ENVIRONMENTAL ETHOS

ADVERTISED PLAN

BAIRNSDALE SOLAR DEVELOPMENT

GLINT AND GLARE ASSESSMENT REPORT

FINAL ISSUE

Prepared For
Bison Energy Pty Ltd

May 2023

ENVIRONMENTAL
ETHOS

Prepared By Environmental Ethos
for Bison Energy Pty Ltd

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Cover Image: John Carmemolla

CONTENTS

EXECUTIVE SUMMARY

The proposed Bairnsdale Solar Development comprises of the installation and operation of a 5MW solar farm and BESS, located approximately 2km west of Bairnsdale.

The structure of the solar farm will be a single axis horizontal tracking system with PV arrays running north/south. The PV arrays will be approximately 1.2 metres high, to centroid.

This glint and glare impact assessment utilised the Solar Glare Hazard Analysis Tool (SGHAT 3.0) in conjunction with a viewshed analysis, to undertake the glare modelling which is the basis for the impact assessment methodology.

The assessment has been undertaken in accordance with the Victoria Government's Solar Energy Facilities Design and Development Guideline, including assessment of the following:

- Dwellings and roads within 1 km 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.

Based on the assumptions and parameters of this desktop assessment, including the normal operation of the solar farm with a tracking/backtracking operation and a minimum limit of 10 degree resting angle, the following results were identified:

- The SGHAT modelling identified no glare is geometrically possible affecting rural and residential dwellings within 1km of the Project, therefore no impact is likely.
- The SGHAT modelling identified no glare is geometrically possible affecting the Princes Highway, local roads, and Gippsland rail line within 1km of the Project, therefore no impact is likely.
- The SGHAT modelling identified no glare affecting the runway approach paths (within the 2 mile flight path limit) for the two runways at Bairnsdale Airport.
- The SGHAT modelling also identified no glare affecting Bairnsdale Christian College, the level railway crossing on Power Station Road, and the entrance to Bairnsdale Power Station.

Management and mitigation measures recommended in this assessment include:

- The Project Environmental Management Plan (EMP) should detail glare management measures, including the parameters detailed in this report. In addition, the EMP should detail a process for monitoring glare hazard and managing possible complaints.

1. INTRODUCTION

This report has been prepared by Environmental Ethos on behalf of Bison Energy Pty Ltd to assess the potential solar glint and glare impact of the proposed Bairnsdale Solar Development (the Project), located at 910 Princes Highway, Bairnsdale, Victoria. The Project comprises of the installation and operation of a 5MW solar farm and Battery Energy Storage System (BESS).

The Project covers an area of approximately 20.73 hectares. The structure of the solar farm will be a single axis horizontal tracking system with PV arrays running north/south.

This glint and glare assessment has been undertaken in accordance with the Solar Energy Facilities Design and Development Guideline (2019)[1] (Development Guidelines), including assessment of the following:

- Dwellings and roads within 1 km 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.

1.1. Location

The Project site is located approximately 2 kilometres (km) west of Bairnsdale, within the Shire of East Gippsland Local Government Area, *refer Figure 1.*

The site is zoned FZ1 Farming Zone and is currently used for grazing. The site adjoins the Bairnsdale Power Station, substation, and Bairnsdale Timber Mill.

The northern boundary of the Project site adjoins the Gippsland Rail line and the southern boundary adjoins the Princes Highway.

The closest avaition infrastructure to the Project site is Bairsdale Airport located approximately 4km to the south.

[1] Solar Energy Facilities Design and Development Guideline, 2019, The State of Victoria Department of Environment, Land, Water and Planning

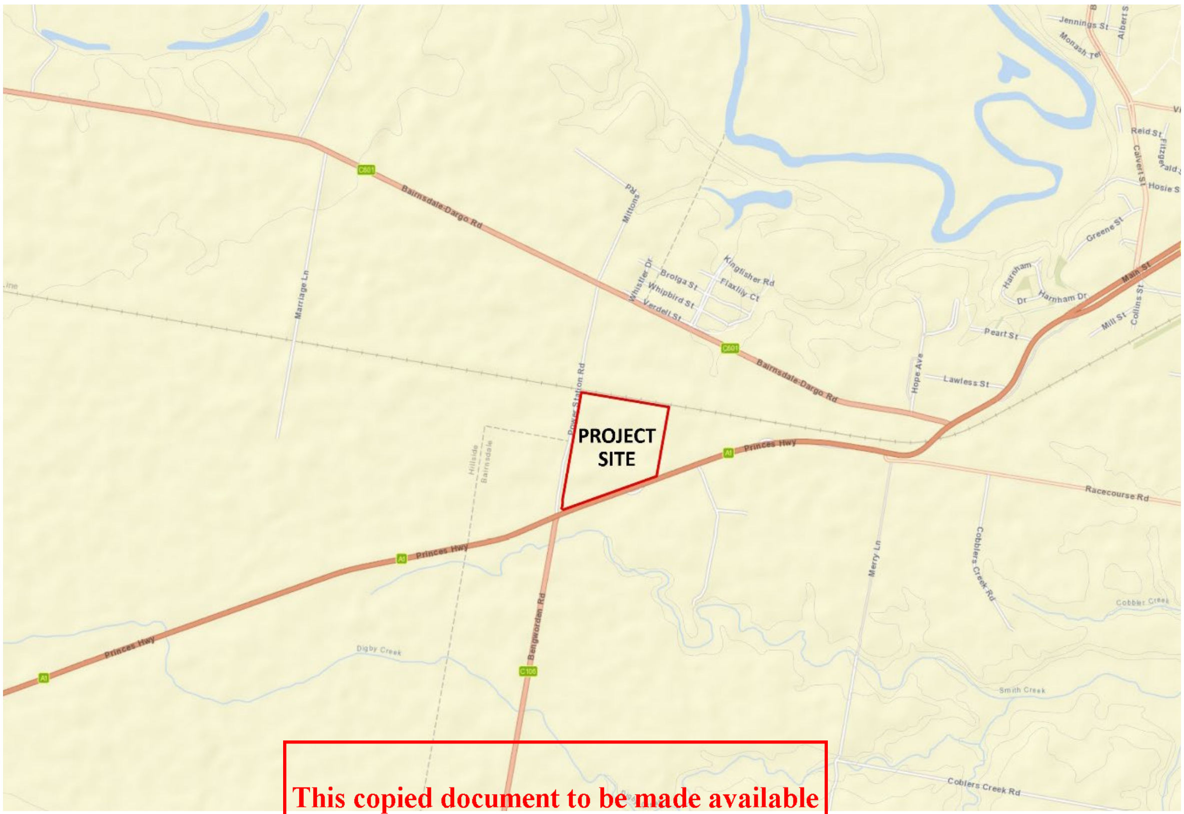


Figure 1. Location Plan

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 glare including size, height, angle and rotation of PV modules, and tracking system operation;
- Identification of the viewshed and potential visibility of the Project;
- Desktop mapping of potential glare at the location of sensitive receptors within the viewshed, based on Solar Glare Hazard Analysis and viewshed analysis;
- Assessment of the potential glare hazard affecting 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."[2]

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

The Victorian 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, (defined as 'glint' in the Development Guidelines), over potentially long duration defined as 'glare' by FAA Guidelines.

The assessment considered the potential for glare to occur throughout the year measurable in duration over 1 minute intervals.

3.2. Solar glare Assessment Parameters

Solar 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 receivers (dwellings, roads, rail, and aviation facilities); and
- Screening potential of surrounding topography, vegetation and buildings.

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

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, distance, and geometry) of the glare source.[3]

Glare can be broadly classified into three categories: low potential for after-image (referred to as “Green Glare” in SGHAT), potential for after-image (referred to as “Yellow Glare” in SGHAT), and potential for permanent eye damage (referred to as “Red Glare” in SGHAT), *Figure 2* illustrates the glare intensity categories used in this study.

