ENVIRONMENTAL ETHOS

GREENTECH SOLAR PROJECT NO. 3

GLINT AND GLARE ASSESSMENT REPORT
FINAL ISSUE

Prepared For
ACENERGY PTY LTD

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for ACEnergy Pty Ltd

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EXECUTIVE SUMMARY

This glint and glare impact assessment utilised the Solar Glare Hazard Analysis Tool (SGHAT 3.0) in conjunction with a viewshed analysis, to prepare the glint and glare modelling which is the basis for the desktop based impact assessment methodology. The assessment considered dwellings and transport routes within 2km of the Project.

The closet airport to the Project site is Griffith Airport, approximately 34km to the south east. These facilities are outside the viewshed of the Project, and not considered 'close' enough to be affected by the Project. Therefore flight paths were not included in this glare assessment.

A small airstrip is located approximately 2km to the south of the Project, adjoining the existing feedlot. Flight paths for this facility were included in the assessment.

Based on the assumptions and parameters of this desktop assessment, the following results were identified:

- The SGHAT modelling identified no glare is geometrically possible affecting rural dwellings within 2km of the Project, therefore no impact is likely.
- The SGHAT modelling identified no glare is geometrically possible affecting local roads within 2km of the Project, therefore no impact is likely.
- The SGHAT modelling identified no glare is geometrically possible affecting the local airstrip to the south of the Project, therefore no impact is likely.

1. INTRODUCTION

This report has been prepared by Environmental Ethos on behalf of ACEnergy Pty Ltd to assess the potential solar glint and glare impact of the proposed Greentech Solar Farm No.3, located near Tabbita, NSW. The Project comprises of the installation and operation of an approximate 4.95MWac solar farm.

The Project site is currently located over part of Lot 5 DP1210276, the footprint of the solar farm covers an area of approximately 16.5 hectares (ha). The PV arrays will run north/south and will be mounted on a single axis horizontal tracking system. The solar panels, including the mounting structures, will be a maximum height of approximately 1.4 metres to centroid.

1.1. Location

The Project site is located approximately 9.6 kilometres west of Tabbita, and 33km north west of Griffith, *refer Figure 1.* The site is zoned RU1 Rural Zone and is currently used for cropping. Farming is the predominant land use within the area.

Figure 1. Location Plan

The closet airport to the Project site is Griffith Airport, approximately 34km to the south east. These facilities are outside the viewshed of the Project, and not considered 'close' enough to be affected by the Project. Therefore flight paths were not included in this glare assessment.

A small airstrip is located approximately 2km to the south of the Project, adjoining the existing feedlot. Flight paths for this facility were included in the assessment.

2. SCOPE OF THE ASSESSMENT

The scope of this glint and glare impact assessment includes the following:

- Description of the methodology used to undertake the study;
- Assessment of the baseline conditions;
- Description of the elements of the Project with the potential to influence glint and glare including size, height, and angle of PV modules, the type of framing system, as well as operational considerations for the tracking system;
- Identification of the viewshed and potential visibility of the Project;
- Desktop mapping of potential glint and glare at the location of sensitive receptors within the viewshed, based on Solar Glare Hazard Analysis and viewshed analysis;
- Assessment of the likely hazard of glint and glare on sensitive receptors during operation of the Project; and
- Assessment of potential mitigations measures to avoid, mitigate, or manage potential impacts.

3. METHODOLOGY

3.1. Glint and Glare Definitions

Glint and glare refers to the human experience of reflected light.

This study utilises Solar Glare Hazard Analysis software developed in the USA to address policy adherence required for the 2013 U.S. Federal Aviation Administration (FAA) Interim Policy 78 FR 63276. The FAA definitions of glint and glare are as follows:

"Reflectivity refers to light that is reflected off surfaces. The potential effects of reflectivity are glint (a momentary flash of bright light) and glare (a continuous source of bright light). These two effects are referred to hereinafter as "glare," which can cause a brief loss of vision, also known as flash blindness."[1]

The FAA Technical Guidelines distinguishes between glint and glare according to time duration, without correlation to light intensity.

For the purpose of this study the term 'glare' is used in reference to the more intense light impact of direct solar reflectivity from PV modules over potentially long duration, such as from a stationary fixed frame solar systems, or relatively slow moving solar tracking systems (consistent with terminology used by Solar Glare Hazard Analysis software based on FAA Guidelines).

3.2. Glare Assessment Parameters

Glare assessment modelling for solar farms is based on the following factors:

- the tilt, orientation, and optical properties of the PV modules in the solar array;
- sun position over time, taking into account geographic location;
- the location of sensitive receptors (viewers); and

[1] Federal Aviation Administration, Version 1.1 April 2018, Technical Guidance for Evaluating Selected Solar Technologies on Airports

- Screening potential of surrounding topography and vegetation.

3.3. Glare Intensity Categories

The potential hazard from solar glare is a function of retinal irradiance (power of electromagnetic radiation per unit area produced by the sun) and the subtended angle (size and distance) of the glare source.[2]

Glare can be broadly classified into three categories: low potential for after-image, potential for after-image, and potential for permanent eye damage, *Figure 2* illustrates the glare intensity categories used in this study.

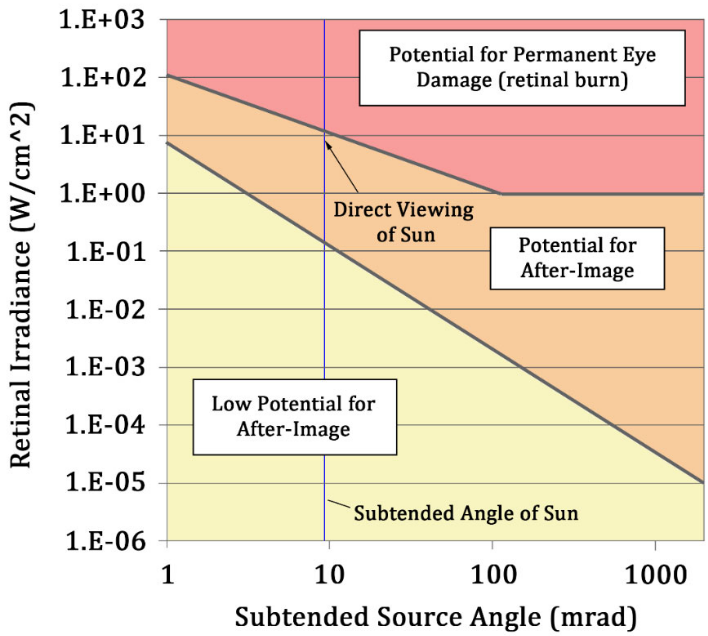


Figure 2. Ocular impacts and Hazard Ranges[3]

The amount of light reflected from a PV module depends on the amount of sunlight hitting the surface, as well as the surface reflectivity. The amount of sunlight interacting with the PV module will vary based on geographic location, time of year, cloud cover, and PV module orientation. 1000W/m^2 is generally used in most counties as an estimate of the solar energy interacting with a PV module when no other information is available. This study modelled scenarios using 2000 W/m^2 in order to cover potentially higher solar energy levels in Australia as compared to other parts of the world. Flash blindness for a period of 4-12 seconds (i.e. time to recovery of vision) occurs when 7-11 W/m^2 (or 650-1,100 lumens/m^2) reaches the eye[4].

