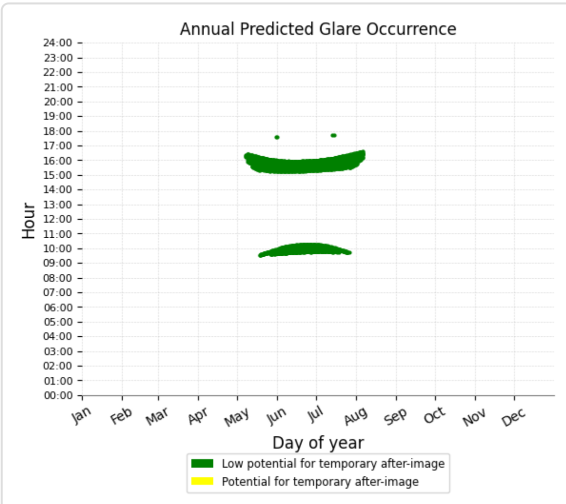
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
35	3,345	55.8	0	0.0
17	0	0.0	0	0.0
1-ATCT	1,791	29.9	0	0.0

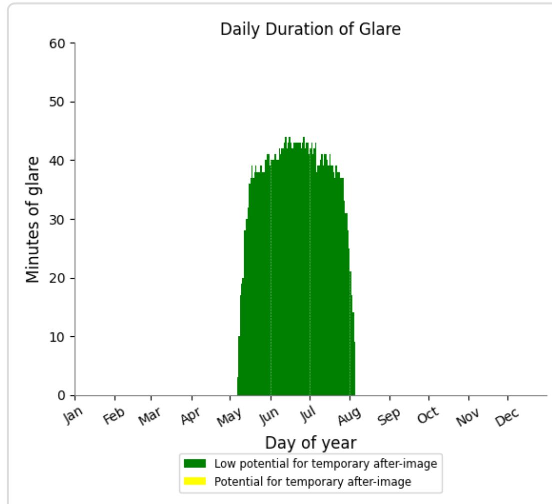
PV array and 35

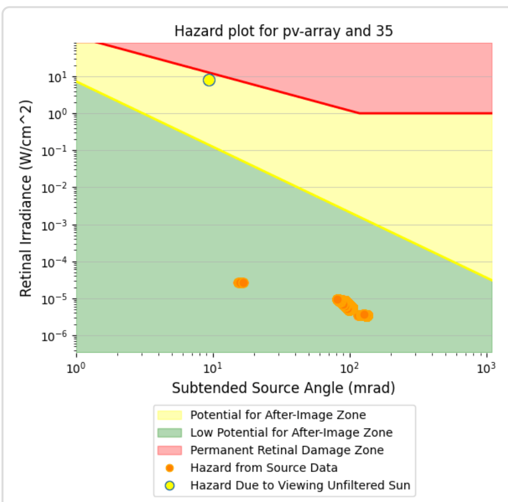
Receptor type: 2-mile Flight Path

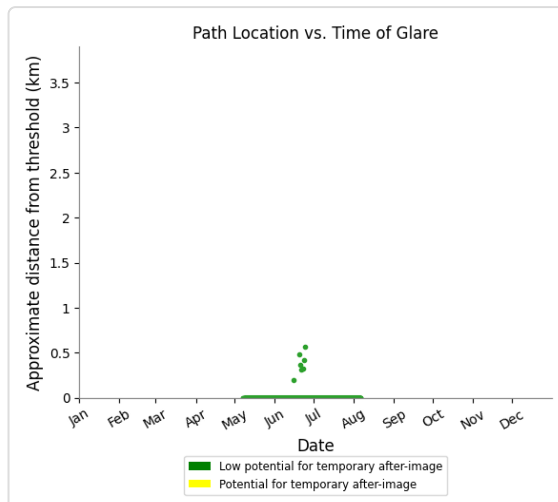
0 minutes of yellow glare

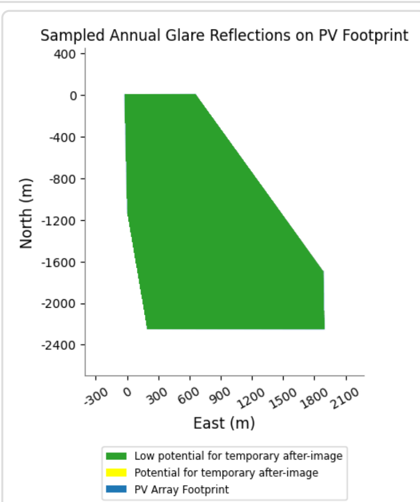
3,345 minutes of green glare

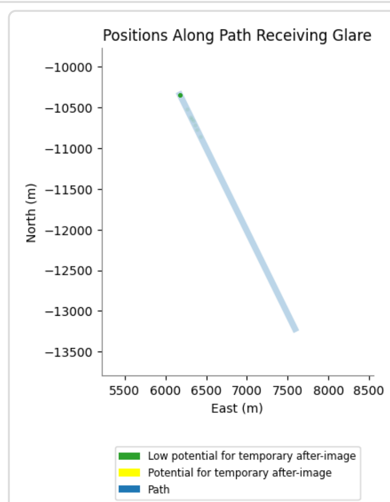












PV array and 17

Receptor type: 2-mile Flight Path

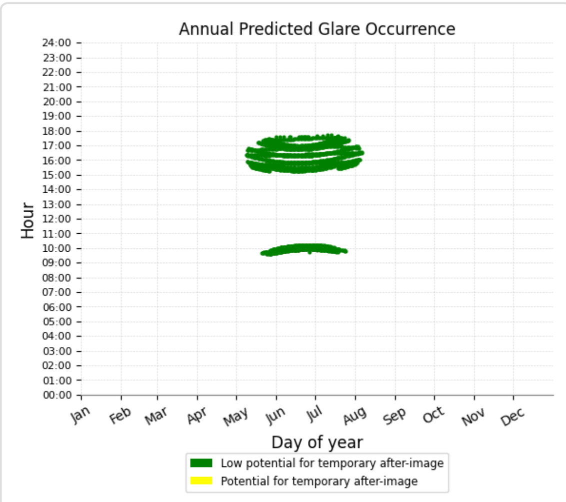
No glare found

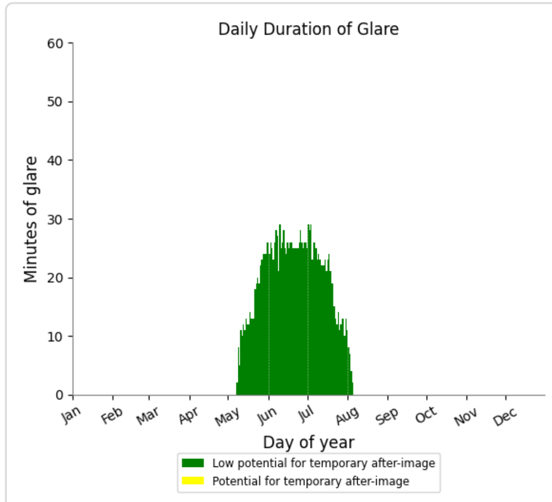
PV array and 1-ATCT

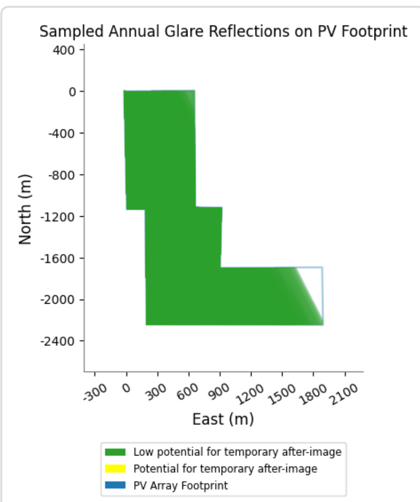
Receptor type: Observation Point

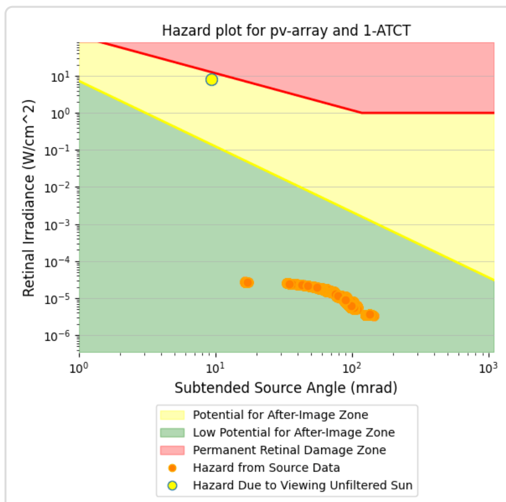
0 minutes of yellow glare

1,791 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.
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 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

FORGESOLAR GLARE ANALYSIS

Project: **Sansol**
Site configuration: **Original-temp-16**

Client: Acciona

Created 18 May, 2022
Updated 18 May, 2022
Time-step 1 minute
Timezone offset UTC2
Site ID 69273.12207
Category 100 MW to 1 GW
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
