ENVIRONMENTAL ETHOS

ADVERTISED PLAN

CHARAM SOLAR FARM

GLINT AND GLARE IMPACT ASSESSMENT REPORT

UPDATED FINAL ISSUE

Prepared For

GREEN GOLD ENERGY

October 2023

ENVIRONMENTAL
ETHOS

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for GREEN GOLD ENERGY

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EXECUTIVE SUMMARY

The Solar Energy Facilities Design and Development Guideline (October 2022) triggers the assessment of glint and glare resulting from solar farms including potential impacts to dwellings and roads within 1 km of a proposed facility, aviation infrastructure including any air traffic control tower or runway approach path close to a proposed facility, and any other receptor to which a responsible authority considers solar reflection may be a hazard.

This glint and glare impact assessment utilised the Solar Glare Hazard Analysis Tool (SGHAT 2023C) in conjunction with a viewshed analysis, to prepare the glint and glare modelling which is the basis for the impact assessment methodology.

The closest aviation infrastructure to the Project is Easthope Airport at approximately 25km to the west. Approach flight paths to the runways and the aviation control tower were not tested in the glare modelling, since the Project is outside the viewshed of the airport.

The assessment noted the recent addition of a graded track on the property adjoining the eastern boundary of the Project site. The property has no planning permit for use of this track for aircraft landing and therefore it has not been included in the assessment. However it is noted that due to the proximity of the solar farm it is not recommended the track is used for aircraft landing should this be the intended purpose.

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

- No dwellings were identified within the Project's viewshed up to 2km from the site;
- The assessment identified no railway infrastructure within 1km of the Project.
- The SGHAT modelling, based on a standard tracking and backtracking operation with a minimum resting angle of 5 degrees, identified no glare is geometrically possible affecting local roads within 1km of the Project, therefore no impact is likely.

Management and mitigation measures recommended in this assessment include:

- The Project Environmental Management Plan (EMP) should detail glare management measures required to avoid impacts to receivers, including the tracking and backtracking parameters detailed in this report. In addition, monitoring of glare hazard potential is required and a process for managing complaints, including rectification, should be included in the Project EMP.

1. INTRODUCTION

This updated report has been prepared by Environmental Ethos on behalf of Green Gold Energy to assess the potential solar glint and glare impact of the amended Charam Solar Farm (the Project), located at Goroke Harrow Road, Charam, Victoria. The assessment is based on the revised site plan revision H, dated 20 September 2023.

The size of the solar farm remains the same as the 2021 layout at up to 4.95MW and covers a similar area of approximately 9.1 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, also remain the same as the 2021 layout at an approximate height of 1.63 metres when flat, rotating to approximately 2.63 metres maximum height.

1.1. Location

The Project site is located approximately 4.9 kilometres west of Wombelano, *refer Figure 1.* The Project site adjoins Charam-Wombelano Road on the northern boundary, which runs parallel to the Hume Freeway. The site is zoned FZ Farming Zone and is currently used for grazing. Farming is the predominant land use within the area.

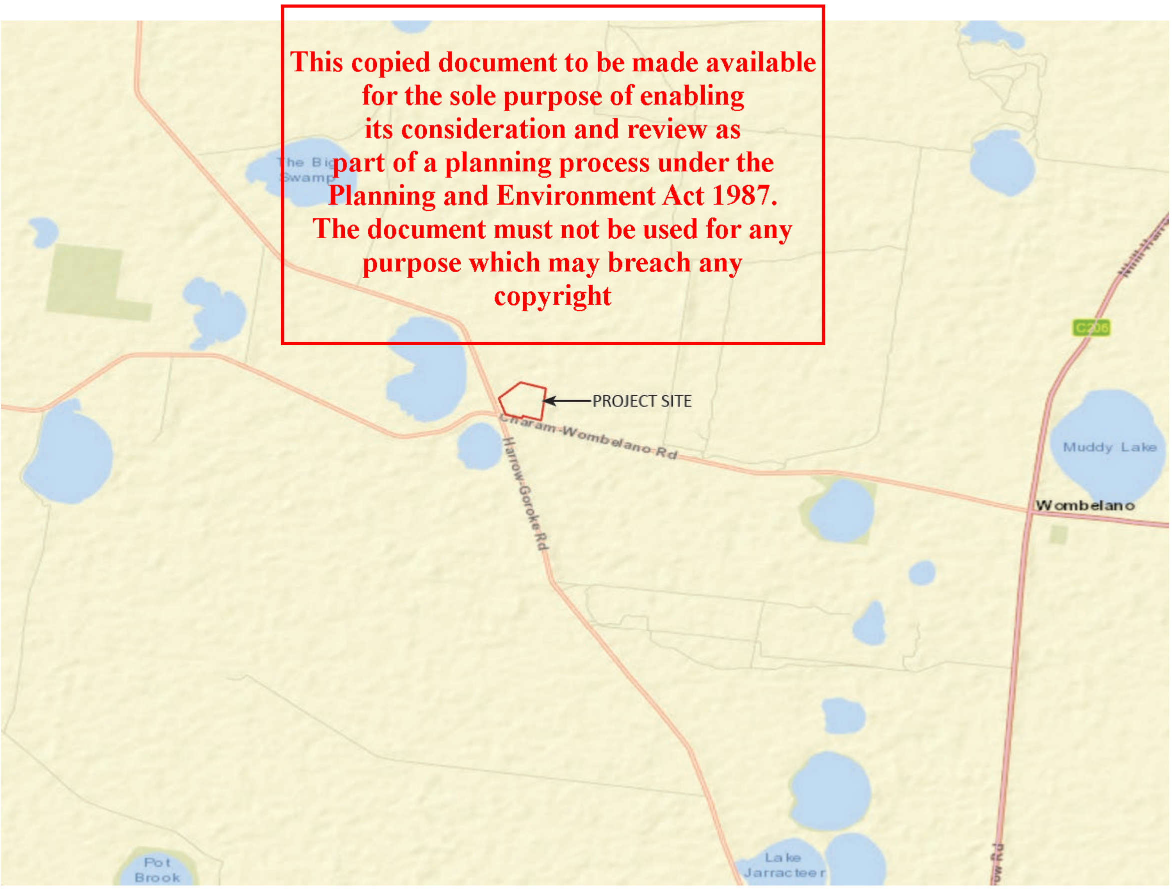


Figure 1. Location Plan

The closet airport to the Project site is Edenhope, approximately 25km to the west of the Project Site. This facility is not within the viewshed of the Project and, at a distance greater than 10km from the site, it is not considered 'close'. Therefore flight paths were not included in this glare 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;
- Assessment of potential mitigations measures to avoid, mitigate, or manage potential impacts; and
- Consideration of impacts before and after mitigation measures are established, on surrounding sensitive receptors including:
    - Dwellings and roads within 1km of the proposed facility, taking into consideration their height within the landscape;
    - Aviation infrastructure including any air traffic control tower or runway approach path close to the proposed facility;
    - Any other receptor to which a responsible authority considers solar reflection may be a hazard.