[2] HO, C.K., C.M. Ghanbari, and R.B. Diver, 2011, Methodology to Assess Potential Glint and Glare hazards from Concentrated Solar Power Plants
[3] Source: Solar Glare Hazard Analysis Tool (SGHAT) Presentation (2013) https://share.sandia.gov/phlux/static/references/glint-glare/SGHAT_Ho.pdf
[4] Sandia National Laboratory, SGHAT Technical Manual

3.4. Reflection and Angle of Incidence

PV modules are designed to maximise the absorption of solar energy and therefore minimise the extent of solar energy reflected. PV modules have low levels of reflectivity between 0.03 and 0.20 depending on the specific materials, anti-reflective coatings, and angle of incidence.[5]

The higher reflectivity values of 0.20, that is 20% of incident light being reflected, can occur when the angle of incidence is greater than 50°. *Figure 3 and 4* show the relationship between increased angles of incidence and increased levels of reflected light. Where the angle of incidence remains below 50° the amount of reflected light remains below 10%. The angle of incidence is particularly relevant to specular reflection (light reflection from a smooth surface). Diffuse reflection (light reflection from a rough surface) may also occur in PV modules, however diffuse reflection scatters light and is much less intense than direct reflection.

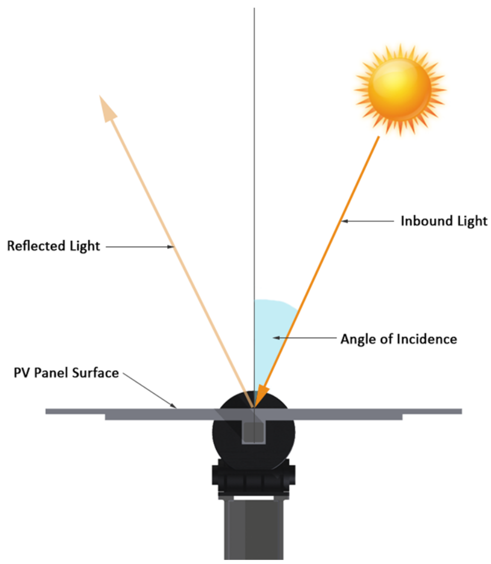


Figure 3. Angle of Incidence Relative to PV Panel Surface

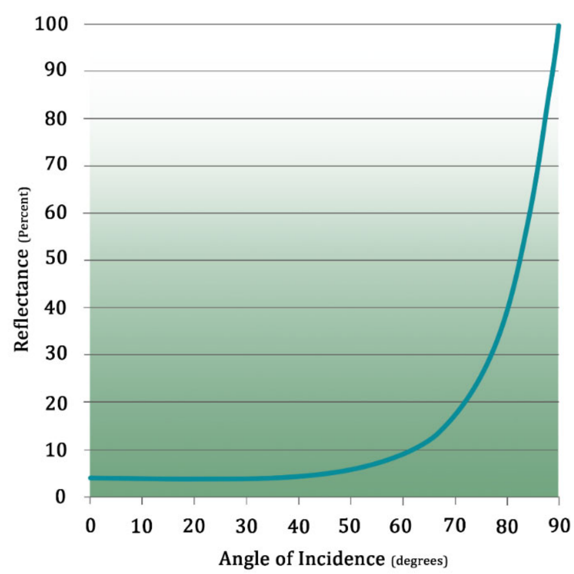


Figure 4. Angles of Incidence and Increased Levels of Reflected Light (Glass (n-1.5))

A single axis tracking system is designed to rotate the PV arrays and maintain a perpendicular angle relative to the sun. Therefore during the tracking phase low angles of incidence occur and the potential for glare is reduced. Once the tracking mechanism reaches its fixed maximum angle of rotation, the PV modules position relative to the sun becomes fixed and therefore the angle of incidence increases and the potential for glare increases. Some tracking systems utilise 'backtracking' to avoid PV modules over-shadowing each other. During the backtracking procedure (early morning and late afternoon) the tracking system begins to rotate away from the sun to reduce shadow casting to adjoining PV panels, *refer Figure 5*. During the backtracking phase, higher angles of incidence will occur in comparison to the tracking phase, and this may increase the potential for glare.

[5] *Ho, C. 2013 Relieving a Glare Problem*

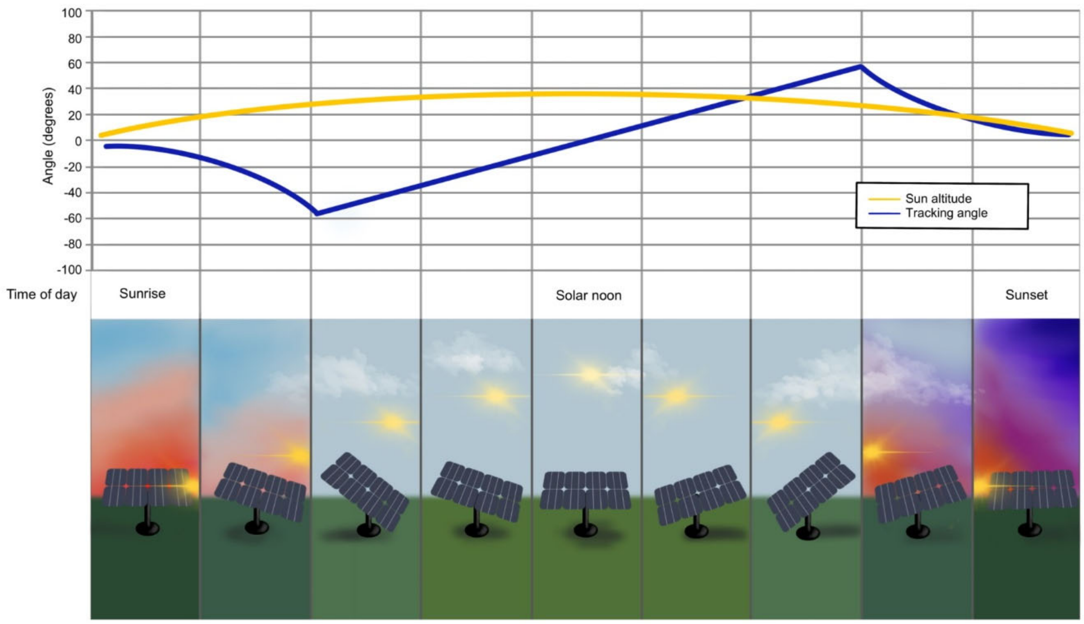


Figure 5. Diagrammatic illustration of a backtracking procedure for a horizontal single axis tracking system. (Source: ForgeSolar).