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
	°	°	min	hr	min	hr	kWh
PV array	SA tracking	SA tracking	1,537	25.6	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	1,206	20.1	0	0.0
1-ATCT	331	5.5	0	0.0

Component Data

PV Arrays

Name: PV array
Axis tracking: Single-axis rotation
Backtracking: None
Tracking axis orientation: 0.0°
Tracking axis tilt: 0.0°
Tracking axis panel offset: 0.0°
Max tracking angle: 55.0°
Rated power: -
Panel material: Deeply textured glass
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-27.562174	22.940655	1134.77	2.50	1137.27
2	-27.562136	22.947328	1137.47	2.50	1139.97
3	-27.572242	22.947407	1139.75	2.50	1142.25
4	-27.572280	22.949982	1140.75	2.50	1143.25
5	-27.577504	22.949824	1141.26	2.50	1143.76
6	-27.577466	22.959737	1144.54	2.50	1147.04
7	-27.582465	22.959818	1145.27	2.50	1147.77
8	-27.582427	22.942652	1140.25	2.50	1142.75
9	-27.572430	22.942512	1138.25	2.50	1140.75
10	-27.572418	22.940728	1137.75	2.50	1140.25
11	-27.562146	22.940456	1134.75	2.50	1137.25

Flight Path Receptors

Name: 17
Description:
Threshold height: 15 m
Direction: 154.0°
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	-27.637172	22.993009	1167.25	15.00	1182.25
Two-mile	-27.611186	22.978685	1156.11	194.82	1350.93

