LIDL Newcastle, Co. Dublin

Glint & Glare Assessment Report

2020
CIBSE BUILDING PERFORMANCE CONSULTANCY

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Executive Summary

Lawler Sustainability conducted an analysis on the risk of glint and glare for the proposed rooftop solar Photovoltaic (PV) array at Lidl Newcastle, Co. Dublin. This report assesses the potential for ocular impact of glare which would emanate from sunlight reflections of the PV array and its possibility to cause an impact to observers in the surrounding area. Nine receptors were assessed in the vicinity of the proposed Lidl store. Receptors included eight from neighbouring properties, three route receptors, four 2-mile flight receptors, and one Air Traffic Control Tower (ATCT) receptor at Baldonnel Aerodrome. A solar exposure analysis was conducted to determine the amount of sunlight the roof space would receive during different time periods of the year.

Table 1 below demonstrates a brief overview of the results of this glint and glare report. The results indicate that **some receptors have low level potential for ocular impact of glare while others have none**. The ATCT at Baldonnel Aerodrome appears to have a very low risk of glare but upon further investigation on the local landscape, there are nearby buildings and tall vegetation which obstruct the direct line of sight of the proposed PV array at LIDL Newcastle. In addition, the roof space where the proposed solar PV array is to be located is **not overshadowed** by any surrounding buildings and can receive 96% of sunlight annually, and between 91-93% sunlight during wintertime.

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Table 1. Summary of results

Receptor	Potential for ocular glare
OP: OP 1	Low
OP: OP 2	Low
OP: OP 3	Low
OP: OP 4	Low
OP: OP 5	Low
OP: OP 6	Low
OP: OP 7	None
OP: OP8 ATCT	Low
OP: OP 9	None
Route 1 Peamount Road	Low
Route 2 Aylmer Road Route	Low
3 Athgoe-Main street	Low
Flight Path Receptor FP1	Low
Flight Path Receptor FP2	Low
Flight Path Receptor FP3	None
Flight Path Receptor FP4	None

Introduction

LIDL Ireland GmbH have requested Lawler Sustainability to conduct a Glare & Glint analysis on a proposed Photovoltaic (PV) installation at LIDL Newcastle, Co. Dublin. The PV array is assumed to be 165 kW_p and installed at the same pitch of the roof (~4°).

This report has assessed the potential for glare on the surrounding properties and roads around the LIDL Newcastle, Co. Dublin using the ForgeSolar toolset. ForgeSolar uses GlareGauge which is the leading solar glare analysis tool used globally to satisfy local standards and policies. The tool uses the Solar Glare Hazard Analysis Tool (SGHAT) developed by Sandia National Laboratories which uses a sun-path algorithm for every minute of the year (assuming 100% sunshine for all daylight hours) to determine if and when reflections may occur at selected receptors. If reflection is found to be present, further analysis is then conducted to determine the significance of the potential glare that could be experienced and whether if these effects are likely to be experienced by an observer in that location. In some cases, where there is significant glare found in the analysis, mitigation factors can then be discussed and assessed further.

Solar Photovoltaic Array Proposal

The proposed solar photovoltaic (PV) array will be mounted on the sloped roof of the LIDL store at Newcastle, Co. Dublin. The PV panels will be facing East with a pitch angle equivalent to the slope of the roof (~4°). The PV panels will be fixed in position and will not track the sun throughout the day or year.

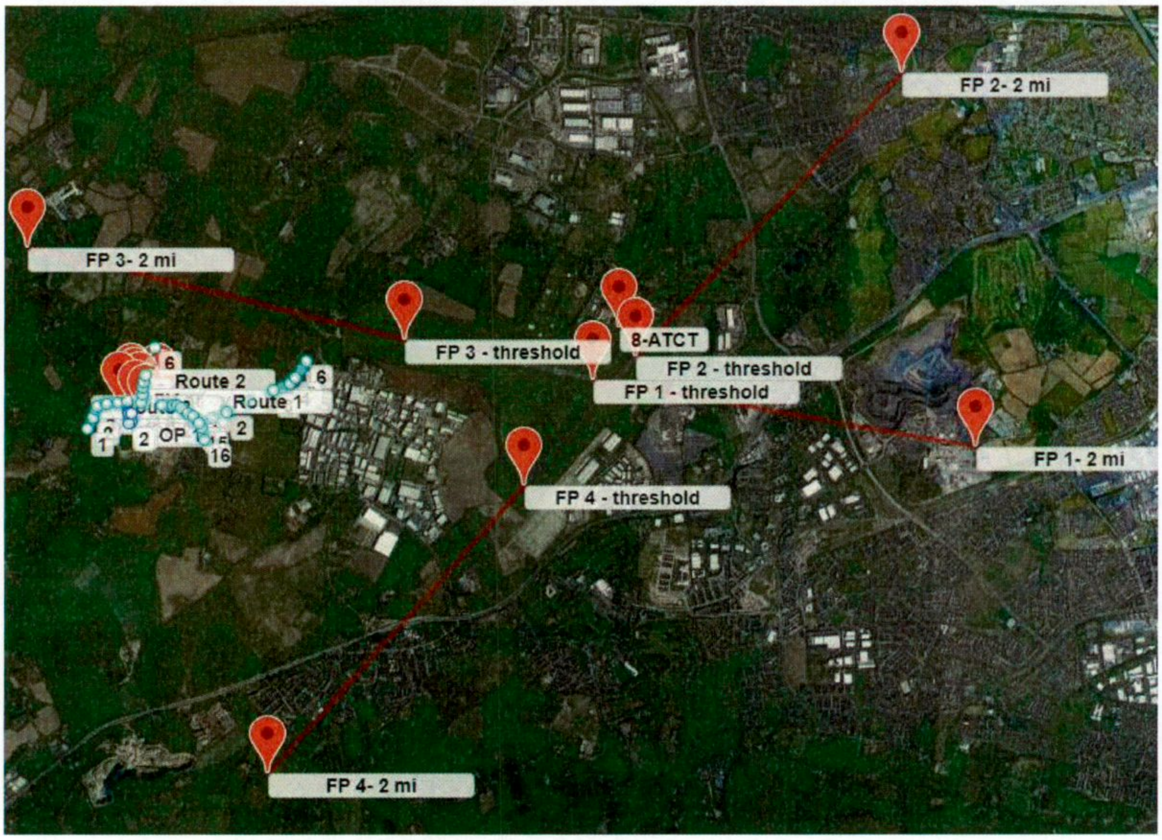

Figure 1. Site location highlighting point receptors and route receptors

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About Glint and Glare

What are Glint and Glare?

The United States Federal Aviation Administration (FAA) have best defined glint and glare as[1]:

- Glint is a momentary flash of bright light, and
- Glare is a continuous source of bright light.

The difference between glint and glare is duration. Glint is often caused by a reflection off a moving source, whereas glare is generally associated with stationary objects that reflect sunlight.

The ocular impact of solar glare is split into three categories[2]:

- Green – low potential to cause after-image (flash blindness)
- Yellow – potential to cause temporary after-image
- Red – potential to cause retinal burn (permanent eye damage)

These categories assume a typical blink response in the observer. Note that retinal burn is generally not possible for PV glare since PV modules do not focus reflected sunlight.

The ocular impact of glare is visualised with the Glare Hazard Plot (Figure 2). This chart displays the ocular impact as a function of glare subtended source angle and retinal irradiance. Each minute of glare is displayed on the chart as a small circle in its respective hazard zone. For convenience, a reference point is highlighted which illustrates the hazard from viewing the sun without filtering, i.e., looking at the sun. Each plot includes predicted glare for one PV array and one receptor.

[1] Federal Aviation Administration, November 2010: Technical Guidance for Evaluating Selected Solar Technologies on Airports October 2019.

[2] Ho, C. K., Ghanbari, C. M., and Diver, R. B., 2011, "Methodology to Assess Potential Glint and Glare Hazards from Concentrating Solar Power Plants: Analytical Models and Experimental Validation", ASME J. Sol. Energy Eng., 133.