This assessment is based on a geometric analysis that considered both tracking and backtracking phases of the solar farm.

3.5. Viewshed Analysis

A desktop viewshed analysis was undertaken using ArcGIS 3D modelling. The extent of visibility of the proposed solar farm was assessed relative to the location of sensitive receptors (dwellings, roads, etc.) Sensitive receptors outside the viewshed, i.e. without line-of-sight to the Project, were not included in the glare modelling since those locations are screened by existing topography. Viewshed modelling is based on a digital terrain model and does not take into consideration the screening effect of vegetation. Sensitive receptors within the viewshed that may not have line-of sight to the Project due to intervening vegetation were included in the glare modelling, this represents a conservative analysis of the Project's potential visibility.

3.6. Solar Glare Hazard Analysis

This assessment has utilised the Solar Glare Hazard Analysis Tool (SGHAT 3.0) co-developed by Sandi National Laboratory[6] and ForgeSolar (Sim Industries) (referred to as GlareGauge) to assess potential glare utilising latitude and longitudinal coordinates, elevation, sun position, and vector calculations. The PV module orientation, reflectance environment and ocular factors are also considered by the software. If potential glare is identified by the model, the tool calculates the retinal irradiance and subtended angle (size/distance) of the glare source to predict potential ocular hazards according to the glare intensity categories (refer *Section 3.3*).

The sun position algorithm used by SGHAT calculates the sun position in two forms: first as a unit vector extending from the Cartesian origin toward the sun, and second as azimuthal and altitudinal angles. The algorithm enables determination of the sun position at one (1) minute intervals throughout the year.

[6] https://share.sandia.gov/phlux/static/references/glint-glare/SGHAT_Technical_Reference-v5.pdf

The SGHAT is a high level tool and does not take into consideration the following factors:

- Gaps between PV modules;
- Atmospheric conditions; and
- Vegetation between the solar panels and the viewer (sensitive receptor).

Backtracking

Backtracking operations are generally optimised dependent on individual project parameters including; distance between panels, width of each panel, angle of the sun, field slope angle, and local weather (wind loading).

SGHAT software includes a backtracking feature which simulates various backtracking strategies based on generic operational parameters. Backtracking options include flat or sloping terrain and the tracking data (angle/time/sun elevation) is plotted in a Component Data File. Since some of the parameters are generic, some deviate from a project specific system design may occur, however the feature provides preliminary indication of the potential for glare as a consequence of a backtracking operation.

Route Parameters

The assessment of potential glare impacts to route receptors, people travelling along roads and rail, includes the parameters of direction of travel (single or both directions) and field-of-view (FOV). FOV defines the left and right field-of-view of observers traveling along a route. A view angle of 90° means the observer has a field-of-view of 90° to their left and right, i.e. a total FOV of 180°, refer *Figure 6.*

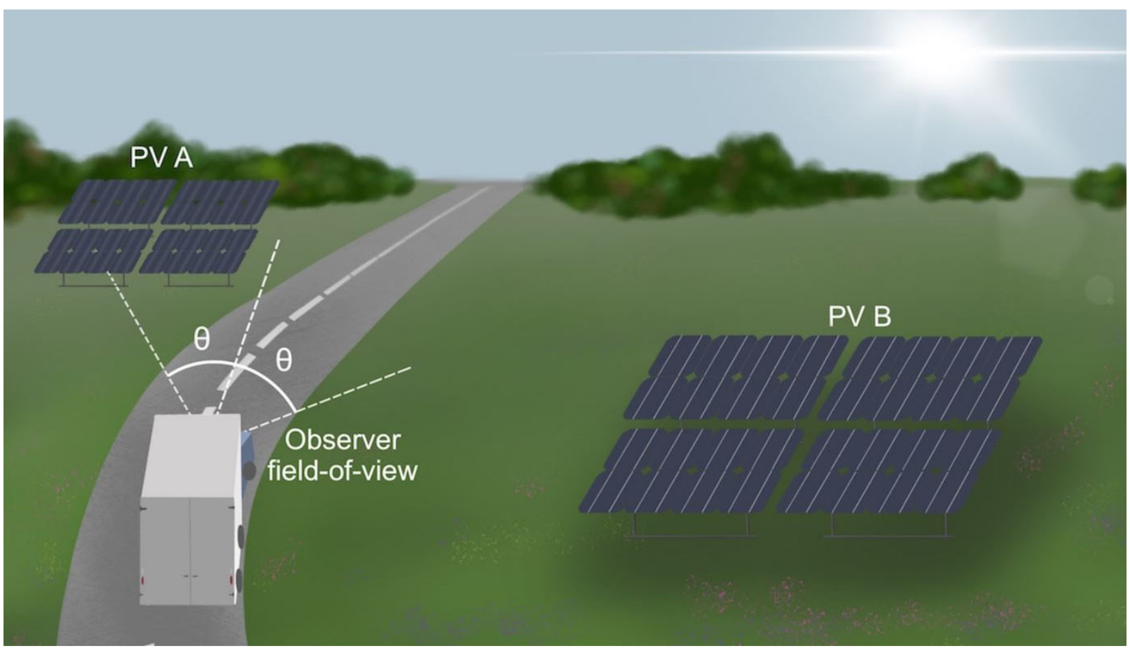


Figure 6. Diagrammatic illustration of Observer Field of View relative to PV array (source: ForgeSolar).

FAA research has identified 'impairment ratings' based on simulations of glare at various angles and duration, and the effect on a pilot's ability to fly a plane[7]. The research identified impairment was highest when the glare source was within a FOV of 25° or less. The impact of glare fell below 'slight impairment' rating when the

7 https://www.faa.gov/data_research/research/med_humanfacs/oamtechreports/2010s/media/201512.pdf

glare source was at an angle of 50° from the direction of travel. When the glare source was located at an angle of 90° the impairment rating reduced further. In relation to piloting a plane, the report noted there was no significant difference in impairment when the source of glare angle was increased from 50° to 90°. In conclusion the research noted 'these results taken together suggest that any sources of glare at an airport may be potentially mitigated if the angle of the glare is greater than 25° from the direction that the pilot is looking in'.

