HAZELWOOD NORTH SOLAR FARM

Glint & Glare

Prepared for:

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Manthos Investments Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

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DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
640.30523.00000-R02-v1.0	27 June 2023	Peter Hayman	Dr Peter Georgiou	Dr Peter Georgiou

EXECUTIVE SUMMARY

SLR has been engaged by Manthos Investments Pty Ltd c/- Robert Luxmoore Pty Ltd to carry out a Reflective Glare assessment of the proposed Hazelwood North Solar Farm (the "Project").

The following potential glare conditions have been considered:

- Daytime Reflective glare (and glint) arising from the solar PV panels within the facility:
  - Motorist "Disability" Reflective Glare and Pedestrian "Discomfort" Reflective Glare;
  - Rail Operator Reflective Glare;
  - Residential "Nuisance" Glare
- Night-time Illumination glare if any 24/7 operational security lighting is incorporate into the Project in the future (noting that lighting is not currently planned).

The Project is located between Morwell and Traralgon and will comprise over 1 million 540W JINKO solar panels mounted on a single-axis ±50° tracking system including backtracking. The Project is located to the south of the M1 with the panels covering an area of approximately 640 hectares.

Initially it should be noted that solar PV panels are designed to capture (absorb) the maximum possible amount of light within the layers below the front (external) surface. Consequently, solar PV panels are designed to minimise reflections off the surface of each panel as this will increase the energy available for conversion.

Aviation Glare

This has been covered in the aviation report completed by others.

Motorist and Rail Traffic "Disability" Glare

Due to the terrain, solar geometry and surrounding vegetation there will be minimal glare for surrounding road and rail users. This is particularly important for major nearby roads such as the M1 and the railway line. One section at the west end of Walshs Road was identified as having the potential for moderate glare impact. Recommendations for additional screening have been made in Section 5.4.

Residential Nuisance Glare

105 Romuald Road, Hazelwood North was identified as having the potential for low glare impact from the Project. Upon further investigation of the duration and times when this occurred it is expected that the sun itself will dominate any view from the receiver location and the glare should not be an issue. Nil glare was found at all other modelled locations.

Night-Time Illumination Glare

Consideration has been given to the night-time lighting at the Project site related to equipment and/or buildings, fire access routes and egress, personnel safety, emergency lighting, etc. SLR understand that, at this stage, night-time security/emergency lighting will be incorporated at various parts of the site infrastructure.

EXECUTIVE SUMMARY

For any 24/7 lighting implemented at the site for operational purposes, there should be negligible impact, assuming the lighting design is in accordance with AS 4282-2019 *Control of the Obtrusive Effect of Outdoor Lighting*. It is noted that equipment such as the batteries are located in the middle of the site making them even less obtrusive.

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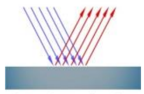
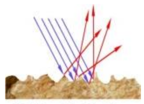
Abbreviations and Definitions

Terms relevant to Daytime Reflective Glare	
PV Panel	Photovoltaic (PV) panels are designed to absorb solar energy and retain as much of the solar spectrum as possible in order to produce electricity.
Glare	Glare refers to the reflections of the sun off any reflective surface, experienced as a source of excessive brightness relative to the surrounding diffused lighting. Glare covers reflections: . Which can be experienced by both stationary and moving observers (the latter referred to as "glint"). . Which are either specular or diffuse.
Specular	A reflection which is essentially mirror-like – there is virtually no loss of intensity or angle dispersion between the incoming solar ray and outgoing reflection.  Specular Reflection
Diffuse	A reflection in which the outgoing reflected rays are dispersed over a wide ("diffuse") range of angle compared to the incoming (parallel) solar rays, typical of "rougher" surfaces.  Diffuse Reflection
KVP	Key View Points (KVPs) are offsite locations where receivers of interest have the potential to experience adverse reflective glare.

Terms relevant to Night-Time Illumination	
Luminous intensity	The concentration of luminous flux emitted in a specific direction. Unit: candela (Cd).
Luminance **AS 1158.2:2020**	This is the physical quantity corresponding to the brightness of a surface (eg a lamp, luminaire or reflecting material such as façade glazing) when viewed from a specified direction. Unit: Cd/m^2
Illuminance **AS 1158.2:2020**	This is the physical measure of illumination. It is the luminous flux arriving at a surface divided by the area of the illuminated surface – the unit is lux (lx) … 1 lx = 1 lm/m^2 The term covers both "Horizontal Illuminance" (the value of illuminance on a designated horizontal plane at ground level) and "Vertical Illuminance" (the value of illuminance on a designated vertical plane at a height of 1.5m above ground level).
Glare **AS 1158.2:2020**	Condition of vision in which there is a discomfort or a reduction in the ability to see, or both, caused by an unsuitable distribution or range of luminance, or to extreme contrast in the field of vision. Glare can include: (a) Disability Glare – glare that impairs the visibility of objects without necessarily causing discomfort. (b) Discomfort Glare – glare that causes discomfort without necessarily impairing the visibility of objects.
Threshold Increment (TI) **AS 4282:2019**	TI is the measure of disability glare expressed as the percentage increase in contrast required between an object and its background for it to be seen equally well with a source of glare present. Higher TI values correspond to greater disability glare.

1 Introduction

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Manthos Investments Pty Ltd c/- Robert Luxmoore Pty Ltd to carry out a Reflective Glare assessment of the proposed 500 MW Hazelwood North Solar Farm (the "Project").

The Project is located over approximately 1,100 hectares of land between Morwell and Traralgon and will comprise:

- A number of panel blocks totalling approximately 560 MW DC, with approximately 1,000,000 solar panels on single axis tracker systems. The project also includes substations and inverter stations along with two battery storage areas.

The following potential glare conditions have been considered:

- Daytime — Reflective glare (and glint) arising from the solar PV panels within the facility
- Night-time — Illumination glare from 24/7 operational security lighting within the facility

1.1 Structure of Report

The remainder of this report is structured as follows:

- **Section 2** describes the Project and surrounding environment;
- **Section 3** describes the input parameters needed to carry out the glare analysis;
- **Section 4** presents the analysis and results covering aviation glare;
- **Section 5** presents the analysis and results covering road and rail disability glare;
- **Section 6** presents the analysis and results covering industrial machinery disability glare;
- **Section 7** presents the analysis and results covering residential nuisance glare;
- **Section 8** presents the analysis and results covering night-time illumination glare;
- **Section 9** presents the conclusions of the study.

2 Proposed Hazelwood North Solar Farm Project

2.1 Site Location

The Project is seeking approval for a 560 MW DC photovoltaic (PV) solar plant as shown in **Figure 1**.

- The Project's northern boundary runs along the southern side of the Princes Highway.
- The Project lies approximately 3 km east of the town of Morwell and 3 km southwest of Traralgon. Some rural properties are much closer particularly near the southwest corner of the Project area.

In terms of the relative heights of the Project and surrounds:

- Ground elevations (ASL) at the Project site generally range from 60 m to 100 m, with the site generally sloping down from the southeast to northwest.
- This trend continues in the surrounding area however there is a rise in Morwell when moving west away from the site after crossing Waterhole Creek.

From the above, it can be seen that the terrain in the vicinity of the Project site in all directions of interest is reasonably flat, with generally moderate variations to observers (motorists, rail, residences, etc) when compared to the solar farm.