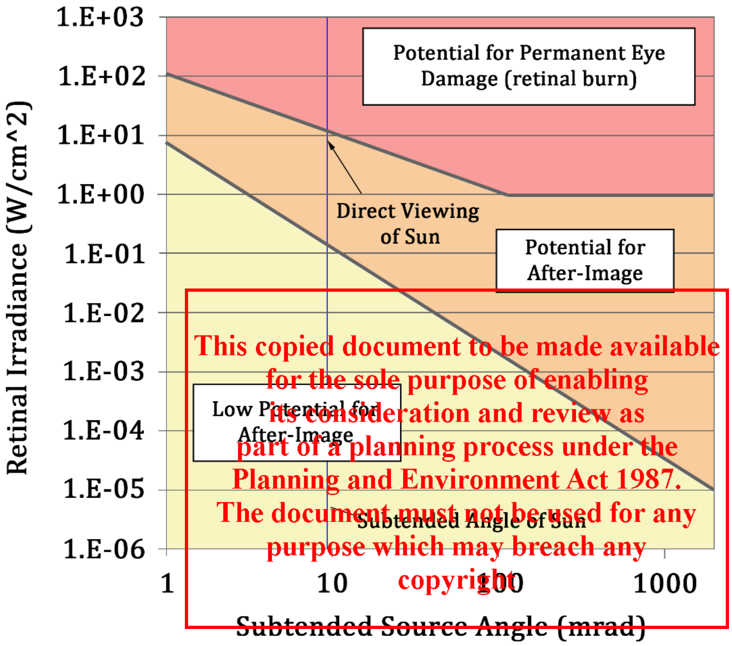


Figure 2. Ocular impacts and Hazard Ranges[4]

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[5]. 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[6].

[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
[4] Source: Solar Glare Hazard Analysis Tool (SGHAT) Presentation (2013) https://share.sandia.gov/phlux/static/references/glint-glare/SGHAT_Ho.pdf
[5] Global Solar Atlas 2.0, Solar resource data: Solargis
[6] 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.[7]

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 or scattered light reflection) may also occur in PV modules, however diffuse reflection is significantly less intense than specular reflection.

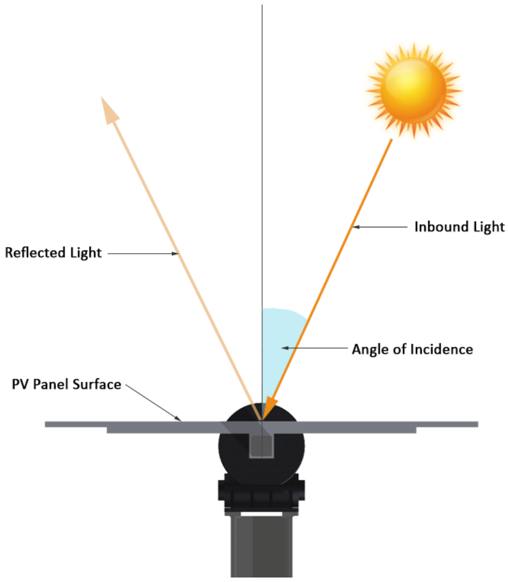


Figure 3. Angle of Incidence Relative to PV Panel Surface

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

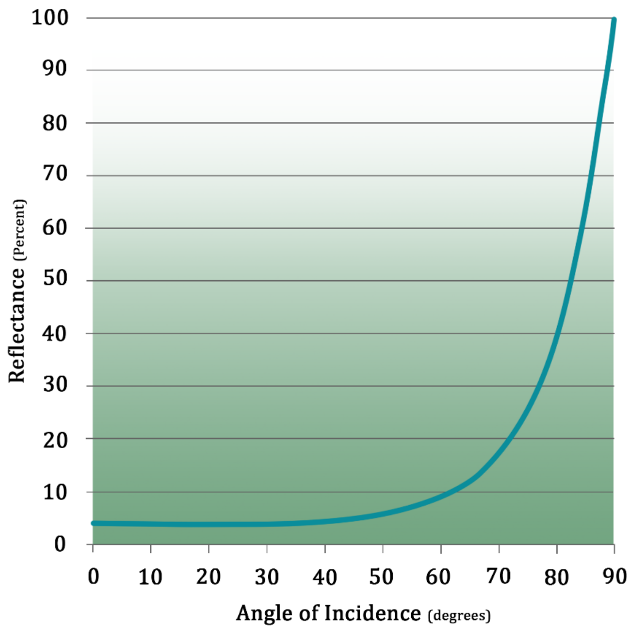


Figure 4. Angles of Incidence and Increased Levels of Reflected Light (Glass (n-1.5))

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.

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.

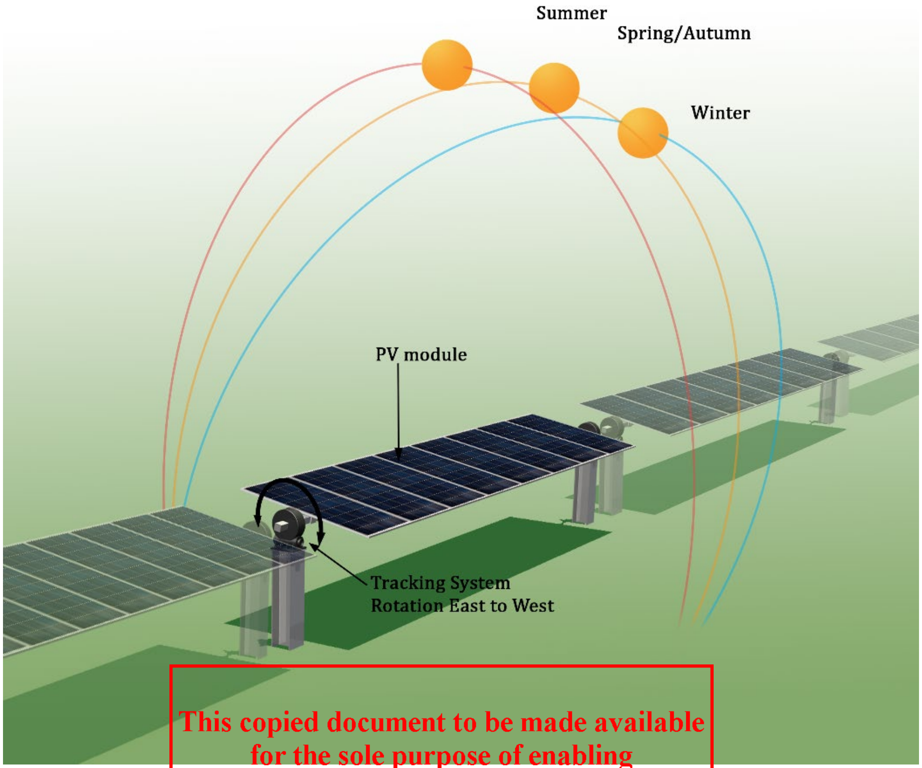


Figure 5. Diagrammatic illustration of sun position relative to PV module mounted on a horizontal single axis tracking system.

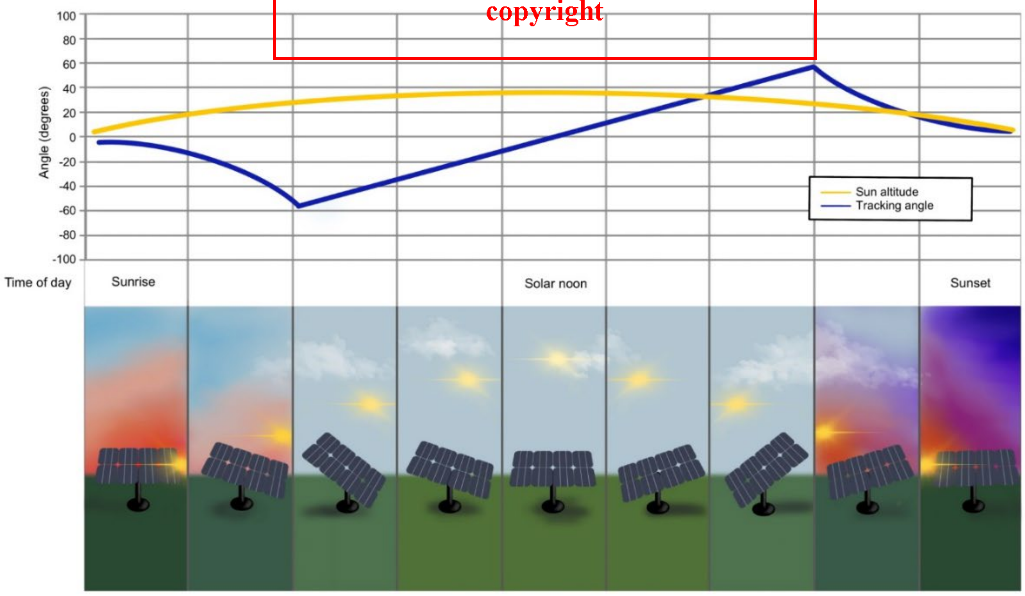


Figure 6. Diagrammatic illustration of a backtracking procedure for a horizontal single axis tracking system. (Source: ForgeSolar).