Name: 35
Description:
Threshold height: 15 m
Direction: 334.0°
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	-27.655499	23.003189	1179.25	15.00	1194.25
Two-mile	-27.681486	23.017515	1199.91	163.02	1362.94

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	-27.649551	22.997970	1175.04	10.00

Map image of 1-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	SA tracking	SA tracking	1,537	25.6	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	1,206	20.1	0	0.0
1-ATCT	331	5.5	0	0.0

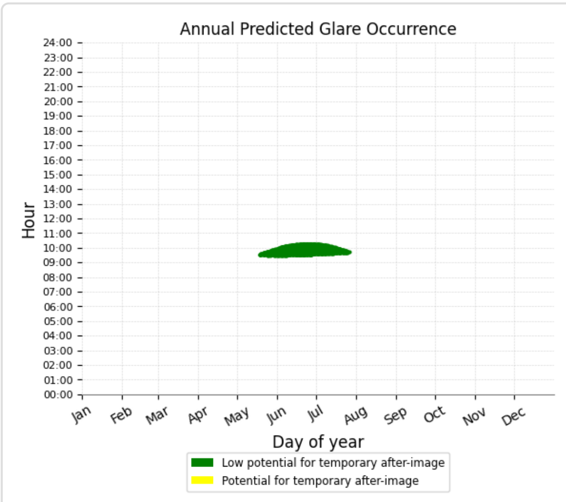
PV: PV array low potential for temporary after-image

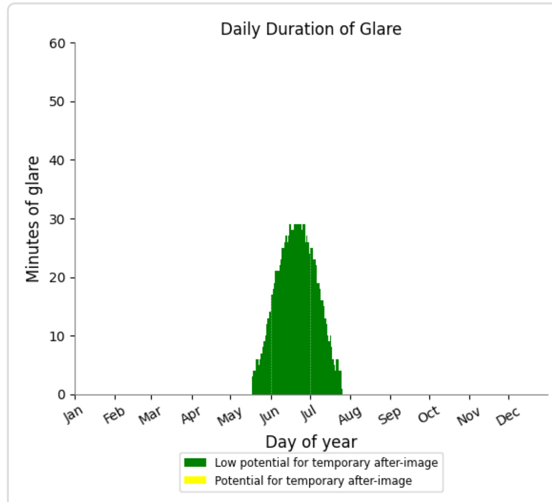
Receptor results ordered by category of glare

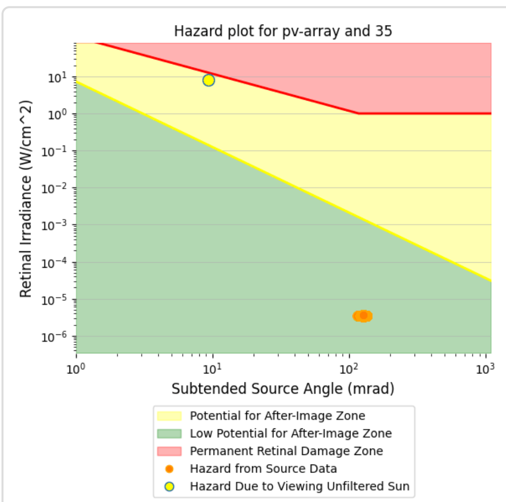
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
35	1,206	20.1	0	0.0
17	0	0.0	0	0.0
1-ATCT	331	5.5	0	0.0

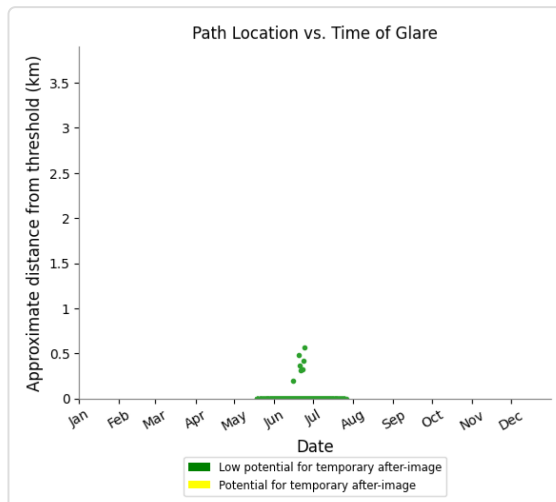
PV array and 35

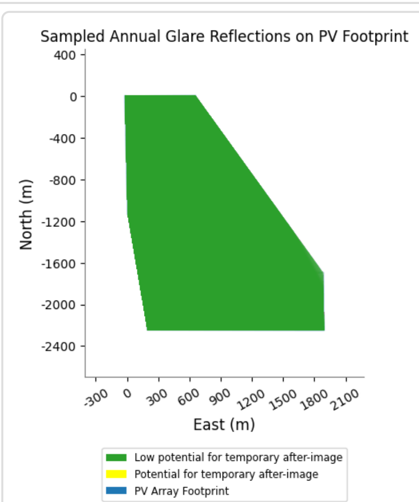
Receptor type: 2-mile Flight Path
0 minutes of yellow glare
1,206 minutes of green glare

