Solar Glint and Glare Assessment

Fosterville Solar Farm
Axedale, VIC

B – 9 December 2021

PREPARED FOR
Energy Forms

PRESENTED BY
Landrum & Brown Worldwide Australia Pty Ltd

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1 Introduction

1.1 The Development

Energy Forms has asked Landrum & Brown Worldwide (Australia) Pty Ltd to prepare a Solar and Glare assessment for the Photo Voltaic (PV) Solar Array to be installed on the proposed Fosterville Solar Farm at Brownes Lane, Axedale 3551 VIC.

Energy Forms is providing planning advice to FRV Services Australia Pty Ltd with a view to achieve planning approval for a solar farm and battery energy storage system in the Greater Bendigo Local Government area in Victoria. The project is expected to be up to 100MV of PV.

Fosterville Solar Farm is located from the following certified aerodromes, 83km from Shepparton Airport, 67km from Echuca Airport, 60km from Mangalore Airport, and 19km from Bendigo Airport. As shown in Figure 1. The site is also in the broad vicinity of Elmore and Avonmore; certified landing areas.

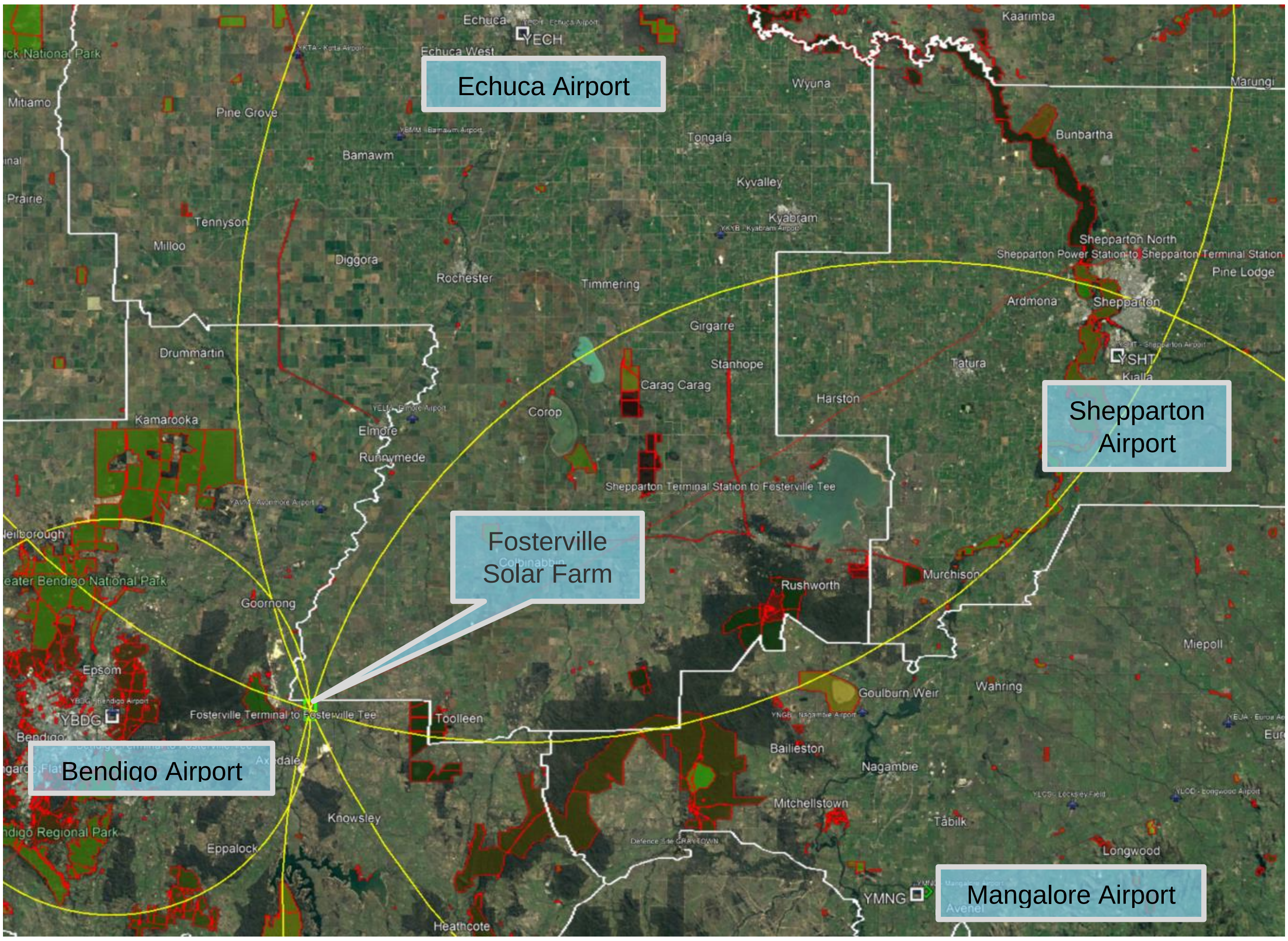


Figure 1: Fosterville Location (Google Earth)

The solar array will tilt in one axis to follow the sun in order to provide more efficient power output.

The solar panels will be provided with an anti-reflective coating.

1.2 Report Process

The following items were considered in the preparation of this report:

- Assessment of the aviation specific requirements of the Victorian DELWP Solar Energy Facilities Design and Development guidelines;
- The main potential impact on aviation is likely to be due to reflected glare of a nature that could adversely affect pilot vision, especially at lower altitudes on final approach to a runway.
- The Civil Aviation Safety Authority (CASA) does not publish specific regulations in relation to solar glare. The only requirement is to present a safety case in the application to the airport owner/operator and to CASA to show that the operation of the solar farm does not cause a hazard or eye damage.
- In order to make an objective assessment of the glare risk, the Forge Solar Glare Analysis tool was used. This tool complies with United States Federal Aviation Administration (FAA) Interim Policy 78 FR 63276. CASA has indicated that it accepts the FAA Test;
- If glare is found, the tool calculates the retinal irradiance and subtended angle (size/distance) of the glare source. The results are presented in a simple, easy-to-interpret plot that specifies when glare that will cause eye damage will occur throughout the year;
- Possible impacts to road users on the nearby road network, residential dwellings and recreational areas are considered through use of the Forge Solar Glare Analysis tool;
- Glint and Glare assessment for aircraft operations in the area and at nearby airports; and
- Analysis of Obstacle Limitation Surfaces (OLS) and Procedures for Air Navigation Services – Aircraft Operations (PANS-OPS).

Glint is defined as a momentary flash of bright light, while glare is a continuous source of excessive brightness relative to ambient lighting (Federal Aviation Administration (FAA), 2018).

Given that aviation impacts are of primary concern to the scope being delivered by L&B. Road traffic impacts (against DELWP guidelines) are secondary but considered by the analysis approach and are therefore included in this report.

The impacts of solar reflection vary for each type of receptor. DELWP provide the following criteria for glint and glare effects as a guide to assessment.

- **No impact:** a solar reflection is not geometrically possible, or it will not be visible from the assessed receptor. No mitigation is required.
- **Low impact:** a solar reflection is geometrically possible, but the intensity and duration of an impact is considered to be small and can be mitigated with screening or other measure.
- **Moderate impact:** a solar reflection is geometrically possible and visible, but the intensity and duration of an impact varies according to conditions. Mitigation measures (such as through design, orientation, landscaping or other screening method) to reduce impacts to an acceptable level will be required.
- **Major impact:** a solar reflection is geometrically possible and visible under a range of conditions that will produce impacts with significant intensity and duration. Significant mitigation measures are required if the proposed development is to proceed.

A study of the amount of Glint and/or Glare present at specified locations, using the Forge Solar evaluation tool, will determine the quantity and intensity of the reflected sun light and the effect on a human retina.

A Glossary of Aeronautical terms and Abbreviations is shown at Annex C.

For the purposed of the analysis with ForgeSolar, the site was divided into 2 PV arrays.

- PV array North of Over Head HV Power Line; and
- PV array South of Over Head HV Power Line.

The proposed Fosterville Solar Farm will be located from Airservices Australia AIP certified airports at approximately 19km (10.3nm) east of Bendigo Airport, 60km (32.4nm) north west of Mangalore Airport, 67km (36.2nm) south south-west of Echuca Airport and 83km (44.8nm) south west of Shepparton Airport. There are also uncertified aircraft landing area (ALA) at approximately   Fosterville Solar Farm is outside the circuit area used by aircraft conducting take-off and landing operations in the following airports.