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 3.0) co-developed by Sandi National Laboratory[8] 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.

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

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

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.*

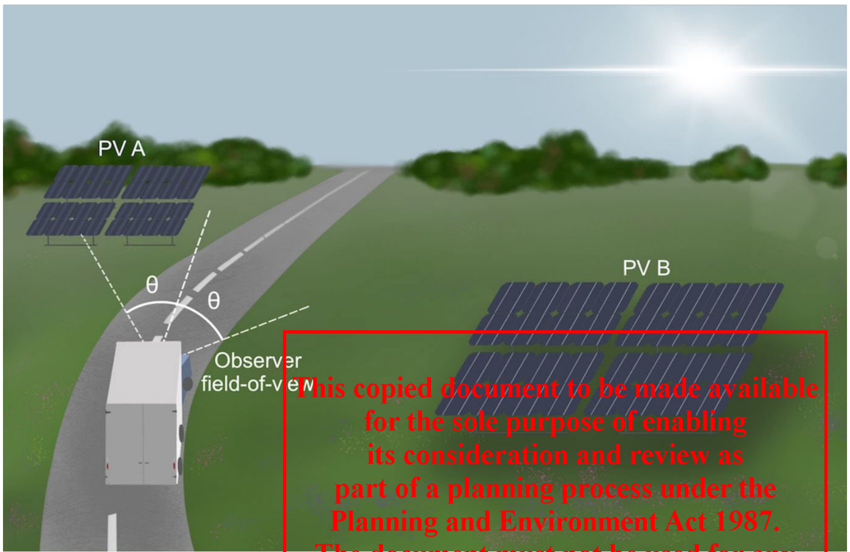


Figure 7. Diagrammatic illustration of Observer Field of View relative to PV array (source: ForgeSolar).

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[9]. 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.

SGHAT default parameter for FOV is 50°, this assessment used an FOV of 90°, representing a conservative assessment of potential glare hazard to drivers using roads and rail network within the vicinity of the solar farm.

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 8*.

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

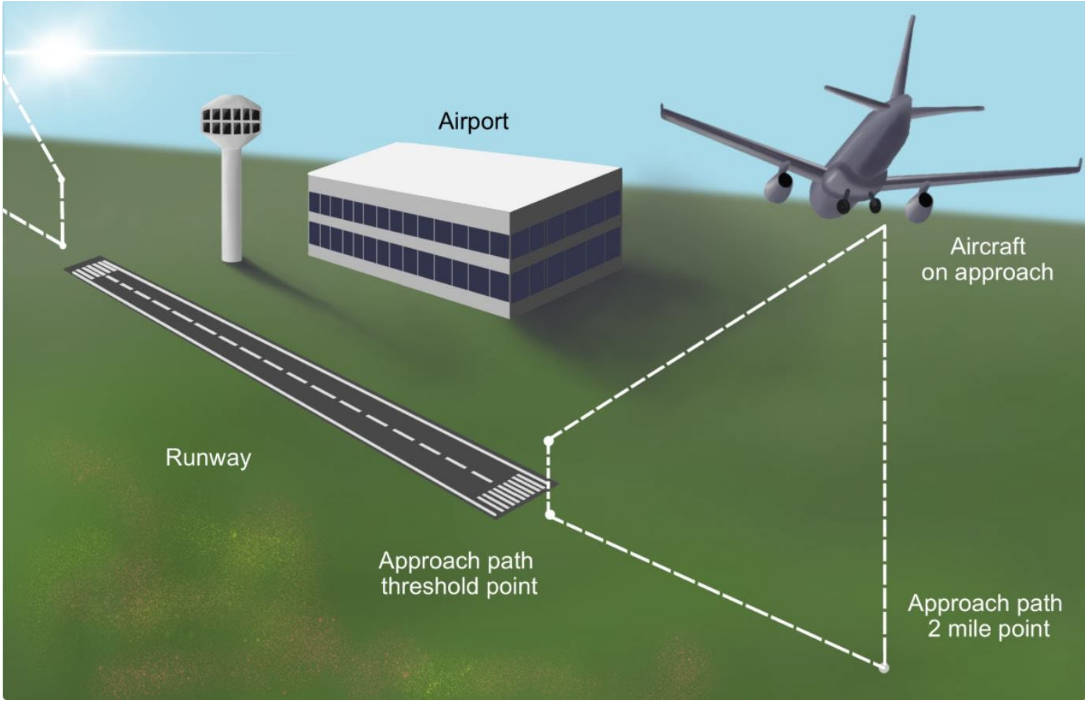


Figure 8. Diagrammatic illustration of SHGAT flight parameters (source: Forgesolar).

Airport specific flight path parameters were not available for this assessment, therefore SGHAT default parameters were used including glide slope 3° and threshold crossing height 15 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 *Figure 9.*

Figure 9. 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.

Where required, 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 licence 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 grazing land, which is generally flat. An existing telecom tower is located on the western boundary and an existing farm shed on the eastern boundary. The Princes Highway adjoins the Project site's southern boundary, there is no screening along this boundary. Power Station Road adjoins the Project site's western boundary, this boundary is partially screened by existing vegetation. The eastern boundary is densely planted with shelterbelt trees and generally well screened. The northern boundary adjoining the Gippsland rail line is partially screened by vegetation.

The level railway crossing on Power Station Road is not screened from the Project site.

Land use surrounding the site includes power generation, industry, and grazing. Constructed elements within the landscape include the highway, rail line, local roads, rural and residential buildings, schools and infrastructure (power lines).

Residential dwellings surrounding the Project site are generally rural properties. A residential area 500m to the north of the Project site is well screened by existing vegetation.

Bairnsdale Christian College is located approximately 450m to the north east of the Project site, the school is also screened by existing vegetation.

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 Bairnsdale Airport 4km south of the Project site (the closest BOM records for cloud cover statistics) recorded 161.2 cloudy days per year (mean number over the period 1942 to 2010)[10]. Since atmospheric conditions have not been factored into this assessment modelling, statistically the glare potential represents a conservative assessment.