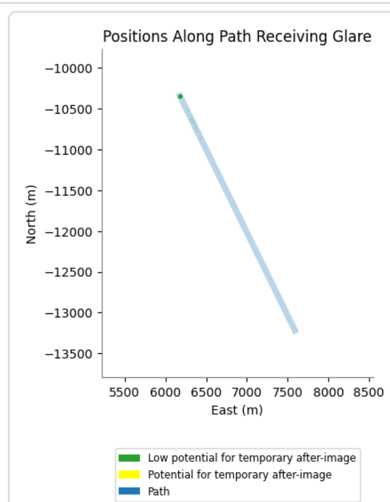












PV array and 17

Receptor type: 2-mile Flight Path

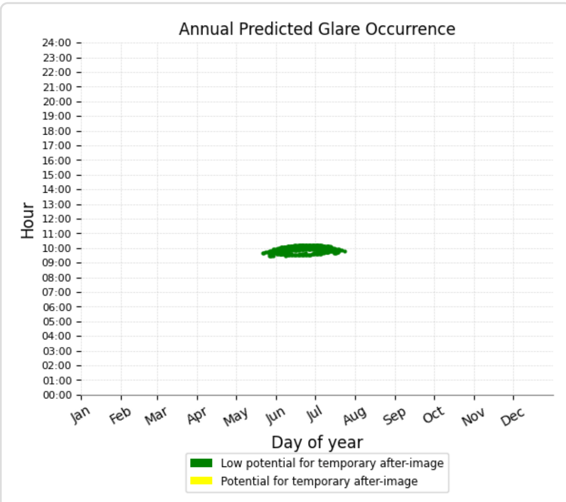
No glare found

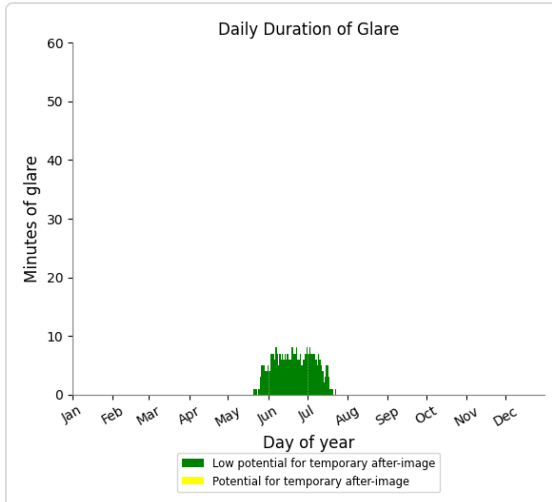
PV array and 1-ATCT

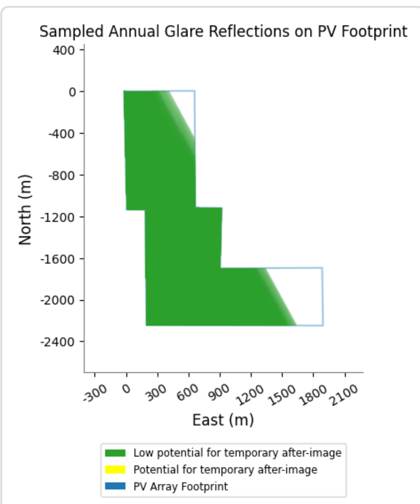
Receptor type: Observation Point

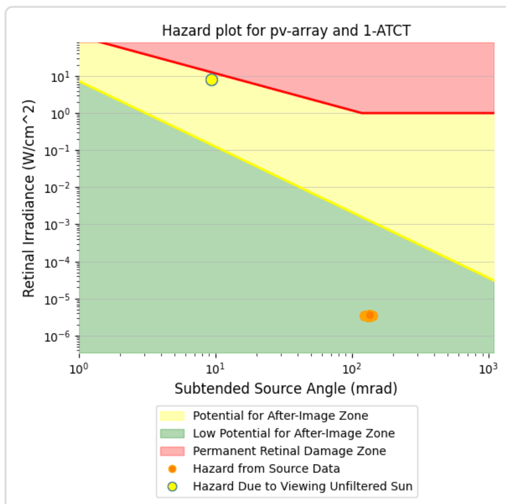
0 minutes of yellow glare

331 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.
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 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

FORGESOLAR GLARE ANALYSIS

Project: **Sansol**
Site configuration: **Original-temp-17**

Client: Acciona

Created 18 May, 2022
Updated 18 May, 2022
Time-step 1 minute
Timezone offset UTC2
Site ID 69274.12207
Category 100 MW to 1 GW
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
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
	°	°	min	hr	min	hr	kWh
PV array	SA tracking	SA tracking	1,621	27.0	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	1,206	20.1	0	0.0
1-ATCT	415	6.9	0	0.0

Component Data

PV Arrays

Name: PV array
Axis tracking: Single-axis rotation
Backtracking: None
Tracking axis orientation: 0.0°
Tracking axis tilt: 0.0°
Tracking axis panel offset: 0.0°
Max tracking angle: 55.0°
Rated power: -
Panel material: Deeply textured glass
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-27.562174	22.940655	1134.77	2.50	1137.27
2	-27.562136	22.947328	1137.47	2.50	1139.97
3	-27.572242	22.947407	1139.75	2.50	1142.25
4	-27.572280	22.949982	1140.75	2.50	1143.25
5	-27.577504	22.949824	1141.26	2.50	1143.76
6	-27.577466	22.959737	1144.54	2.50	1147.04
7	-27.582465	22.959818	1145.27	2.50	1147.77
8	-27.582427	22.942652	1140.25	2.50	1142.75
9	-27.572430	22.942512	1138.25	2.50	1140.75
10	-27.572418	22.940728	1137.75	2.50	1140.25
11	-27.562146	22.940456	1134.75	2.50	1137.25