The physical distance makes it unlikely that Fosterville Solar Farm will cause any significant glare issued for pilots on approach or on departure from the airstrip. Accordingly, it was not deemed necessary to perform a specific assessment of aircraft flight paths in this study.

A copy of the full glare analysis is attached in Appendix A.

2 Proposed Layout and Technical Information

2.1 General Layout

Fosterville Solar Farm PV plant as shown on Figure 2 below.

Geographical location as follows:

- Coordinates (UTM 55H) 279898.25 m E, 5932373.11m S
- Altitude 175 m

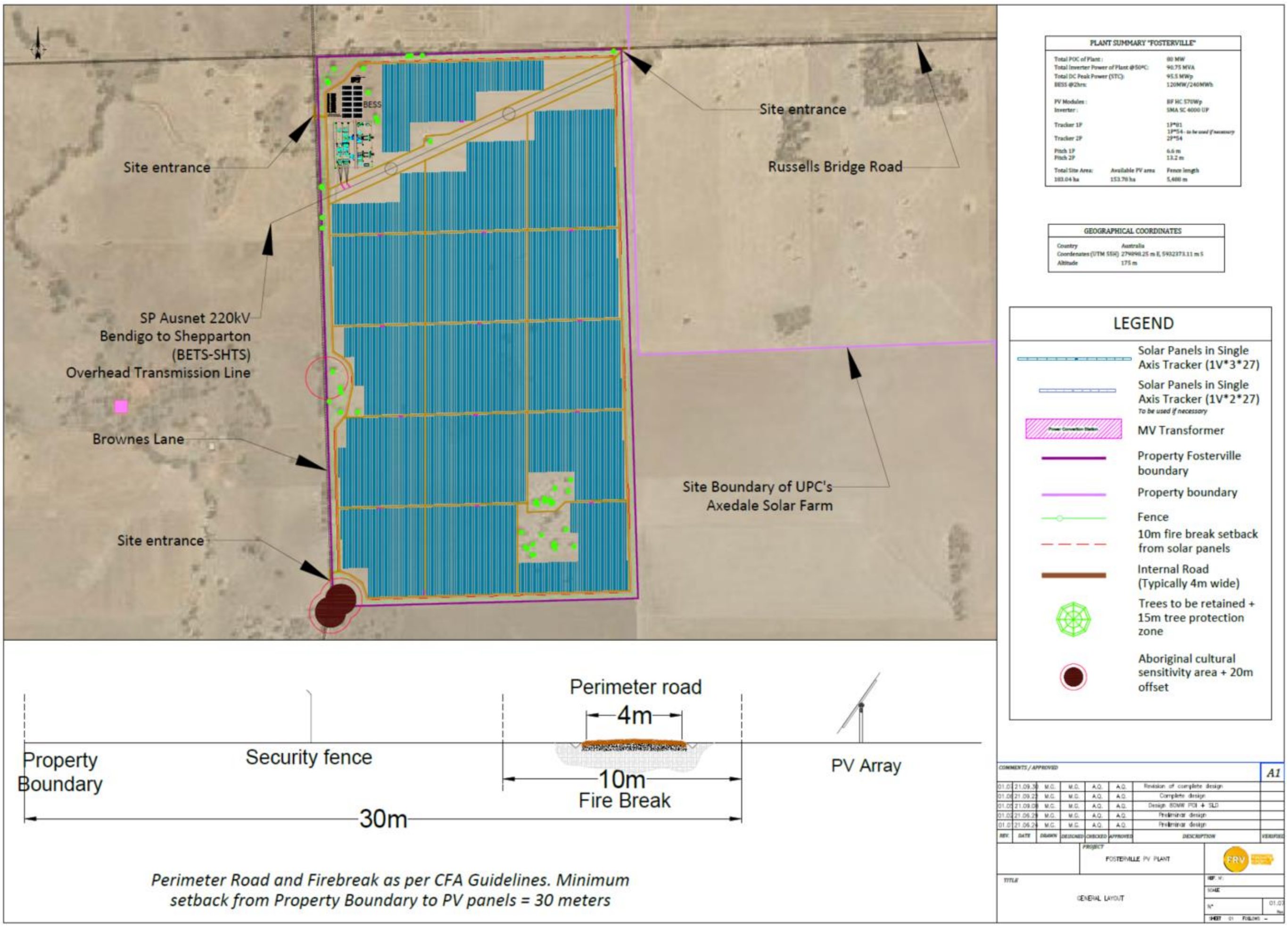


Figure 2: Fosterville Solar Farm Layout (Energy Forms)

2.2 Input Assumptions from Supplied Data

The proposed PV solar panels will have a maximum height of 5.5m when the panels are at 60^0 tilt angle and height of 2.72m when in horizontal position, above ground level (AGL).

The solar panel arrays will be equipped with a smart solar tracker system with up to 60 degrees single axis tilt as they follow the sun throughout the day and will have an anti-reflective coating included. They tilt along one axis.

At solar noon the PV panels are horizontal. They tilt from 60° east of vertical in the morning to 60° west of vertical in the late afternoon to follow the sun. Refer to Figure 3

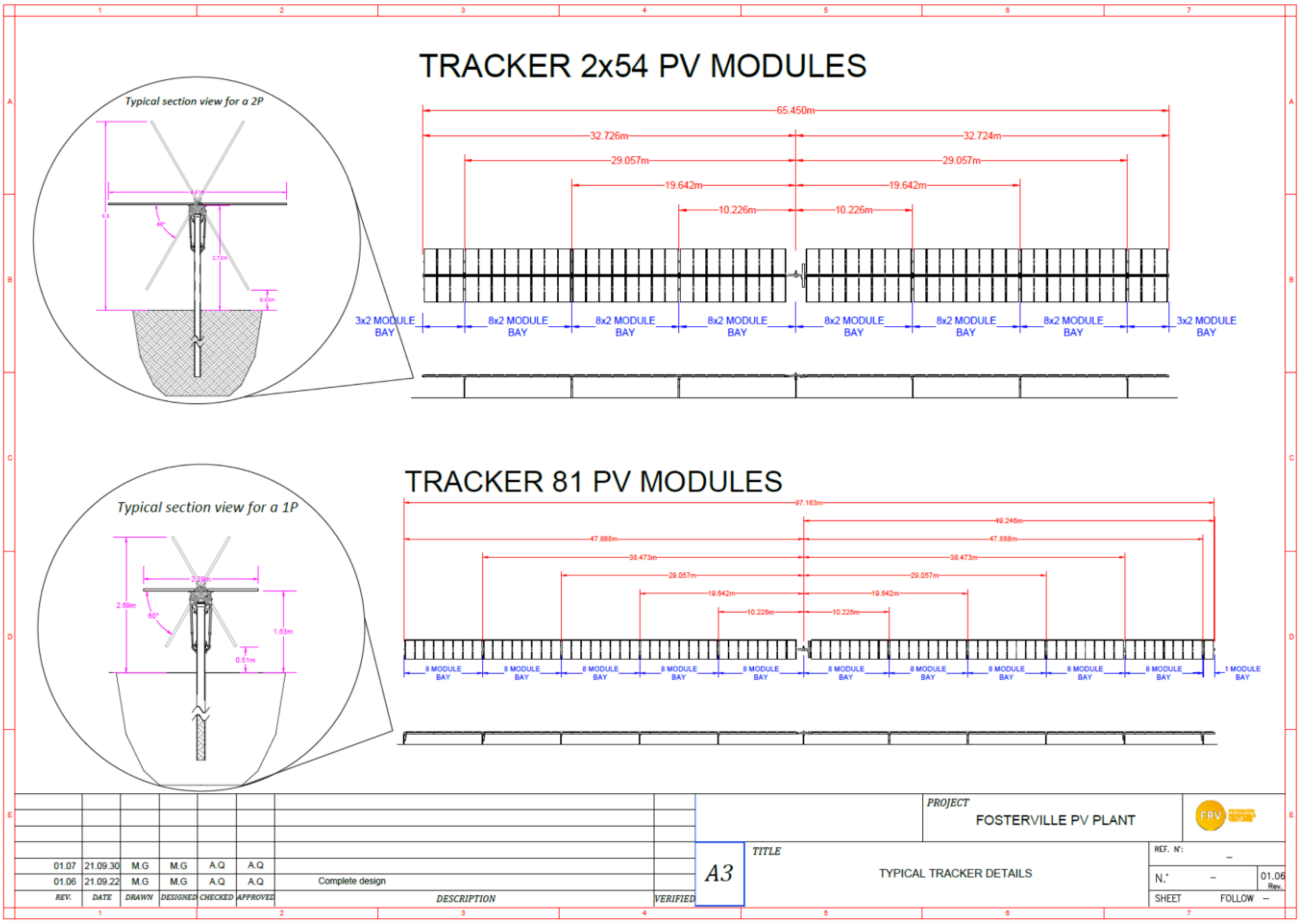


Figure 3: Typical Tracker Details (Energy Forms)

2.3 Plant Summary Details

Data	Unit / Value
Total POC of Plant	80 MW
Total Inverter Power of Plant @ 50^{0}C	90.75 MVA
Total DC Peak Power (STC)	95.5 MWp
BESS @ 2hrs	120 MW / 240 MWh
PV Modules	BF HC 570 Wp
Tracker 1P	1P x 81
	1P x 54 – *to be used if necessary*
Tracker 2P	2P x 54
Pitch 1P	6.6 m
Pitch 2P	13.2 m

3 FAA Standards for Measuring Ocular Impacts

The FAA has published documents to assist in evaluating the effect of solar technologies on airports including:

- Technical Guidance for Evaluating Selected Solar Technologies on Airports, [FAA Solar Guide], FAA-ARP-TR-10-1, November 2010, read in conjunction with;
- Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports, 23 October 2013.