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]

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

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

The Solar Energy Facilities Design and Development Guideline, (October 2022[2]) (Development Guidelines), identifies the difference between glint and glare as intensity:

"Glint can be caused by direct reflection of the sun from the surface of an object, whereas glare is a continuous source of brightness. Glare is much less intense than glint."(p23)

This differentiation is consistent with the descriptions of glint and glare as:

- Glint being specular reflection, a momentary flash of light produced as a direct reflection of the sun in the surface of an object (such as a PV panel); and
- Glare being a continuous source of brightness relative to the ambient lighting, glare is not a direct reflection of the sun, but rather a reflection of the bright sky around the sun.

Solar Glare Hazard Analysis software evaluates the potential impact of light produced as a direct reflection of the sun from PV modules, this is consistent with the Development Guidelines reference to 'glint', as the more intense type of solar reflectivity. However, the FAA Guidelines refers to direct solar reflection from stationary objects such as fixed frame solar systems, or relatively slow moving objects such as solar tracking systems, as 'glare' since the source of the solar reflectance occurs over a long (not momentary) duration.

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 (consistent with terminology used by Solar Glare Hazard Analysis software based on FAA Guidelines). The assessment of direct solar reflectivity from PV modules addresses the Development Guidelines requirements to consider the impacts of glint (defined as the more intense solar reflectivity), and also glare as a reflection of light surrounding the sun.

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
- 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.[3]

[2] The State of Victoria Department of Environment, Land, Water and Planning, October 2022, Solar Energy Facilities Design and Development Guideline

[3] HO, C.K., C.M. Ghanbari, and R.B. Diver, 2011, Methodology to Assess Potential Glint and Glare hazards from Concentrated Solar Power Plants

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.

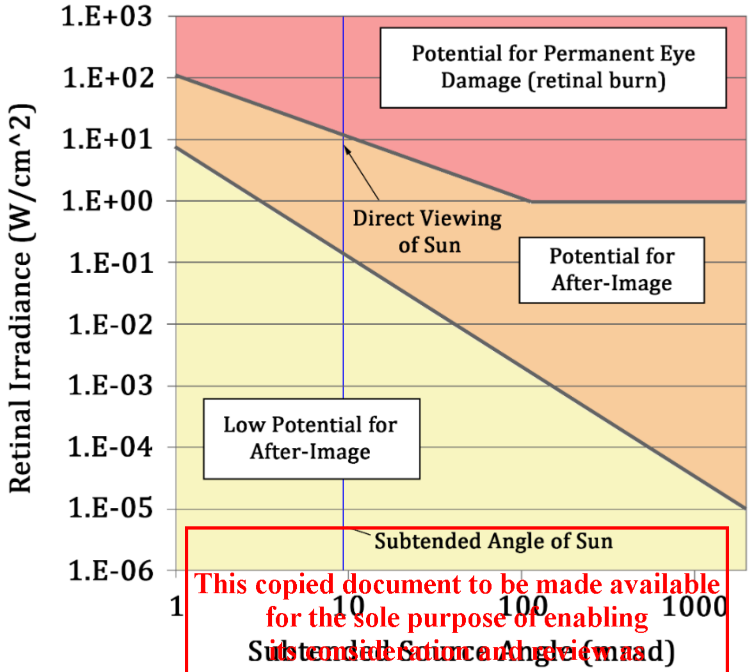


Figure 2. Ocular impacts and Hazard Ranges[4]

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[5].

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.[6]

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

[4] Source: Solar Glare Hazard Analysis Tool (SGHAT) Presentation (2013) https://share.sandia.gov/phlux/static/references/glint-glare/SGHAT_Ho.pdf
[5] Sandia National Laboratory, SGHAT Technical Manual
[6] *Ho, C. 2013 Relieving a Glare Problem*

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 this is typically a result of dust or similar materials building up on the PV module surface, which would potentially reduce the reflection.

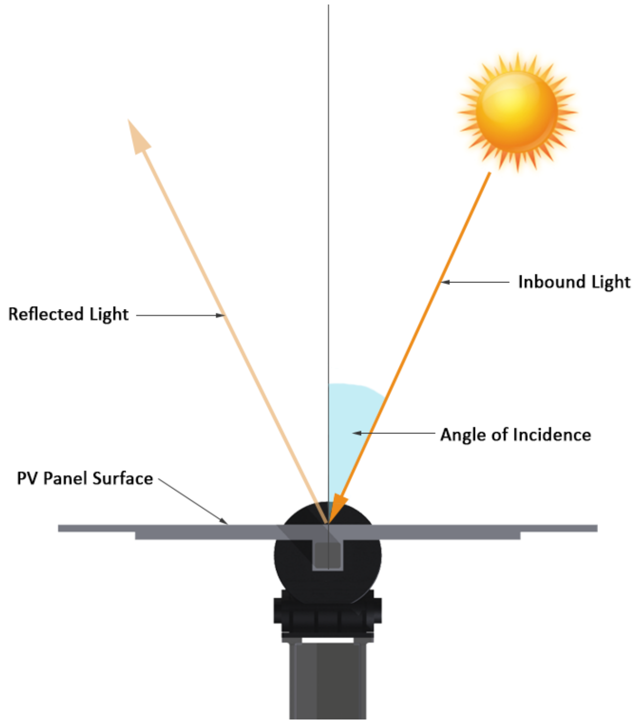


Figure 3. Angle of Incidence Relative to PV Panel Surface

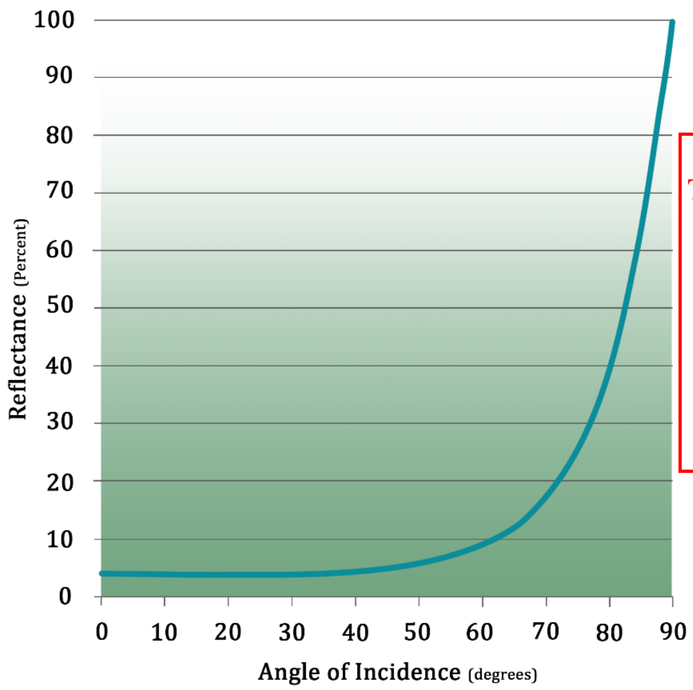


Figure 4. Angles of Incidence and Increased Levels of Reflected Light (Glass (n-1.5))

The sun changes its east-west orientation throughout the day, and the sun's north-south position in the sky changes throughout the year. The sun reaches its highest position at noon on the Summer Solstice (21 December in the Southern Hemisphere) and its lowest position at sunrise and sunset on the Winter Solstice (21 June in the Southern Hemisphere).