Flight Path Receptors

Name: 17
Description:
Threshold height: 15 m
Direction: 154.0°
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	-27.637172	22.993009	1167.25	15.00	1182.25
Two-mile	-27.611186	22.978685	1156.11	194.82	1350.93

Name: 35
Description:
Threshold height: 15 m
Direction: 334.0°
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	-27.655499	23.003189	1179.25	15.00	1194.25
Two-mile	-27.681486	23.017515	1199.91	163.02	1362.94

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	-27.649551	22.997970	1175.04	15.00

Map image of 1-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	SA tracking	SA tracking	1,621	27.0	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	1,206	20.1	0	0.0
1-ATCT	415	6.9	0	0.0

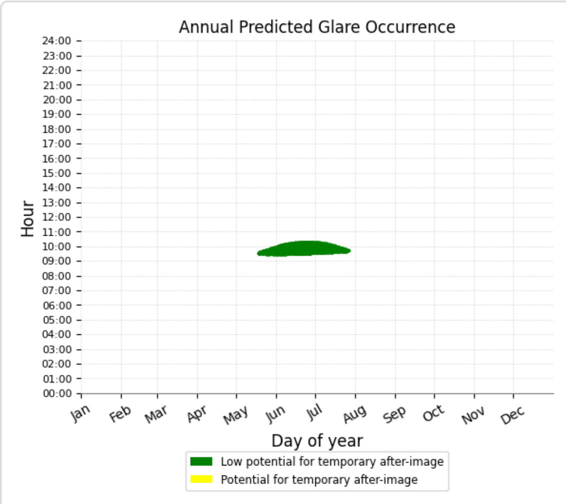
PV: PV array low potential for temporary after-image

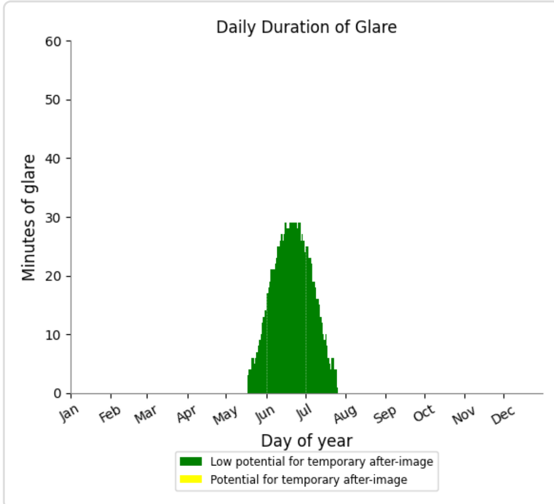
Receptor results ordered by category of glare

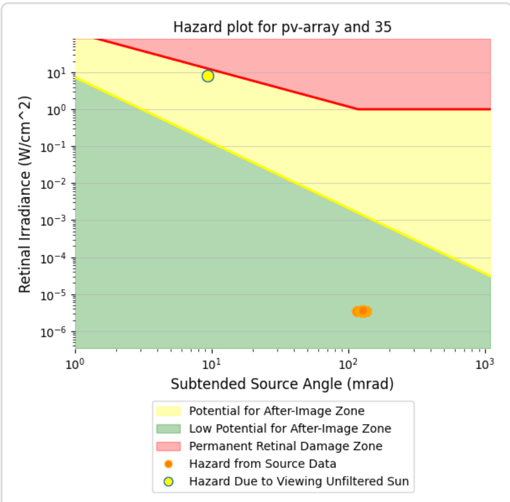
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
35	1,206	20.1	0	0.0
17	0	0.0	0	0.0
1-ATCT	415	6.9	0	0.0

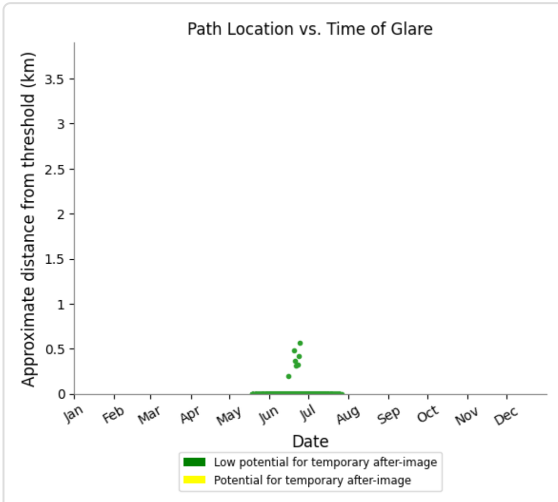
PV array and 35

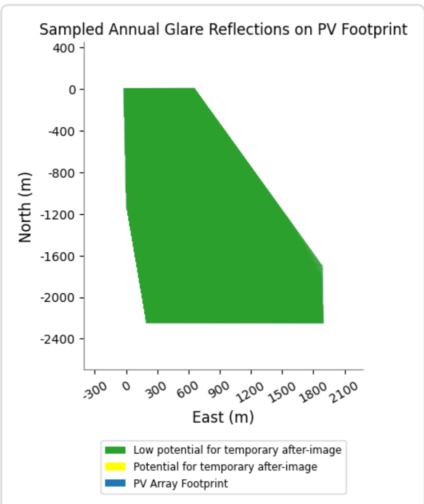
Receptor type: 2-mile Flight Path
0 minutes of yellow glare
1,206 minutes of green glare