SGHAT default parameters is FOV 50°, this assessment increased the FOV to 90°, representing a conservative assessment of potential hazard to drivers using the road network within the vicinity of the solar farm.

Driver's eye height settings for the SGHAT model were as follows:

- Road users: standard cars are approximately 1.5m, higher vehicles such as truck are approximately 2.4m, 2.4m was used in the modelling.

Flight Path Parameters

SGHAT utilises a 2 mile flight path formula that simulates an aircraft following a straight-line approach path towards a runway, refer Figure 7.

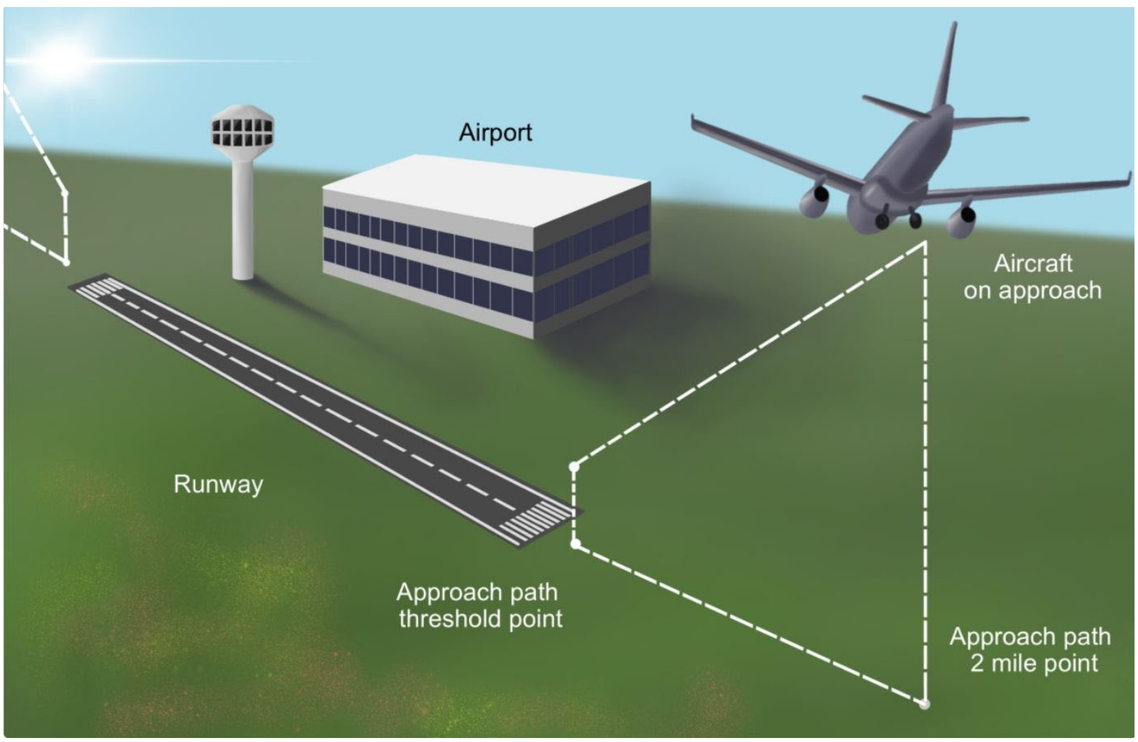


Figure 7. Diagrammatic illustration of SHGAT flight parameters (source: Forgesolar).

Airport specific flight path parameters were not available for this assessment, therefore SGHAT default parameters were used including glide slope (3^{o}) and threshold crossing height (15.24 metres).

The pilot's field of view (FOV) from the cockpit can be set within the model. The vertical FOV of the pilot, measures positive downward angles from the approach path vector. Values range from 0° to 90°, where 90° implies no downward restriction. A default value of 30° assumes glare appearing beyond the corresponding FOV is mitigated.

Azimuthal viewing angle, left and right field-of-view of the pilot during approach, range from 0° to 180°. A view angle of 180° implies the pilot can see glare emanating from behind the plane. A view angle of 50° (default) implies the pilot has a FOV of 50° to their left and right during approach, i.e. a total FOV of 100°, refer Figure8.

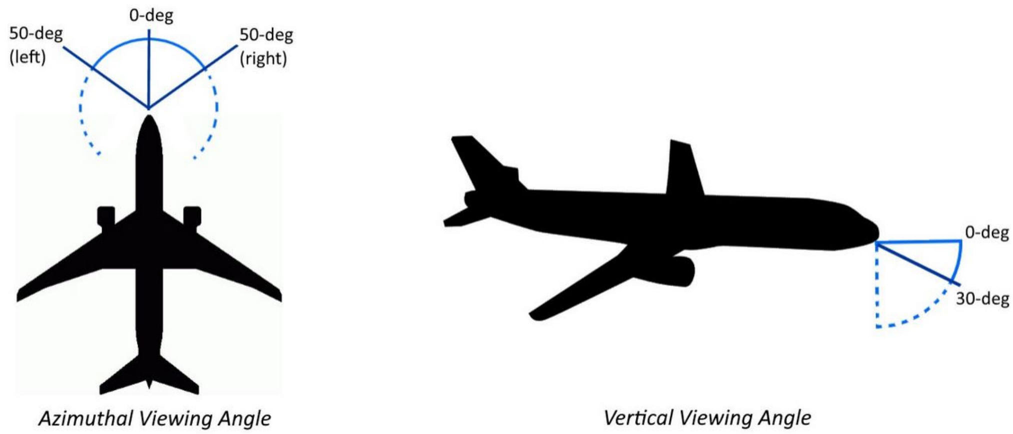


Figure 8. Diagrammatic illustration of Pilot's field of view (FOV) parameters (source: Forgesolar).

3.7. Hazard Assessment

Once the potential for solar glare has been identified through the viewshed analysis and SGHAT, which is based on topography only, an assessment of the likelihood of glare hazard occurring is undertaken, taking into consideration existing mitigating factors such as existing vegetation, buildings, and minor topographic variations outside the parameters of the modelling. Embedded mitigation measures, such as proposed vegetation screens to be undertaken as part of the Project, are also considered to identify residual glare potential. An assessment is then undertaken to identify the potential significance of the glare hazard based on the magnitude (amount and intensity) of the glare hazard generated, duration and frequency, distance from the Project, and the sensitivity of the receptors (viewers). Additional mitigation measures, beyond those previously considered as part of the Project, are recommended to avoid, reduce or manage the identified risks.

3.8. Limitations to the assessment

This desktop assessment is based on a geometric analysis of potential glare using SGHAT software modelling. The parameters of the modelling are based on the default values within the software. Where these values have been altered (generally increased), this has been noted in the assessment.