In a fixed PV solar array, the angle of incidence varies as the sun moves across the sky, that is the angle of incidence are at their lowest around noon where the sun is directly overhead, and increase in the early mornings and late evenings as the incidence angles increase. If the PV array is mounted on a tracking system, this variation is reduced because the panel is rotated to remain perpendicular to the sun. Therefore a PV modular array using a tracking system has less potential to cause glare whilst it tracks the sun. *Figure 5* illustrates a PV module mounted horizontal single axis tracking system following the east to west path of the sun.

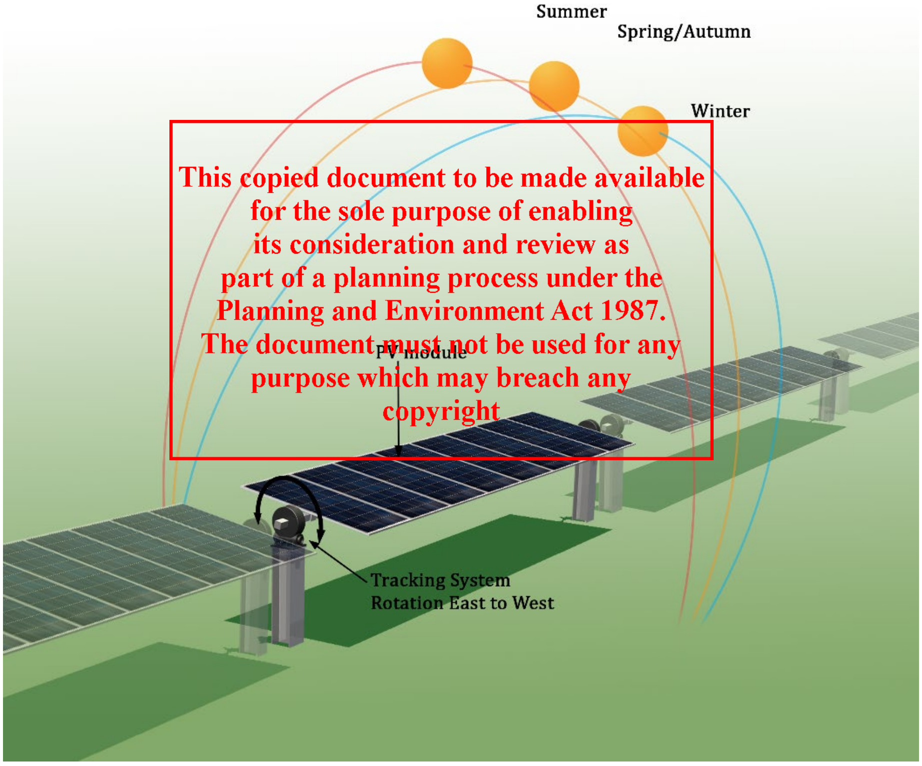


Figure 5. Diagrammatic illustration of sun position relative to PV module mounted on a horizontal single axis tracking system.

A single axis tracking system has a fixed maximum angle of rotation, once the tracking mechanism reaches this maximum angle, 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 6*. During the backtracking phase, higher angles of incidence will occur in comparison to the tracking phase, and this may increase the potential for glare.

Tracking systems operate from a set resting angle, resting angles define the final angle at the beginning and end of the backtracking cycle. Generally resting angles range between 0 and 30 degrees, depending on the type of system used and the site requirements. A slight angle (5 degrees) is commonly used to allow rain and dew to sheet off the panels, some systems use higher angles in more extreme climatic conditions. Shallow resting angles increase the angle of incidence between the sun and PV model, therefore the shallower the angle the more likely glare may occur.

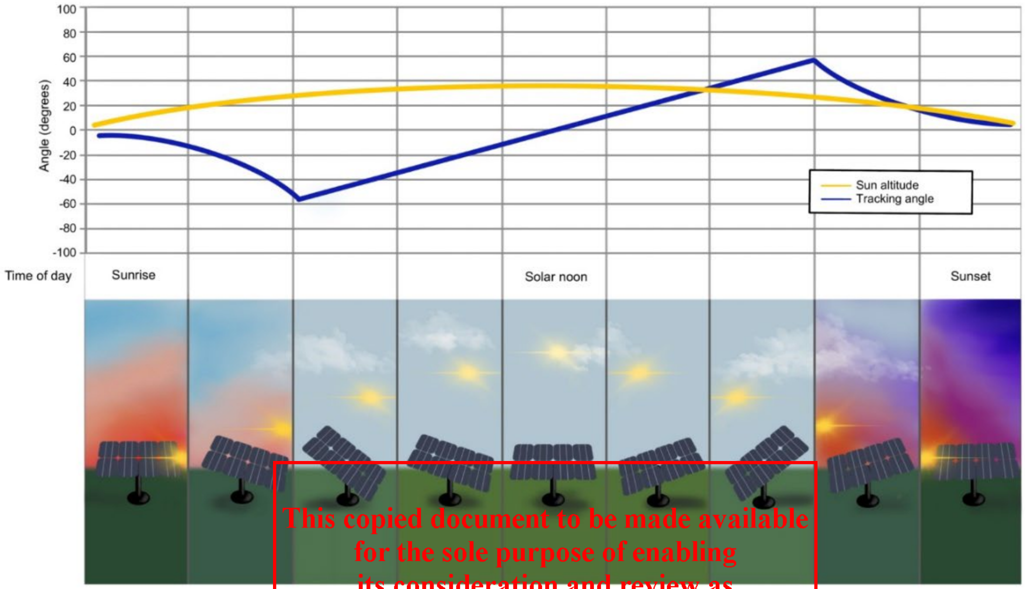


Figure 6. Diagrammatic illustration of a backtracking procedure for a horizontal single axis tracking system. (Source: ForgeSolar).

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.) The desktop viewshed analysis is based on topography only and does not take into consideration existing vegetation.

3.6. Solar Glare Hazard Analysis

This assessment has utilised the Solar Glare Hazard Analysis Tool (SGHAT version 2023C) co-developed by Sandi National Laboratory [7] 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

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

angles. The algorithm enables determination of the sun position at one (1) minute intervals throughout the year.

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

- Gaps between PV modules; and
- Atmospheric conditions.

Updated SGHAT analysis now includes the ability to include 'obstructions' in the modelling (such as vegetation and buildings). This feature was not used as part of this assessment since detailed information on the screening height and density of existing vegetation was not available at the time of the assessment.