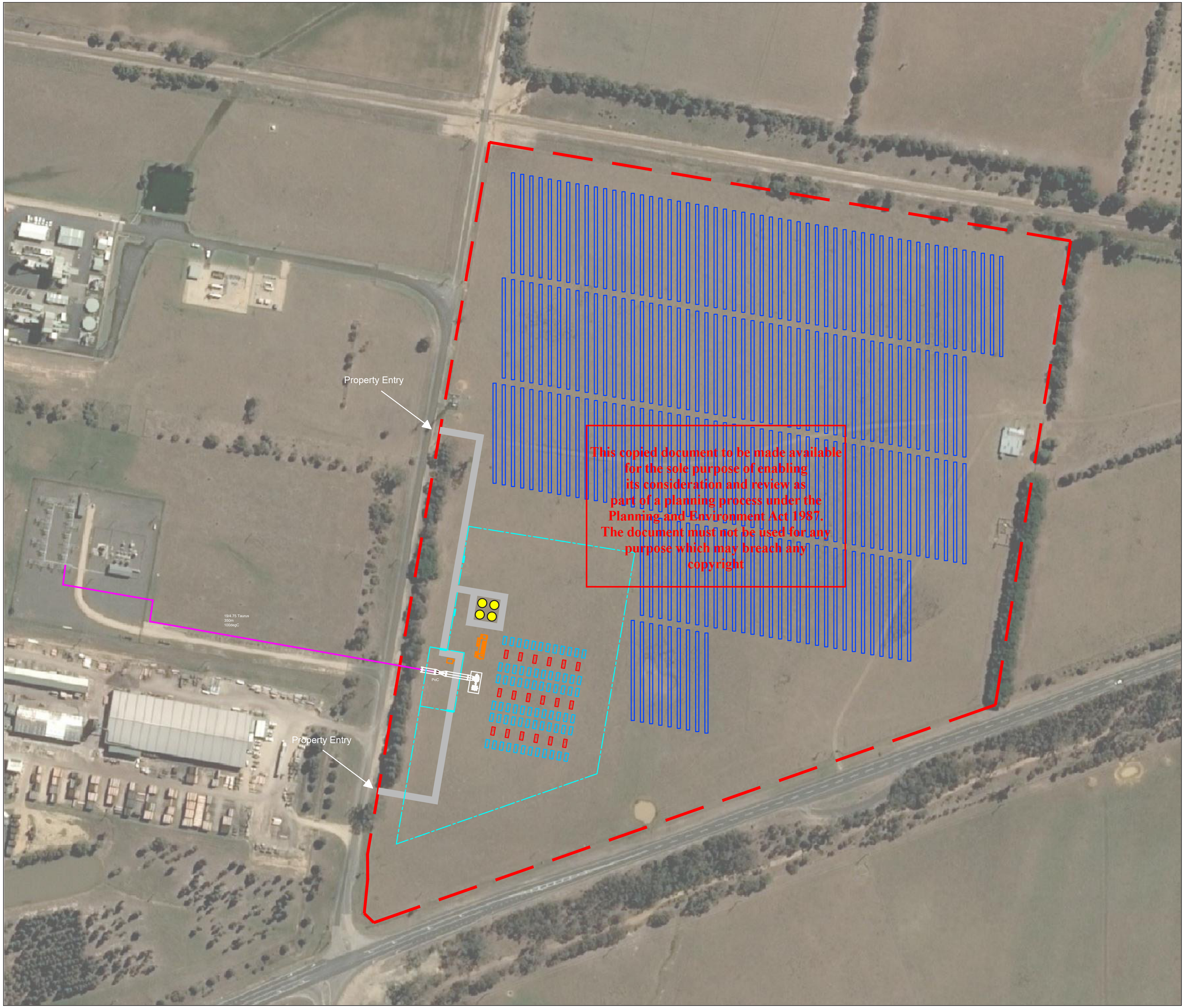
5. PROJECT DESCRIPTION

The general layout of the Project is as shown in *Figure 10.* 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

Reflectance values for the PV modules were based on the default values for smooth glass with anti-reflective coating contained in SGHAT, and vary dependent on the sun/module incidence angle (refer *Figure 11*).

[10] http://www.bom.gov.au/climate/averages/tables/cw_085279.shtml



ENVIRONMENTAL ETHOS

LEGEND

- Solar Farm Boundary
- Security Fence
- Security Gate
- Access Track
- 66kV AusNet Feeder
- 72,000L Water Tank
- Power Station
- Battery Container
- Site Buildings
- Point of Connection (PoC)
- Solar Panels

ADVERTISED PLAN

SOURCE: Bison Energy Pty Ltd
SITE PLAN BDBS-002
REV. 3.1 11 12 2022

PROJECT NO. 23001
CREATED BY: SC
DATE: 21 04 2023
VERSION: A

BAIRNSDALE SOLAR PROJECT

GLINT AND GLARE IMPACT ASSESSMENT

PROJECT LAYOUT PLAN

FIGURE 10.0

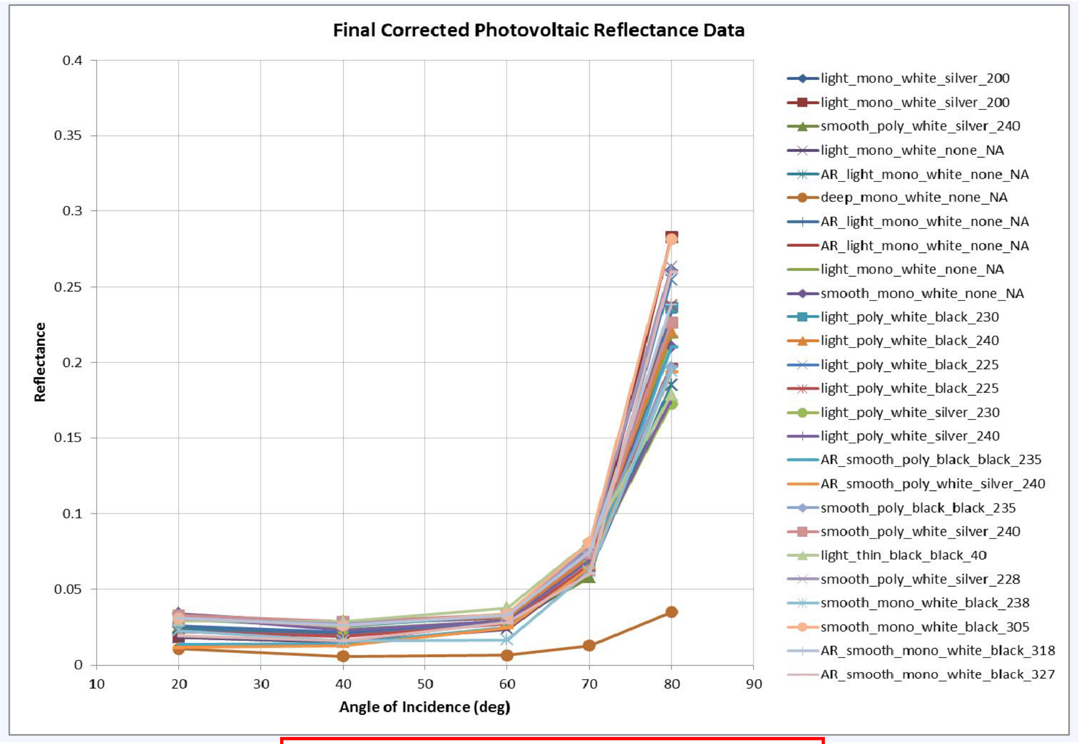


Figure 11. Photovoltaic Reflectance Data (Source Yellowhair[11])

5.2. Horizontal single axis tracking system

The Project will use a horizontal single axis tracking system aligned north-south, with a maximum rotation range of 120° (+/- 60°). The zenith tilt angle of the panels was assumed to be set at zero, that is, the panels are not tilted up a north-south alignment but remain horizontal along the plane of the tracker.

The height of the PV tracking system will depend on the final design, the current proposal is a maximum height to centroid of 1.2m and maximum height at full rotation 2.5m.

The configuration of the tracking system rows vary slightly dependent on the type of system used, generally rows are approximately 5-7 metres apart.

5.3. Associated infrastructure

In addition to the PV arrays, the Project will also include a BESS, solar inverters, control/switch building, power line, and perimeter fencing. 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 is proposed around the perimeter of the Project sufficient to provide visual screening once established.

[11] Yellowhair, J. and C.K. Ho. "Assessment of Photovoltaic Surface Texturing on Transmittance Effects and Glint/Glare Impacts". *ASME 2015 9th International Conference on Energy Sustainability collocated with the ASME 2015 Power Conference*

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 Project, 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 12.*

The Digital Elevation Model (DEM) for the viewshed modelling was set as 'Finest' (> 10 m). The viewshed analysis focussed on potential visibility of the Project within 2km of the site.

Contour information for the site shows the Project site and surrounding area is generally flat. Slightly undulating terrain in the north and east provides partial screening in these direction.

24 residential receivers were assessed within 1km of the Project, and a further 4 assessed at approximately 1.5km from the Project. Residential receiver locations shown in *Figure 12* are consist with the observation points (OP) in the glare modelling. The residential area to the north of the Project is screened by vegetation, however a small number of dwellings were identified in the viewshed model as potentially having partial visibility of the Project based on terrain alone. Whilst this area is unlikely to have line of sight to the Project a representative number of dwellings were selected to test in the glare modelling (OP19 to OP25).

In addition, the school to the north east of the Project site was also considered in the modelling (OP8).

Two other observation points were included in the glare modelling based on their sensitivity to potential glare and visual exposure to the Project site, these included:

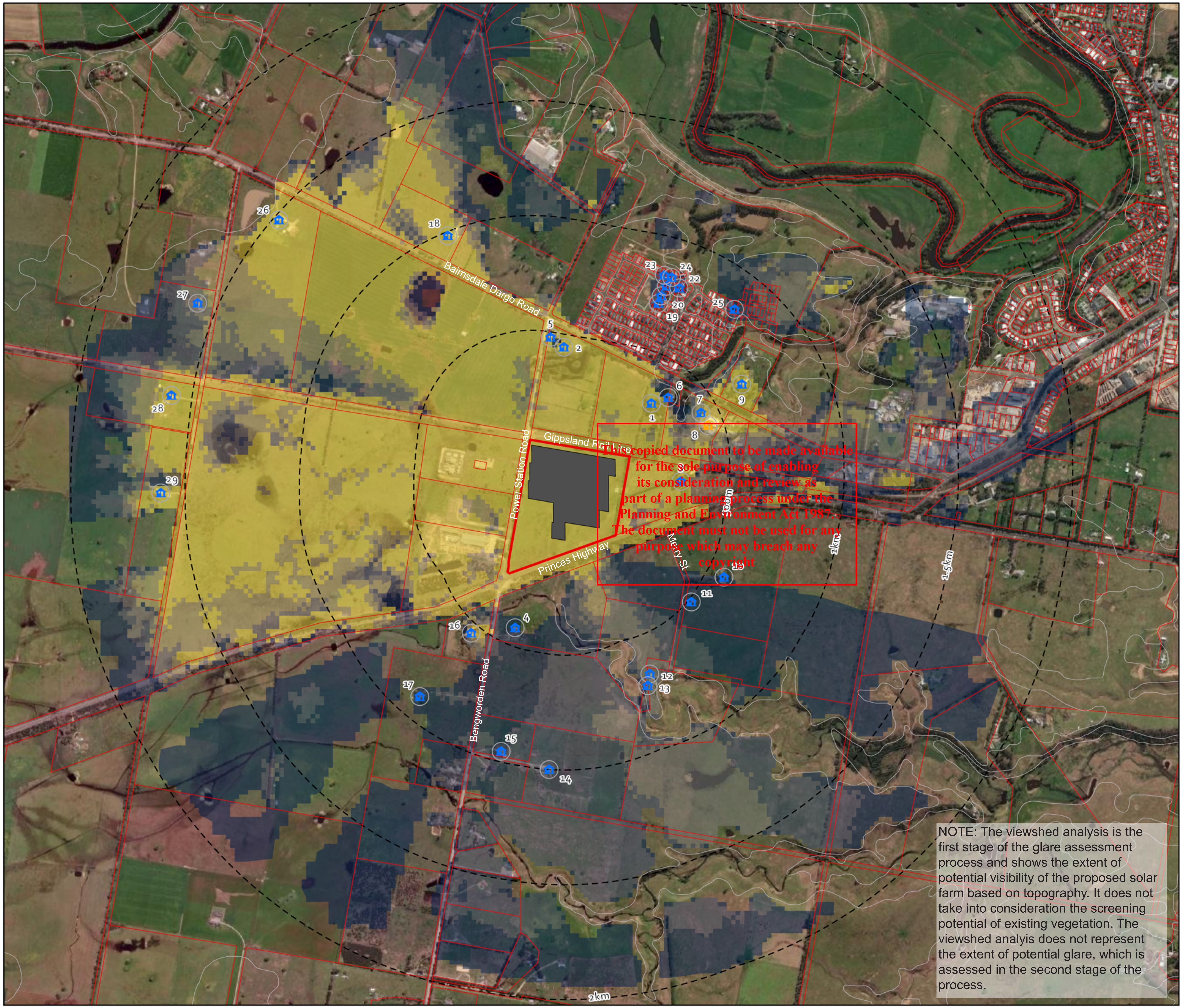
- Level railway crossing on Power Station Road (OP30)
- Intersection of Power Station Road and Bairnsdale Power Station access road (OP31)

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

- Princes Highway
- Railway Line
- Power Station Road
- Bairnsdale Dargo Road
- Bengworden Road
- Merry Street

The potential glare hazard impact for travellers along surrounding roads was assessed for the sections of roads within a minimum 1km radius of the Project site

Bairnsdale Airport has two runways RWY04/22 and RWY 13/31, both were included in the glare modelling. The Airport does not have an air traffic control tower.



ENVIRONMENTAL ETHOS

N

DATUM GDA 1994,
PROJECTION MGA ZONE 56

0 0.25 0.5 1 Kilometers

SCALE 1:20,000 @ A3

Legend

- SITE BOUNDARY
- PV MODULE AREA
- DISTANCE FROM SOLAR FARM
- NON-DWELLING (SCHOOL)
- DWELLINGS

EXTENT OF VISIBILITY*

LESS VISIBLE

MORE VISIBLE

ADVERTISED PLAN

*(Analysis based on Digital Terrain Model)

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

PROJECT No. 23001
CREATED BY: SC
DATE: 19 04 2023
VERSION: A

BAIRNSDALE SOLAR FARM

GLINT AND GLARE ASSESSMENT

VIEWSHED ANALYSIS

FIGURE 12.0

6.2. Solar Glare Hazard Analysis

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

Table 1. Input data for SGHAT Analysis – 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	10 degrees
Reflectivity	Vary with sun
Correlate slope error with surface type?	Yes
Slope error	8.43 mrad
Height of panels above ground	1.2m 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 10° (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 13 and 14*.

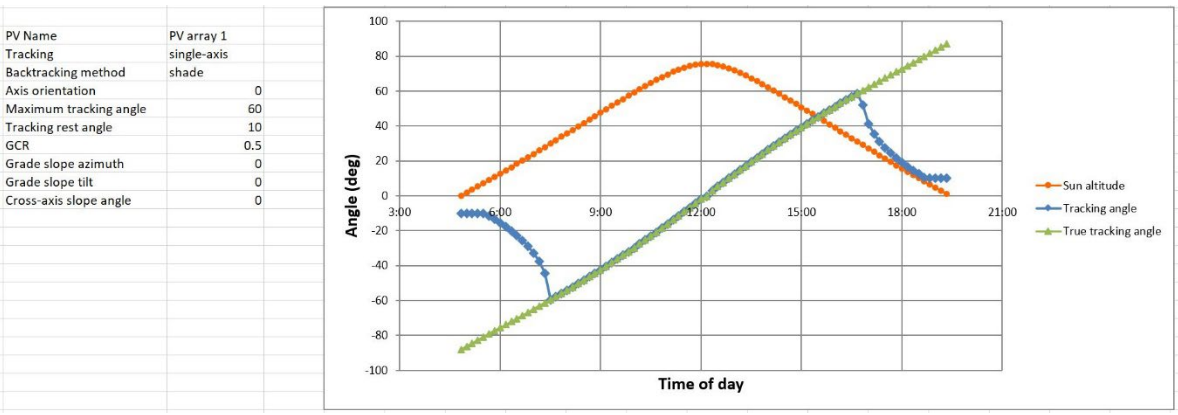


Figure 13. Tracking/backtracking angle per time slot – mid summer

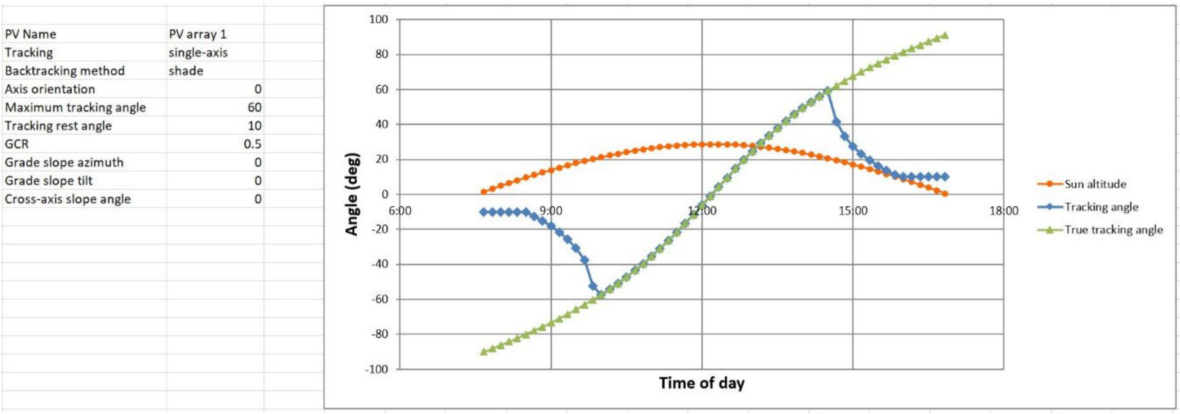


Figure 14. Tracking/backtracking angle per time slot – mid winter

6.3. Solar Glare Hazard Analysis Tool (SGHAT) Results

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

All observation point locations and numbers shown in *Figure 12* are consist with the glare modelling results provided in the appendices and detailed in *Table 2*.

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

Sensitive Receptor	Glare Potential
Observation Points OP1 to OP28 - Rural and residential dwellings	No Glare
Observation Point OP8 - School	No Glare
Observation Point OP30 – Level railway crossing	No Glare
Observation Point OP31 – Entry to Bairnsdale Power Station	No Glare
Princes Highway	No Glare
Railway Line	No Glare
Power Station Road	No Glare
Bairnsdale Dargo Road	No Glare
Bengworden Road	No Glare
Merry Street	No Glare
Bairnsdale Airport runways RWY04/22 and RWY 13/31	No Glare

The SGHAT modelling identifies that under normal operation of the solar farm, based on the model parameters and limits detailed in this report, no glare hazard is geometrically possible, *refer Appendix A and B.*

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 10 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.