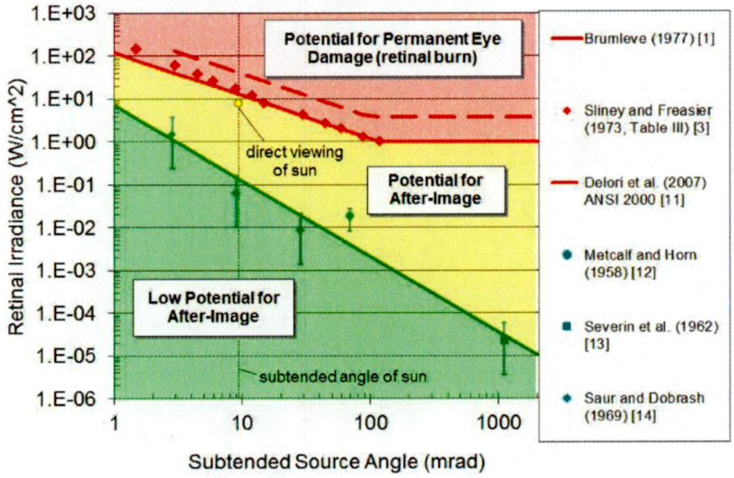

Figure 2. Sample glare hazard plot defining ocular impact as function of retinal irradiance and subtended source angle[3]

Solar Reflectance of PV Panels

PV panels have low reflectivity characteristics, as sunlight is used to induce electrical generation in the PV panels, the panels' function is to absorb the light, not to reflect it. The material used for this function is therefore black or dark blue. Figure 3 below displays that the reflectance of PV panels is remarkably like that of water. However, the amount of light reflected off solar PV panels can increase during certain times of the day, generally early morning, or late evening, which can have the potential for glare in certain directions.

[3] Federal Aviation Administration, November 2010: Technical Guidance for Evaluating Selected Solar Technologies on Airports October 2019.

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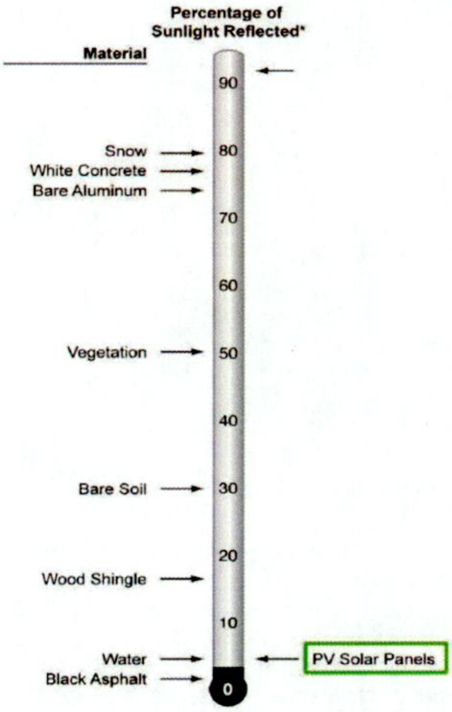

Figure 3. Reflectivity produced by different surfaces[4]

Sandia National Laboratories developed five generic PV module material reflectance profiles by analysing over twenty PV module samples. These profiles are available in ForgeSolar and allow for customizing the material properties of the PV array during analysis. It is known from the current PV supplier that the reflectivity of their PV modules, which will be used for the proposed development, are light textured glass with anti-reflective coating. Figure 4 below highlights the reflectance of each material profile as a function of incidence angle, where an angle of 0° implies the panels are directly facing the sun.

[4] FAA 2010 Solar Guidance

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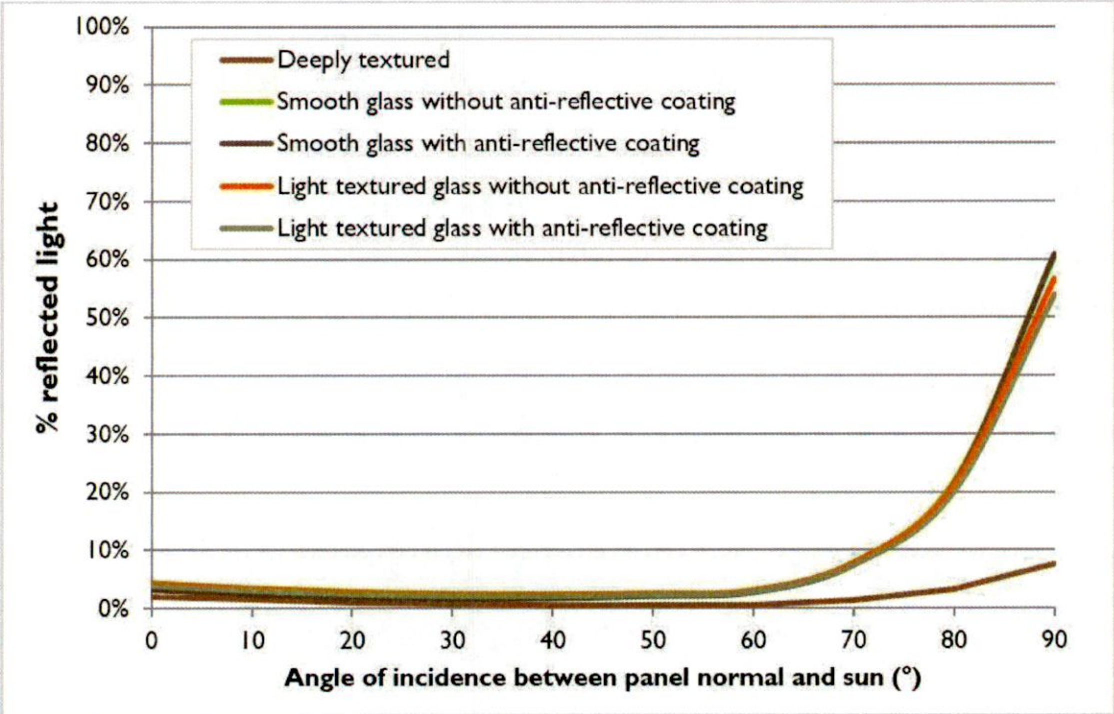

Figure 4. Reflectance profiles of typical PV module materials[5]

Studies have found that 7 W/m^2 is enough to cause an after-image lasting 4 to 12 seconds[6]. This represents a reflection of only 1-2% of typical solar irradiance for a given location, which generally ranges between 800-1000 W/m^2. A panel that absorbs 90% of direct sunlight may reflect up to 60% when not directly facing the sun. This is common for low-tilt panels during sunrise and sunset. The claim that PV panels reflect less than 5% of sunlight only holds true when the panels are directly facing the sun, which for fixed-mount panels, only applies for a few minutes of the day at most.

[5] 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, the ASME 2015 13th International Conference on Fuel Cell Science, Engineering and Technology, and the ASME 2015 Nuclear Forum. 2015. American Society of Mechanical Engineers.
[6] Ho, C. K., Ghanbari, C. M., and Diver, R. B., 2009, "Hazard Analyses of Glint and Glare from Concentrating Solar Power Plants", SAND2009-4131C, in proceedings of SolarPACES 2009, Berlin, Germany, Sept. 15-18.

Sunshine Hours in Ireland

According to Met Eireann[7], Ireland normally gets between 1100 and 1600 hours of sunshine each year with the sunniest months being May and June. Also, Irish skies are estimated to be completely covered by cloud for well over 50% of the time. The graph below represents the average monthly amount of sunshine hours that Ireland receives which is based on data from Dublin Airport and world data website[8].