Backtracking

A single axis horizontal tracking system can be programed to operate a 'backtracking' procedure (*refer section 3.4*). Backtracking algorithms are becoming increasingly sophisticated with each system optimised dependent on individual project parameters including; distance between panels, width of each panel, incidence angle of the sun, field slope angle, and local weather (wind loading).

SGHAT software includes a backtracking feature which can be used to simulate various backtracking strategies. SGHAT also provides tracking data and plots, detailing the range of rotation over time. Whilst the backtracking feature simulates a generic operation based on the models parameters, the software may deviate from real-world backtracking behaviour due to a specific project system design, environmental conditions, and other factors. However, the backtracking feature does provide an understanding of potential glare implications of operating a backtracking procedure.

Observation Point Receptor (OP)

In SGHAT modelling the Observation Point receptor ("OP") simulates an observer at a single, discrete location, defined by a latitude, longitude, elevation, and height above ground. OPs generally define the location of a residential receiver (dwelling) and are subscribed a unique number in the modelling. In addition, an OP can be marked to represent an Air Traffic Control Tower ("ATCT") for aviation purposes.

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 7*.

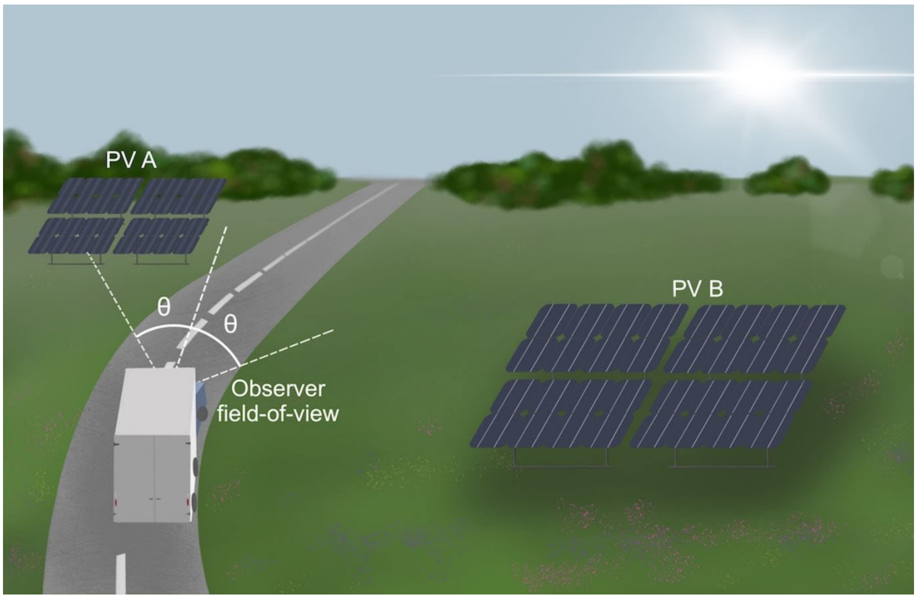


Figure 7. Diagrammatic illustration of Observer Field of View relative to PV array (source: ForgeSolar).

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[8]. 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 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 roads and rail network within the vicinity of the solar farm.

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.

Where required, additional mitigation measures, beyond those previously considered as part of the Project, are recommended to avoid, reduce or manage the identified risks.

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

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 site is located within the Wimmera Plains landscape region, which is characterised by the numerous lakes and wetlands scattered across the relatively flat plain. The site and surrounding area is used for grazing, with some areas of cropping. Large areas of State Forest are also characteristic of the area. Vegetation along the roads immediately adjoining the Project site consists of scattered native trees in the south eastern corner, with little to no screening along the south and western boundaries.

The area is sparsely populated and no rural or residential dwellings were identified within 2km of the Project.

Constructed elements within the landscape include roads, rural buildings (sheds), transmission lines, and substation.

The property adjoining the Project's eastern boundary includes the relatively recent addition of a graded track possibly intended for use as an Aircraft Landing Area (ALA). No planning permit was identified for the property, which is zoned farming, the proposed use of the graded track as an 'airstrip' has not been verified.

A wind farm planning application has been lodged for a site to the south west of the solar farm. Wind farms are not considered sensitive to potential solar glint and glare and are often co-located renewable energy generators.

Existing features in the landscape with the potential to contribute to glare include water bodies and the wetlands, which may contribute to glare when holding water. Generally, these wetlands are surrounded by native trees, and support vegetation such as sedges and reeds, the contribution to glare is dependent on the amount of water held which varies dependent on climatic conditions.

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 Horsham Polkemmet Road weather station 58 km north east of the Project site (the closest BOM records for cloud cover statistics) recorded 141 cloudy days per year (mean number over the period 1957 to 2008)[9]. Cloudy days predominantly occur during the winter months, May to September. 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 8*. 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 system. Whilst specific products are yet to be determined for the Project, the general technical properties of the main elements influencing glare are described below.