The information in the remainder of this section has been sourced from the above documents.

3.1 Ocular Impact to Pilots and Air Traffic Controllers

The FAA has determined that glint and glare from solar energy systems could result in an ocular impact to pilots and/or air traffic controllers that could compromise the safety of the aviation system and the health of aircrew and air traffic controllers.

The FAA has adopted the Solar Glare Hazard Analysis Plot[1], shown in **Figure 2** below, as the standard for measuring the ocular impact of any proposed solar energy system on an airport.

In the USA, in order to obtain FAA approval to develop a solar installation on the airport, the airport operator is required to demonstrate that the proposed solar energy system meets the following standards:

1. No potential for glint or glare in the existing or planned Air Traffic Control Tower (ATCT) cab; and
2. No potential for glare or ‘‘low potential for after-image’’ (shown in Figure 1) along the final approach path for any existing landing threshold or future landing thresholds. The final approach path is defined as two (2) miles from fifty (50) feet above the landing threshold using a standard three (3) degree glidepath. Ocular impact must be analysed over the entire calendar year in one (1) minute intervals from when the sun rises above the horizon until the sun sets below the horizon.

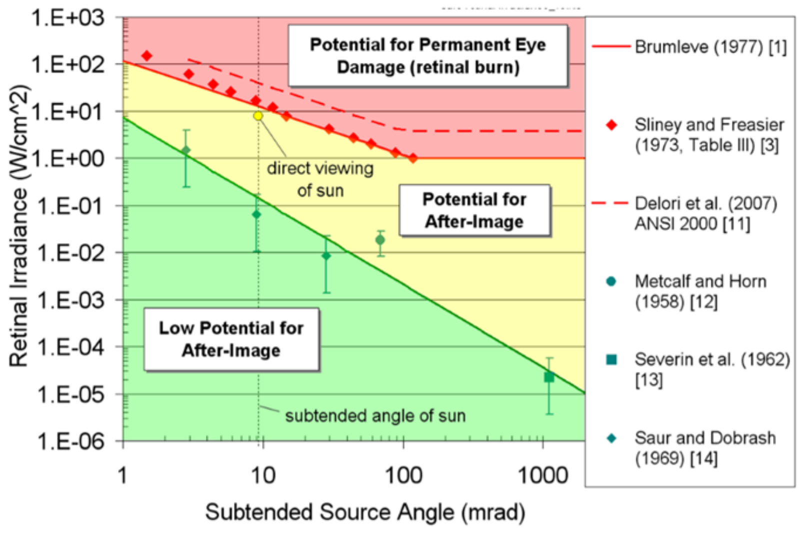


Figure 3 - Glare hazard plot illustrating the ocular impact as a function of retinal irradiance and subtended source angle [1, 3].

Figure 4: FAA Solar Glare Ocular Hazard Plot (Source: Sandia National Laboratories)

[1] https://share.sandia.gov/phlux

The Ocular Hazard Plot classifies viewed glare into three levels based on the retinal irradiance and subtended source angle.

The subtended source angle: represents the size of the glare viewed by an observer,

The retinal irradiance: determines the amount of energy impacting the retina of the observer.

Larger source angles can result in glare[2] of high intensity, even if the retinal irradiance is low.

1. **Low Potential Hazard (Green):** Indicates that there is glare present however there is only a low potential for a temporary after-image. Results in the area of the plot **pass** the FAA test for Ocular Hazard as a result of glare.
2. **Medium Potential Hazard (Yellow):** Indicates that there is glare present with the potential to leave a temporary after-image of the glare. Results in this area of the plot **fail** the FAA test for Ocular Hazard as a result of glare.
3. **High Potential Hazard (Red):** Indicates that there is glare present with the potential for permanent eye damage if observed. Results in this area of the plot **fail** the FAA test for Ocular Hazard as a result of glare.

3.2 Reflectivity

Reflectivity refers to light that is reflected off surfaces. It is reflected at the same angle as the light hits the reflector.

Glint is a momentary flash of bright light, whereas glare is a continuous source of bright light.

Larger reflections in the form of glare from many surfaces is present in current aviation operations, road activity and normal human activities whenever the angle of the sun subtends an angle from the reflective surface, directly to an observer. Existing reflective surfaces may include hangar roofs, airport parking, terminal windows and bodies of water.

Observers that are moving will generally only experience a momentary flash of glare, unless they are travelling directly along the reflective angle or directly facing the sun. All roads oriented in an approximate east-west angle will experience varying degrees of direct sun glare at various times throughout the year.

PV Solar energy employs glass panels that are designed to increase electricity production efficiency by maximising absorption and minimise reflection. To limit reflection, PV solar panels are constructed of dark, light-absorbing materials and can be covered with anti-reflective coating.

The chosen PV panels, with anti-reflective coating reflect as little as 5.94%[3] of the incoming sunlight. They are less reflective than other forms of reflective surface in everyday use.

[2] Glint and glare are potential impacts of light being reflected off surfaces. In comparison with Concentrated Solar Power (CSP) systems which use large reflective surfaces to focus the sun's energy onto a single point to produce heat which is converted to electricity, Photo Voltaic (PV) cells are more compatible with airport activities because it is low profile, modular, and designed to absorb sunlight rather than reflect it, minimising potential impacts of glare. (FAA-ARP-TR-10-1, pp.5-8)

[3] CPVT - Xinyi PV Products Test Report 2015DACS00122

4 Assumptions and Limitations of the Forge Solar Glare Analysis Tool

As with all modelling tools, certain assumptions are made to represent real-life data. These assumptions also produce limitations on the output of the modelling task.

Some of the assumptions and limitations of the models and methods used in the Forge tool are:

- The software only applies to flat reflective surfaces;
- The tool 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, the models have been validated 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;
  - The tool assesses the worst-case situation with the entire area of the solar farm covered with PV panels, i.e. no gaps between individual PV panels;
- The tool assumes that the PV array is aligned with a plane defined by the total heights of the coordinates outlined in the Google map;
- The tool does not consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc;
- The variable direct normal irradiance (DNI) feature scales the 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.

5 Potential Impacts of Solar Glare

L&B employs a software tool developed by ForgeSolar, which satisfies the FAA standards for glare analysis in aviation contexts.

It also reports glare values that may be present at specified “observation points” such has houses and other buildings as well as vehicle drivers on nearby roads.

Inputs to the software include:

- type of PV surface, i.e. smooth glass without anti reflective coating (ARC) through to deeply textured glass with ARC;
- tilt angle of the solar panels above horizontal and whether they are fixed or rotate to follow the sun;
- azimuth of the solar panels in relation to true north;
- final approach flight paths; and
- location of observation points such as residences and roads.

The software produces a report that indicates whether any “after-image” glare or retinal damage may occur to potential observers.

The glare analysis does not account for physical obstructions between reflectors and receptors or cloud cover that limits the amount of glare. This includes buildings, tree cover and geographic obstructions. The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. 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, rather than discrete, spectrum.

6 GlareGauge (ForgeSolar) Inputs

The sections below detail the inputs by L&B for analysis in GlareGauge. All azimuth values are relative to true north and all angles relative to horizontal.

6.1 PV system parameters

An overview of the input data used for the modelling of the Fosterville Solar Farm is shown in Table 1. Site specific inputs are detailed, and boundaries of the system are based on the proposed development areas shown in Figure 2. If any of the development areas change it is recommended that the glare potential be reanalysed.