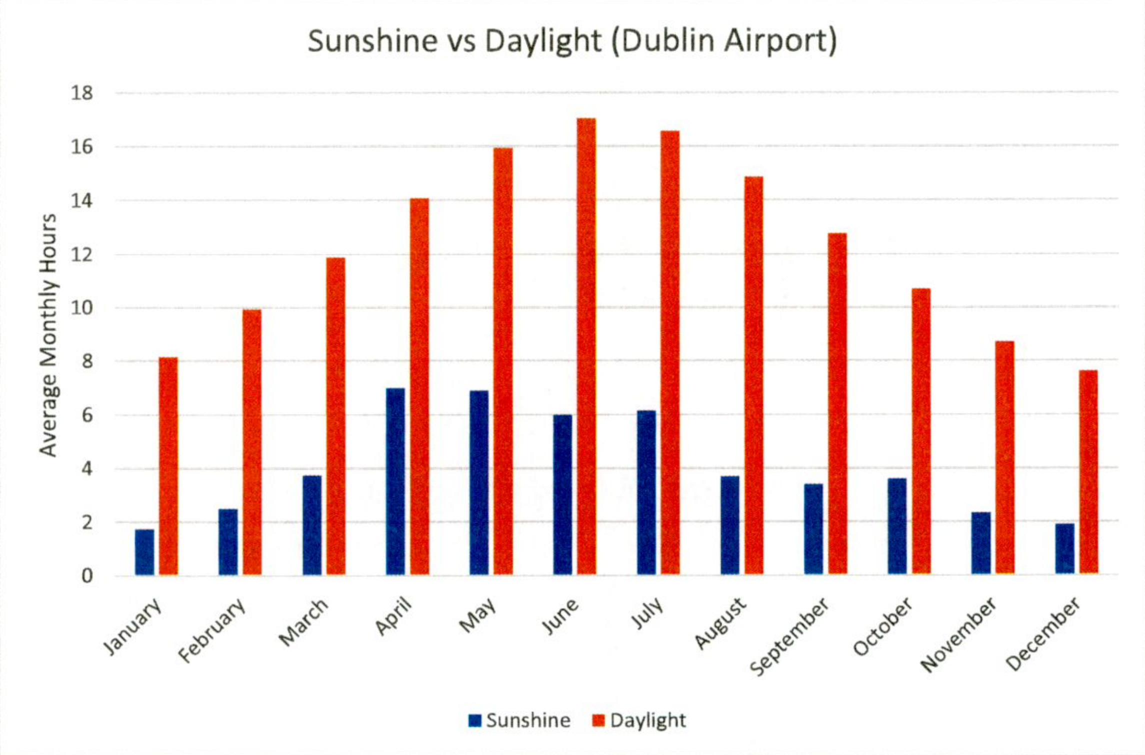

Figure 5. Sunshine vs Daylight (Dublin Airport)

[7] https://www.met.ie/climate/what-we-measure/sunshine
[8] https://www.worlddata.info/europe/ireland/sunset.php

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Relevant Guidance and Studies

Ireland

There is currently no policy, guidance, or recommendations in Ireland in relation to the assessment of glint and glare effects on residential buildings, road and rail users, and aviation. A report produced by Future Analytics, in conjunction with the Sustainable Energy Authority of Ireland (SEAI), contains a set of planning policy and development guidance recommendations for utility scale solar PV schemes in Ireland[9]. This is not a formal guidance document, but it sets out recommended elements of the assessment based on international practice.

United Kingdom (UK)

Studies have been conducted in the UK which helps to establish an accepted best practice and planning guidance recommends the assessment of glint and glare effects. However, there currently is no specific guidance by way of a prescriptive methodology document. The Civil Aviation Authority (CAA) have produced an interim guidance document[10] in relation to the development of solar PV systems on, and in the vicinity (<15 km) of aerodromes. The Building Research Establishment (BRE) have also developed several relevant papers, however neither the BRE or the CAA have produced a methodology for assessing the effects of glint and glare on rail and road users, aviation, or residential buildings.

Germany

The Light Guidelines[11] produced by The Federal Ministry of the Environment defines acceptable levels of glare as being anything less than 30 minutes per day or 30 hours per year. The guidance also stipulates that there is only additional impact to an observer because of

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[9] Future Analytics. October 2016. Planning and Development Guidance Recommendations for Utility Scale Solar Photovoltaic Schemes in Ireland

[10] Civil Aviation Authority. December 2010. "Interim CAA Guidance - Solar Photovoltaic Systems".

[11] Leitlinie des Ministeriums fur Umwelt. Gesundheit und Verbraucherschutz zur Messung und Beurteilung von Lichtimmissionen (LichtLeitlinie). 2014 Available : http://www.mlul.brandenburg.de/media_fast/4055/licht_leitlinie.pdf

glare from a solar PV array if the angle between the source of the glare and the sun is greater than ten degrees.

United States of America (USA)

The FAA in the USA have produced a document called the "Technical Guidance for Evaluating Selected Solar Technologies on Airports"[12] which is accepted internationally as the most detailed methodology for assessing the effects of glint and glare. This document recommends the use of a particular analysis tool, the Solar Glare Hazard Analysis Tool (SGHAT), when conducting glint and glare assessments of solar PV systems.

[12] Federal Aviation Administration. November 2010. "Technical Guidance for Evaluating Selected Solar Technologies on Airports"

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Methodology

Lawler Sustainability, considering all the studies and guidelines mentioned in the previous section, have created a methodology for assessing the effects of glint and glare. The ForgeSolar tool has been used to satisfy aviation policy throughout the world, including that of the FAA, hence, this is the tool that Lawler Sustainability has employed and prescribed a methodology to all receptor types including road and rail, aviation, and residential buildings. Until formal guidance is provided in Ireland, the methodology that is described in this section will be used and is broken down into the following seven key stages:

1. Study area assessment
2. Solar PV array layout
3. Identifying receptors to suit analysis
4. Geometric evaluation
5. Glare analysis
6. Interpretation of results
7. Mitigation measures

1. Study area assessment

In the first stage of the glint and glare assessment, the area of the proposed development is identified along with any high-risk areas that could be susceptible to glare e.g., airport runways and air traffic control towers.

2. Solar PV array layout

The next stage identifies the size of the proposed solar PV array and its assumed area. Consideration is also given to the PV system if it is fixed mount or on a tracking system, and if it is roof mounted or mounted on the ground. Where possible, the characteristics of the proposed PV modules to be installed are determined e.g., if the panel has anti-reflective coating.

3. Identifying receptors to suit analysis

Once the study area and solar PV system have been defined, the location of potential receptors can be identified in the surrounding area which may include, but is not limited to, roads, railways, residential buildings, commercial buildings, runways, and air traffic control towers. The potential receptors undergo a geometrical analysis to consider if landform such as mountains, vegetive, hills, or built environment elements of the landscape may screen the development from view. This is accomplished using desk-based analysis of Google Street view and Google Earth. The orientation of the receptors is also considered as it may dictate whether the receptors are in direct line of sight of the solar PV array. For example, a dwelling may be located within the surrounding area of the solar PV array, but the orientation of the dwelling's glazing may be facing away from the panels which would receive little or no impact of glare.

4. Geometric Evaluation

As mentioned previously in this report, Lawler Sustainability use the ForgeSolar tool to perform calculations for glint and glare analysis. A number of parameters are considered to run these calculations which include, but are not limited to:

- The time zone for the proposed development.
- The apparent height and position of the sun at a particular moment in time of day and year.
- The orientation, height, and pitch of the solar PV array.
- The height and location of each receptor.

5. Glare analysis

Once all parameters and receptors are set within the ForgeSolar tool, the glare analysis can commence. The software performs an annual analysis of the proposed development to determine expected glare from PV arrays towards receptors. Another tool within ForgeSolar that is called GlaReduce Optimisation Tool can be used to conduct a module optimisation analysis. This evaluates a single PV array over a range of tilts and orientations to aid in identifying the optimal module configuration.

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6. Interpretation of results

The results from the ForgeSolar tool are collated into a comprehendible table and graph with comments as to the likely impact of glint and glare of the proposed solar PV array on all assessed receptors. Based on the theoretical amount of time a receptor may potentially experience glare, a determination of the classification of glare is made using the table below. This table has been inspired by the German light guidelines as mentioned previously.

Table 2. Classification of Glare based on theoretical amount of time of glare from results

Glare Classification	Description
High	Potential for more than 30 mins of glare per day and/or more than 30 hours per year.
Low	Potential for less than 30 mins of glare per day and/or less than 30 hours per year
None	No geometric potential for glare / Any potential for glare fully screened by interviewing landform, vegetation, or the built environment

The above table is a guide only as additional factors such as intervening screening (vegetative, built environment elements, and hills) and receptor orientation may better determine a more realistic classification of glare.

7. Mitigation measures

Depending on the severity of the glare experienced at any of the receptors, mitigation measures may be recommended to reduce the impact of glare. This can be achieved in a number of ways such as recommending that vegetative screening be added to form a visual barrier between the solar PV array and the receptor or suggesting that the PV modules be orientated or positioned differently to reduce the effect of glare. Tracking systems can also be installed on PV systems which can help to reduce the impact of glare.