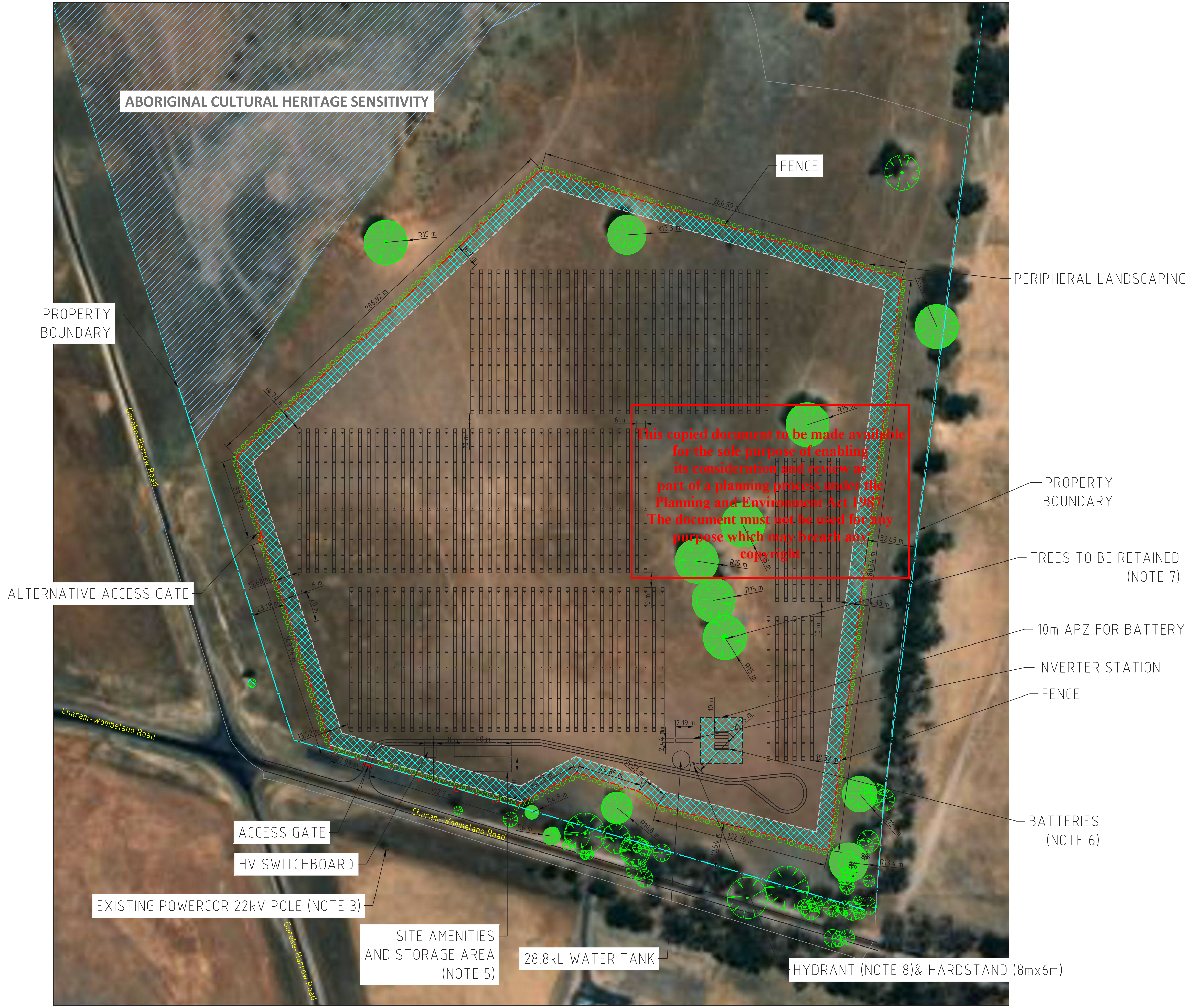
5.1. PV modules

Each PV panel typically comprises of 72 polycrystalline silicon solar cells overlayed by a 3.2 to 4.0 mm tempered glass front and held in an anodised aluminium alloy frame. Half cut cell technology is also available which consists of 144 monocrystalline cells connected in series to reduce ribbon resistant. Dual-glass and frameless PV systems area also available. The approximate dimensions for a typical solar panel is 2 metres x 1 metre, the current selected panels for this Project are 2256 x 1133 x 35 mm. The proposed solar array arrangement for this Project is one (1) solar panels in portrait, resulting in an array width of approximately 2.3 metres.

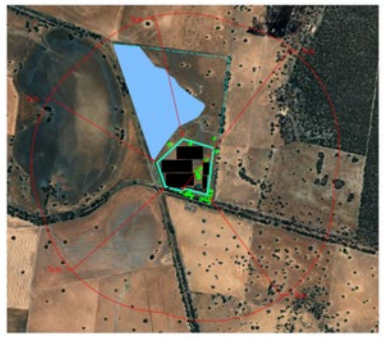
5.2. Horizontal single axis tracking system

A horizontal single axis tracking system rotates the PV panels across an east to west arc, following the sun's trajectory across the sky. The purpose of the tracking system is to optimize solar energy collection by holding the PV module perpendicular to the sun. The tracking system is capable of a maximum rotation range of 90° (+/- 45°) or 120° (+/- 60°) depending on the system used. The Project modelling utilised a rotation range of 120° (+/- 60°), refer *Figure 9.*

[9] http://www.bom.gov.au/climate/averages/tables/cw_079023.shtml



ENVIRONMENTAL ETHOS



LOCATION PLAN (N.T.S)

NOTES

1. ACTUAL DIMENSIONS AND CLEARANCES MAY VARY SUBJECT TO SITE CONDITIONS.
2. DIMENSIONS OF ELECTRICAL EQUIPMENT ARE INDICATIVE ONLY. ACTUAL DIMENSIONS TO BE CONFIRMED.
3. LOCATION OF POWERCOR 22kV OVERHEAD LINE AND SYSTEM CONNECTION POINT TO BE CONFIRMED.
4. EXISTING POWERCOR 22kV POLE IS FOR ILLUSTRATION ONLY. ACTUAL POSITION IS SUBJECT TO THE ACTUAL MEASUREMENT ON SITE.
5. SITE STORAGE AND AMENITY FACILITIES TO BE ON SITE ONLY DURING CONSTRUCTION PHASE. NO PERMANENT BUILDINGS TO BE KEPT ON SITE AFTER CONSTRUCTION COMPLETED.
6. THE NUMBER OF BATTERY UNITS TO BE DETERMINED (2 OR 4).
7. TREES (RIVER RED GUM TREE) TO BE RETAINED ON SITE PER INDICATION.
8. A AT LEAST 60m LONG HOSE IS INCLUDED WITH THE HYDRANT.

ADVERTISED PLAN

SYSTEM SPECIFICATIONS				
DC	6.17	MW	TOTAL MODULES	10287
MODULE CAPACITY	600	W	MODULES PER STRING	27
NUMBER OF INVERTERS	1	-	NUMBER OF STRINGS	381
INVERTER MODEL	SG4950-HV-MV	-	MODULE MODEL	LR5-72HTH-600M
NUMBER OF BATTERIES	TBD	-	BATTERY MODEL	ST-2752UX

LEGEND

- PROPOSED PV ARRAY
- SECURITY FENCE
- PROPERTY BOUNDARY
- TREE WITH 15m PROTECTION ZONE
- 10m WIDE ASSET PROTECTION ZONE

SOURCE: GREEN GOLD ENERGY SITE PLAN
REV. H 20/09/2023

PROJECT NO. 20008
CREATED BY: SC
DATE: 26 09 2023 VERSION: B

CHARAM SOLAR FARM

GLINT AND GLARE IMPACT ASSESSMENT

PROJECT LAYOUT PLAN

FIGURE 8.0

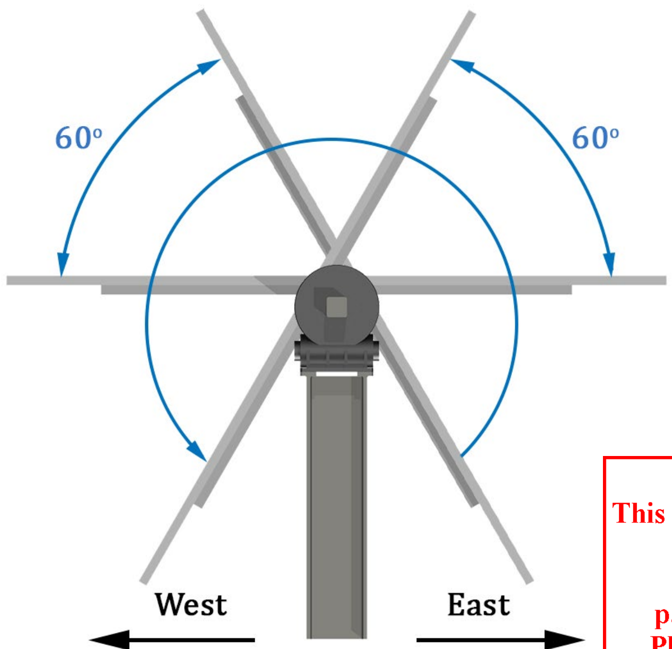


Figure 9. Illustration of PV Module Rotation Angles

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 2.63 metres (1.63 metres when the panels are held at 0 degrees (flat) and 2.63 metres at maximum tilt). A height of 1.7 metres at the centroid was used in the modelling to allow for any slight variation in the height of the mounting system and maximum angle of the PV modules. The glare assessment modelling uses an analytical approach to simulate light reflection from a planar PV footprint relative to the location of sensitive receptors.