Input Data	Units	Value	Comments
General Project Parameters			
Reflectivity calculations	-	Varies with incident angle	As incident angle increases, the reflectivity increases.
Reflection diffusion	-	Correlated to module surface type	Calculates the spread of the reflected beam according to the glass texturing and ARC
Time Zone	UTC	+10	VIC time zone
Peak DNI	KWh/m^2	5.25 (Daily) 1917.25 (Yearly)	Source: https://solargis.com/maps-and-gis-data/download/australia
Peak DNI	W/m2	varies	DNI will be scaled each time step based on sun position
Orientation of Array	degrees	0	Rows aligned in North-South direction
Solar panel surface material	-	Smooth glass with Anti-Reflective Coating (ARC)	As tentatively advised by FRV / Energy Forms
Time interval	mins	1	Model interval throughout the year
Mounting type	-	Single axis tracking	Refer to Figure 3
Single Axis Tracking Parameters			
Tilt of tracking axis	degrees	0	0^0 = Facing upwards. Panels rotate during operation according to single axis tracking operation.
Orientation of tracking axis	degrees	0	0^0 = Rows aligned north-south
Offset angle of panel	degrees	0	Angle between tracking axis and panel
Tracking Range	degrees	+/- 60^0 (range of 120^0)	Refer to Figure 3
Height of panel above ground	m	2.72	Post height from ground measured to the point of tracking rotation as per tracker datasheet (Tracker 2 x 54 PV Modules) *Used as tentatively advised by FRV / Energy Forms

Height of panel above ground	m	1.63	Post height from ground measured to the point of tracking rotation as per tracker datasheet (Tracker 1 x 81 PV Modules)

Table 1: General PV system Inputs for GlareGauge

6.2 Observation Points and nearby Roads

The Observation Point receptor ("OP") simulates an observer at a single, discrete location, defined by a latitude, longitude, elevation, and height above ground.

The Route receptor is a generic multi-line representation which can simulate observers traveling along continuous paths such as roads, railways, helicopter paths, and multi-segment flight tracks.

As per DELWP, any assessment of glint and glare should use an accepted methodology based on best practice and consider impacts on dwellings and roads within 1 km of the proposed facility, taking into consideration their height within the landscape.

Figure 5 shows the location of the roads and receptors assessed.

The Solar Glare Analysis Report is attached at Appendix A

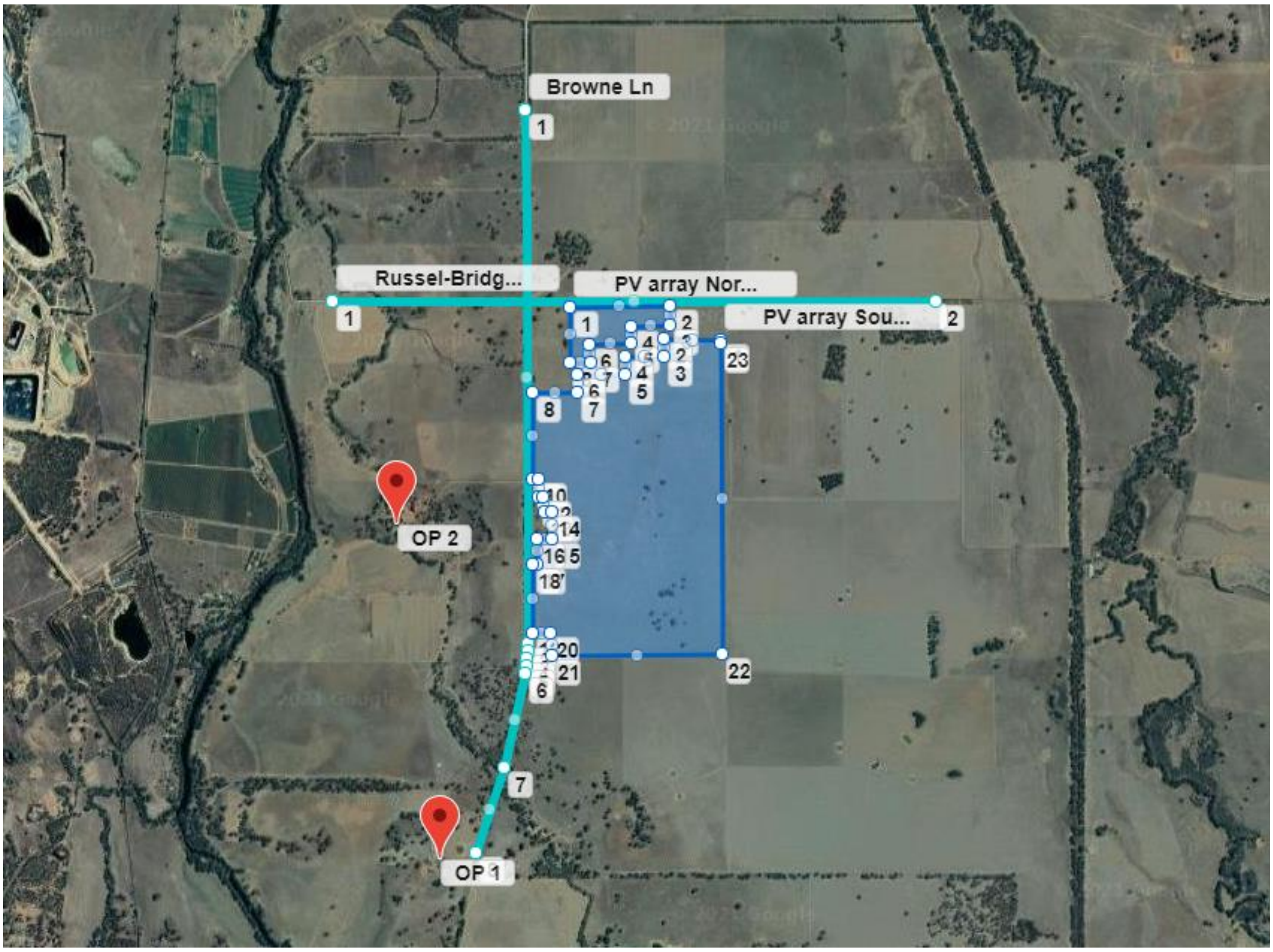


Figure 5: Receptor Locations

7 Results and Conclusions

7.1 Results

This study indicates that Fosterville solar farm will have glare with potential for temporary after-image issue on elements of ground level (road) locations, refer to Table 2: Summary of Results below and Figure 5.

Components	Green glare (mins)	Yellow glare (mins)	Comments
OP: OP 1	0	0	No glare found
OP: OP 2	0	0	No glare found
Route: Browne Ln	0	1330	Glare found
Route: Russel-Bridge Rd	60	1983	Glare found

Table 2: Summary of Results

7.2 Aviation Conclusions

The proposed Fosterville Solar Farm will be located from Airservices Australia AIP certified airports at approximately 19km (10.3nm) east of Bendigo Airport, 60km (32.4nm) north west of Mangalore Airport, 67km (36.2nm) south south-west of Echuca Airport and 83km (44.8nm) south west of Shepparton Airport. Fosterville Solar Farm is outside the circuit area used by aircraft conducting take-off and landing operations in the following airports.

The proposed development is 28km from Elmore and 19km from Avonmore aircraft landing areas.

The physical distance makes it unlikely that Fosterville Solar Farm will cause any significant glare issued for pilots on approach or on departure from the airstrips. Accordingly, it was not deemed necessary to perform a specific assessment of aircraft flight paths in this study.

On the basis of the airport locations in relation to the proposed development, we conclude that there are no aviation glint and glare issues.

7.3 Local Residential Conclusions

On the basis of the ForgeSolar assessment on the properties within 1 km of the proposed development, we conclude that there are no glint and glare issues on residential properties within 1km of the site.

7.4 Road Transport Conclusions

Glint is typically defined as a momentary flash of bright light, often caused by a reflection off a moving source. A typical example of glint is a momentary solar reflection from a moving car. Glare is defined as a continuous source of bright light. Glare is generally associated with stationary objects, which, due to the slow relative movement of the sun, reflect sunlight for a longer duration. The ForgeSolar output describes “glare” which is both glint and glare in the above context.

The output from the study indicates both “green” and “yellow” glare in the terms defined by ForgeSolar. As these definitions do not align with those from DELWP there is a need to consider equivalence between the two sets of definitions.