Site Plan

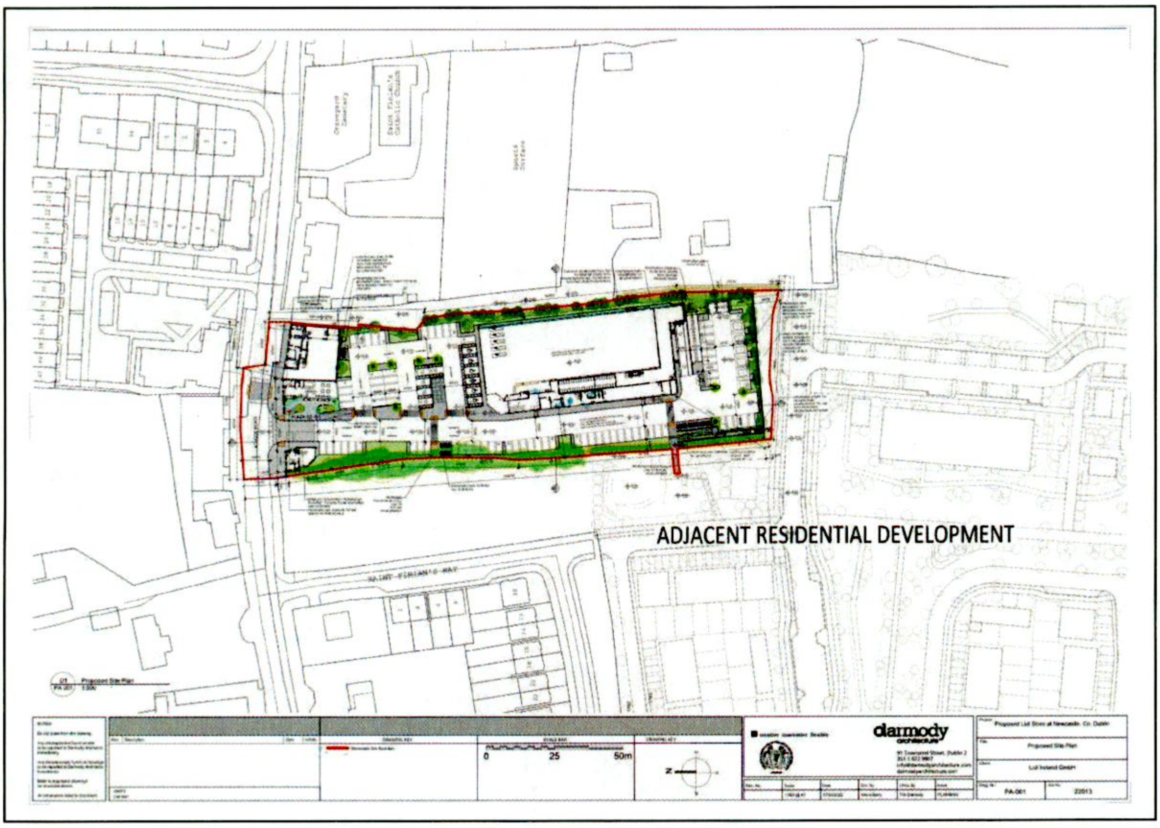

Figure 6. Site Plan for Lidl Newcastle, Co. Dublin [Source: Darmody Architects] (Not to Scale)

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Solar PV Array Description and Parameters

Table 3. Solar PV array details

Name:	Rooftop solar PV array at Lidl Newcastle, Co. Dublin
Footprint area:	2602 m^2
Axis tracking:	Fixed (no rotation)
Tilt:	4.0°
Orientation:	80.0°
Rated power:	165.0 kW
Panel material:	Light textured glass with AR coating
Vary reflectivity with sun position?	Yes
Correlate slope error with surface type?	Yes
Slope error:	9.16 mrad

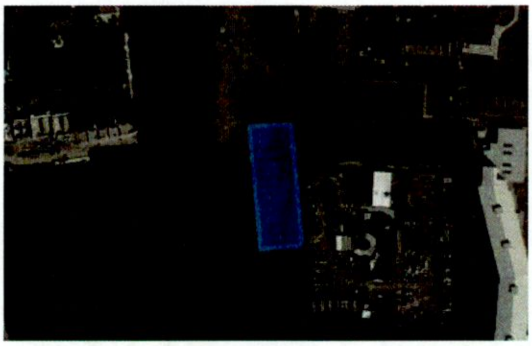

Figure 7. Proposed solar PV array

Table 4. Solar PV array positioning

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	53.298423	-6.502478	92.00	5.06	97.06
2	53.298403	-6.502851	92.00	6.72	98.72
3	53.299057	-6.502953	92.00	6.72	98.72
4	53.299075	-6.502580	92.00	5.06	97.06

Route Receptors

Table 5. Route receptor one details

Name:	Route 1 Peamount Road
Route type	Two-way
View angle:	50.0°

Figure 8. Route receptor one

Table 6. Route receptor two details

Name:	Route 2 Aylmer Road
Route type	Two-way
View angle:	50.0°

Figure 9. Route receptor two

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Table 7. Route receptor three details

Name:	Route 3 Athgoe-Main street
Route type	Two-way
View angle:	50.0°

Figure 10. Route receptor three

Discrete Observation Receptors

Table 8. Discrete Observation Receptors

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	m	m	m
OP 1	53.298433	-6.500818	95.54	4.80	100.34
OP 2	53.298751	-6.502072	95.85	1.75	97.60
OP 3	53.299435	-6.501480	93.52	1.75	95.27
OP 4	53.299677	-6.502122	92.91	1.75	94.66
OP 5	53.299988	-6.499228	91.56	4.80	96.36
OP 6	53.299452	-6.498727	93.11	4.80	97.91
OP 7	53.300020	-6.502612	91.68	5.00	96.68
OP 8 ATCT	53.305501	-6.441800	93.51	20.00	113.51
OP 9	53.299419	-6.503997	95.06	4.80	99.86

Two Mile Flight Path Receptors

Table 9. FP1 Details

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	m	m	m
Threshold	53.301677	-6.444973	96.05	15.24	111.29
2-mile point	53.296657	-6.397271	110.81	169.17	279.97

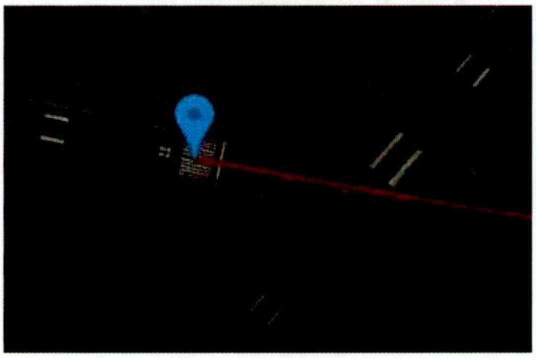

Figure 11. FP1

Table 10. FP2 Details

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	m	m	m
Threshold	53.303362	-6.439660	93.37	15.24	108.61
2-mile point	53.324473	-6.406562	64.98	212.31	277.29

Figure 12. FP2

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Table 11. FP3 Details

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	m	m	m
Threshold	53.304658	-6.468496	86.24	15.00	101.24
2-mile point	53.311544	-6.515543	72.40	197.52	269.92

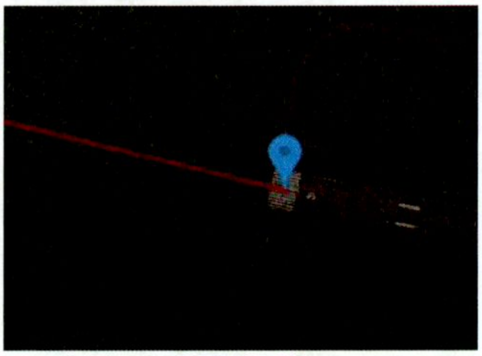

Figure 13. FP3

Table 12. FP4 Details

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	m	m	m
Threshold	53.293763	-6.453556	98.42	15.00	113.42
2-mile point	53.272095	-6.485621	153.93	128.17	282.10