Figure 1 Hazelwood North Solar Farm - Location Map

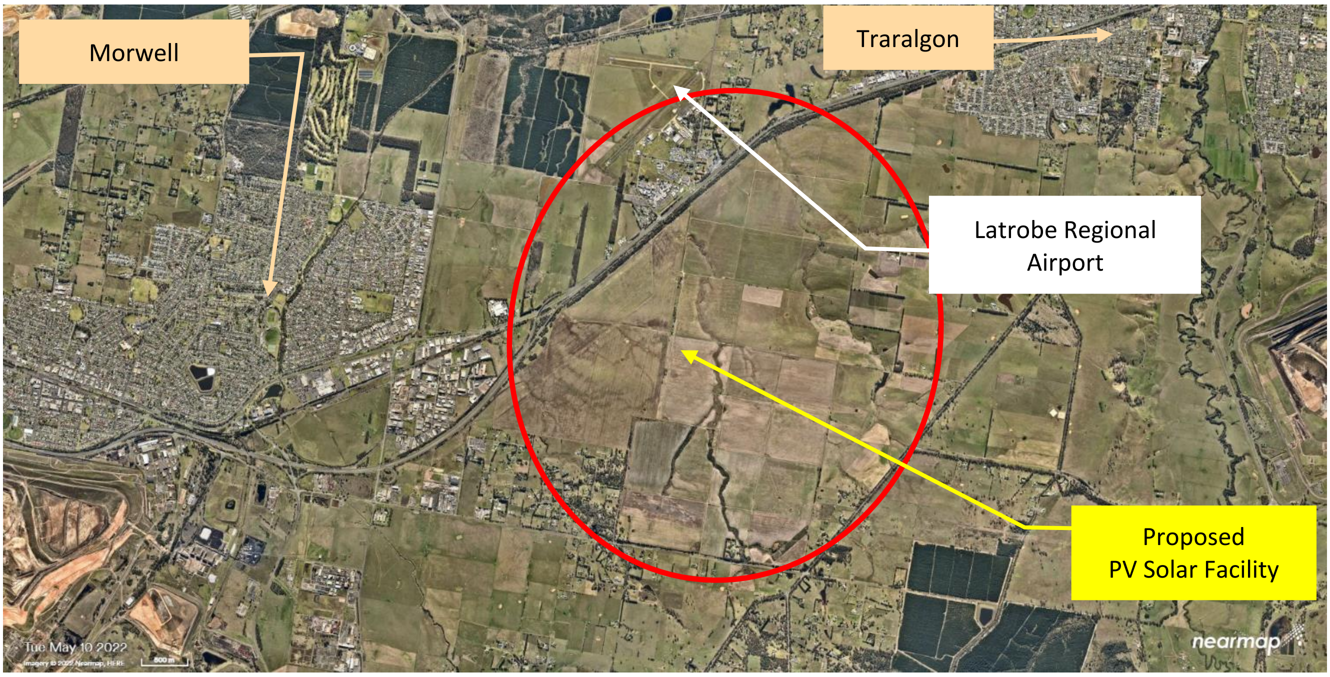


Image: Nearmap (May 2022)

2.2 Site Description and Key Project Components

From a Reflective Glare point of view, the key components of the Project are:

- the photovoltaic (PV) modules in relation to their daytime reflective glare potential; and
- the facility's security/emergency lighting design in relation to potential night-time illumination glare issues, if such 24/7 lighting is incorporated into the Project – note: detailed plans of this are not yet available.

Solar Panel Mounted Array – refer Figure 2

The proposed ground-mounted array (refer **Figure 2**) would consist of approximately 9,000 Voyager Trackers oriented in a north/south direction, supporting 540W solar panels (a little over 1,000,000 panels in total);

- The panel support system is a Single Axis Tracking system with a range of +/- 50 degrees.
- Panels will track from east to west with no tilt toward the north.
- The height to the top of the panels when horizontal will be approximately 1.52 metres which is slightly above the torque tube. (refer **Figure 3**)

Figure 2 Hazelwood North Solar Farm Site Layout

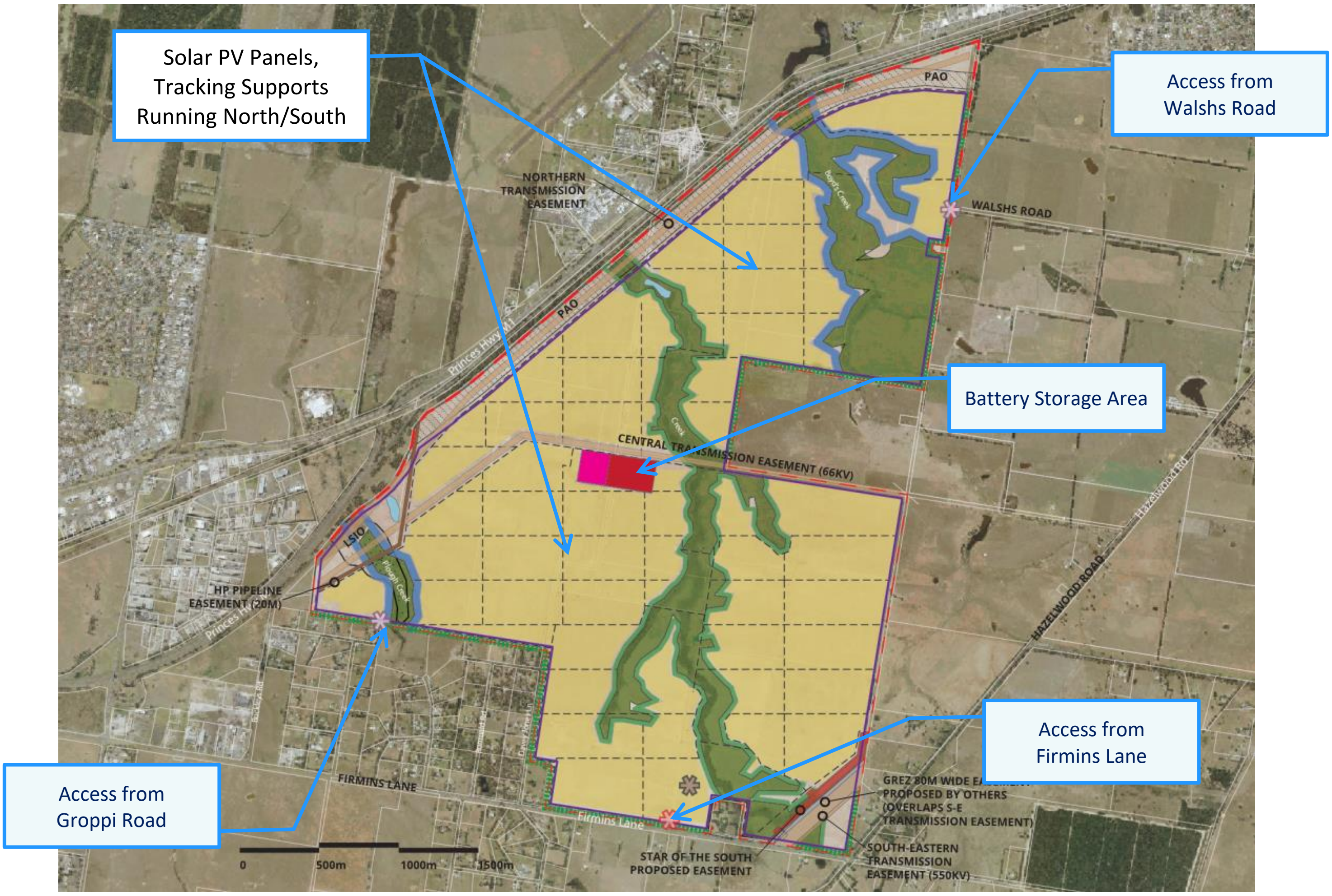
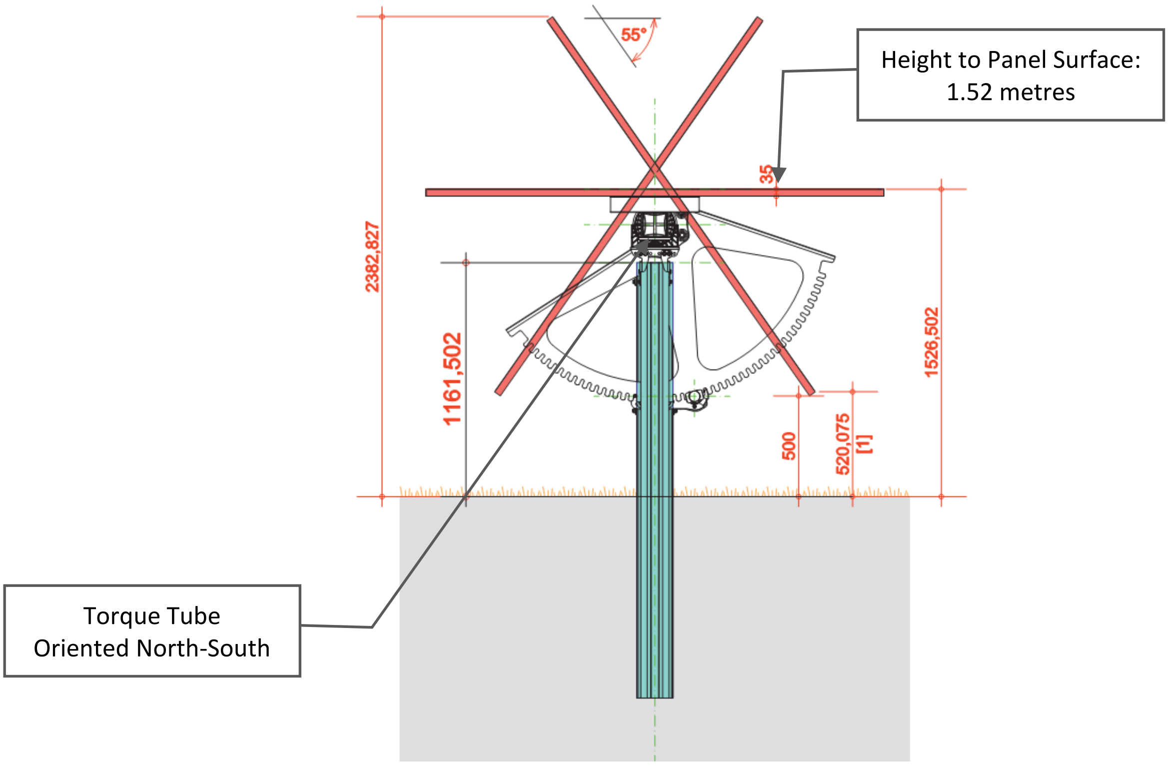