The configuration of the tracking system rows vary slightly dependent on the type of system used, generally rows are approximately 5-7 metres apart, 6 metres is the current proposed distance (pitch) between piers.

5.3. Associated infrastructure

In addition to the PV arrays, the Project will also include a central inverter and battery energy storage container. These elements do not generally create specular reflection as they comprise of non-reflective surfaces typically found in the built environment.

5.4. Landscape Screening

Landscape screen planting (Landscaping Buffer) is proposed around the perimeter of the Project sufficient to provide visual screening once established.

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 the 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 10.*

The Digital Elevation Model (DEM) for the viewshed modelling was set as 'Finest' (> 10 m). Contour information for the site was assessed and shows the Project site is located within a generally flat landscape.

The desktop visibility assessment identified the Project is screened by slightly undulating terrain to the east and west. The Project was identified as potentially visible to the north and south.

No dwellings were identified within the viewshed up to 2km from the Project site

Two (2) roads pass through the viewshed and these were included in the glare modelling, as follows:

- Charam Wombelano Road
- Harrow Goroke Road

Edenhope Airport is the closest aviation facilities to the Project at approximately 25km to the west of the Project site. Approach flight paths to the runways and the aviation control tower were not tested in the glare modelling, since the Project is outside the viewshed of the airport.

There is no railway infrastructure within the Project viewshed.

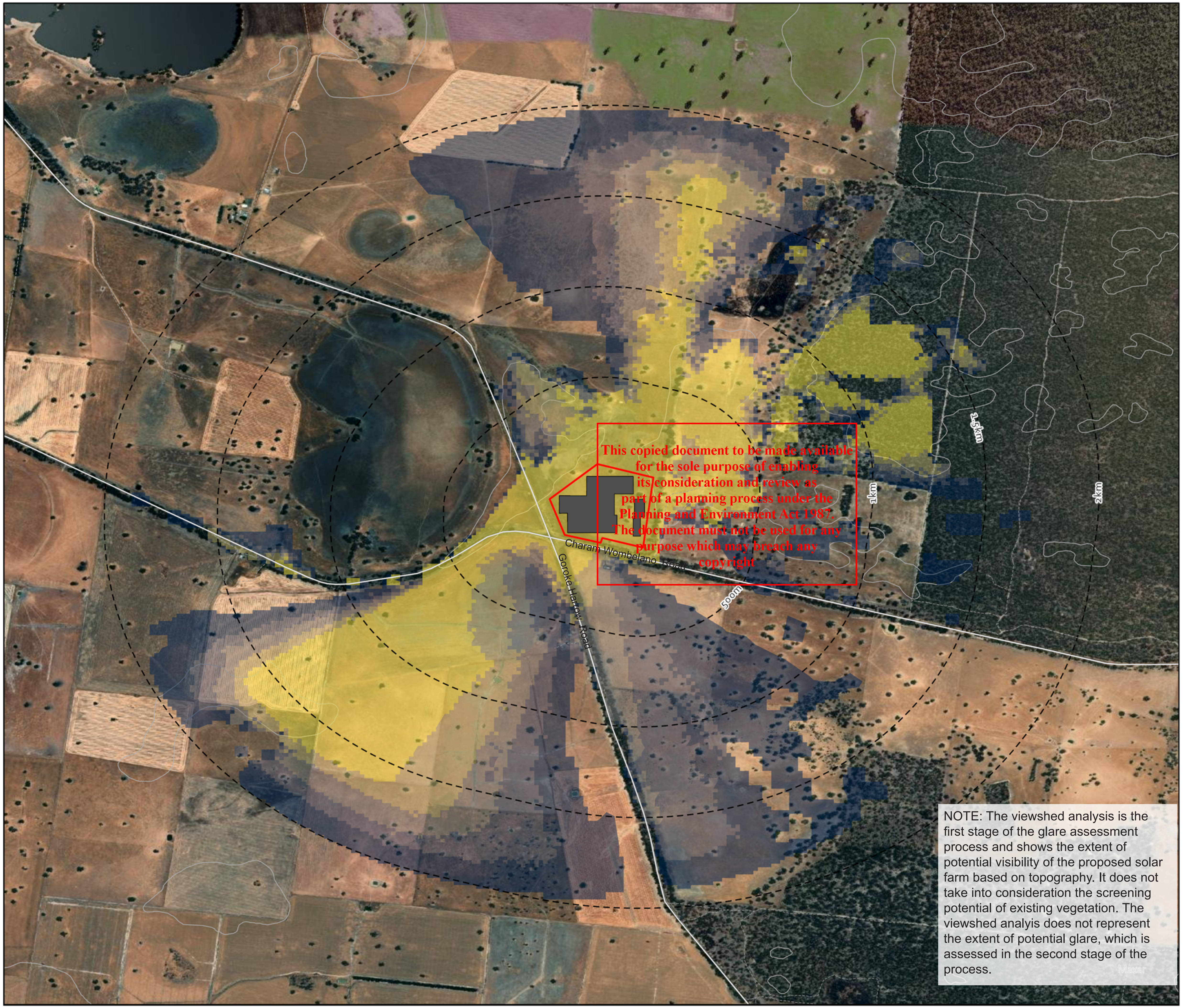
The potential glare hazard impact surrounding local roads have been assessed in *Section 6.3.*

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 (Parallel to ground)
Orientation of tracking axis	0
Offset angle of module	0
Module Surface material	Smooth glass with anti-reflective coating (ARC)
Maximum tracking angle	60 degrees
Resting (Stowing) angle	5 degrees
Reflectivity	Vary with sun



NOTE: The viewshed analysis is the first stage of the glare assessment process and shows the extent of potential visibility of the proposed solar farm based on topography. It does not take into consideration the screening potential of existing vegetation. The viewshed analyis does not represent the extent of potential glare, which is assessed in the second stage of the process.

ENVIRONMENTAL ETHOS

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DATUM GDA 1994,
PROJECTION MGA ZONE 56

0 0.25 0.5 1 Kilometers

SCALE 1:20,000 @ A3

Legend

- SITE BOUNDARY
- DISTANCE FROM SOLAR FARM
- PV MODULE AREA
- 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. 20008
CREATED BY: SC
DATE: 26 09 2023
VERSION: B

CHARAM SOLAR FARM

GLINT AND GLARE ASSESSMENT

VIEWSHED ANALYSIS

FIGURE 10.0

Correlate slope error with surface type?	Yes
Slope error	8.43 mrad
Height of panels above ground	1.7m to centroid

SGHAT modelling includes tracking and backtracking operations based on generic parameters. The maximum rotation angle of the tracking system was set at +/- 60° and the minimum resting angle was set at 5 ° (being the fixed angle at which the backtracking process starts and finishes during daylight hours).