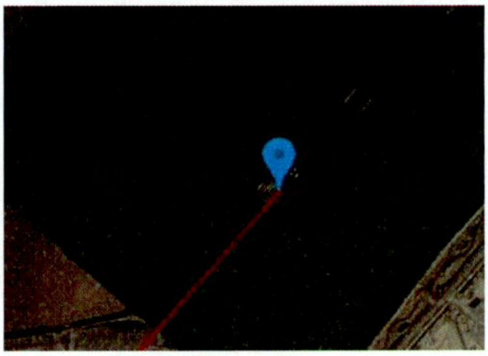

Figure 14. FP4

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Glint and Glare Analysis

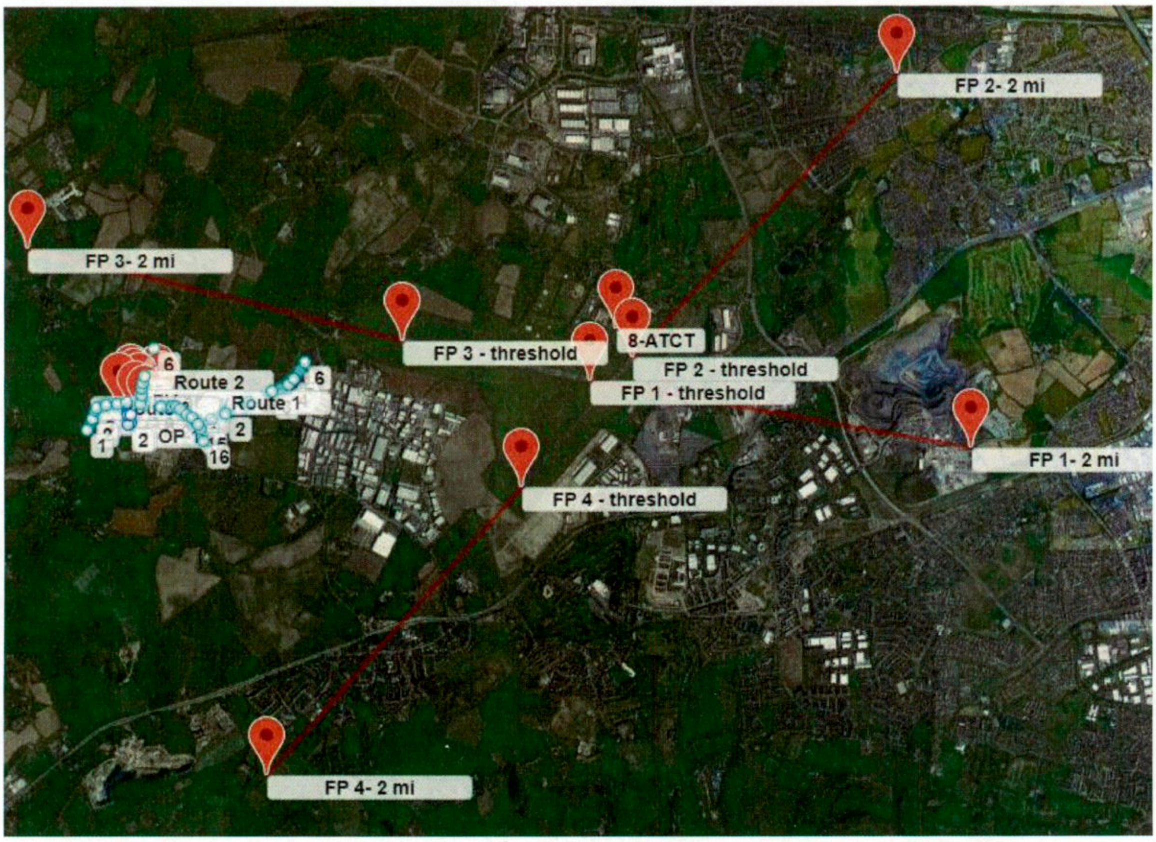

Figure 10. Glare analysis receptors surrounding Lidl Newcastle, Co. Dublin

The PV array of the LIDL Newcastle, Co. Dublin store is directed towards the East direction (80°).

The analysis simulated eight receptors from neighbouring properties in the vicinity. Each floor is considered to be 3 m high for residential properties and 4 m high for commercial properties, with an eye-level at 1.8 m. In addition, 3 No. vehicular route receptors were assessed. A height of 1.5 m was assumed for a car and a 2.7 m for a truck.

Another receptor studied was the ATCT serving Baldonnel Aerodrome located in about 6 km. The ATCT is assumed to be 20 m high. Also, four 2-Miles Flight Receptors were assessed in the analysis, two for each runway at Baldonnel Aerodrome.

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Glint and Glare Results

The results indicated in the following tables highlight potential for yellow hazard glare from the solar PV array at the LIDL store. OP 1, OP 2, OP 3 have more than 30 minutes of yellow hazard glare per day and 30 hours per year. Although not yellow glare, OP 8 (ATCT) also appears to experience some glare. Hence, the following section will investigate these receptors further.

Table 7. Summary of results

PV Name	Tilt	Orientation	Annual "Green" Glare	Annual "Yellow" Glare	Annual Energy Produced*
	deg	deg	min	min	kWh
Rooftop solar PV array at LIDL Newcastle	4.0	80.0	22,886	42,585	256,200.0

*Please note that the value listed here is an approximate of the potential yield from the proposed solar PV array. Please refer to more specialised software for estimating solar energy yields.

Table 8. Distinct glare minutes per month

PV	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
rooftop-PV-a (green)	61	196	1167	1023	0	0	0	544	1379	424	87	53
rooftop-PV-a (yellow)	1589	1312	399	308	1793	1926	1901	874	127	1182	1624	1299

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Table 9. Receptor analysis annual results

Component	Annual Green glare (min)	Annual Green glare (hours)	Annual Yellow glare (min)	Annual Yellow glare (hours)
FP: FP 1	1890	31.5	0	0.0
FP: FP 2	3197	53.3	0	0.0
FP: FP 3	0	0.0	0	0.0
FP: FP 4	0	0.0	0	0.0
OP: OP 1	302	5.0	8712	145.2
OP: OP 2	0	0.0	19932	332.2
OP: OP 3	102	1.7	6490	108.2
OP: OP 4	0	0.0	2	0.0
OP: OP 5	3361	56.0	4	0.1
OP: OP 6	3007	50.1	0	0.0
OP: OP 7	0	0.0	0	0.0
OP: OP 8 ATCT	870	14.5	0	0.0
OP: OP 9	0	0.0	0	0.0
Route 1 Peamount Road	4385	73.1	0	0.0
Route 2 Aylmer Road	551	9.2	351	5.9
Route 3 Athgoe-Main str.	5221	87.0	1537	25.6

Identification of landscape screening

The observation receptors surrounding the LIDL store have been further assessed using Google Streetview to determine if there are any landscape screens which could block the effects of solar glare from the rooftop PV array.

OP 1, OP 2, OP 3

The figures below demonstrate the street view of OP 1, OP 2, OP 3. It is apparent that there is no direct line of sight of the rooftop solar PV array of the LIDL store (identified in each figure). Hence, to conclude, the risk of glare at OP 1, OP 2, OP 3 is extremely low.

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Figure 11. OP 1 streetview

Figure 17. OP 2 Streetview

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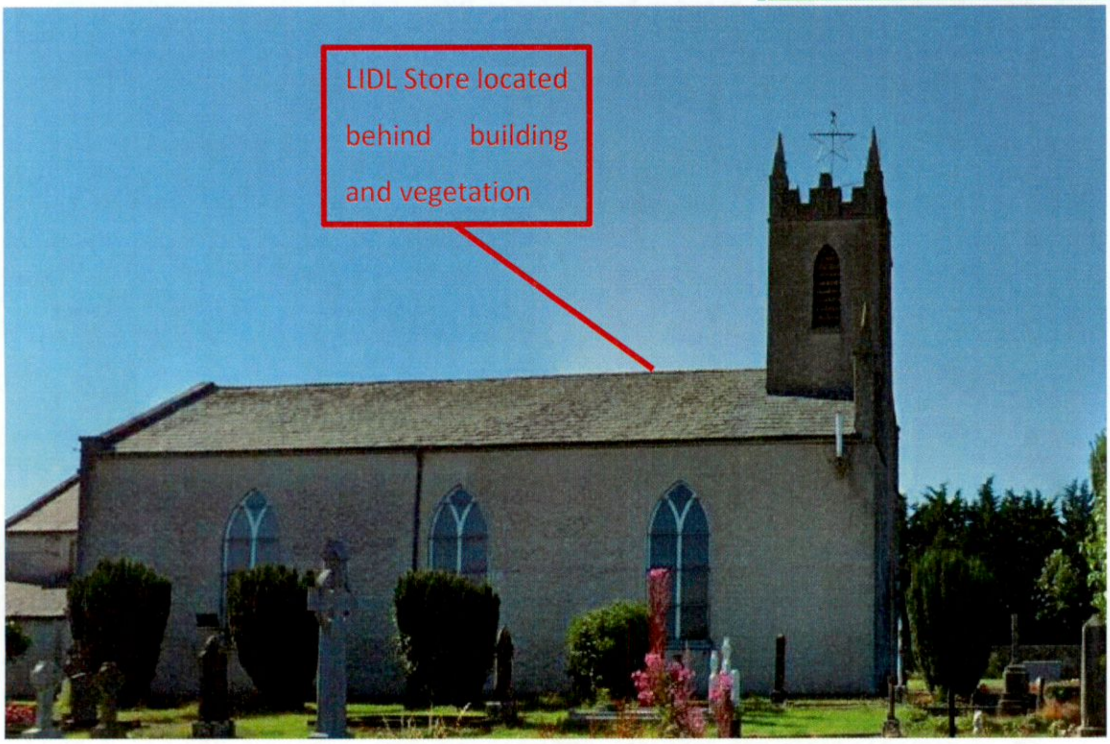


Figure 12. OP 3 streetview

ATCT Assessment

The results from the SGHAT reveal that the ATCT at Baldonnel airport may experience Green glare during the evening time in March and September. Upon investigating the landscape screening near the proposed PV array at LIDL Newcastle, there is a church and tall vegetation which is in the line of sight between the ATCT and the proposed PV array at LIDL Newcastle. The tallest point of the roof structure at LIDL Newcastle is expected to be ~7 m from ground level. The church and vegetation appear to cover this height and can be concluded that the glare emanating from the proposed PV array would be obstructed causing low/minimal glare to the ATCT.