Figure 3 Panel Mounting System



3 Glare Impact Assessment – Inputs

The following potential glare conditions have been considered:

- Daytime Reflective glare (and glint) arising from the solar PV panels
- Night-time Illumination glare if any 24/7 operational security lighting is located within the site

3.1 Project Site Solar Angles – Annual Variations

One of the challenging issues encountered with daytime solar panel glare is the varying nature of the reflections, whose duration will vary with time of day and day of the year as the sun's rays follow variable incoming angles between the two extremes of:

- summer solstice – sunrise incoming rays from just south of east, maximum angle altitude rays at midday, sunset incoming rays from just south of west
- winter solstice – sunrise incoming rays from the northeast, minimum angle altitude rays at midday, sunset incoming rays from the northwest

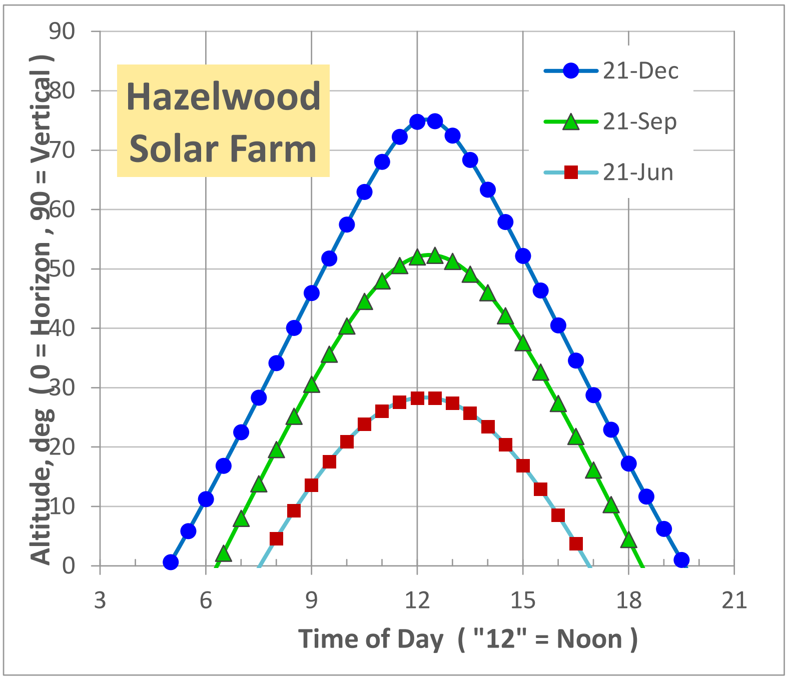
Any solar glare analysis must take into account the complete cycle of annual reflection variations noted above.

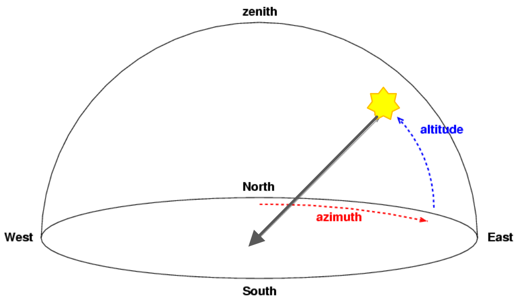
The potential range of incoming solar angles at the Project site relevant to daytime glare is shown in **Figure 4** with relevant critical angles summarised in **Table 1**.

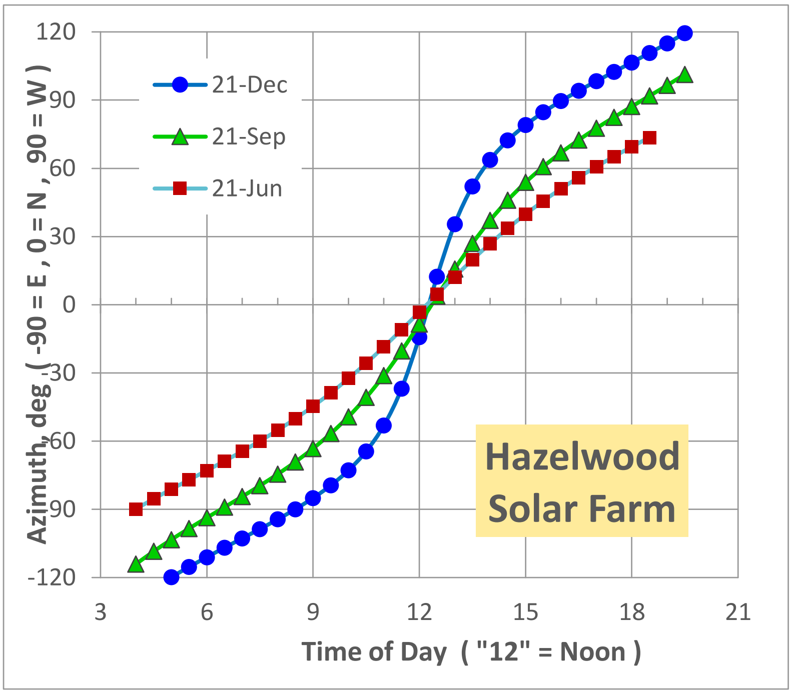
Table 1 Key Annual Solar Angle Characteristics for Project Site

Day of Year	Sunrise	Sunset	Azimuth Range (sunrise-sunset)	Max Altitude
Summer Solstice (DST)	5:46 am	8:36 pm	±120.4° East & West of North	74.8°
Equinox	6:19 am	6:23 pm	±90.7° East & West of North	52.2°
Winter Solstice	7:32 am	4:53 pm	±59..6° East & West of North	28.3°

Figure 4 Project Site Incoming Solar Angle Variations







3.2 Solar Panel Reflectivity

Solar PV panels are designed to capture (absorb) the maximum possible amount of light within the layers below the front (external) surface. Consequently, solar PV panels are designed to minimise reflections off the surface of each panel. Reflections are a function of:

- the angle at which the light is incident onto the panel (which will vary depending on the specific location, time of day and day of the year), and
- the index of refraction of the front surface of the panel and associated degree of diffuse (non-directional) versus specular (directional or mirror-like) reflection which is a function of surface texture of the front module (reflecting) surface.