The assessment considers potential impacts of solar glare under normal operational procedures, potential impacts during construction and non-operational events have not been assessed.

Field tests has not been undertaken as part of the assessment, therefore the modelling is reliant on the algorithms contained in the software.

SGHAT software is used under license to Sims Industries d/b/a ForgeSolar, refer to assumptions and limitations listed in the data output (Appendices) and for further information refer to www.forgesolar.com/help/.

Environmental Ethos does not verify the accuracy of the SGHAT software modelling. Responsibility and accountability for the accuracy of the SGHAT software (GlareGauge) resides with Sims Industries d/b/a ForgeSolar.

4. EXISTING CONDITIONS

The baseline is a statement of the characteristics which currently exist in the Project area. The baseline glare condition assessment takes into consideration the following:

- Characteristics of the environment that may affect the potential for glare;
- Land use and human modifications to the landscape such as roads, buildings and existing infrastructure which may influence glare and sensitivity to glare.

4.1. Baseline Conditions

The Project covers an area of cleared cropping land, which is generally flat. Tabbita Lane adjoins the Project site's southern boundary, this boundary is partially screened by existing vegetation.

Land use surrounding the site includes arable cropping land and intensive agricultural enterprises including a large feedlot to the south of the Project, and a number of poultry farms to the east. To the west of the Project is a large orchard plantation.

Constructed elements within the landscape include the local roads, rural buildings (including large sheds and silos), and infrastructure (transmission lines).

Turkey dams are also characteristic of the landscape and generally association with intensive agricultural and orchard properties. These water bodies are generally not visible from surrounding roads.

There are no existing features in the landscape with the potential to contribute to glare.

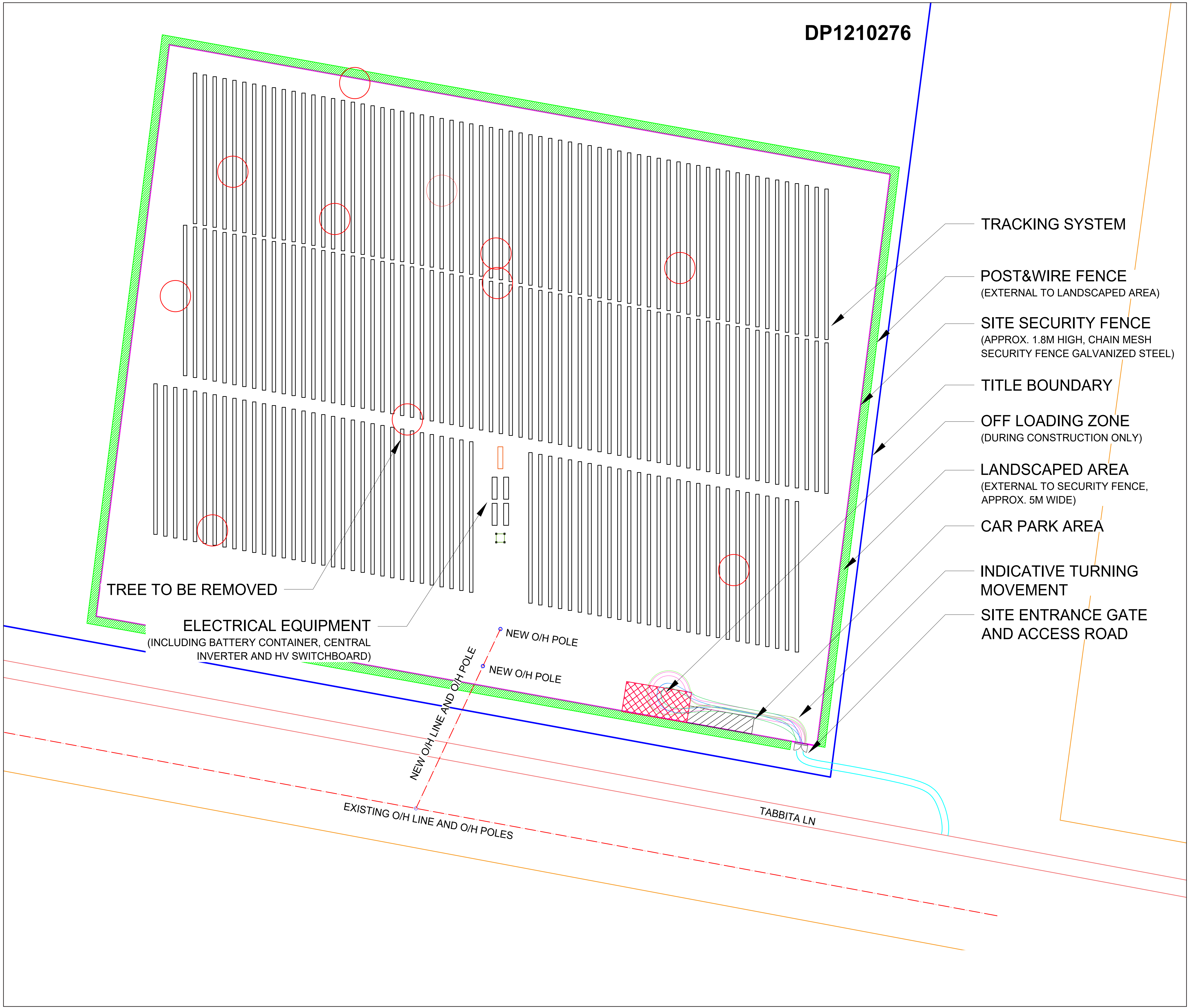
4.2. Atmospheric Conditions

Atmospheric conditions such as cloud cover, dust and haze will impact light reflection, however these factors have not been accounted for in this glare assessment. The Bureau of Meteorology statistics for Yenda (Henry Street) 45km east of the Project site (the closest BOM records for cloud cover statistics) recorded 118.2 cloudy days per year (mean number over the period 1971 to 2085)[8]. Cloudy days predominantly occur during the winter months, May to August. Since atmospheric conditions have not been factored into this assessment modelling, statistically the glare potential represents a conservative assessment.

5. PROJECT DESCRIPTION

The general layout of the solar farm is as shown in *Figure 9.* The main elements of the Solar Farm with the potential to influence glare are the tilt, orientation, and optical properties of the PV modules in the solar array, and the rotational capabilities of the tracking system. Whilst specific products may vary dependent on supply at the time of construction, the general technical properties of the main elements influencing glare are described below.