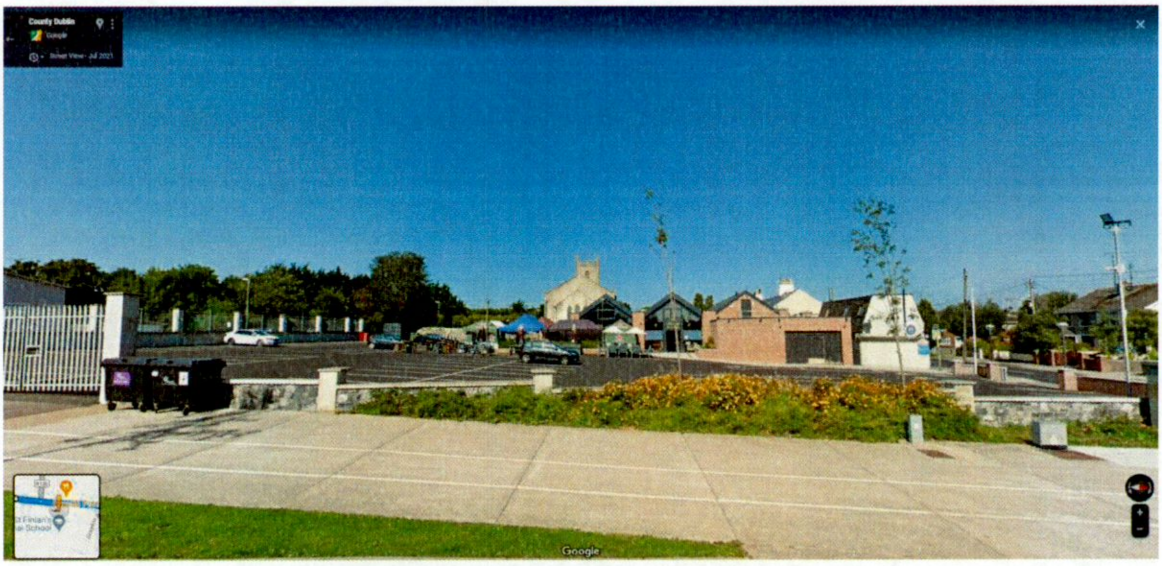


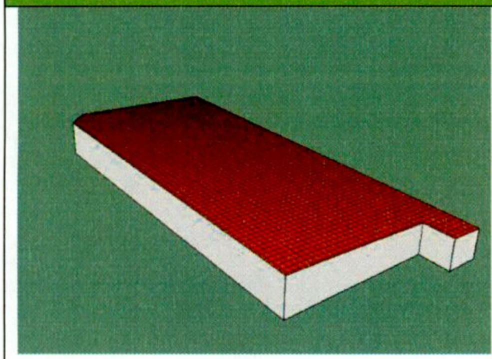
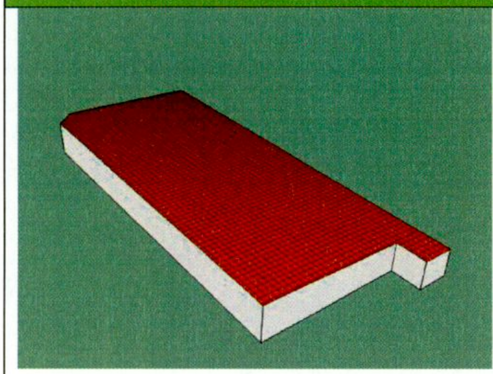
Figure 13. Streetview of proposed PV array, situated in the line of sight from the ATCT at Baldonnel Aerodrome

Solar Exposure Analysis

A solar exposure analysis was conducted using the SunCast application within the Integrated Environmental Solutions (IES) software. SunCast can be used to visualise the shading impact of a building or surrounding buildings and assesses the amount of solar exposure a surface may receive throughout a period. Three assessments were conducted over separate time periods to include a full year and wintertime (January 1st – March 31st and September 21st – December 31st).

The results are set out in the table below:

Table 10. Solar Exposure Results

Full Year Solar Exposure	
 *Figure 14. annual solar exposure*	100% of the roof area where the PV installation is planned, is receiving 96% of sunlight annually.
Jan-March Solar Exposure	
 *Figure 21. Solar exposure from January 1st to March 31st*	100% of the roof area where the PV installation is planned, is receiving more than 93% of sunlight from 1st of January to March 31st.

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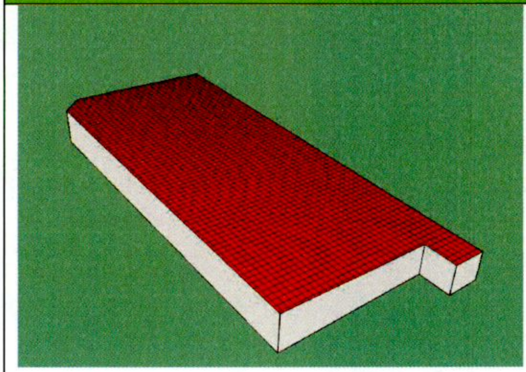
September-December Solar Exposure	
 *Figure 21. Solar exposure from September 21st to December 31st*	100% of the roof area where the PV installation is planned, is receiving more than 93% of sunlight from 21st of September to December 31st.

Conclusion

A glint and glare analysis was completed for the proposed Solar PV installation at Lidl Newcastle, Co. Dublin. Eight receptors were assessed from neighbouring properties, three route receptors, one ATCT, and four 2-Mile Flight Paths. Due to the local landscape screening, there is an extremely low risk of glint or glare from the solar PV panels at the nine receptors studied within the vicinity of the proposed store at Lidl Newcastle, Co. Dublin.

In addition, the roof space where the proposed solar PV array is to be installed is not overshadowed by any surrounding buildings and can receive 96% of sunlight annually, and around 93% sunlight during wintertime.

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Appendix

Please note the following assumptions will apply to the following graphs:

- 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 modelling 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 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.)
- Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
- Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.

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- Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.

Project: **5197 Lidl Newcastle**
Site configuration: **Lidl Newcastle Planning**

Created 06 Jul, 2022
Updated 11 Jul, 2022
Time-step 1 minute
Timezone offset UTC0
Site ID 71860.12665
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
Methodology V2

Glare Policy Adherence

The following table estimates the policy adherence of this glare analysis according to the **2021** U.S. Federal Aviation Administration Policy:

Review of Solar Energy System Projects on Federally-Obligated Airports

This policy may require the following criteria be met for solar energy systems on airport property:

- No glare of any kind for Air Traffic Control Tower(s) ("ATCT") at cab height.
- Default analysis and observer characteristics, including 1-minute time step.

ForgeSolar is not affiliated with the U.S. FAA and does not represent or speak officially for the U.S. FAA. ForgeSolar cannot approve or deny projects - results are informational only. Contact the relevant airport and FAA district office for information on policy and requirements.