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 11 and 12*.

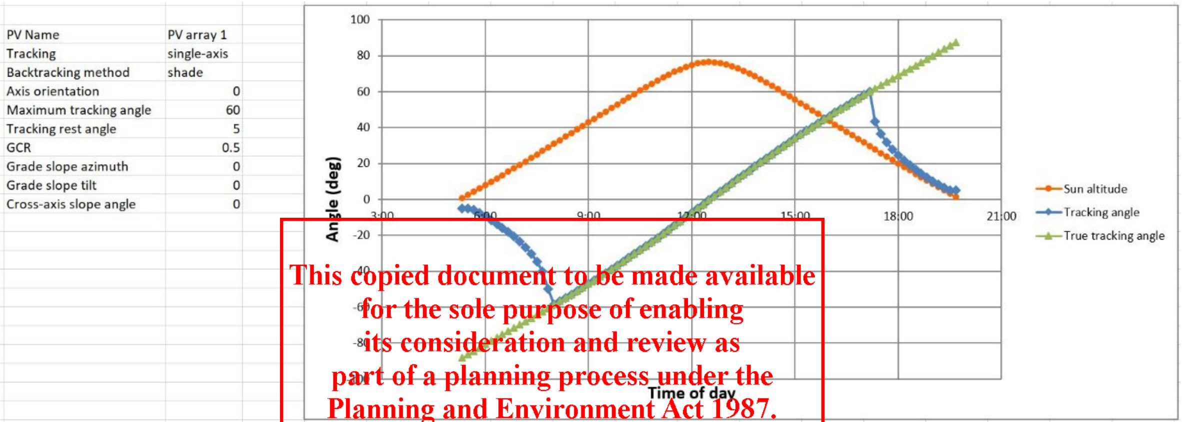


Figure 11. Tracking/backtracking angle per time slot – mid summer

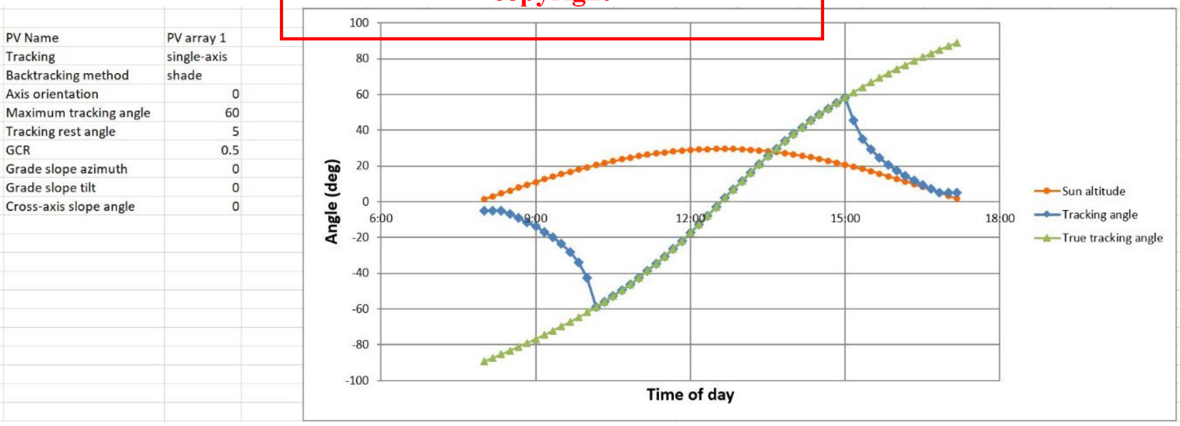


Figure 12. Tracking/backtracking angle per time slot – mid winter

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*.

Table 2. SGHAT Assessment Results

Sensitive Receptor	Glare Potential
Charam Wombelano Road	No Glare
Harrow Goroke Road	No Glare

The SGHAT modelling identified no glare hazard potential is likely to affect travellers along both local roads within the Project viewshed, *refer Appendix A.*

Assessment of the baseline conditions surrounding the Project site noted the recent addition of a graded track on the adjoining property to the east. This track has not been included in the assessment as there is no planning permit for a change in land use for the property and the purpose of the track has not been verified. However it is noted in this report that should the intended use of the track include landing aircraft, this activity should not be undertaken due to the proximity of the solar farm and potential aviation safety risks associated with glint and glare affecting the approach flight paths.

7. MANAGEMENT AND MITIGATION MEASURES

The SGHAT modelling identified that under normal operation of the solar farm tracking system, with a backtracking operation and minimum limit of 5 degree resting angle, no additional mitigation measures are required to manage the potential impacts of glare on receivers.

The Project Environmental Management Plan (EMP) should detail glare management measures required to avoid impacts to receivers, including the tracking and backtracking parameters detailed in this report. In addition, monitoring of glare hazard potential is required and a process for managing complaints, including rectification, should be included in the Project EMP.

8. SUMMARY

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

- No dwellings were identified within the Project's viewshed up to 2km from the site;
- The SGHAT modelling identified no glare is geometrically possible affecting local roads within 1km of the Project, therefore no impact is likely.
- The assessment identified no railway infrastructure within 1km of the Project.
- Easthope Airport is the closest aviation facilities to the Project at approximately 25km to the west of the Project site. Approach flight paths to the runways and the aviation control tower were not tested in the glare modelling, since the Project is outside the viewshed of the airport.

APPENDIX A:

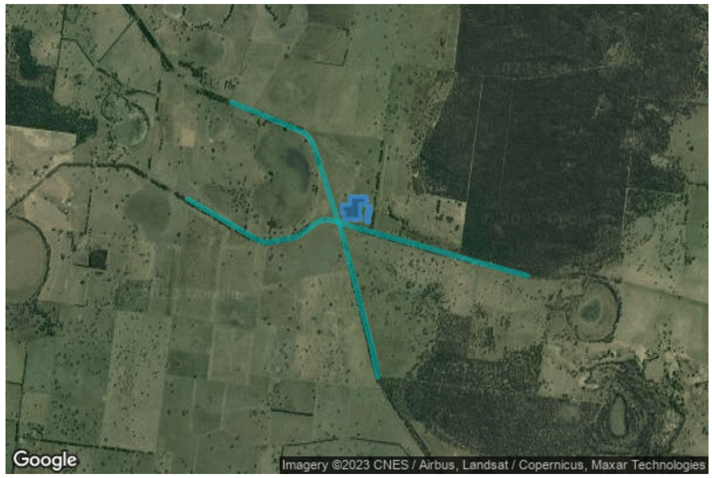
SOLAR GLARE HAZARD ANALYSIS

FORGESOLAR GLARE ANALYSIS

Project: **Charam Solar Farm**
Site configuration: **Charam Solar Farm Sept 2023 Update**