Representative reflectivity curves are shown in **Figure 5**.

Figure 5 Typical Reflectivity Curves as a Function of Incidence Angle

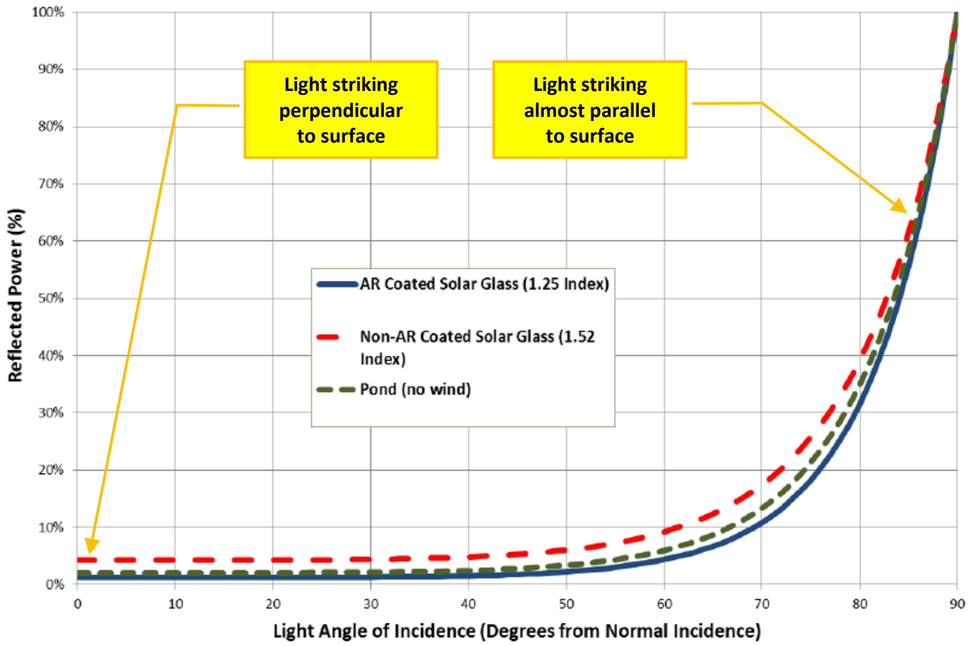


Figure 5 shows that:

- When an oncoming solar ray strikes the surface of a solar PV panel close to perpendicular to the panel surface (ie low "incident" angle), reflectivity is minimal, less than 5% for all solar panel surface types.
- It is only when an incoming solar ray strikes the panel at large "incidence" angles, ie closer to parallel to the panel, that reflectivity values increase. When this happens, reflections become noticeable and potentially at "glare" level for all solar panel surface types.
- However, for very high incidence angle, it would almost always be the case that the observer (motorist, train driver, resident, etc) would perceive reflections coming from virtually the same direction as the incoming solar rays themselves. Such a condition would not constitute a glare situation as the intensity of the incoming solar ray itself would dominate the field of vision perceived by the observer.

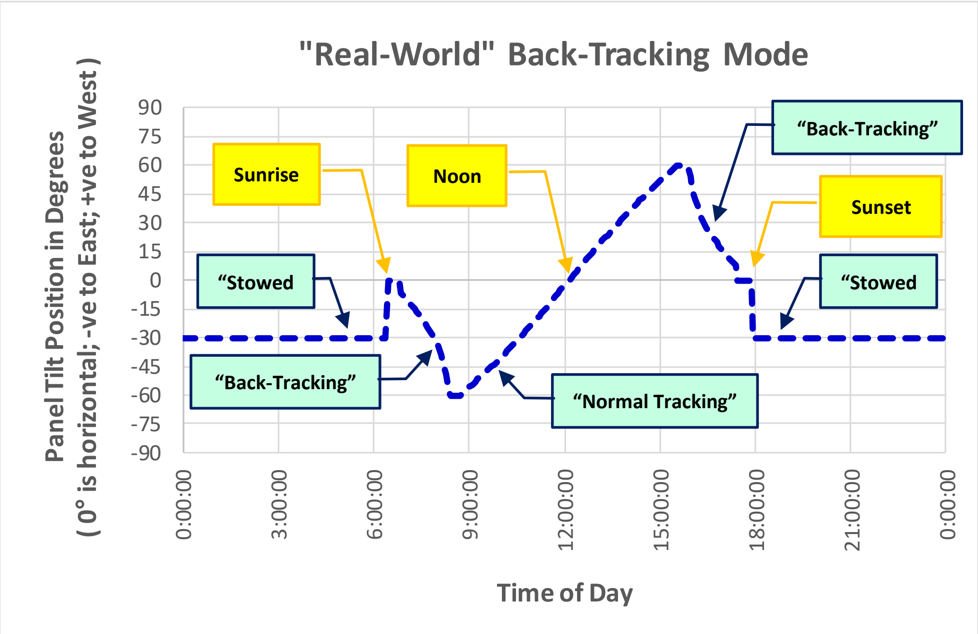
3.3 Modelling Real-World Tracking Axis Operational Modes

Recently, sophisticated "back-tracking" operational modes have been developed, typically by the manufacturers of the tracking systems that support solar panels.

- Algorithms are developed (usually fine-tuned during the commissioning stage of a solar facility) aimed at minimising inter-row shading in the early morning and late afternoon. These algorithms are based on the location of a solar facility (ie its latitude), topography, panel row spacing, etc.
- They typically involve constantly re-positioning panels in the early morning and late afternoon, starting and ending in a more or less horizontal position, so as to "just" avoid inter-row shading.
- During these early morning and late afternoon periods, panel motion is referred to as being in "back-tracking" mode.
- During the remaining hours in the middle of the day, solar panels follow the straightforward "normal tracking" mode, ie moving between their maximum (±60°) tilt positions.
- There is typically a transition period between the two tracking modes (say ~15 minutes), calculated according to the local site tracking system algorithms.

A real-world example of a "back-tracking" mode is shown in **Figure 6**.

Figure 6 Example 24-Hour "Back-Tracking" Operational Mode (around equinox)



In the real-world "back-tracking" mode example shown in **Figure 6**, the following can be seen:

- The sun reaches an altitude angle of 30° in the morning at around 8:30am and again in the afternoon at around 3:45pm. During these hours (ie between around 8:30am and 3:45pm), the panels operate in "normal tracking" mode, ie from -60° facing East to +60° facing West.
- From sunrise till 8:30am and from 3:45pm to sunset, the panels operate in "back-tracking" mode, starting at sunrise and ending at sunset in a horizontal position.
- Overnight, the panels are "stowed" in a fixed position (in this case, -30°) to minimise wind loading and ensure any moisture (dew or rain) does not pool on the panel overnight and cause increased soiling.

The proposed solar farm will employ regular tracking between plus and minus 50 degrees as well as backtracking outside of these angles. The commercially available software programs also have features to model backtracking modes making analysis possible over the complete range of motion.