DELWP Classification	ForgeSolar Classification
No impact: a solar reflection is not geometrically possible, or it will not be visible from the assessed receptor. No mitigation is required.	Not shown on output.
Low impact: a solar reflection is geometrically possible, but the intensity and duration of an impact is considered to be small and can be mitigated with screening or other measure.	Green Glare
Moderate impact: a solar reflection is geometrically possible and visible, but the intensity and duration of an impact varies according to conditions. Mitigation measures (such as through design, orientation, landscaping or other screening method) to reduce impacts to an acceptable level will be required.	Yellow Glare
Major impact: a solar reflection is geometrically possible and visible under a range of conditions that will produce impacts with significant intensity and duration. Significant mitigation measures are required if the proposed development is to proceed.	Red Glare

In this context the green glare should be consider acceptable as the impact is to minor roads being used in a transient manner. 60mins (0.01% per year) of green glare (low potential to cause after-image) are found on Russel-Bridge Rd.

The yellow glare found on Browne Ln and Russel-Bridge Rd should be considered as moderate impact. There are 1330mins (0.25%) on Browne Ln and 1983mins (0.38%) on Russel-Bridge Rd. The moderate impact can reasonably be assumed to be mitigated by existing trees along the road, the transient nature of any receivers, the dirt and hence dusty nature of the road, and finally, the fact that the assessment takes no account of cloud cover / adverse weather conditions. All of these factors can reasonably be considered to mitigate the potential impact to an acceptable level.

On the basis of the above, we consider that the proposed solar development has no significant impact glint and glare impacts on local roads.

Appendix A – ForgeSolar Glare Analysis Report

Appendix B – Glossary of Aeronautical Terms and Abbreviations

To facilitate the understanding of aviation terminology used in this report, the following is a glossary of terms and acronyms that are commonly used in aeronautical impact assessments and similar aeronautical studies.

Aeronautical Terms:

AC (Advisory Circulars) are issued by CASA and are intended to provide recommendations and guidance to illustrate a means, but not necessarily the only means, of complying with the Regulations.

Aeronautical study is a tool used to review aerodrome and airspace processes and procedures to ensure that safety criteria are appropriate.

AIPs (Aeronautical Information Publications) are publications promulgated to provide operators with aeronautical information of a lasting character essential to air navigation. They contain details of regulations, procedures and other information pertinent to flying and operation of aircraft. In Australia, AIP is issued by Airservices Australia on behalf of CASA.

Air routes exist between navigation aid equipped aerodromes or waypoints to facilitate the regular and safe flow of aircraft operating under IFR.

Airservices Australia is the Australian government-owned corporation providing safe and environmentally sound air traffic management and related airside services to the aviation industry.

Altitude is the vertical distance of a level, a point or an object, considered as a point, measured from mean sea level.

ATC (Air Traffic Control) service is a service provided for the purpose of:

a. preventing collisions:
    1. between aircraft; and
    2. on the manoeuvring area between aircraft and obstructions; and
b. expediting and maintaining an orderly flow of air traffic.

CASA (Civil Aviation Safety Authority) is the Australian government authority responsible under the *Civil Aviation Act 1988* for developing and promulgating appropriate, clear and concise aviation safety standards. As Australia is a signatory to the ICAO *Chicago Convention*, CASA adopts the standards and recommended practices established by ICAO, except where a difference has been notified.

CASR (Civil Aviation Safety Regulations) are promulgated by CASA and establish the regulatory framework (*Regulations*) within which all service providers must operate.

Civil Aviation Act 1988 (the Act) establishes the CASA with functions relating to civil aviation, in particular the safety of civil aviation and for related purposes.

ICAO (International Civil Aviation Organization) is an agency of the United Nations which codifies the principles and techniques of international air navigation and fosters the planning and development of international air transport to ensure safe and orderly growth. The ICAO Council adopts standards and recommended practices concerning air navigation, its infrastructure, flight inspection, prevention of unlawful interference, and facilitation of border-crossing procedures for international civil aviation. In addition, the ICAO defines the protocols for air accident investigation followed by transport safety authorities in countries signatory to the Convention on International Civil Aviation, commonly known as the *Chicago Convention*. Australia is a signatory to the *Chicago Convention*.

IFR (Instrument Flight Rules) are rules applicable to the conduct of flight under IMC. IFR are established to govern flight under conditions in which flight by outside visual reference is not safe. IFR flight depends upon flying by reference to instruments in the flight deck, and navigation is accomplished by reference to electronic signals. It is also referred to as, “a term used by pilots and controllers to indicate the type of flight plan an aircraft is flying,” such as an IFR or VFR flight plan. Pilots must hold IFR qualifications and aircraft must be suitably equipped with appropriate instruments and navigation aids to enable flight in IMC.

IMC (Instrument Meteorological Conditions) are meteorological conditions expressed in terms of visibility, distance from cloud and ceiling, less than the minimum specified for visual meteorological conditions.

LSALT (Lowest Safe Altitudes) are published for each low-level air route segment. Their purpose is to allow pilots of aircraft that suffer a system failure to descend to the LSALT to ensure terrain or obstacle clearance in IMC where the pilot cannot see the terrain or obstacles due to cloud or poor visibility conditions. It is an altitude that is at least 1,000 feet above any obstacle or terrain within a defined safety buffer region around a particular route that a pilot might fly.

MDA (Minimum Descent Altitude) is the lowest altitude that can be used during a non-precision approach in IMC. Flight below the MDA reduces the clearance above obstacles and is not permitted in IMC.

MOS (Manual of Standards) comprises specifications (Standards) prescribed by CASA, of uniform application, determined to be necessary for the safety of air navigation.

NOTAMs (Notices to Airmen) are notices issued by the NOTAM office containing information or instruction concerning the establishment, condition or change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to persons concerned with flight operations.

Obstacles. All fixed (whether temporary or permanent) and mobile objects, or parts thereof, that are located on an area intended for the surface movement of aircraft or that extend above a defined surface intended to protect aircraft in flight.

OLS (Obstacle Limitation Surfaces) are a series of planes associated with each runway at an aerodrome that defines the desirable limits to which objects may project into the airspace around the aerodrome so that aircraft operations may be conducted safely.

PANS OPS (Procedures for Air Navigation Services – Aircraft Operations) is an Air Traffic Control term denominating rules for designing instrument approach and departure procedures. Such procedures are used to allow aircraft to land and take off under Instrument Meteorological Conditions (IMC) or Instrument Flight Rules (IFR). ICAO document 8168-OPS/611 (volumes 1 and 2) outlines the principles for airspace protection and procedure design which all ICAO signatory states must adhere to. The regulatory material surrounding PANS OPS may vary from country to country.

PANS OPS Surfaces. Similar to an Obstacle Limitation Surface, the PANS OPS protection surfaces are imaginary surfaces in space which guarantee the aircraft a certain minimum obstacle clearance. These surfaces may be used as a tool for local governments in assessing building development. Where buildings may (under certain circumstances) be permitted to infringe the OLS, they cannot be permitted to infringe any PANS OPS surface, because the purpose of these surfaces is to guarantee pilots operating under IMC an obstacle free descent path for a given approach.

Prescribed airspace is an airspace specified in, or ascertained in accordance with, the Regulations, where it is in the interests of the safety, efficiency or regularity of existing or future air transport operations into or out of an airport for the airspace to be protected. The prescribed airspace for an airport is the airspace above any part of either an OLS or a PANS OPS surface for the airport and airspace declared in a declaration relating to the airport.

Radar Terrain Clearance Chart (RTCC) is a chart that provides air traffic controllers with the lowest usable altitude that they can vector an aircraft using prescribed surveillance procedures within controlled airspace. There is a protection surface below this usable altitude which is shown in airport master plans.

Regulations (Civil Aviation Safety Regulations)

VFR (Visual Flight Rules) are rules applicable to the conduct of flight under VMC. VFR allow a pilot to operate an aircraft in weather conditions generally clear enough to allow the pilot to maintain visual contact with the terrain and to see where the aircraft is going. Specifically, the weather must be better than basic VFR weather minima. If the weather is worse than VFR minima, pilots are required to use instrument flight rules. Pilots must be specifically qualified and aircraft specifically equipped to enable flight in IMC,

VMC (Visual Meteorological Conditions) are meteorological conditions expressed in terms of visibility, distance from cloud and ceiling, equal or better than specified minima.

Abbreviations

Abbreviations used in this report, and the meanings assigned to them for the purposes of this report are detailed in the following table.