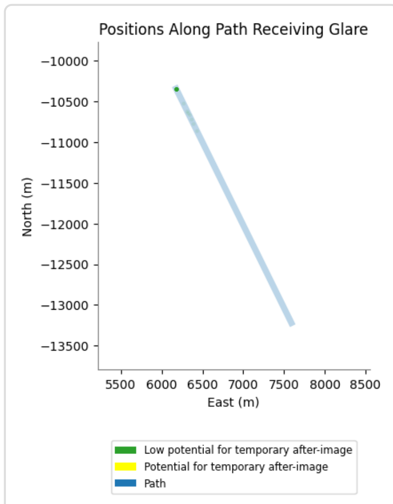












PV array and 17

Receptor type: 2-mile Flight Path

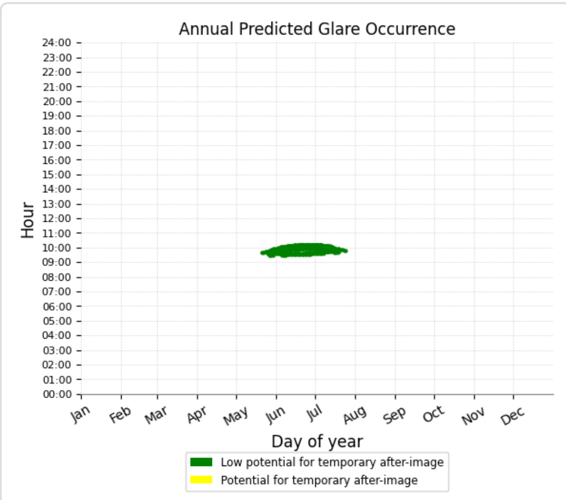
No glare found

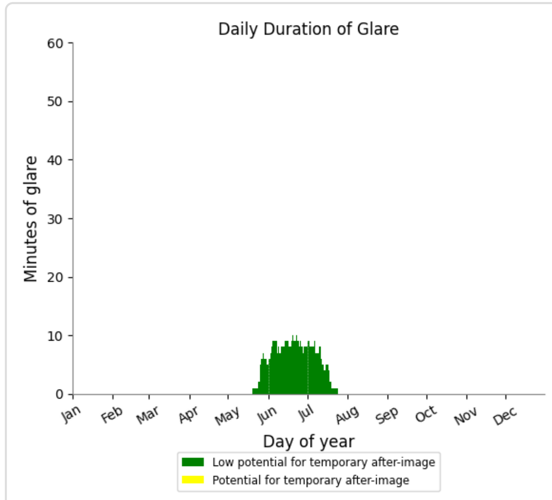
PV array and 1-ATCT

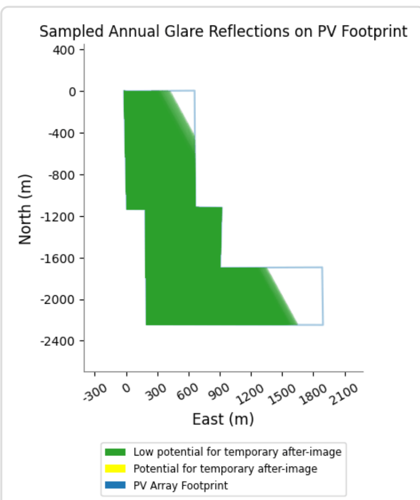
Receptor type: Observation Point

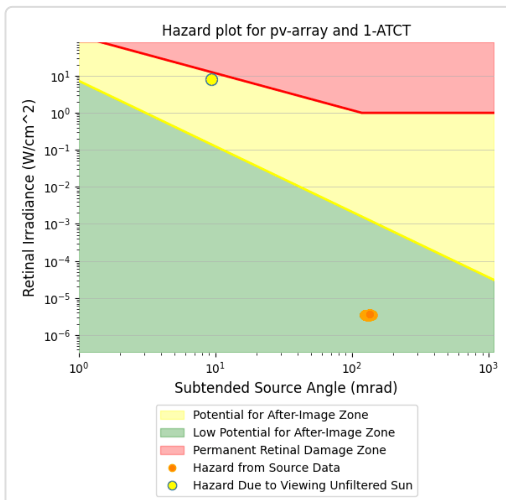
0 minutes of yellow glare

415 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.
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.
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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.
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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.)
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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

FORGESOLAR GLARE ANALYSIS

Project: **Sansol**
Site configuration: **Original-temp-18**

Client: Acciona

Created 18 May, 2022
Updated 18 May, 2022
Time-step 1 minute
Timezone offset UTC2
Site ID 69275.12207
Category 100 MW to 1 GW
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
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
	°	°	min	hr	min	hr	kWh
PV array	SA tracking	SA tracking	1,793	29.9	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	1,206	20.1	0	0.0
1-ATCT	587	9.8	0	0.0