The Project includes landscape planting to the perimeter of the site which will provide screening between the solar farm and surrounding sensitive receivers. Monitoring of glare hazard potential would no longer be required once the screen planting is sufficiently established to block line of sight to the solar farm.

8. SUMMARY

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

- The viewshed modelling identified the site and surrounding area as generally flat with slightly undulating terrain in the north and east providing partial screening in these directions.
- 24 residential receivers were assessed within 1km of the Project, and a further 4 assessed at approximately 1.5km from the Project site.
- Additional sensitive receivers assessed in the glare modelling included Bairnsdale Christian College, the level railway crossing on Power Station Road, and the entrance to Bairnsdale Power Station.
- The Princes Highway, Gippsland Rail line, and four local roads were also assessed in the glare modelling.
- The two runways at Bairnsdale Airport located approximately 4km to the south of the Project site were assess in terms of potential glare affecting the 2 mile flight paths to the runways.
- Glare (SGHAT) modelling identified that under normal operation of the solar farm with a tracking/backtracking operation and a minimum limit of 10 degree resting angle (being the fixed angle at which the backtracking process starts and finishes during daylight hours), no potential glare hazard impacts were identified as affecting rural/residential receivers, the Princes Highway and local roads, railway line, and Bairnsdale Airport flight paths.
- The Project EMP should detail glare management measures required to avoid impacts to sensitive receptors, including the parameters and limits detailed in this report regarding the tracking system operation. In addition, monitoring of glare hazard potential is required and a process for managing complaints, including rectification, should be included in the Project EMP.

APPENDIX A:

SOLAR GLARE HAZARD ANALYSIS RESULTS

FORGESOLAR GLARE ANALYSIS

Project: **BairnsdaleSF**
Site configuration: **BairnsdaleSF_Update**

Created 23 Mar, 2023
Updated 21 Apr, 2023
Time-step 1 minute
Timezone offset UTC10
Site ID 87117.15292
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
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	-

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
Bairnsdale Dargo Road	0	0.0	0	0.0
Merry St	0	0.0	0	0.0
Power Station and Bengworden Rds	0	0.0	0	0.0
Princes Highway	0	0.0	0	0.0
Railway Line	0	0.0	0	0.0
RWY 04	0	0.0	0	0.0
RWY 13	0	0.0	0	0.0
RWY 22	0	0.0	0	0.0
RWY 31	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 5	0	0.0	0	0.0

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 6	0	0.0	0	0.0
OP 7	0	0.0	0	0.0
OP 8	0	0.0	0	0.0
OP 9	0	0.0	0	0.0
OP 10	0	0.0	0	0.0
OP 11	0	0.0	0	0.0
OP 12	0	0.0	0	0.0
OP 13	0	0.0	0	0.0
OP 14	0	0.0	0	0.0
OP 15	0	0.0	0	0.0
OP 16	0	0.0	0	0.0
OP 17	0	0.0	0	0.0
OP 18	0	0.0	0	0.0
OP 19	0	0.0	0	0.0
OP 20	0	0.0	0	0.0
OP 21	0	0.0	0	0.0
OP 22	0	0.0	0	0.0
OP 23	0	0.0	0	0.0
OP 24	0	0.0	0	0.0
OP 25	0	0.0	0	0.0
OP 26	0	0.0	0	0.0
OP 27	0	0.0	0	0.0
OP 28	0	0.0	0	0.0
OP 29	0	0.0	0	0.0
OP 30	0	0.0	0	0.0
OP 31	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: 10.0°
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	-37.842232	147.567870	36.04	1.20	37.24
2	-37.842771	147.572040	34.17	1.20	35.37
3	-37.843468	147.572044	34.55	1.20	35.75
4	-37.843453	147.571715	34.52	1.20	35.72
5	-37.844875	147.571710	36.46	1.20	37.66
6	-37.844831	147.571270	35.72	1.20	36.92
7	-37.845534	147.571273	35.35	1.20	36.55
8	-37.845356	147.569528	32.51	1.20	33.71
9	-37.846052	147.569525	33.83	1.20	35.03
10	-37.845968	147.568873	33.38	1.20	34.58
11	-37.845289	147.568869	33.41	1.20	34.61
12	-37.845295	147.568926	33.27	1.20	34.47
13	-37.844514	147.568924	34.48	1.20	35.68
14	-37.844339	147.567732	37.75	1.20	38.95
15	-37.843655	147.567719	36.84	1.20	38.04
16	-37.843664	147.567804	36.86	1.20	38.06
17	-37.842891	147.567784	36.41	1.20	37.61
18	-37.842909	147.567883	36.49	1.20	37.69

Route Receptors

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-37.843361	147.588358	33.26	2.40	35.66
2	-37.843022	147.586641	33.00	2.40	35.40
3	-37.842700	147.584302	32.79	2.40	35.19
4	-37.842548	147.582650	33.00	2.40	35.40
5	-37.841141	147.579024	33.40	2.40	35.80
6	-37.838820	147.572844	34.03	2.40	36.43
7	-37.836447	147.566771	35.00	2.40	37.40
8	-37.835413	147.564132	33.19	2.40	35.59
9	-37.832871	147.557523	35.11	2.40	37.51
10	-37.830905	147.552309	28.88	2.40	31.28

Name: Merry St
Path type: Two-way
Observer view angle: 90.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-37.850987	147.574752	30.35	2.40	32.75
2	-37.849386	147.575085	33.01	2.40	35.41
3	-37.848175	147.575364	33.39	2.40	35.79
4	-37.847378	147.575428	32.24	2.40	34.64
5	-37.847053	147.575153	32.32	2.40	34.72
6	-37.845291	147.574423	34.40	2.40	36.80

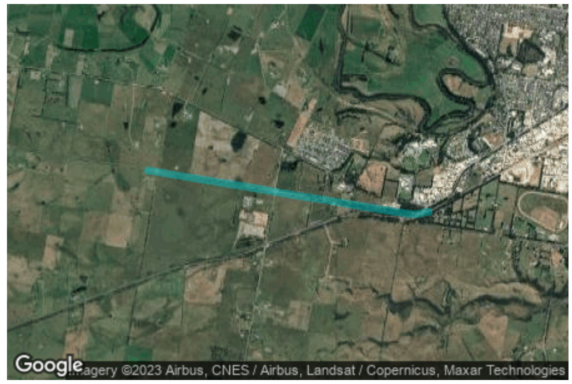
Name: Power Station and Bengworden Rds
Path type: Two-way
Observer view angle: 90.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-37.837286	147.568745	34.33	2.40	36.73
2	-37.837947	147.568488	33.70	2.40	36.10
3	-37.838896	147.568338	33.97	2.40	36.37
4	-37.840116	147.568069	33.58	2.40	35.98
5	-37.840980	147.567833	32.31	2.40	34.71
6	-37.841776	147.567619	33.35	2.40	35.75
7	-37.842056	147.567597	34.98	2.40	37.38
8	-37.843403	147.567308	36.45	2.40	38.85
9	-37.844231	147.567109	37.65	2.40	40.05
10	-37.846063	147.566696	34.92	2.40	37.32
11	-37.847055	147.566460	36.18	2.40	38.58
12	-37.847538	147.566331	36.04	2.40	38.44
13	-37.848351	147.566181	36.00	2.40	38.40
14	-37.850350	147.565731	35.43	2.40	37.83
15	-37.852570	147.565216	36.57	2.40	38.97
16	-37.854383	147.564797	36.36	2.40	38.76

Name: Princes Highway
Path type: Two-way
Observer view angle: 90.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-37.843505	147.588583	33.90	2.40	36.30
2	-37.844072	147.587832	32.88	2.40	35.28
3	-37.844564	147.587124	32.68	2.40	35.08
4	-37.844818	147.586405	33.71	2.40	36.11
5	-37.844801	147.585439	33.82	2.40	36.22
6	-37.844530	147.583669	32.70	2.40	35.10
7	-37.844386	147.582092	34.88	2.40	37.28
8	-37.844225	147.579946	34.00	2.40	36.40
9	-37.844369	147.578122	33.00	2.40	35.40
10	-37.844699	147.576406	34.89	2.40	37.29
11	-37.844962	147.575354	35.31	2.40	37.71
12	-37.845936	147.571986	36.31	2.40	38.71
13	-37.846843	147.568885	35.11	2.40	37.51
14	-37.847580	147.566331	36.04	2.40	38.44
15	-37.848342	147.564218	36.61	2.40	39.01
16	-37.849461	147.558242	36.80	2.40	39.20
17	-37.850037	147.554637	37.00	2.40	39.40
18	-37.851528	147.549015	38.48	2.40	40.88