COMPONENT	STATUS	DESCRIPTION
Analysis parameters	PASS	Analysis time interval and eye characteristics used are acceptable
ATCT(s)	FAIL	Receptor(s) marked as ATCT receive green and/or yellow glare

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PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	0.0	80.0	17,536	20,249	236,100.0

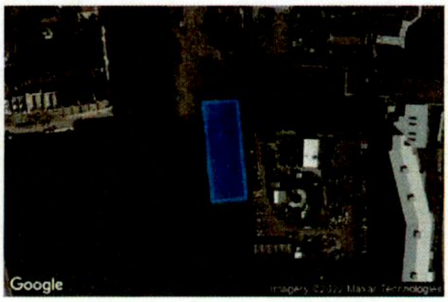
Component Data

PV Array(s)

Total PV footprint area: 1,824 m^2

Name: PV array 1
Footprint area: 1,824 m^2
Axis tracking: Fixed (no rotation)
Tilt: 0.0 deg
Orientation: 80.0 deg
Rated power: 150.0 kW
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	53.298423	-6.502478	92.00	5.06	97.06
2	53.298403	-6.502851	92.00	6.72	98.72
3	53.299057	-6.502953	92.00	6.72	98.72
4	53.299075	-6.502580	92.00	5.06	97.06



Name: FP 1
Description:
Threshold height : 15 m
Direction: 280.0 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
Threshold	53.301677	-6.444973	96.05	15.24	111.29
2-mile point	53.296657	-6.397271	110.81	169.17	279.97

Name: FP 2
Description:
Threshold height : 15 m
Direction: 223.1 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
Threshold	53.303362	-6.439660	93.37	15.24	108.61
2-mile point	53.324473	-6.406562	64.98	212.31	277.29

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Name: FP 3
Description:
Threshold height : 15 m
Direction: 103.8 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

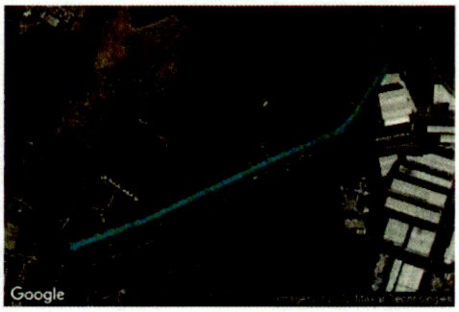
Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	53.304658	-6.468496	86.24	15.00	101.24
2-mile point	53.311544	-6.515543	72.40	197.52	269.92

Name: FP 4
Description:
Threshold height : 15 m
Direction: 41.5 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	53.293763	-6.453556	98.42	15.00	113.42
2-mile point	53.272095	-6.485621	153.93	128.17	282.10

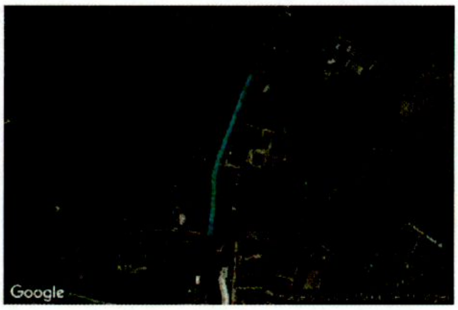
V

Name: Route 1 Peamount Road
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	53.298389	-6.494124	90.78	2.70	93.48
2	53.299150	-6.490675	87.58	2.70	90.28
3	53.300797	-6.484903	86.19	2.70	88.89
4	53.301317	-6.482789	85.23	2.70	87.93
5	53.301706	-6.482134	85.26	2.70	87.96
6	53.303020	-6.480685	85.77	2.70	88.47

Name: Route 2 Aylmer Road
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	53.299895	-6.501270	91.25	2.70	93.95
2	53.300514	-6.501152	89.82	2.70	92.52
3	53.301030	-6.501104	88.55	2.70	91.25
4	53.301412	-6.501065	86.02	2.70	88.72
5	53.301916	-6.500879	84.60	2.70	87.30
6	53.303955	-6.499548	81.55	2.70	84.25

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Name: Route 3 Athgoe-Main street
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	53.297941	-6.507975	95.97	2.70	98.67
2	53.298749	-6.507293	94.40	2.70	97.10
3	53.299367	-6.507028	92.85	2.70	95.55
4	53.299556	-6.506765	92.99	2.70	95.69
5	53.299793	-6.505579	91.78	2.70	94.48
6	53.299922	-6.504254	91.27	2.70	93.97
7	53.299957	-6.502988	91.87	2.70	94.57
8	53.299700	-6.498788	91.01	2.70	93.71
9	53.299696	-6.497443	90.67	2.70	93.37
10	53.299648	-6.496939	90.26	2.70	92.96
11	53.299473	-6.496319	90.36	2.70	93.06
12	53.299129	-6.495432	90.69	2.70	93.39
13	53.298892	-6.494863	91.03	2.70	93.73
14	53.298404	-6.494117	90.78	2.70	93.48
15	53.298028	-6.493805	92.51	2.70	95.21
16	53.297131	-6.493414	94.87	2.70	97.57

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	m	m	m
OP 1	53.298433	-6.500818	95.54	4.80	100.34
OP 2	53.298751	-6.502072	95.85	1.75	97.60
OP 3	53.299435	-6.501480	93.52	1.75	95.27
OP 4	53.299677	-6.502122	92.91	1.75	94.66
OP 5	53.299988	-6.499228	91.56	4.80	96.36
OP 6	53.299452	-6.498727	93.11	4.80	97.91
OP 7	53.300020	-6.502612	91.68	5.00	96.68
8-ATCT	53.305501	-6.441800	93.51	30.00	123.51
OP 9	53.299419	-6.503997	95.06	4.80	99.86

8-ATCT map image

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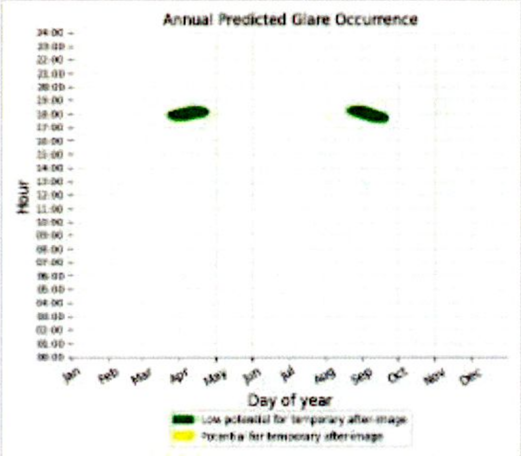
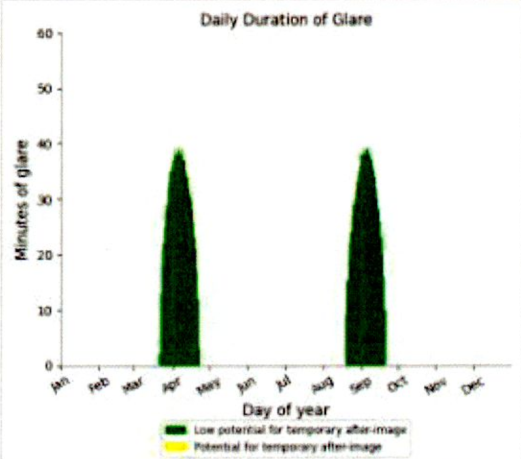
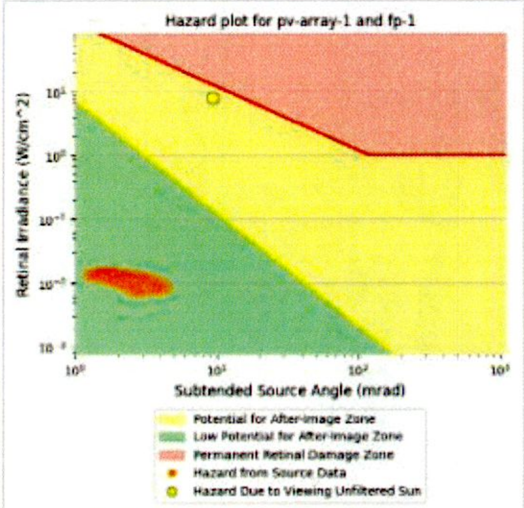
PV array 1 - Receptor (FP 1)

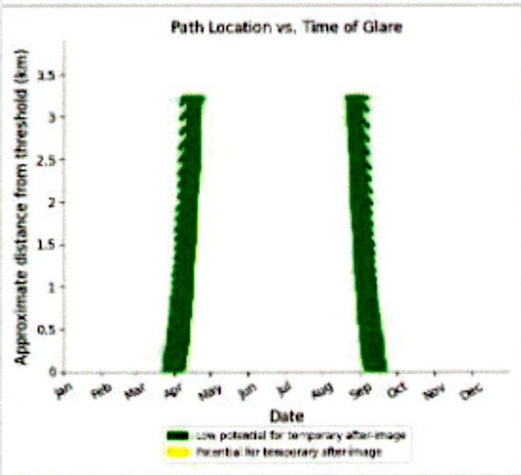
PV array is expected to produce the following glare for observers on this flight path:

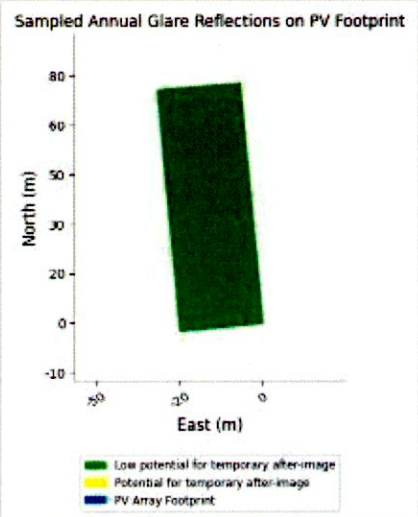
- 1,890 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.