4 Requirements

The Department of Environment, Land, Water and Planning[1] has produced a *"Design and Development Guideline", October 2022* which covers Solar Energy Facilities and defines four impact levels for glare as detailed here:

- 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 measures.
- 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.

To determine these impact levels at a particular location SLR typically refers the NSW guideline which gives a minute value for each level enabling interpretation of the SGHAT results. An extract from the NSW guideline is shown in **Figure 7**.

Figure 7 Extract form NSW Large-Scale Solar Energy Guideline

Table 2: Impact rating and performance objectives for glare impacts to residential dwellings

High glare impact	Moderate glare impact	Low glare impact
> 30 minutes per day > 30 hours per year	< 30 minutes & > 10 minutes per day < 30 hours & > 10 hours per year	< 10 minutes per day < 10 hours per year
Significant amount of glare that should be avoided.	Implement mitigation measures to reduce impacts as far as practicable.	No mitigation required.

The NSW guideline can be used to match the results of the modelling to the Victorian guideline

[1] DELWP in now the Department of Transport and Planning

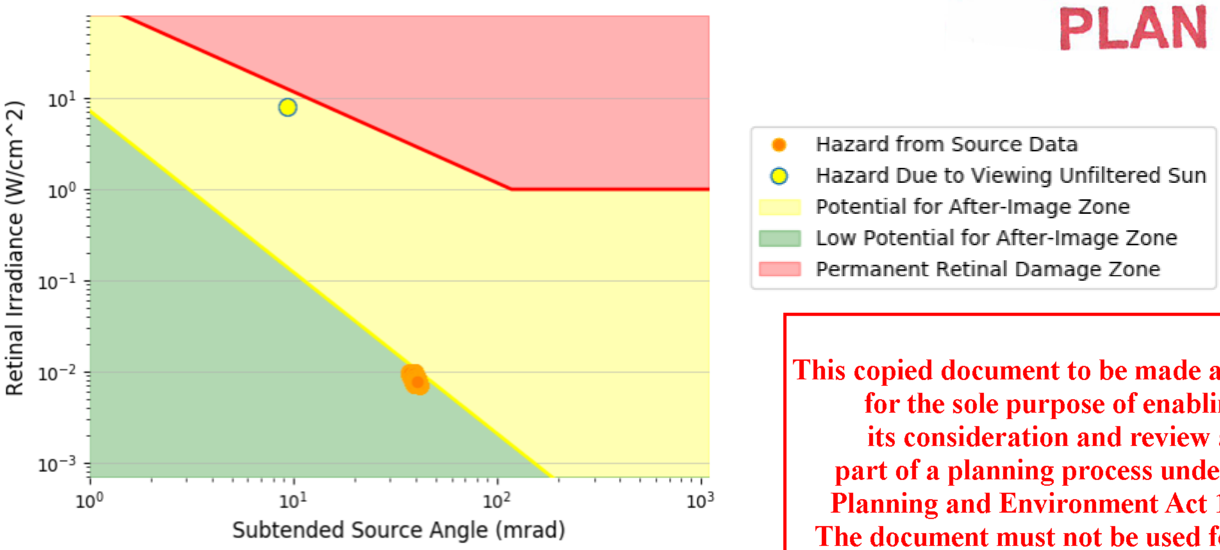
5 Glare Impact – Motorist and Rail Disability Glare

5.1 Modelling outputs

The SGHAT modelling provides output in the form of an ocular hazard analysis plot, a sample of this is shown in **Figure 8**.

The analysis contained in this plot is derived from solar simulations that extend over the ENTIRE CALENDAR YEAR in 1-MINUTE intervals, sunrise to sunset.

Figure 8 Example Solar Glare Ocular Hazard Plot (SGHAT Software Output)



In **Figure 8**, the following is noted:

- SGHAT ocular impact is a function of both the "retinal irradiance" (ie the light seen by the eye) and "subtended source angle" (ie how wide an arc of view the light appears to be arriving from).
- SGHAT ocular impact falls into three categories:
  - . GREEN: low potential to cause "after-image"
  - . YELLOW: potential to cause temporary "after-image"
  - . RED: potential to cause retinal burn (permanent eye damage)
- "After Image" is the term applied to a common retinal phenomenon that most people have experienced at some point or other, such as the effect that occurs when a photo with flash is taken in front of a person who then sees spots in front of their eyes for a few seconds. A more extreme example of "after-image" occurs when staring at the sun. "After-image" (also known as "photo bleaching") occurs because of the de-activation of the cells at the back of the eye's retina when subjected to a very bright light.
- The SGHAT plot provides an indication of the relative intensity of both the incoming reflection and the sources of light itself (ie the sun).

. The occurrence of glare is shown in the plot as a series of orange circles, one circle for each minute that a reflection is visible.

. A reference point is also shown in each SGHAT plot, the yellow circle with the green outline, representing the hazard level of viewing the sun without filtering, ie staring at the sun.

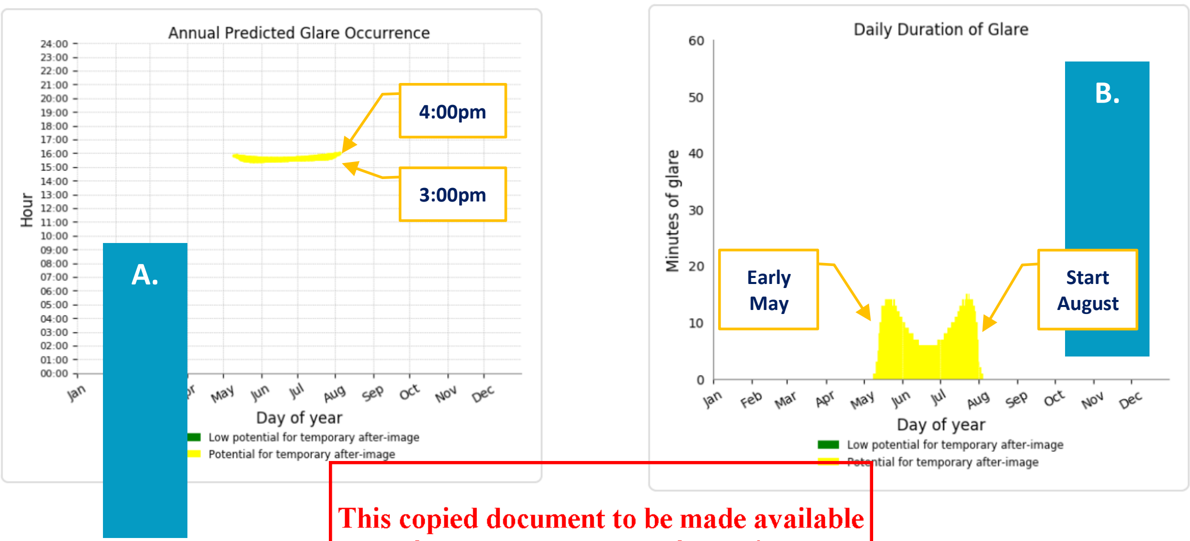
- In **Figure 8**, it can be seen that the reflection visible by the receiver is roughly 1,000 times less intense than the light from the sun.
- Finally, in relation to PV Solar facilities, it is important to note that the third SGHAT Ocular Plot “RED” category is **not possible**, since PV modules DO NOT FOCUS reflected sunlight.