[8] http://www.bom.gov.au/climate/averages/tables/cw_075079.shtml



ENVIRONMENTAL ETHOS

LEGEND

SITE ACCESS GATE(APPROX. 8m WIDE) AND ROAD(APPROX. 4m WIDE)

HV O/H POLE / HV UG/OH POLE

HV SWITCHBOARD PLATFORM

SOLAR FARM FENCE, APPROX. 1.8 METER HIGH CHAIN MESH SECURITY FENCE GALVANISED STEEL

LANDSCAPED AREA

SITE CAR PARK ZONE (≈40m*10m)

ROAD / HIGHWAY

SITE CONSTRUCTION OFFLOAD ZONE (≈40m*18m)

SITE BOUNDARY

PV TRACKER - 3 STRING

NEIGHBOURING'S BOUNDARY

SOURCE: ACENERGY
SITE PLAN - 1 G-1.1_000530
REV. A 13/05/2022

PROJECT NO. 22013
CREATED BY: SC
DATE: 26 05 2022
VERSION: A

GREENTECH
SOLAR PROJECT NO. 3

GLINT AND GLARE IMPACT ASSESSMENT

PROJECT LAYOUT PLAN

FIGURE
9.0

5.1. PV modules

The approximate dimensions for a typical solar panel is 2 metres x 1 metre. The proposed PV panel arrangement for this Project is one (1) solar panel in portrait, resulting in a maximum array width of approximately 2.12 metres.

5.2. Horizontal single axis tracking system

A horizontal single axis tracking system is capable of a maximum rotation range of 90^o (+/- 45^o) or 120^o (+/- 60^o) depending on the system used. The Project modelling utilised a rotation range of 120^o (+/- 60^o), refer *Figure 10.*

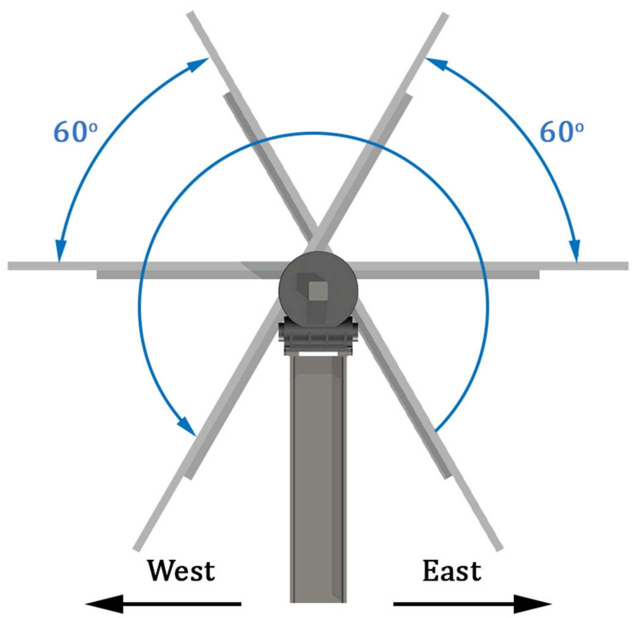


Figure 10. Illustration of PV Module Rotation Angles

The zenith tilt angle of the panels was assumed to be set at zero, that is, the panels are not tilted on a north – south alignment but remain horizontal along the plane of the tracker. This enables the height of the panel to remain consistent relative to each other and avoids potential over shadowing.

The maximum height of the PV modules above natural ground was assumed to be approximately 1.4 metres when the panels are held at 0 degrees (flat) and approximately 2.2 metres at maximum tilt. A height of 2.2 meters was used in the viewshed modelling as this covers all visibility of the panels to full tilt. A height of 1.4 metres to the tilt axis (centroid) was used in the glare modelling as the software uses an analytical approach to simulate light reflection from a planar PV footprint with the centroid value denoting the point of axis.

5.3. Solar Inverters, Control Room, and Fencing

The proposed solar farm will also include a central inverter, an HV switchboard, battery storage containers, and perimeter fencing. These elements are not considered likely to influence glare as they generally comprise of non-reflective surfaces typically found in the built environment.

5.4. Landscaping

The proposed solar farm includes landscape screening to the perimeter of the Project. Two rows of planting will be located on the outside of the security fence to screen the solar farm from external views.

6. DESKTOP GLARE ASSESSMENT

The aim of the desktop glare assessment is to identify if any sensitive receptors have the potential to be impacted by glare. The software modelling systems used in the desktop assessment include viewshed modelling to identify the location of sensitive receptors with line of sight to the solar farm, and SGHAT to identify the potential and ocular significance of glare.

6.1. Viewshed Analysis

The results of the viewshed analysis (based on topography) are shown in *Figure 11.*

Solar Farms are characterised by their low horizontal profile. The major elements of a solar farm are the PV models, these are generally 2 to 4 metres above ground level. In this Project the maximum height of panels at full rotation was assessed at 2.2 metres above ground level. At distances greater than 1 km a 2.2 metre high horizontal object in the landscape becomes visually insignificant (perceived as a narrow line in the distance) when viewed across a flat plain. At distances greater than 2 km the Project will be barely visible, therefore the viewshed analysis focussed on potential visibility of the Project within 2km of the site.

The desktop visibility assessment identified the Project is mainly visible from the north and east. With patchy visibility to the south and west due to slight undulation in the topography.

The viewshed analysis identified 1 rural dwellings within 2 km of the Project site that have the potential to have line of sight to the proposed solar farm, based on topography.

The following roads pass through the viewshed and these were included in the glare modelling (both directions of travel) as follows:

- Tabbita Lane: > 500m from Project site
- Kings Road: > 1km from Project site

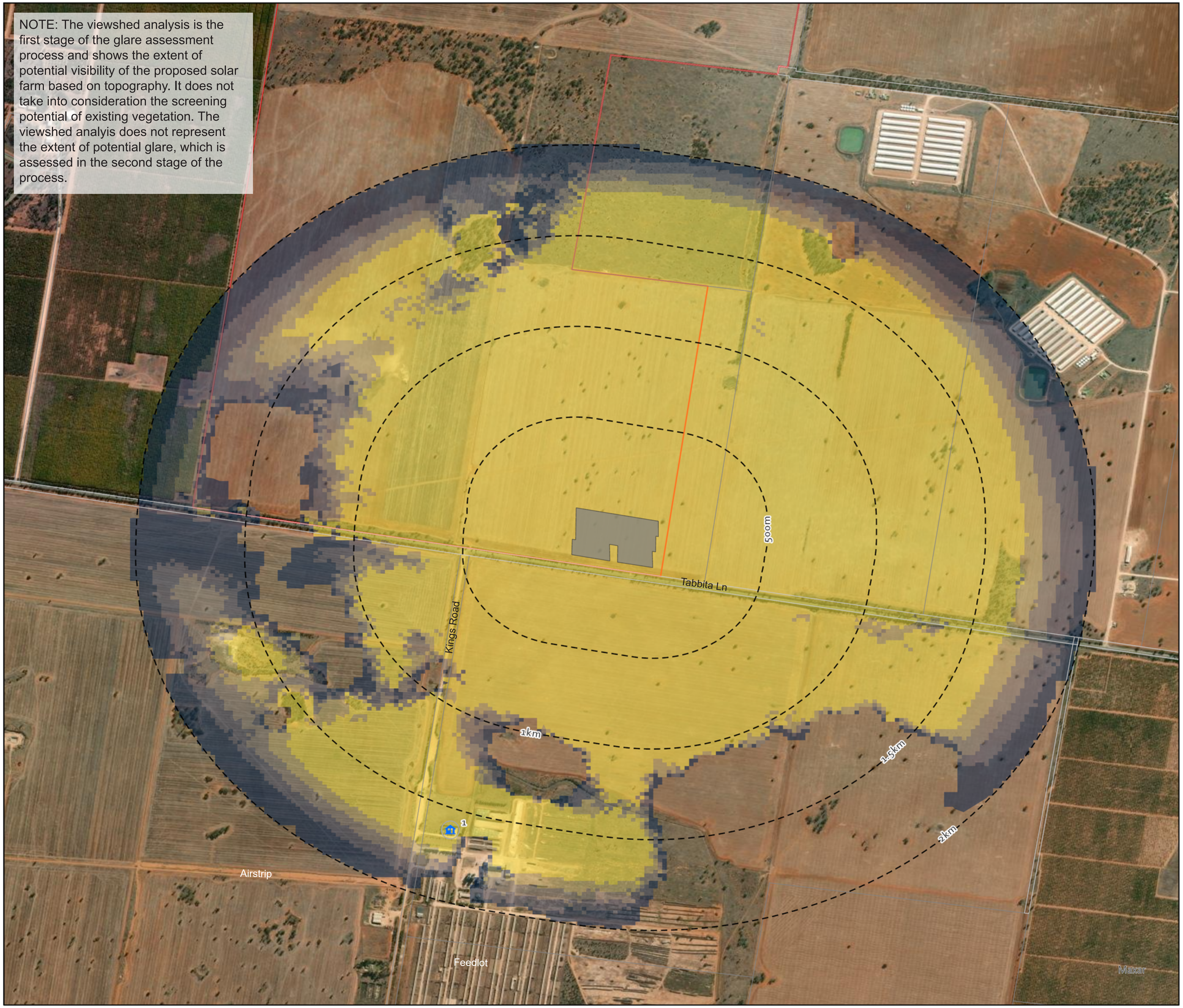
The potential glare hazard impact for identified dwellings, surrounding roads, and airstrip with potential views to the site have been assessed in Section 6.2.

6.2. Solar Glare Hazard Analysis

The parameters used in the SGHAT model are detailed in *Tables 1.*

Table 1. Input data for SGHAT Analysis – Horizontal Single Axis Tracking System

SGHAT Model Parameters	Values
Time Zone	UTC +10
Axis Tracking	Horizontal Single Axis
Backtracking	Shade (flat land)
Tilt of tracking axis	0
Orientation of tracking axis	0
Offset angle of module	0



ENVIRONMENTAL ETHOS

N

0 0.25 0.5 1
SCALE 1:20,000 @ A3 Kilometers

Legend

SITE BOUNDARY

PV MODULE AREA

DISTANCE FROM SOLAR FARM

DWELLINGS

EXTENT OF VISIBILITY*
Less visible
More visible

*(Analysis based on Digital Terrain Model)

*RURAL DWELLING LOCATIONS BASED ON DESKTOP ASSESSMENT GROUND-TRUTHING EXCLUDED

PROJECT No. 22013
CREATED BY: SC
DATE: 25 05 2022
VERSION: A

GREENTECH SOLAR PROJECT NO. 3

GLINT AND GLARE ASSESSMENT

VIEWSHED ANALYSIS

FIGURE 11.0

Module Surface material	Smooth glass with anti-reflective coating (ARC)
Maximum tracking angle	60
Ground Coverage Ratio	0.5
Resting angle (Stowing)	5
Reflectivity	Vary with Sun
Correlate slope error with surface type?	Yes
Slope error	8.43 mrad
Height of panels above ground	1.4m to centroid

6.3. Solar Glare Hazard Analysis Tool (SGHAT) Results

The assessment outcomes for the SGHAT modelling are detailed in *Appendix A*, and outlined in *Table 2*.

All observation point locations and numbers shown in *Figure 11* are consist with the glare modelling results provided in the appendix and detailed in *Table 2*.

Table 2. SGHAT Assessment Results – Horizontal Single Axis Tracking System

Sensitive Receptor	Glare Potential
Observation Points OP1 - Rural dwellings	No Glare
Tabbita Lane	No Glare
Kings Road	No Glare
Airstrip (East and West flight paths)	No Glare

Under normal operation of the solar farm, SGHAT modelling identified no glare hazard potential is likely to affect rural dwellings, travellers along the surrounding local roads, and airstrip flight paths, *refer Appendix A.*

SGHAT modelling includes tracking and backtracking operations based on generic parameters, the general alignment of the rotation angle over time is plotted in the Component Data File. An outline of the typical rotation angles for the model's tracking/backtracking data for summer and winter solstice is outlined in *Figures 12 and 13*.