Component Data

PV Arrays

Name: PV array
Axis tracking: Single-axis rotation
Backtracking: None
Tracking axis orientation: 0.0°
Tracking axis tilt: 0.0°
Tracking axis panel offset: 0.0°
Max tracking angle: 55.0°
Rated power: -
Panel material: Deeply textured glass
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-27.562174	22.940655	1134.77	2.50	1137.27
2	-27.562136	22.947328	1137.47	2.50	1139.97
3	-27.572242	22.947407	1139.75	2.50	1142.25
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8	-27.582427	22.942652	1140.25	2.50	1142.75
9	-27.572430	22.942512	1138.25	2.50	1140.75
10	-27.572418	22.940728	1137.75	2.50	1140.25
11	-27.562146	22.940456	1134.75	2.50	1137.25

Flight Path Receptors

Name: 17
Description:
Threshold height: 15 m
Direction: 154.0°
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	-27.637172	22.993009	1167.25	15.00	1182.25
Two-mile	-27.611186	22.978685	1156.11	194.82	1350.93

Name: 35
Description:
Threshold height: 15 m
Direction: 334.0°
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	-27.655499	23.003189	1179.25	15.00	1194.25
Two-mile	-27.681486	23.017515	1199.91	163.02	1362.94

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	-27.649551	22.997970	1175.04	25.00

Map image of 1-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	SA tracking	SA tracking	1,793	29.9	0	0.0	-

Total annual 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
17	0	0.0	0	0.0
35	1,206	20.1	0	0.0
1-ATCT	587	9.8	0	0.0

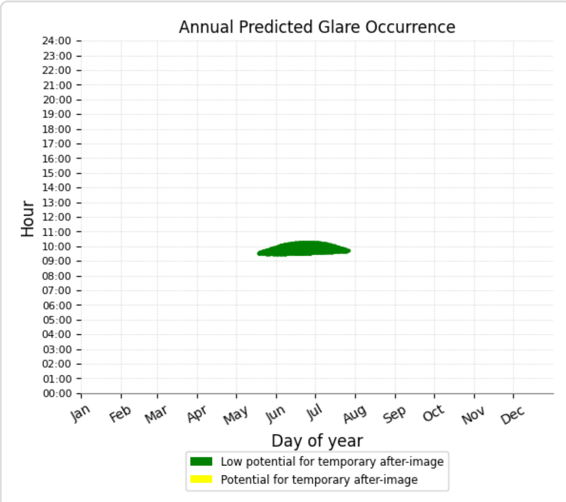
PV: PV array low potential for temporary after-image

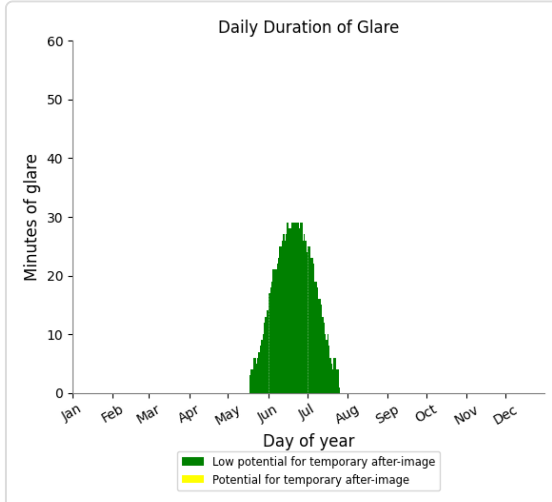
Receptor results ordered by category of glare

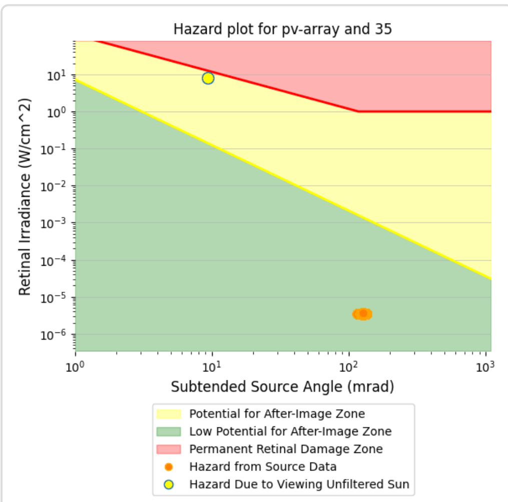
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
35	1,206	20.1	0	0.0
17	0	0.0	0	0.0
1-ATCT	587	9.8	0	0.0