Additional Information Available with the SGHAT Analysis Tool

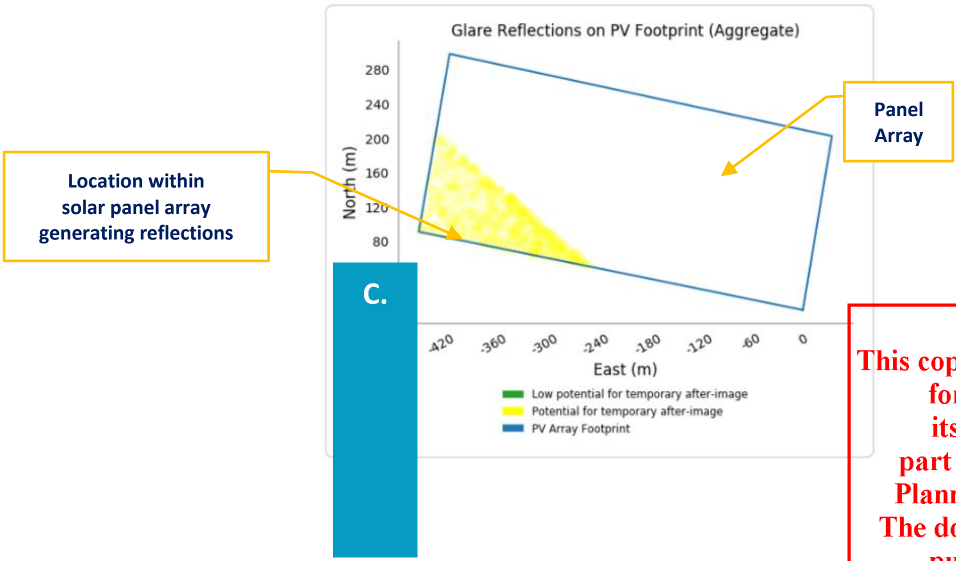
In addition to the above “assessment” output, the SGHAT software package also produces information which reveals the extent of visibility of reflections at any chosen receiver position, regardless of whether the reflections constitute a glare condition or not – an example is shown in **Figure 10**.

- **Figure 9-A**: shows the am/pm time periods when reflections occur at a specific position throughout the year, in this case typically between around 3:30 pm and 4:00 pm.
- **Figure 9-B**: shows the months during the year and the minutes per day when reflections occur at a specific position, in this case from early-May to the start of August, for periods ranging up to 13 minutes per day.
- As noted above, this information is made possible because the SGHAT analysis covers the entire solar annual cycle in 1-minute intervals to ascertain any potential impacts on surrounding receivers.
- Finally, **Figure 9-C** shows WHERE within the solar farm panel array the reflection rays of interest are emanating from, in this case from panels near the southwest corner.

Figure 9 Example Solar Glare Output Plots (SGHAT Software Output)



(Fig.9 cont'd)



5.2 Motorist and Rail Disability Glare

The "major" and "minor" thoroughfares used for the analysis in the immediate vicinity of the Project are listed below

- Princes Highway (M1) – Both Directions "major"
- Princes Drive – Both Directions "major"
- Railway between Morwell and Traralgon – Both Directions "major"
- Airfield Road – Southbound "minor"
- Ambrose Road – Northbound "minor"
- Davey Jones Lane – Both Directions "minor"
- Firmins Lane – Both Directions "major"
- Groppi Road – Eastbound "minor"
- Hazelwood Road – Northbound "minor"
- Jeeralang North Road – Northbound "minor"
- Malcolm Way – Northbound "minor"
- Northern Avenue – Southbound "minor"
- Romauld Road – North, East & Westbound "minor"
- Sanders Road – Westbound "minor"
- Village Avenue – Southbound "minor"
- Walshs Road – Westbound "minor"

The initial model was set up as per the design from OTG Energy dated 8 August 2022. The trackers had a range of motion of +/- 50 degrees and the system had a ground coverage ratio of 45%. For the initial run, backtracking was allowed all the way 0 degrees meaning that the panels would be essentially horizontal at the beginning and end of the day. The height of possible receivers was varied depending on the road in question with 1.5 metres above the ground used for local traffic while 2.5-3 metres was used for the railway and places where heavy vehicles might be expected, such as the M1.

Due to the complex shape of the overall panel layout and to account for differences in ground elevations, the full array was broken up into 13 sections. This provides greater reliability for the modelling .

Table 2 shows the total minutes of potential SGHAT "Yellow" glare, with the yearly total over all panel arrays broken up into the impact categories coloured by the classification under the NSW guideline.

- Green for Low Impact
- Orange for Moderate Impact
- Red for High Impact

Table 2 Minutes of "Yellow" Glare (50° tracking, Back-tracking with 0° rest)

Road	PV Array Sub-Section													Yearly Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	
Airfield Road														0
Ambrose Road														0
Davey Jones Lane									127	509				636
Firmins Lane				8933	355	408			422	474			265	10857
Groppi Road			9		543	709		138		149	6		3	1557
Hazelwood Road		172	71	143	1209				199	171	120	127	386	2598
Jeeralang North Road														0
M1		589	19		13	4100				73	26	118	54	4992
Malcolm Way					207									207
Northern Avenue		348												348
Princes Drive			256		474	3571		362		211	320	11	443	5648
Railway	35	601	259		569	5136		316		269	285	689	465	8624

Road	PV Array Sub-Section													Yearly Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	
Romuald Road 1														0
Romuald Road 2			31		684				1037	3634	12		437	5835
Sanders Road		152	711		1009				54	124	269	220	220	2759
Village Avenue														0
Walshs Road	2745	2466				25	145	229			180	319	301	6410

It can be seen that there is glare possible at a number of locations such as Firmins Lane, Walshs Road, the M1 and the Railway.

The next step was to model a Back-tracking scenario limiting the rest angle to 3° degrees.

The results of this second stage showed moderate or high impact glare only occurring at Firmins Lane, Walshs Road and the east west part of Romauld Road.

A third stage was then modelled which incorporated blockages such as tree lines into the model. After this modelling run, there remained moderate glare of 695 minutes per year only for traffic travelling west along Walshs Road.

It should also be noted that when reflections were registered by the modelling, they were in the early morning or late afternoon, ie close to sunrise and sunset. At these times the sun is below 5 degrees in altitude and any location receiving glare would also be looking almost directly at the sun which would be much brighter than any glare.

5.3 Residential Observer Glare

SLR chose 40 representative locations within and beyond 1 kilometre from the proposed solar facility. With addresses given in the table below.

Table 3 Observer Locations

SGHAT Location	Address	SGHAT Location	Address
OP1	20 National Rd Morwell VIC 3840	OP21	660 Hazelwood Rd, Hazelwood North VIC 3840
OP2	5203 Princes Hwy, Morwell VIC 3840	OP22	485 Firmins Ln, Hazelwood North VIC 3840
OP3	50 Airfield Rd, Traralgon VIC 3844	OP23	665 Hazelwood Rd, Hazelwood North VIC 3840
OP4	15 Northern Ave, Traralgon VIC 3844	OP24	665 Firmins Ln, Hazelwood North VIC 3840
OP5	40 Northern Ave, Traralgon VIC 3844	OP25	30 Meles Rd, Hazelwood North VIC 3840
OP6	5483 Princes Hwy, Traralgon VIC 3844	OP26	5 Jeeralang N Rd, Hazelwood North VIC 3840
OP7	70 Northern Ave, Traralgon VIC 3844	OP27	540 Firmins Ln, Hazelwood North VIC 3840
OP8	70 Easterly Dr, Traralgon VIC 3844	OP28	744 Hazelwood Rd, Hazelwood North VIC 3840
OP9	15 Bradford Dr, Traralgon VIC 3844	OP29	440 Firmins Ln, Hazelwood North VIC 3840
OP10	35 Bradford Dr, Traralgon VIC 3844	OP30	380 Firmins Ln, Hazelwood North VIC 3840
OP11	5533 Princes Hwy, Traralgon VIC 3844	OP31	10 Davey Jones Ln, Hazelwood North VIC 3840
OP12	5567 Princes Hwy, Traralgon VIC 3844	OP32	10 Tanners Rd, Hazelwood North VIC 3840
OP13	29 Madsen Ave, Traralgon VIC 3844	OP33	35 Davey Jones Ln, Hazelwood North VIC 3840
OP14	6 Penny Ct, Traralgon VIC 3844	OP34	105 Romuald Rd, Hazelwood North VIC 3840
OP15	11 Armagh Ct, Traralgon VIC 3844	OP35	87 Romuald Rd, Hazelwood North VIC 3840
OP16	410 Hazelwood Rd, Traralgon VIC 3840	OP36	75 Malcolm Way, Hazelwood North VIC 3840
OP17	322 Hazelwood Rd, Traralgon VIC 3844	OP37	75 Groppi Rd, Hazelwood North VIC 3840
OP18	580 Hazelwood Rd, Hazelwood North VIC 3840	OP38	17 Groppi Rd, Hazelwood North VIC 3840
OP19	620 Hazelwood Rd, Hazelwood North VIC 3840	OP39	73 Bridle Rd, Morwell VIC 3840
OP20	Latrobe Regional Hospital	OP40	61 McMillan St, Morwell VIC 3840

The same procedure for assessing Residential Glare was used as per the Road and Rail Glare.