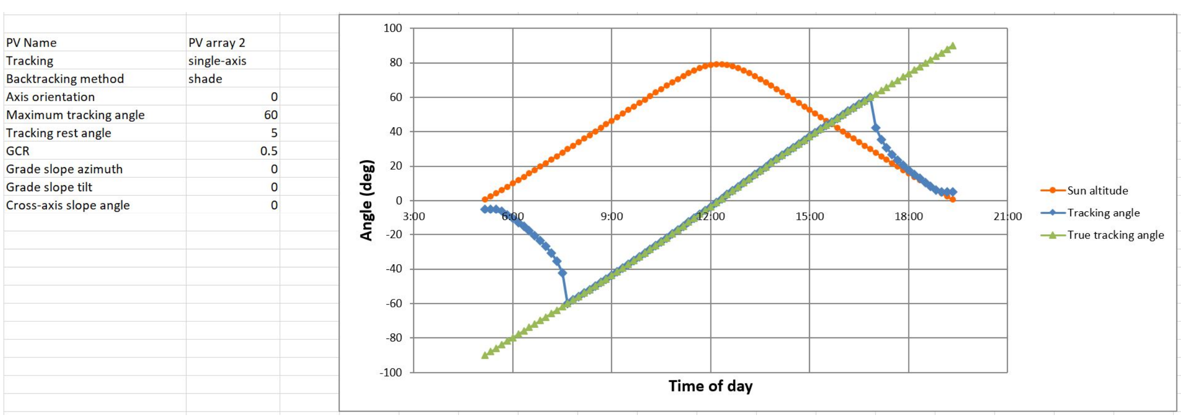


Figure 12. Tracking/backtracking angle per time slot – mid summer

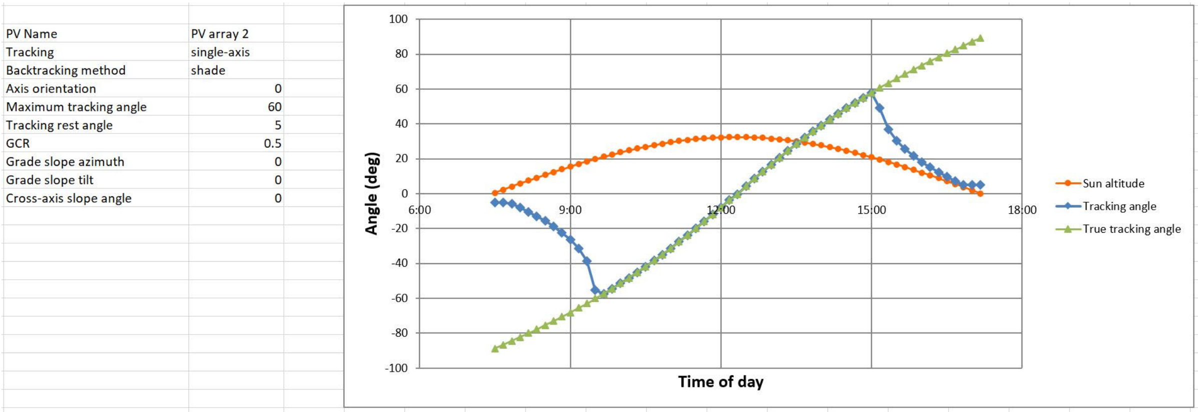


Figure 13. Tracking/backtracking angle per time slot – mid winter

7. MANAGEMENT AND MITIGATION MEASURES

Under normal operation of the solar farm no glare potential was identified as geometrically possible, therefore no mitigation measures are considered necessary.

8. SUMMARY

In summary, based on the assumptions and parameters of this desktop assessment, the following results were identified:

- The SGHAT modelling identified no glare is geometrically possible affecting rural dwellings within 2km of the Project, therefore no impact is likely.
- The SGHAT modelling identified no glare is geometrically possible affecting local roads within 2km of the Project, therefore no impact is likely.
- The SGHAT modelling identified no glare is geometrically possible affecting the local airstrip to the south of the Project, therefore no impact is likely.

APPENDIX A:

SOLAR GLARE HAZARD ANALYSIS –DWELLINGS, TRANSPORT ROUTES AND FLIGHT PATHS

FORGESOLAR GLARE ANALYSIS

Project: **Greentech Solar Farms**
Site configuration: **Greentech SF 3 Dwellings_Roads_FPs**

Created 25 May, 2022
Updated 03 Jun, 2022
Time-step 1 minute
Timezone offset UTC10
Site ID 69643.12319
Category 1 MW to 5 MW
DNI peaks at 2,000.0 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 2	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
Kings Road	0	0.0	0	0.0
Tabbita Lane	0	0.0	0	0.0
FP 1	0	0.0	0	0.0
FP 2	0	0.0	0	0.0
OP 1	0	0.0	0	0.0

Component Data

PV Arrays

Name: PV array 2
Description: Griffith Solar Farm East
Axis tracking: Single-axis rotation
Backtracking: Shade
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 5.0°
Ground Coverage Ratio: 0.5
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-34.091356	145.738905	120.91	1.40	122.31
2	-34.090518	145.738897	120.71	1.40	122.11
3	-34.090525	145.739063	120.95	1.40	122.35
4	-34.089072	145.739050	120.73	1.40	122.13
5	-34.089725	145.743129	122.30	1.40	123.70
6	-34.090423	145.743137	123.44	1.40	124.84
7	-34.090423	145.743033	123.12	1.40	124.52
8	-34.091331	145.743043	122.59	1.40	123.99
9	-34.091336	145.742909	122.38	1.40	123.78
10	-34.092007	145.742925	121.48	1.40	122.88
11	-34.091736	145.741236	120.35	1.40	121.75
12	-34.090980	145.741254	121.03	1.40	122.43
13	-34.090923	145.740790	121.00	1.40	122.40
14	-34.091642	145.740766	120.79	1.40	122.19

Route Receptors

Name: Kings Road
Path type: Two-way
Observer view angle: 90.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-34.091267	145.733540	120.00	2.40	122.40
2	-34.101289	145.731861	116.01	2.40	118.41
3	-34.109355	145.730316	119.46	2.40	121.86

Name: Tabbita Lane
Path type: Two-way
Observer view angle: 90.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-34.098034	145.779871	121.71	2.40	124.11
2	-34.096030	145.765395	119.99	0.00	119.99
3	-34.093670	145.749095	121.98	2.40	124.38
4	-34.091289	145.733646	120.00	2.40	122.40
5	-34.088587	145.716651	112.00	2.40	114.40
6	-34.087806	145.711190	111.70	2.40	114.10

Flight Path Receptors

Name: FP 1
Description:
Threshold height: 15 m
Direction: 95.7°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-34.106861	145.717693	114.77	15.24	130.01
Two-mile	-34.103969	145.682909	108.38	190.31	298.69

Name: FP 2
Description:
Threshold height: 15 m
Direction: 274.9°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-34.107620	145.728782	117.92	15.24	133.16
Two-mile	-34.110105	145.763612	120.87	180.97	301.84

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	-34.105084	145.732723	120.55	1.50

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 2	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
Kings Road	0	0.0	0	0.0
Tabbita Lane	0	0.0	0	0.0
FP 1	0	0.0	0	0.0
FP 2	0	0.0	0	0.0
OP 1	0	0.0	0	0.0

PV: PV array 2 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Kings Road	0	0.0	0	0.0
Tabbita Lane	0	0.0	0	0.0
FP 1	0	0.0	0	0.0
FP 2	0	0.0	0	0.0
OP 1	0	0.0	0	0.0

PV array 2 and Kings Road

Receptor type: Route

No glare found

PV array 2 and Tabbita Lane

Receptor type: Route

No glare found

PV array 2 and FP 1

Receptor type: 2-mile Flight Path

No glare found

PV array 2 and FP 2

Receptor type: 2-mile Flight Path

No glare found

PV array 2 and OP 1

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