Name: Railway Line
Path type: Two-way
Observer view angle: 90.0°



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-37.843996	147.588701	34.17	3.00	37.17
2	-37.844259	147.587049	32.85	3.00	35.85
3	-37.844216	147.585879	34.00	3.00	37.00
4	-37.843793	147.582532	34.01	3.00	37.01
5	-37.843064	147.577007	34.53	3.00	37.53
6	-37.842759	147.574786	35.34	3.00	38.34
7	-37.842420	147.571975	34.25	3.00	37.25
8	-37.841946	147.568359	35.00	3.00	38.00
9	-37.841844	147.567651	33.70	3.00	36.70
10	-37.841336	147.564046	35.92	3.00	38.92
11	-37.840870	147.560259	36.95	3.00	39.95
12	-37.839895	147.552856	36.43	3.00	39.43
13	-37.839692	147.551504	37.55	3.00	40.55
14	-37.839531	147.550088	37.81	3.00	40.81

Flight Path Receptors

Name: RWY 04
Description:
Threshold height: 15 m
Direction: 55.0°
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	-37.890363	147.564331	50.75	15.24	65.99
Two-mile	-37.906946	147.534285	56.00	178.68	234.67

Name: RWY 13
Description:
Threshold height: 15 m
Direction: 145.0°
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	-37.883431	147.565747	50.20	15.24	65.44
Two-mile	-37.859747	147.544711	38.97	195.15	234.12

Name: RWY 22
Description:
Threshold height: 15 m
Direction: 235.0°
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	-37.884724	147.574568	49.71	15.24	64.95
Two-mile	-37.868141	147.604611	30.21	203.43	233.64

Name: RWY 31
Description:
Threshold height: 15 m
Direction: 325.0°
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	-37.889705	147.571292	49.49	15.24	64.73
Two-mile	-37.913389	147.592330	41.00	192.42	233.42

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	-37.840634	147.573840	33.41	1.50
OP 2	2	-37.838401	147.569495	33.84	1.50
OP 3	3	-37.843693	147.575313	35.75	1.50
OP 4	4	-37.849414	147.567078	34.86	1.50
OP 5	5	-37.838049	147.568841	34.14	1.50
OP 6	6	-37.840428	147.574762	31.80	1.50
OP 7	7	-37.840987	147.576350	33.77	1.50
OP 8	8	-37.841389	147.576645	34.44	1.50
OP 9	9	-37.839912	147.578386	33.75	1.50
OP 10	10	-37.847408	147.577442	33.22	1.50
OP 11	11	-37.848413	147.575814	33.74	1.50
OP 12	12	-37.851270	147.573785	30.18	1.50
OP 13	13	-37.851580	147.573723	29.64	1.50
OP 14	14	-37.855005	147.568761	33.13	1.50
OP 15	15	-37.854348	147.566323	35.61	1.50
OP 16	16	-37.849620	147.564926	36.49	1.50
OP 17	17	-37.852127	147.562396	36.16	1.50
OP 18	18	-37.834024	147.563756	34.46	1.50
OP 19	19	-37.836901	147.574023	30.77	1.50
OP 20	20	-37.836460	147.574313	30.55	1.50
OP 21	21	-37.836045	147.574592	29.95	1.50
OP 22	22	-37.836202	147.574882	29.52	1.50
OP 23	23	-37.835473	147.574013	30.77	1.50
OP 24	24	-37.835604	147.574318	30.35	1.50
OP 25	25	-37.836926	147.577950	29.98	1.50
OP 26	26	-37.833523	147.555307	37.00	1.50
OP 27	27	-37.836749	147.551284	36.10	1.50
OP 28	28	-37.840300	147.549910	38.81	1.50
OP 29	29	-37.844163	147.549556	39.04	1.50
OP 30	30	-37.841805	147.567645	33.46	2.40
OP 31	31	-37.843056	147.567276	36.05	2.40

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	-

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
Bairnsdale Dargo Road	0	0.0	0	0.0
Merry St	0	0.0	0	0.0
Power Station and Bengworden Rds	0	0.0	0	0.0
Princes Highway	0	0.0	0	0.0
Railway Line	0	0.0	0	0.0
RWY 04	0	0.0	0	0.0
RWY 13	0	0.0	0	0.0
RWY 22	0	0.0	0	0.0
RWY 31	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 5	0	0.0	0	0.0
OP 6	0	0.0	0	0.0
OP 7	0	0.0	0	0.0
OP 8	0	0.0	0	0.0
OP 9	0	0.0	0	0.0
OP 10	0	0.0	0	0.0
OP 11	0	0.0	0	0.0
OP 12	0	0.0	0	0.0
OP 13	0	0.0	0	0.0
OP 14	0	0.0	0	0.0
OP 15	0	0.0	0	0.0
OP 16	0	0.0	0	0.0
OP 17	0	0.0	0	0.0
OP 18	0	0.0	0	0.0
OP 19	0	0.0	0	0.0
OP 20	0	0.0	0	0.0
OP 21	0	0.0	0	0.0

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 22	0	0.0	0	0.0
OP 23	0	0.0	0	0.0
OP 24	0	0.0	0	0.0
OP 25	0	0.0	0	0.0
OP 26	0	0.0	0	0.0
OP 27	0	0.0	0	0.0
OP 28	0	0.0	0	0.0
OP 29	0	0.0	0	0.0
OP 30	0	0.0	0	0.0
OP 31	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
Bairnsdale Dargo Road	0	0.0	0	0.0
Merry St	0	0.0	0	0.0
Power Station and Bengworden Rds	0	0.0	0	0.0
Princes Highway	0	0.0	0	0.0
Railway Line	0	0.0	0	0.0
RWY 04	0	0.0	0	0.0
RWY 13	0	0.0	0	0.0
RWY 22	0	0.0	0	0.0
RWY 31	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 5	0	0.0	0	0.0
OP 6	0	0.0	0	0.0
OP 7	0	0.0	0	0.0
OP 8	0	0.0	0	0.0
OP 9	0	0.0	0	0.0
OP 10	0	0.0	0	0.0
OP 11	0	0.0	0	0.0
OP 12	0	0.0	0	0.0
OP 13	0	0.0	0	0.0
OP 14	0	0.0	0	0.0
OP 15	0	0.0	0	0.0
OP 16	0	0.0	0	0.0
OP 17	0	0.0	0	0.0
OP 18	0	0.0	0	0.0
OP 19	0	0.0	0	0.0
OP 20	0	0.0	0	0.0
OP 21	0	0.0	0	0.0
OP 22	0	0.0	0	0.0
OP 23	0	0.0	0	0.0
OP 24	0	0.0	0	0.0

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 25	0	0.0	0	0.0
OP 26	0	0.0	0	0.0
OP 27	0	0.0	0	0.0
OP 28	0	0.0	0	0.0
OP 29	0	0.0	0	0.0
OP 30	0	0.0	0	0.0
OP 31	0	0.0	0	0.0