Table 4 Minutes of "Yellow" Glare (50° tracking, Back-tracking with 0° rest)

Road	PV Array Sub-Section													Yearly Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	
OP1			210			2261		280			3			2754
OP2						2312	52							2364
OP3	1	300												301
OP4		299												299
OP5	3													3
OP6														0
OP7														0
OP8														0
OP9														0
OP10														0
OP11														0
OP12		259												259
OP13		1083												1083
OP14		1142												1142
OP15		1309										1		1310
OP16		4			576					8		88	2	678
OP17		749			83							54	159	1045
OP18					1050				181	481	281	197	28	2218
OP19					374				55	355		103		887
OP20														0
OP21									6	381				387
OP22										170				170
OP23				486	18				1	344			231	1080
OP24					17				10	155			213	395
OP25				397						163			101	661
OP26										75				75
OP27										2				2
OP28														0

Road	PV Array Sub-Section													Yearly Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	
OP29														0
OP30														0
OP31									448					448
OP32														0
OP33					610				9	9				628
OP34			28		464				900	2123	4		538	4057
OP35			7		547					402	1		27	984
OP36			2		16					74				92
OP37			12		645	135		483		279	14		24	1592
OP38			10		513	692				104	6			1325
OP39			63			744		290					272	1369
OP40			1		1	37		9				2	6	56

The initial model showed potential glare issues around OP13-19 and OP33-39.

The second stage (Back-tracking rest angle of 3°) reduced the impact to a moderate level at only OP34 with 1151 minutes throughout the year.

Once blockages were included however, reflections were almost entirely eliminated with only 7 minutes remaining at OP34 leaving it in the Low Impact (NSW Guideline) glare category.

5.4 Recommendations

After the analysis the following potential glare conditions remain.

Table 5 Glare Summary

Road	PV Array Sub-Section													Yearly Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	
OP34											7			7
Walshs Road	695													695

Under the Victorian guideline *("Design and Development Guideline", October 2022)* OP34 would be classified as low impact with only 7 minutes of "yellow" glare on the ocular hazard plot per year. As previously stated, representative residential observers were used for the analysis. isolated dwellings were included while denser groupings were represented by worst case dwellings which either had less protection or were to the east or west of a part of the site.

The glare for OP34 occurs during the winter in the early morning between 7 and 8 am. This is before the sun reaches 10 degrees altitude and any glare would be difficult to distinguish for the sun itself, therefore no additional mitigation will be required.

The 695 minutes of "yellow" glare on the ocular hazard plot per year for Walshs Road would be classed as a moderate impact under the Victorian guideline. To mitigate this SLR recommends that screening be used along the edge of the site around this area as shown in **Figure 10**. The screening should be dense and at least 3 metres in height.

Figure 10 Walshs Road Mitigation Measure

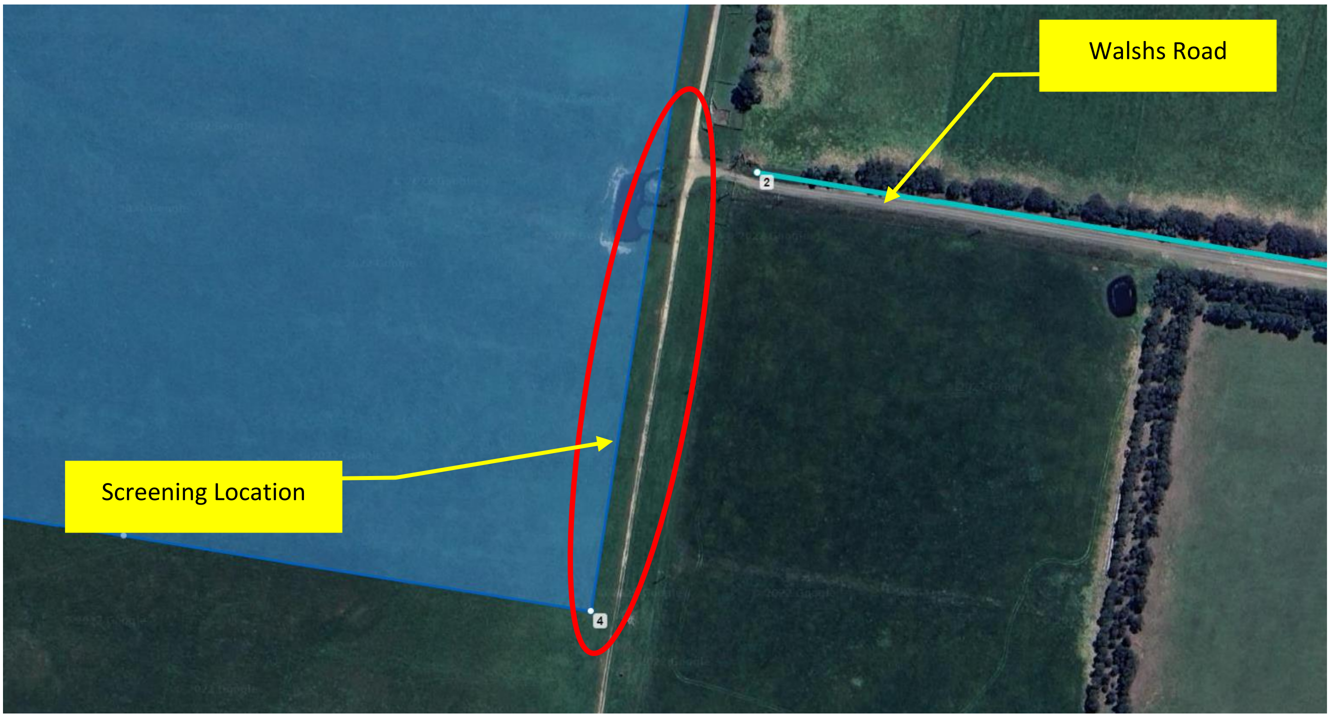


Image: *Forge Solar*

6 Night-Time Illumination Glare

6.1 Night-Time Illumination Glare – Criteria

The effect of light spill from outdoor lighting impacting on residents, transport users, transport signalling systems and astronomical observations is governed by *AS 4282-2019 Control of the Obtrusive effects of Outdoor Lighting*. The adverse effects of light spill from outdoor lighting are influenced by a number of factors:

- The topology of the area. Light spill is more likely to be perceived as obtrusive if the lighting installation is located higher up than the observer. Lighting installations are usually directed towards the ground and an observer could hence have a direct view of the luminaire.
- The surrounding area. Hills, trees, buildings, fences and general vegetation have a positive effect by shielding the observer from the light installation.
- Pre-existing lighting in the area. Light from a particular light source is seen as less obtrusive if it is located in an area where the lighting levels are already high, eg in cities. The same lighting installation would be seen as far more bothersome in a less well-lit residential area.
- The zoning of the area. A residential area is seen as more sensitive compared to commercial areas where high lighting levels are seen as more acceptable.