Created 26 Sep, 2023
Updated 26 Sep, 2023
Time-step 1 minute
Timezone offset UTC10
Minimum sun altitude 0.0 deg
DNI peaks at 2,000.0 W/m^2
Category 1 MW to 5 MW
Site ID 101506.10250

Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
PV analysis methodology V2



Summary of Results No glare predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	SA tracking	SA tracking	0	0.0	0	0.0	-
PV array 2	SA tracking	SA tracking	0	0.0	0	0.0	-

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

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Charam Wombelano Road	0	0.0	0	0.0
Goroke Harrow Road	0	0.0	0	0.0

Component Data

PV Arrays

Name: PV array 1
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	-36.990873	141.550725	181.60	1.70	183.30
2	-36.990873	141.549783	180.17	1.70	181.87
3	-36.991930	141.549800	180.95	1.70	182.65
4	-36.991929	141.549879	181.41	1.70	183.11
5	-36.992701	141.549901	181.99	1.70	183.69
6	-36.992679	141.547469	177.72	1.70	179.42
7	-36.991835	141.547459	178.57	1.70	180.27
8	-36.991837	141.547069	178.49	1.70	180.19
9	-36.990944	141.547056	180.22	1.70	181.92
10	-36.990931	141.548327	177.32	1.70	179.02
11	-36.989989	141.548316	177.64	1.70	179.34
12	-36.989995	141.550728	178.45	1.70	180.15

Name: PV array 2
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	-36.991149	141.550788	182.00	1.70	183.70
2	-36.991147	141.551293	182.01	1.70	183.71
3	-36.992023	141.551306	182.57	1.70	184.27
4	-36.992023	141.551097	182.25	1.70	183.95
5	-36.992989	141.551121	183.69	1.70	185.39
6	-36.992987	141.550724	183.08	1.70	184.78
7	-36.992098	141.550704	181.54	1.70	183.24
8	-36.992104	141.550799	181.73	1.70	183.43

Route Receptors

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-36.999227	141.574211	178.57	2.40	180.97
2	-36.998130	141.569233	179.14	2.40	181.54
3	-36.997179	141.564802	183.25	2.40	185.65
4	-36.995928	141.559448	185.32	2.40	187.72
5	-36.994582	141.553440	184.93	2.40	187.33
6	-36.993331	141.547990	178.64	2.40	181.04
7	-36.993006	141.546627	177.99	2.40	180.39
8	-36.992783	141.545512	177.19	2.40	179.59
9	-36.992714	141.544846	177.63	2.40	180.03
10	-36.992792	141.544117	177.54	2.40	179.94
11	-36.992997	141.543441	177.45	2.40	179.85
12	-36.994180	141.541531	182.28	2.40	184.68
13	-36.994711	141.540415	181.66	2.40	184.06
14	-36.994814	141.539879	180.47	2.40	182.87
15	-36.995354	141.536360	179.28	2.40	181.68
16	-36.995251	141.535351	180.32	2.40	182.72
17	-36.994829	141.534276	182.30	2.40	184.70
18	-36.992680	141.529644	183.02	2.40	185.42
19	-36.990287	141.524497	180.04	2.40	182.44

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-37.011011	141.552374	183.51	2.40	185.91
2	-37.010437	141.552202	181.69	2.40	184.09
3	-37.008792	141.551795	182.75	2.40	185.15
4	-37.007199	141.551419	182.68	2.40	185.08
5	-37.005057	141.550657	181.04	2.40	183.44
6	-37.003420	141.550089	183.66	2.40	186.06
7	-37.001055	141.549327	184.80	2.40	187.20
8	-36.999547	141.548855	183.68	2.40	186.08
9	-36.997611	141.548200	180.51	2.40	182.91
10	-36.994723	141.547299	177.93	2.40	180.33
11	-36.993284	141.546720	177.76	2.40	180.16
12	-36.992589	141.546419	177.99	2.40	180.39
13	-36.987593	141.544413	180.08	2.40	182.48
14	-36.985057	141.543383	178.46	2.40	180.86
15	-36.983805	141.542847	177.53	2.40	179.93
16	-36.982966	141.542182	177.95	2.40	180.35
17	-36.982537	141.541516	179.63	2.40	182.03
18	-36.981954	141.539821	178.87	2.40	181.27
19	-36.980446	141.535379	178.53	2.40	180.93
20	-36.979015	141.530938	175.22	2.40	177.62

Glare Analysis Results

Summary of Results No glare predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	SA tracking	SA tracking	0	0.0	0	0.0	-
PV array 2	SA tracking	SA tracking	0	0.0	0	0.0	-

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

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Charam Wombelano Road	0	0.0	0	0.0
Goroke Harrow Road	0	0.0	0	0.0

PV: PV array 1 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Charam Wombelano Road	0	0.0	0	0.0
Goroke Harrow Road	0	0.0	0	0.0

PV array 1 and Route: Charam Wombelano Road

No glare found

PV array 1 and Route: Goroke Harrow Road

No glare found

PV: PV array 2 no glare found

Receptor results ordered by category of glare

Charam Wombelano Road	0	0.0	0	0.0
Goroke Harrow Road	0	0.0	0	0.0

PV array 2 and Route: Charam Wombelano Road

No glare found

PV array 2 and Route: Goroke Harrow Road

No glare found

Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
"Yellow" glare is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. However, we have validated our models against several systems, including a PV array causing glare to the air-traffic control tower at Manchester-Boston Regional Airport and several sites in Albuquerque, and the tool accurately predicted the occurrence and intensity of glare at different times and days of the year.
Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare. This primarily affects V1 analyses of path receptors.
Random number computations are utilized by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result. This limitation primarily affects analyses of Observation Point receptors, including ATCTs. Note that the SGHAT/ForgeSolar methodology has always relied on an analytical, qualitative approach to accurately determine the overall hazard (i.e. green vs. yellow) of expected glare on an annual basis.
The analysis does not automatically consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc.
The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
The variable direct normal irradiance (DNI) feature (if selected) scales the user-prescribed peak DNI using a typical clear-day irradiance profile. This profile has a lower DNI in the mornings and evenings and a maximum at solar noon. The scaling uses a clear-day irradiance profile based on a normalized time relative to sunrise, solar noon, and sunset, which are prescribed by a sun-position algorithm and the latitude and longitude obtained from Google maps. The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors.
The ocular hazard predicted by the tool depends on a number of environmental, optical, and human factors, which can be uncertain. We provide input fields and typical ranges of values for these factors so that the user can vary these parameters to see if they have an impact on the results. The speed of SGHAT allows expedited sensitivity and parametric analyses.
The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid based on aggregated research data. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Refer to the Help page at **www.forgesolar.com/help/** for assumptions and limitations not listed here.

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

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