Abbreviation	Meaning
AC	Advisory Circular (documents that support CAR 1998)
ACFT	Aircraft
AD	Aerodrome
ADS-B	Automatic Dependent Surveillance – Broadcast
AHD	Australian Height Datum
AIP	Aeronautical Information Publication
Airports Act	Airports Act 1996, as amended
AIS	Aeronautical Information Service
ALT	Altitude
AMSL	Above Mean Sea Level
APARs	Airports (Protection of Airspace) Regulations, 1996 as amended
ARP	Aerodrome Reference Point
AsA	Airservices Australia
ATC	Air Traffic Control(ler)
ATM	Air Traffic Management
BARO-VNAV	Barometric Vertical Navigation
BRA	Building Restricted Area
CAO	Civil Aviation Order
CAR	Civil Aviation Regulation
CASA	Civil Aviation Safety Authority
CASR	Civil Aviation Safety Regulation
Cat	Category
DAP	Departure and Approach Procedures (charts published by AsA)
DER	Departure End of (the) Runway

Abbreviation	Meaning
DME	Distance Measuring Equipment
Doc nn	ICAO Document Number nn
DITRDC	Department of Infrastructure, Transport, Regional Development and Cities
ELEV	Elevation (above mean sea level)
ENE	East North East
ERSA	Enroute Supplement Australia
FAF	Final Approach Fix
FAP	Final Approach Point
FAS	Final Approach Surface of a BARO-VNAV approach
ft	feet
GBAS	Ground Based Augmentation System (satellite precision landing system)
GNSS	Global Navigation Satellite System
GP	Glide Path
HLS	Helicopter Landing Site
IAS	Indicated Airspeed
ICAO	International Civil Aviation Organisation
IHS	Inner Horizontal Surface, an Obstacle Limitation Surface
ILS	Instrument Landing System
ISA	International Standard Atmosphere
km	kilometres
kt	Knot (one nautical mile per hour)
LAT	Latitude
LOC	Localizer
LONG	Longitude
LNAV	Lateral Navigation criteria
m	metres
MAPt	Missed Approach Point
MDA	Minimum Descent Altitude

Abbreviation	Meaning
MGA94	Map Grid Australia 1994
MOC	Minimum Obstacle Clearance
MOS	Manual of Standards, published by CASA
MSA	Minimum Sector Altitude
MVA	Minimum Vector Altitude
NASAG	National Airports Safeguarding Advisory Group
NDB	Non Directional Beacon
NE	North East
NM	Nautical Mile (= 1.852 km)
nnDME	Distance from the DME (in nautical miles)
NNE	North North East
NOTAM	NOtice to AirMen
OAS	Obstacle Assessment Surface
OCA	Obstacle Clearance Altitude
OCH	Obstacle Clearance Height
OHS	Outer Horizontal Surface
OIS	Obstacle Identification Surface
OLS	Obstacle Limitation Surface
PANS OPS	Procedures for Air Navigation Services – Aircraft Operations, ICAO Doc 8168
PBN	Performance Based Navigation
PRM	Precision Runway Monitor
QNH	An altimeter setting relative to height above mean sea level
REF	Reference
RL	Relative Level
RNAV	aRea NAVigation
RNP	Required Navigation Performance
RPA	Rules and Practices for Aerodromes — replaced by the MOS Part 139 — Aerodromes
RPT	Regular Public Transport

Abbreviation	Meaning
RTCC	Radar Terrain Clearance Chart
RWY	Runway
SFC	Surface
SID	Standard Instrument Departure
SOC	Start Of Climb
STAR	STandard ARrival
SGHAT	Solar Glare Hazard Analysis Tool
TAR	Terminal Approach Radar
TAS	True Air Speed
THR	Threshold (Runway)
TNA	Turn Altitude
TODA	Take-Off Distance Available
VNAV	Vertical Navigation criteria
V_n	aircraft critical Velocity reference
VOR	Very high frequency Omni directional Range
WAC	World Aeronautical Chart

Fosterville Solar Farm

Fosterville Solar

Client: Energy Forms

Created Nov. 11, 2021
Updated Dec. 8, 2021
Time-step 1 minute
Timezone offset UTC10
Site ID 61035.10860

Project type Advanced
Project status: active
Category 100 MW to 1 GW

Misc. Analysis Settings

DNI: **varies (1,000.0 W/m^2 peak)**
Ocular transmission coefficient: **0.5**
Pupil diameter: **0.002 m**
Eye focal length: **0.017 m**
Sun subtended angle: **9.3 mrad**

Analysis Methodologies:

- Observation point: **Version 2**
- 2-Mile Flight Path: **Version 2**
- Route: **Version 2**

Summary of Results Glare with potential for temporary after-image predicted

PV Name	Tilt deg	Orientation deg	"Green" Glare min	"Yellow" Glare min	Energy Produced kWh
PV array North of Over Head HV Power Line	SA tracking	SA tracking	60	728	-
PV array South of Over Head HV Power Line	SA tracking	SA tracking	0	2,585	-

Component Data

PV Array(s)

Total PV footprint area: 1,493,147 m^2

Name: PV array North of Over Head HV Power Line
Axis tracking: Single-axis rotation
Tracking axis orientation: 0.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 0.0 deg
Footprint area: 90,288 m^2
Rated power: -
Panel material: Smooth glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 8.43 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	-36.725717	144.536397	175.86	2.72	178.58
2	-36.725665	144.542105	170.66	2.72	173.38
3	-36.726577	144.542105	170.30	2.72	173.02
4	-36.726611	144.539916	172.00	2.72	174.72
5	-36.727419	144.539938	172.00	2.72	174.72
6	-36.727436	144.537535	173.42	2.72	176.14
7	-36.728279	144.537556	175.36	2.72	178.08
8	-36.728296	144.536376	175.36	2.72	178.08

Name: PV array South of Over Head HV Power Line
Axis tracking: Single-axis rotation
Tracking axis orientation: 0.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 0.0 deg
Footprint area: 1,402,859 m^2
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	-36.727247	144.545095	168.82	2.72	171.54
2	-36.727213	144.541812	171.37	2.72	174.09
3	-36.728004	144.541791	171.74	2.72	174.46
4	-36.727987	144.539580	172.01	2.72	174.73
5	-36.728847	144.539559	173.27	2.72	175.99
6	-36.728847	144.536834	175.74	2.72	178.46
7	-36.729638	144.536812	174.16	2.72	176.88
8	-36.729672	144.534270	172.33	2.72	175.05
9	-36.733662	144.534202	173.94	2.72	176.66
10	-36.733657	144.534577	174.35	2.72	177.07
11	-36.734500	144.534593	177.11	2.72	179.83
12	-36.734496	144.534878	176.64	2.72	179.36
13	-36.735196	144.534888	178.04	2.72	180.76
14	-36.735196	144.535350	176.37	2.72	179.09
15	-36.736394	144.535344	176.87	2.72	179.59
16	-36.736403	144.534529	177.64	2.72	180.36
17	-36.737581	144.534539	176.31	2.72	179.03
18	-36.737585	144.534239	176.75	2.72	179.47
19	-36.740774	144.534250	174.38	2.72	177.10
20	-36.740774	144.535312	174.88	2.72	177.60
21	-36.741780	144.535334	175.11	2.72	177.83
22	-36.741712	144.545183	175.83	2.72	178.55
23	-36.727369	144.545096	168.89	2.72	171.61

Route Receptor(s)

Name: Browne Ln
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	-36.716674	144.533855	171.74	1.50	173.24
2	-36.741218	144.533995	174.53	1.50	176.03
3	-36.741544	144.533995	175.40	1.50	176.90
4	-36.741897	144.533941	176.40	1.50	177.90
5	-36.742241	144.533866	177.46	1.50	178.96
6	-36.742574	144.533780	178.14	1.50	179.64
7	-36.746936	144.532605	173.44	1.50	174.94
8	-36.750833	144.530971	174.38	1.50	175.88

Name: Russel-Bridge Rd
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	-36.725445	144.522783	156.99	1.50	158.49
2	-36.725480	144.557459	168.75	1.50	170.25

Discrete Observation Receptors

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	m	m	m
OP 1	-36.751142	144.528910	176.62	3.00	179.62
OP 2	-36.735727	144.526439	168.72	3.00	171.72

Summary of PV Glare Analysis

PV configuration and total predicted glare

PV Name	Tilt deg	Orientation deg	"Green" Glare min	"Yellow" Glare min	Energy Produced kWh	Data File
PV array North of Over Head HV Power Line	SA tracking	SA tracking	60	728	-	
PV array South of Over Head HV Power Line	SA tracking	SA tracking	0	2,585	-	

Distinct glare per month

Excludes overlapping glare from PV array for multiple receptors at matching time(s)