Typical illuminance levels for a variety of circumstances are given in **Table 10** for comparison.

Table 6 Typical Illuminance Levels for Various Scenarios

Lighting Scenario	Horizontal Illuminance (lux)
Moonless overcast night	0.0001
Quarter Moon	0.01
Full Moon	0.1
Twilight	10
Indoor office	300
Overcast day	1,000
Indirect sunlight clear day	10,000-20,000
Direct sunlight	100,000-130,000

Recommended criteria of light technical parameters for the control of obtrusive lighting are given in **Table 11**. The vertical illuminance limits for *curfew hours* as defined in AS 4282-2019 apply in the plane of the windows of habitable rooms or dwellings on nearby residential properties. The vertical illuminance criteria for *pre-curfew hours* apply at the boundary of nearby residential properties in a vertical plane parallel to the boundary.

Values given are for the direct component of illuminance, ie no reflected light is taken into account.

- Limits for luminous intensity for *curfew hours* apply in directions where views of bright surfaces of luminaires are likely to be troublesome to residents, from positions where such views are likely to be maintained.

- Limits for luminous intensity for *pre-curfew* hours apply to each luminaire in the principal plane, for all angles at and above the control direction.

Table 7 Recommended Maximum Values of Light Technical Parameters (AS4282-2019)

Light Technical Parameter	Time of Operation	Zone "A4"	Zone "A3"	Zone "A2"	Zone "A1"	Zone "A0"
Illuminance in vertical plane (E_v)	Pre-curfew hours	25 lx	10 lx	**5 lx**	2 lx	Alarp [1]
	Curfew hours	5 lx	2 lx	**1 lx**	0.1 lx	0 lx
Luminous Intensity emitted by luminaires (I)	Pre-curfew hours	25,000 Cd	12,500 Cd	**7,500 Cd**	2,500 Cd	Alarp [1]
	Curfew hours	2,500 Cd	2,500 Cd	**1,000 Cd**	500 Cd	0 Cd

Zone A0	"Intrinsically Dark", eg UNESCO Starlight Reserve; IDA Dark Sky Parks; major optical observatories; no road lighting, unless specifically required by the relevant road controlling authority
Zone A1	"Dark", eg relatively uninhabited rural areas; no road lighting, unless specifically required by the relevant road controlling authority
Zone A2	"Low District Brightness", eg sparsely inhabited rural and semi-rural areas
Zone A3	"Medium District Brightness", eg suburban areas in towns and cities
Zone A4	"High District Brightness", eg town and city centres and other commercial areas; residential areas abutting commercial areas

Note 1 Alarp = as low as reasonably practical (as close to zero as possible)

The Project is located in a rural area with the potential to impact on surrounding residential properties. As these properties are not located within township environs proper, they would therefore be classed as being in a Zone "A2" area - refer **Table 11**.

The applicable limits for adverse spill light will depend on the time of operation for the lighting installation.

the Project, it is understood that night-time security/emergency lighting will be incorporated at some site areas such as the battery, suggesting the application of the more restrictive limit relevant to *curfew hours*.

Accordingly:

- Light spill from the Project onto the facades of the surrounding residential dwellings should be kept below 1 lux during curfew hours as required by AS 4282-2019.

6.2 Night-Time Illumination Glare – Assessment and Mitigation

Areas within the Project site have been marked for batteries, power conversion unit, fire access routes and egress, etc, and that some of these may need to be operational 24/7. There are 168 flood lights proposed for the battery area.

The only potential for future night-time illumination glare would be associated with the nearest thoroughfares and residential and other sensitive receivers to the Project.

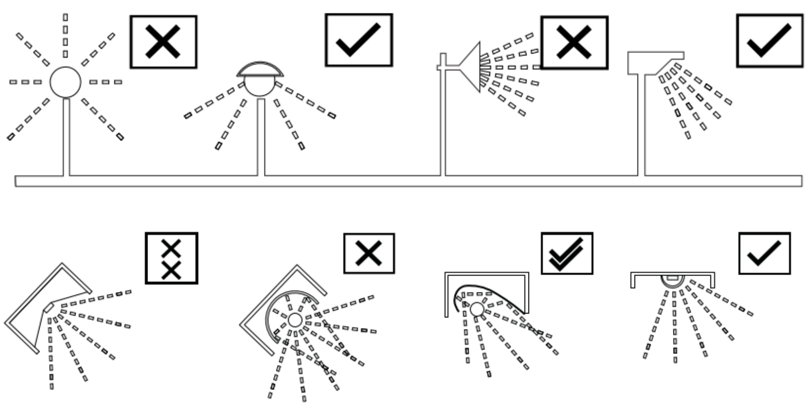
The recommendations set out below are therefore aimed at achieving the best lighting performance (taking into account safety considerations) while having a minimal impact on the surrounding properties, carriageways and nocturnal fauna. In terms of any future potential night-time lighting, the adopted goal of limiting night-time light spill to no more than 1 lux falling on the nearby residential facades during curfew hours are expected to be easily achieved given the distances to the nearest residential and other receivers from some of the Project's infrastructure.

Accordingly, the potential for any future nuisance glare will be non-existent.

AS4282-2019 *Control of the Obtrusive Effect of Outdoor Lighting* sets out general principles that should be applied when designing outdoor light to minimise any adverse effect of the light installation. It is expected that these will be applied to the design of the project lighting.

- Direct lights downward as much as possible and use luminaires that are designed to minimise light spill, eg full cut-off luminaires where no light is emitted above the horizontal plane, ideally keeping the main beam angle less than 70°. Less spill-light means that more of the light output can be used to illuminate the area and a lower power output can be used, with corresponding energy consumption benefits, but without reducing the illuminance of the area - refer **Figure 20**.
- Do not waste energy and increase light pollution by over-lighting.
- Wherever possible use floodlights with asymmetric beams that permit the front glazing to be kept at or near parallel to the surface being lit.

Figure 11 Luminaire Design Features that Minimise Light Spill (refer AS 4282-2019)



7 Conclusion

Motorist and Rail Traffic “Disability” Glare

Due to the terrain, solar geometry and surrounding vegetation there will be minimal glare for surrounding road and rail users. This is particularly important for major nearby roads such as the M1 and the railway line. One section at the west end of Walshs Road was identified as having the potential for moderate glare impact. Recommendations for additional screening have been made in Section 5.4.

Residential Nuisance Glare

105 Romuald Road, Hazelwood North was identified as having the potential for low glare impact from the Project. Upon further investigation of the duration and times when this occurred it is expected that the sun itself will dominate any view from the receiver location and the glare should not be an issue. Nil glare was found at all other modelled locations.

Night-Time Illumination Glare

Consideration has been given to the night-time lighting at the Project site related to equipment and/or buildings, fire access routes and egress, personnel safety, emergency lighting, etc. SLR understand that, at this stage, night-time security/emergency lighting will be incorporated at various parts of the site infrastructure.

For any 24/7 lighting implemented at the site for operational purposes, there should be negligible impact, assuming the lighting design is in accordance with AS 4282-2019 *Control of the Obtrusive Effect of Outdoor Lighting*. It is noted that equipment such as the batteries are located in the middle of the site making them even less obtrusive.

8 Feedback

At SLR, we are committed to delivering professional quality service to our clients. We are constantly looking for ways to improve the quality of our deliverables and our service to our clients. Client feedback is a valuable tool in helping us prioritise services and resources according to our client needs.

To achieve this, your feedback on the team's performance, deliverables and service are valuable and SLR welcome all feedback via https://www.slrconsulting.com/en/feedback. We recognise the value of your time and we will make a $10 donation to our 2022 Charity Partner – Lifeline, for every completed form.

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