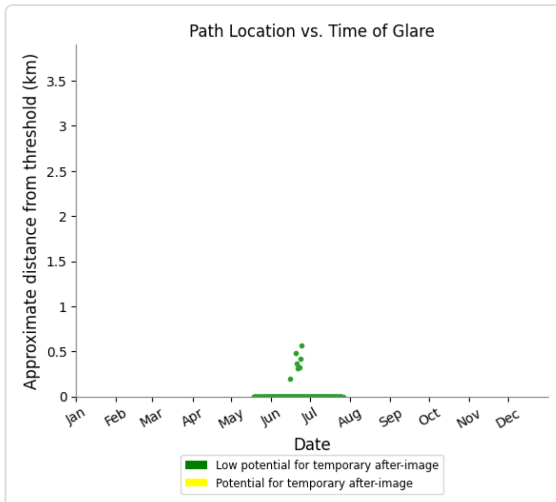
PV array and 35

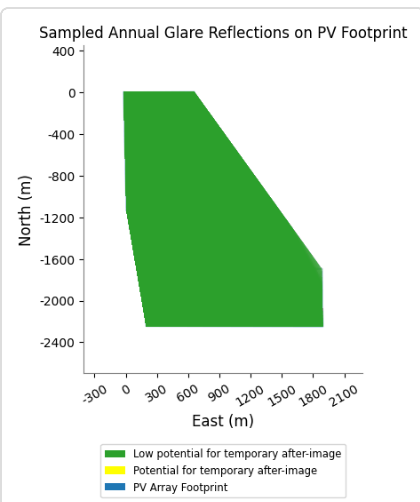
Receptor type: 2-mile Flight Path
0 minutes of yellow glare
1,206 minutes of green glare

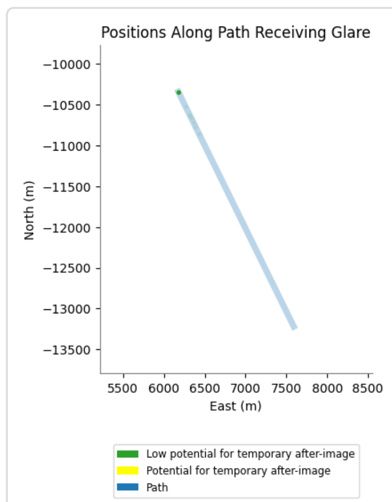












PV array and 17

Receptor type: 2-mile Flight Path

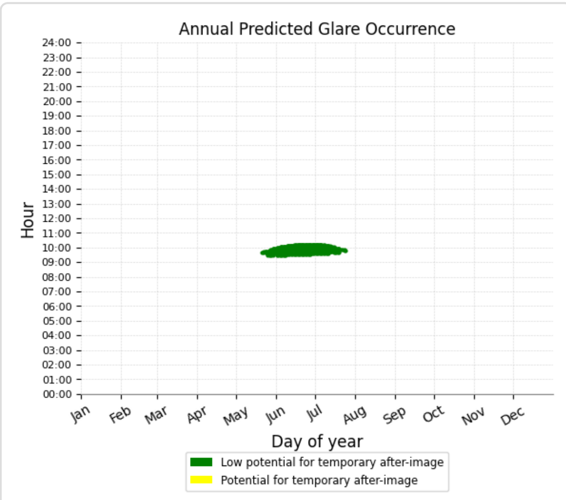
No glare found

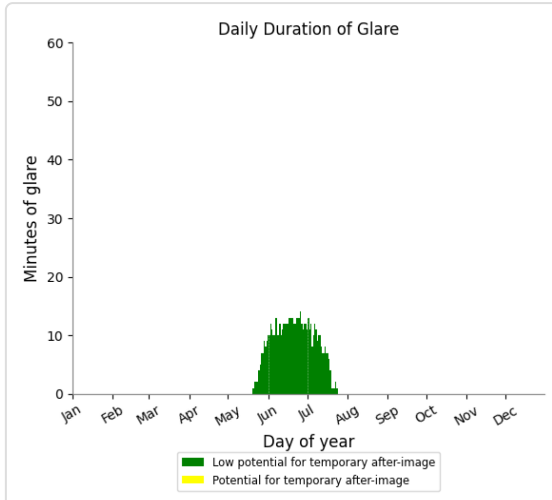
PV array and 1-ATCT

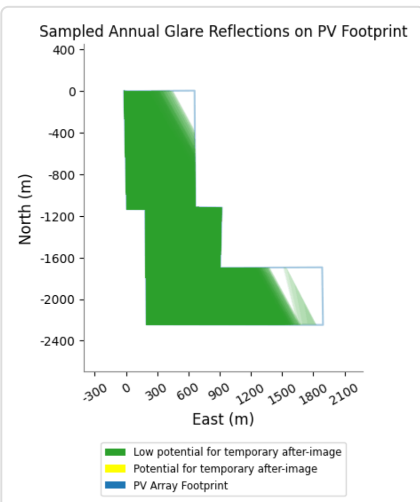
Receptor type: Observation Point

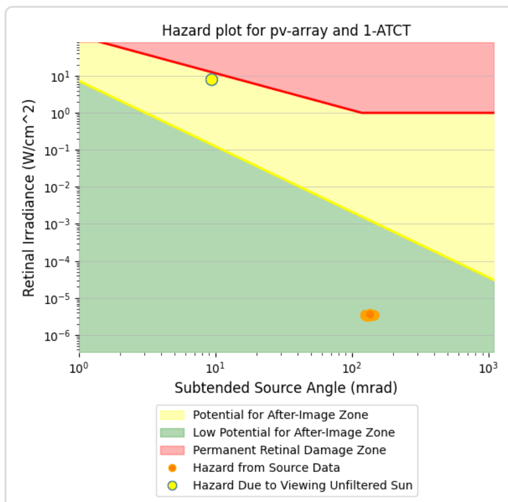
0 minutes of yellow glare

587 minutes of green glare









Assumptions

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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.

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- 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