PV	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
pv-array-nor (green)	0	9	18	0	0	0	0	0	17	15	1	0
pv-array-nor (yellow)	0	167	199	0	0	0	0	0	66	295	1	0
pv-array-sou (green)	0	0	0	0	0	0	0	0	0	0	0	0
pv-array-sou (yellow)	268	254	38	0	291	540	498	1	0	187	258	250

PV & Receptor Analysis Results

Results for each PV array and receptor

PV array North of Over Head HV Power Line potential temporary after-image

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
Route: Browne Ln	0	0
Route: Russel-Bridge Rd	60	728

PV array North of Over Head HV Power Line - OP Receptor (OP 1)

No glare found

PV array North of Over Head HV Power Line - OP Receptor (OP 2)

No glare found

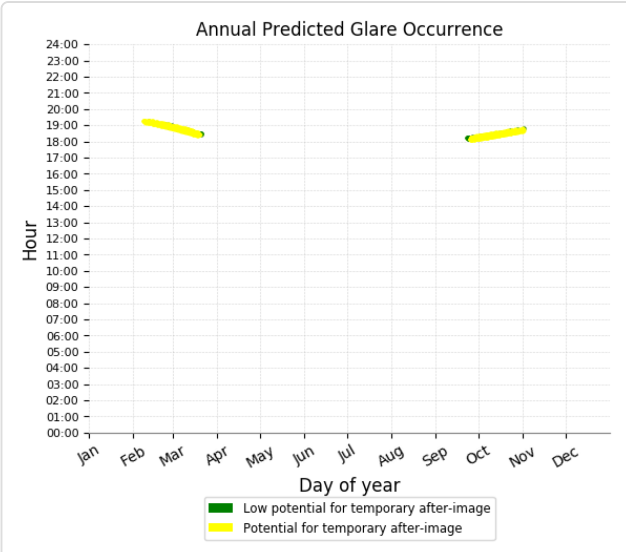
PV array North of Over Head HV Power Line - Route Receptor (Browne Ln)

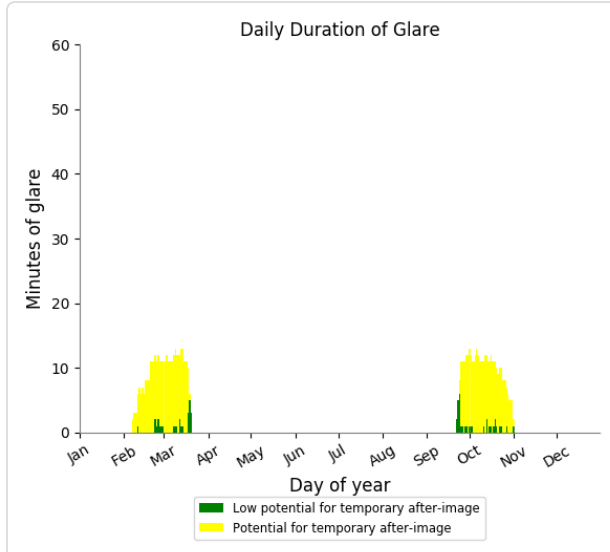
No glare found

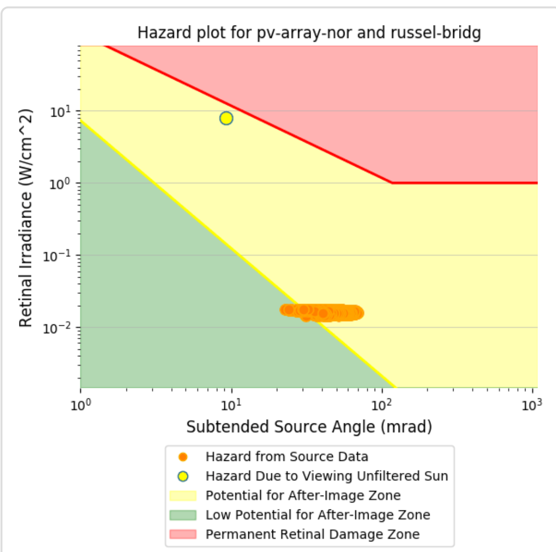
PV array North of Over Head HV Power Line - Route Receptor (Russel-Bridge Rd)

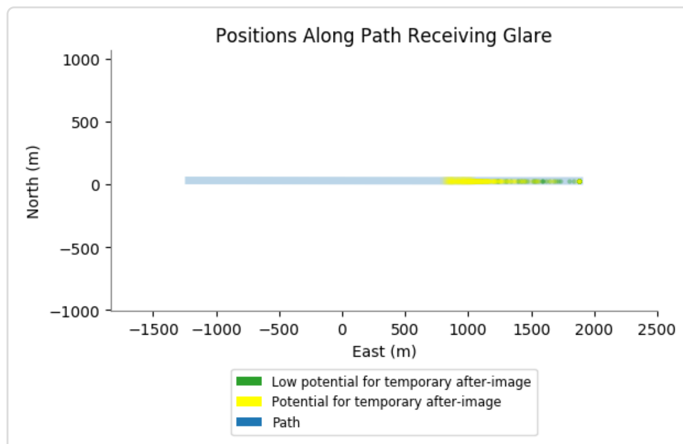
PV array is expected to produce the following glare for receptors at this location:

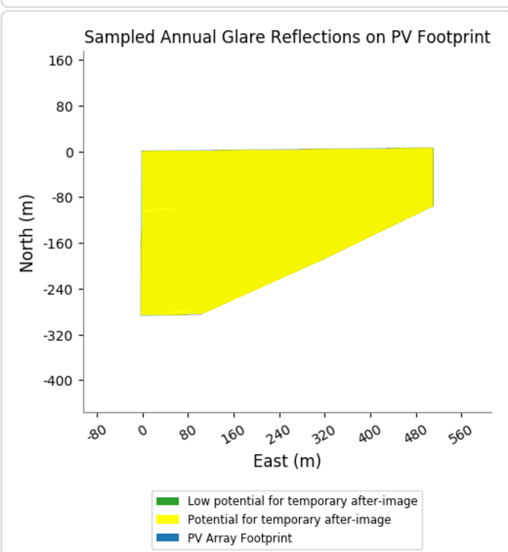
- 60 minutes of "green" glare with low potential to cause temporary after-image.
- 728 minutes of "yellow" glare with potential to cause temporary after-image.











PV array South of Over Head HV Power Line potential temporary after-image

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
Route: Browne Ln	0	1330
Route: Russel-Bridge Rd	0	1255

PV array South of Over Head HV Power Line - OP Receptor (OP 1)

No glare found

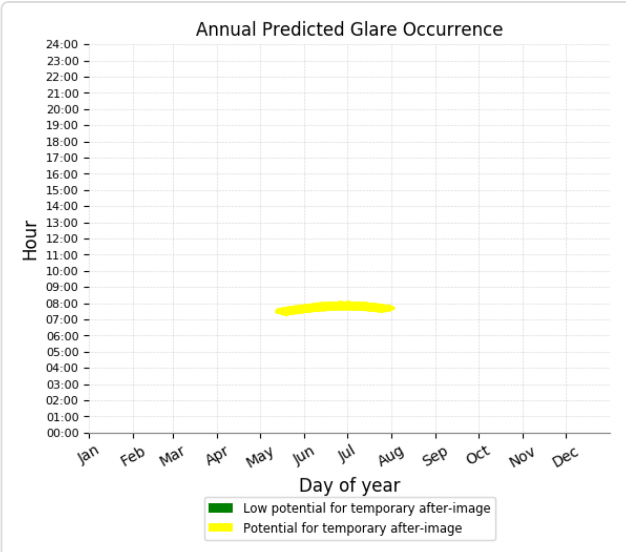
PV array South of Over Head HV Power Line - OP Receptor (OP 2)