PV array 1 and Bairnsdale Dargo Road

Receptor type: Route

No glare found

PV array 1 and Merry St

Receptor type: Route

No glare found

PV array 1 and Power Station and Bengworden Rds

Receptor type: Route

No glare found

PV array 1 and Princes Highway

Receptor type: Route

No glare found

PV array 1 and Railway Line

Receptor type: Route

No glare found

PV array 1 and RWY 04

Receptor type: 2-mile Flight Path

No glare found

PV array 1 and RWY 13

Receptor type: 2-mile Flight Path

No glare found

PV array 1 and RWY 22

Receptor type: 2-mile Flight Path

No glare found

PV array 1 and RWY 31

Receptor type: 2-mile Flight Path

No glare found

PV array 1 and OP 1

Receptor type: Observation Point

No glare found

PV array 1 and OP 2

Receptor type: Observation Point

No glare found

PV array 1 and OP 3

Receptor type: Observation Point

No glare found

PV array 1 and OP 4

Receptor type: Observation Point

No glare found

PV array 1 and OP 5

Receptor type: Observation Point
No glare found

PV array 1 and OP 6

Receptor type: Observation Point
No glare found

PV array 1 and OP 7

Receptor type: Observation Point
No glare found

PV array 1 and OP 8

Receptor type: Observation Point
No glare found

PV array 1 and OP 9

Receptor type: Observation Point
No glare found

PV array 1 and OP 10

Receptor type: Observation Point
No glare found

PV array 1 and OP 11

Receptor type: Observation Point
No glare found

PV array 1 and OP 12

Receptor type: Observation Point
No glare found

PV array 1 and OP 13

Receptor type: Observation Point
No glare found

PV array 1 and OP 14

Receptor type: Observation Point
No glare found

PV array 1 and OP 15

Receptor type: Observation Point
No glare found

PV array 1 and OP 16

Receptor type: Observation Point
No glare found

PV array 1 and OP 17

Receptor type: Observation Point
No glare found

PV array 1 and OP 18

Receptor type: Observation Point
No glare found

PV array 1 and OP 19

Receptor type: Observation Point
No glare found

PV array 1 and OP 20

Receptor type: Observation Point
No glare found

PV array 1 and OP 21

Receptor type: Observation Point
No glare found

PV array 1 and OP 22

Receptor type: Observation Point
No glare found

PV array 1 and OP 23

Receptor type: Observation Point
No glare found

PV array 1 and OP 24

Receptor type: Observation Point
No glare found

PV array 1 and OP 25

Receptor type: Observation Point

No glare found

PV array 1 and OP 26

Receptor type: Observation Point

No glare found

PV array 1 and OP 27

Receptor type: Observation Point

No glare found

PV array 1 and OP 28

Receptor type: Observation Point

No glare found

PV array 1 and OP 29

Receptor type: Observation Point

No glare found

PV array 1 and OP 30

Receptor type: Observation Point

No glare found

PV array 1 and OP 31

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 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

APPENDIX B:

SOLAR GLARE HAZARD ANALYSIS – AVIATION REPORT

FORGESOLAR GLARE ANALYSIS

Project: **BairnsdaleSF**
Site configuration: **BairnsdaleSF_Update**
Analysis conducted by Sian Crawford (sian@environmentalethos.com.au) at 02:32 on 21 Apr, 2023.

U.S. FAA 2013 Policy Adherence

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

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

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

COMPONENT	STATUS	DESCRIPTION
Analysis parameters	PASS	Analysis time interval and eye characteristics used are acceptable
2-mile flight path(s)	PASS	Flight path receptor(s) do not receive yellow glare
ATCT(s)	N/A	No ATCT receptors designated

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

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

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

SITE CONFIGURATION

Analysis Parameters

DNI: peaks at 2,000.0 W/m^2
Time interval: 1 min
Ocular transmission coefficient: 0.5
Pupil diameter: 0.002 m
Eye focal length: 0.017 m
Sun subtended angle: 9.3 mrad
Site Config ID: 87117.15292
Methodology: V2

PV Array(s)

Name: PV array 1
Axis tracking: Single-axis rotation
Backtracking: Shade
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 10.0°
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	-37.842232	147.567870	36.04	1.20	37.24
2	-37.842771	147.572040	34.17	1.20	35.37
3	-37.843468	147.572044	34.55	1.20	35.75
4	-37.843453	147.571715	34.52	1.20	35.72
5	-37.844875	147.571710	36.46	1.20	37.66
6	-37.844831	147.571270	35.72	1.20	36.92
7	-37.845534	147.571273	35.35	1.20	36.55
8	-37.845356	147.569528	32.51	1.20	33.71
9	-37.846052	147.569525	33.83	1.20	35.03
10	-37.845968	147.568873	33.38	1.20	34.58
11	-37.845289	147.568869	33.41	1.20	34.61
12	-37.845295	147.568926	33.27	1.20	34.47
13	-37.844514	147.568924	34.48	1.20	35.68
14	-37.844339	147.567732	37.75	1.20	38.95
15	-37.843655	147.567719	36.84	1.20	38.04
16	-37.843664	147.567804	36.86	1.20	38.06
17	-37.842891	147.567784	36.41	1.20	37.61
18	-37.842909	147.567883	36.49	1.20	37.69

Flight Path Receptor(s)

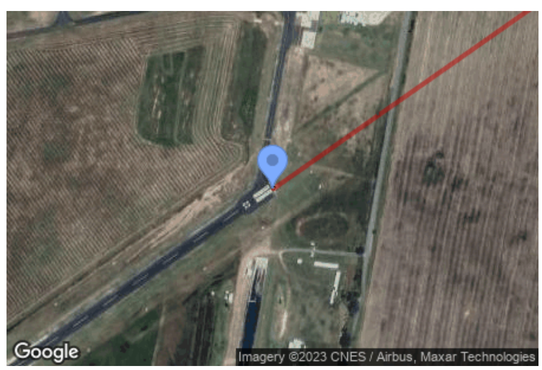
Name: RWY 04
Description:
Threshold height: 15 m
Direction: 55.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-37.890363	147.564331	50.75	15.24	65.99
Two-mile	-37.906946	147.534285	56.00	178.68	234.67

Name: RWY 13
Description:
Threshold height: 15 m
Direction: 145.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

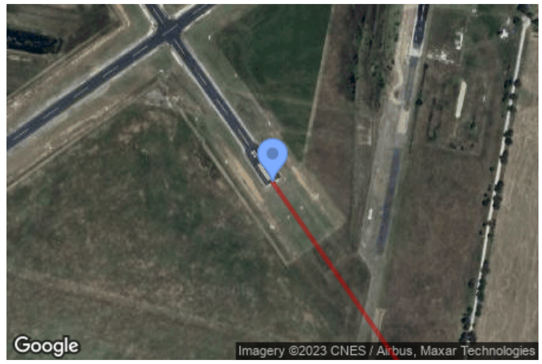
Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-37.883431	147.565747	50.20	15.24	65.44
Two-mile	-37.859747	147.544711	38.97	195.15	234.12

Name: RWY 22
Description:
Threshold height: 15 m
Direction: 235.0°
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	-37.884724	147.574568	49.71	15.24	64.95
Two-mile	-37.868141	147.604611	30.21	203.43	233.64

Name: RWY 31
Description:
Threshold height: 15 m
Direction: 325.0°
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	-37.889705	147.571292	49.49	15.24	64.73
Two-mile	-37.913389	147.592330	41.00	192.42	233.42

Discrete Observation Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	-37.840634	147.573840	33.41	1.50
OP 2	2	-37.838401	147.569495	33.84	1.50
OP 3	3	-37.843693	147.575313	35.75	1.50
OP 4	4	-37.849414	147.567078	34.86	1.50
OP 5	5	-37.838049	147.568841	34.14	1.50
OP 6	6	-37.840428	147.574762	31.80	1.50
OP 7	7	-37.840987	147.576350	33.77	1.50
OP 8	8	-37.841389	147.576645	34.44	1.50
OP 9	9	-37.839912	147.578386	33.75	1.50
OP 10	10	-37.847408	147.577442	33.22	1.50
OP 11	11	-37.848413	147.575814	33.74	1.50
OP 12	12	-37.851270	147.573785	30.18	1.50
OP 13	13	-37.851580	147.573723	29.64	1.50
OP 14	14	-37.855005	147.568761	33.13	1.50
OP 15	15	-37.854348	147.566323	35.61	1.50
OP 16	16	-37.849620	147.564926	36.49	1.50
OP 17	17	-37.852127	147.562396	36.16	1.50
OP 18	18	-37.834024	147.563756	34.46	1.50
OP 19	19	-37.836901	147.574023	30.77	1.50
OP 20	20	-37.836460	147.574313	30.55	1.50
OP 21	21	-37.836045	147.574592	29.95	1.50
OP 22	22	-37.836202	147.574882	29.52	1.50
OP 23	23	-37.835473	147.574013	30.77	1.50
OP 24	24	-37.835604	147.574318	30.35	1.50
OP 25	25	-37.836926	147.577950	29.98	1.50
OP 26	26	-37.833523	147.555307	37.00	1.50
OP 27	27	-37.836749	147.551284	36.10	1.50
OP 28	28	-37.840300	147.549910	38.81	1.50
OP 29	29	-37.844163	147.549556	39.04	1.50
OP 30	30	-37.841805	147.567645	33.46	2.40
OP 31	31	-37.843056	147.567276	36.05	2.40

Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
"Yellow" glare is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.
Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to V1 algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size.
Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual results and glare occurrence may differ.
Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid based on aggregated research data. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
Refer to the Help page at **www.forgesolar.com/help/** for assumptions and limitations not listed here.