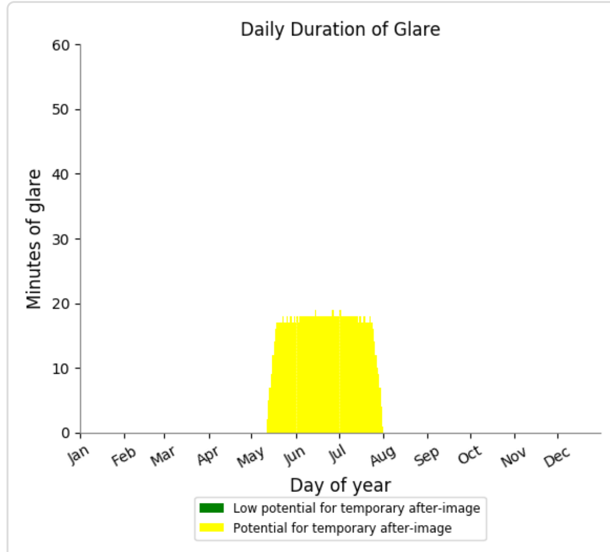
No glare found

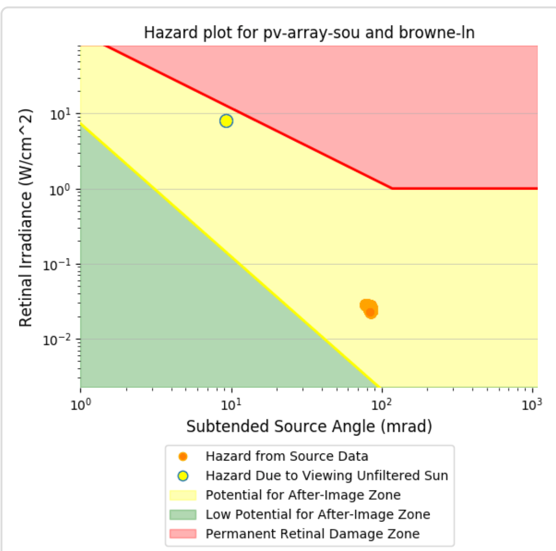
PV array South of Over Head HV Power Line - Route Receptor (Browne Ln)

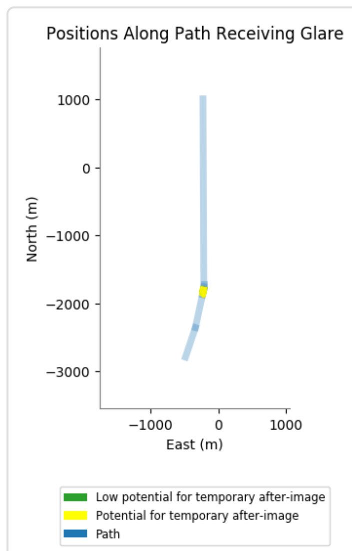
PV array is expected to produce the following glare for receptors at this location:

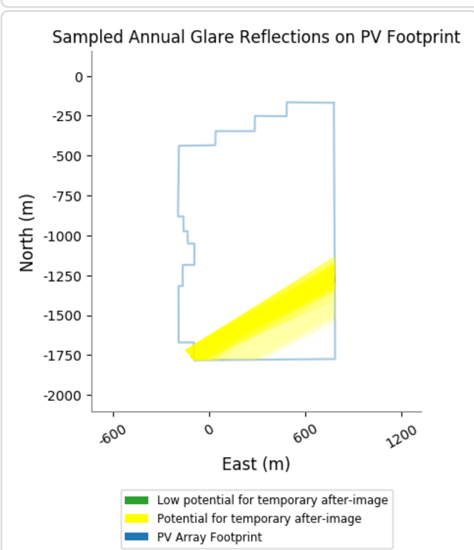
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,330 minutes of "yellow" glare with potential to cause temporary after-image.







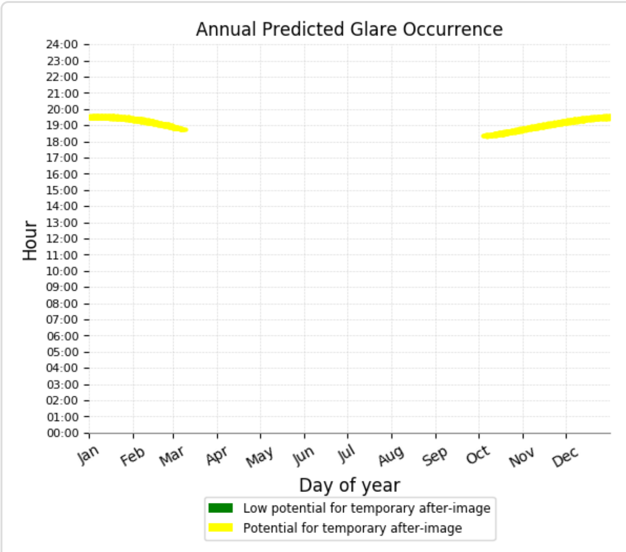


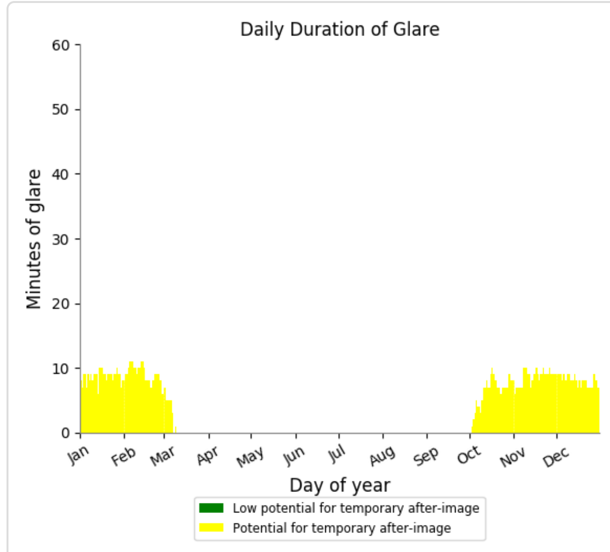


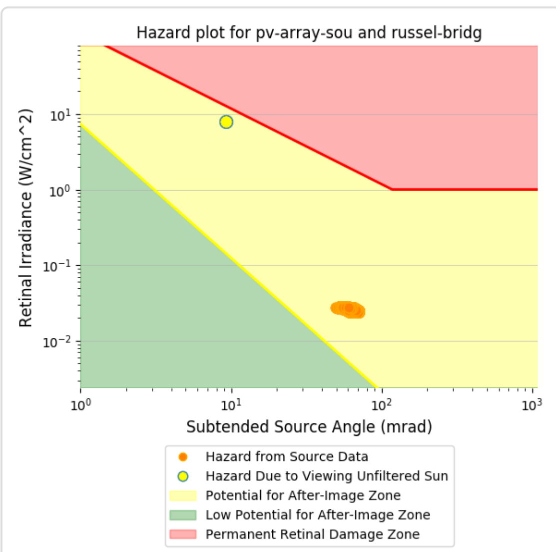
PV array South of Over Head HV Power Line - Route Receptor (Russel-Bridge Rd)

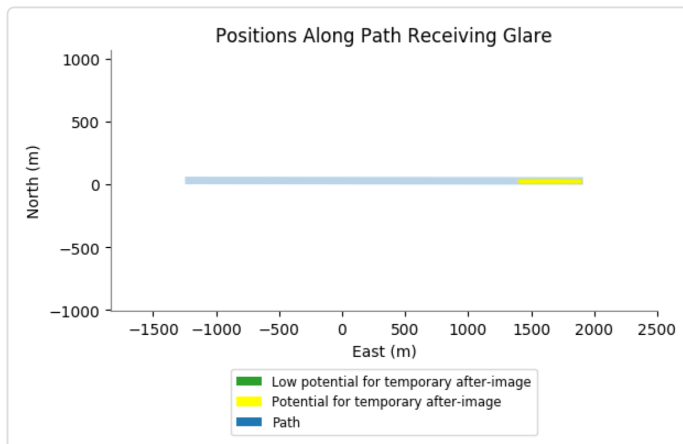
PV array is expected to produce the following glare for receptors at this location:

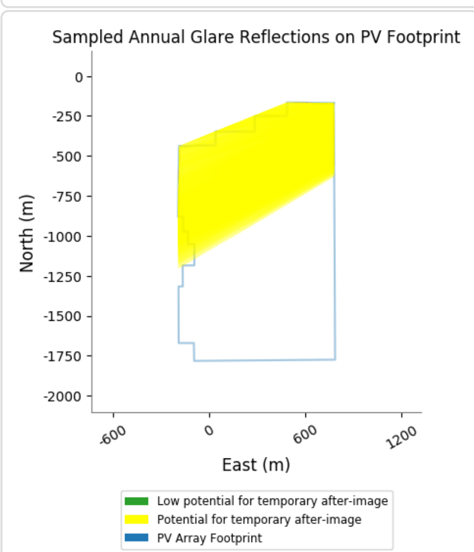
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,255 minutes of "yellow" glare with potential to cause temporary after-image.











Assumptions

- 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
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- 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.
- Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for larg 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.)
- Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, nc discrete, spectrum.
- 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.
- Refer to the **Help page** for detailed assumptions and limitations not listed here.