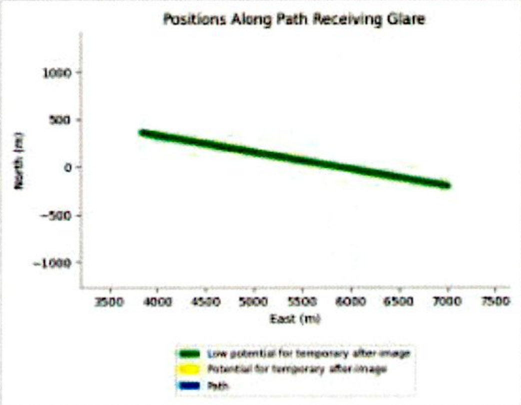








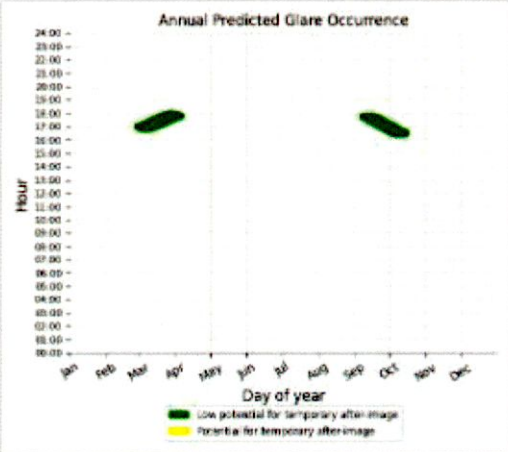


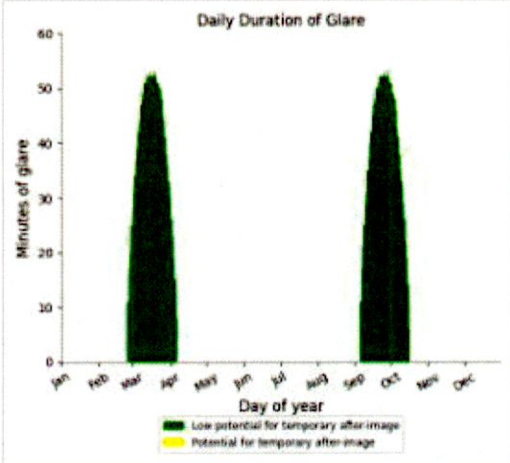


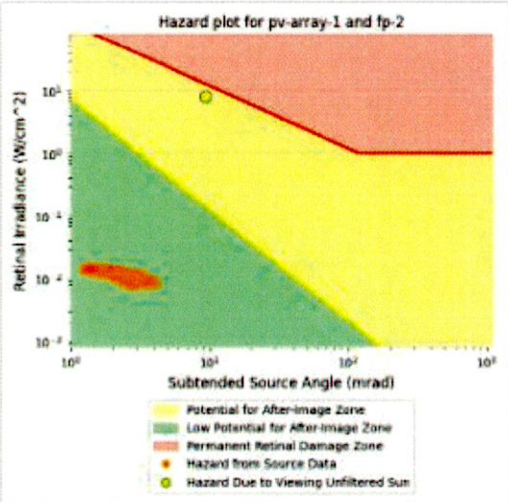
PV array 1 - Receptor (FP 2)

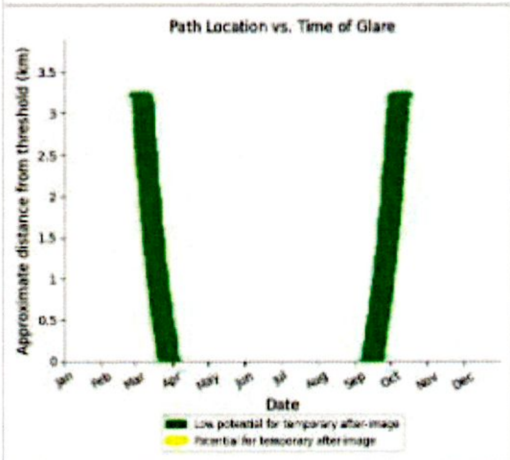
PV array is expected to produce the following glare for observers on this flight path:

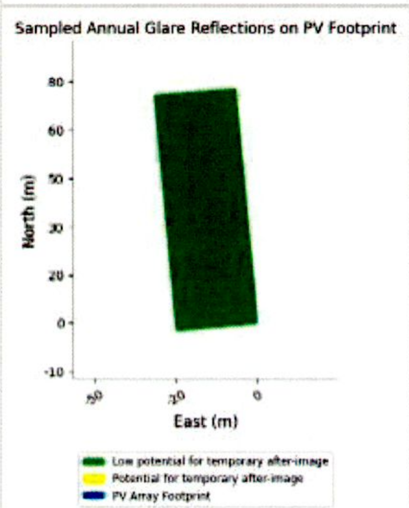
- 3,197 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.

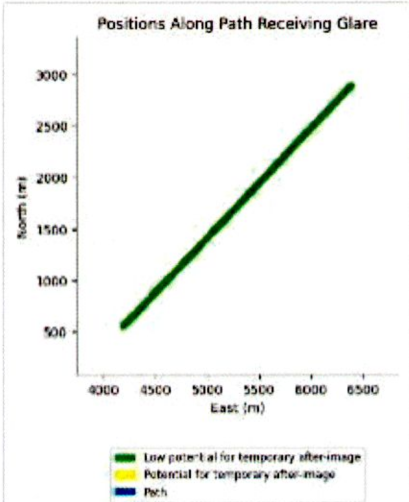








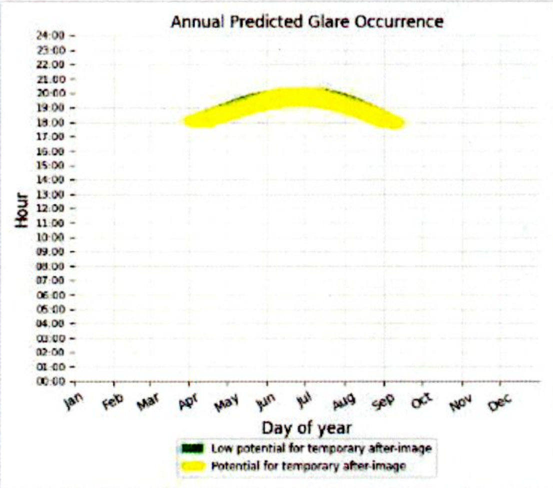


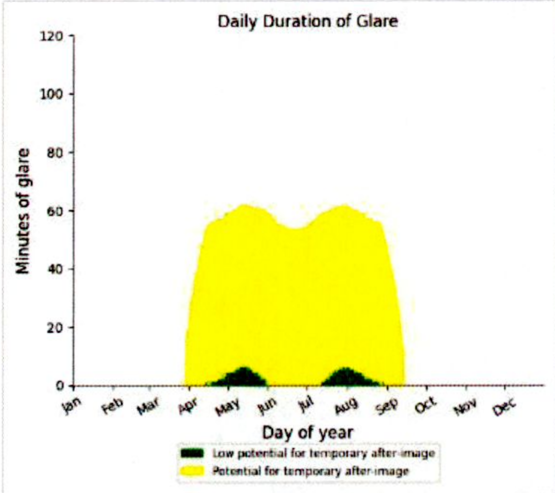


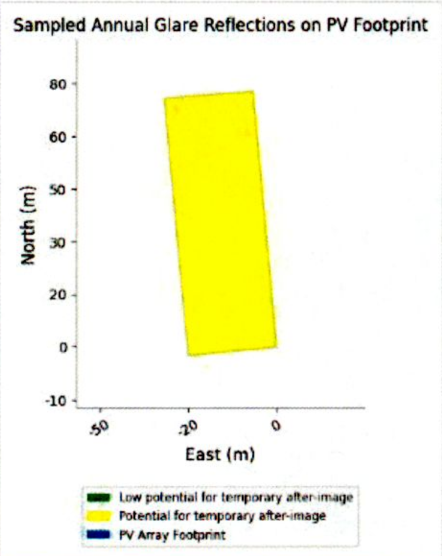
PV array 1 - OP Receptor (OP 1)

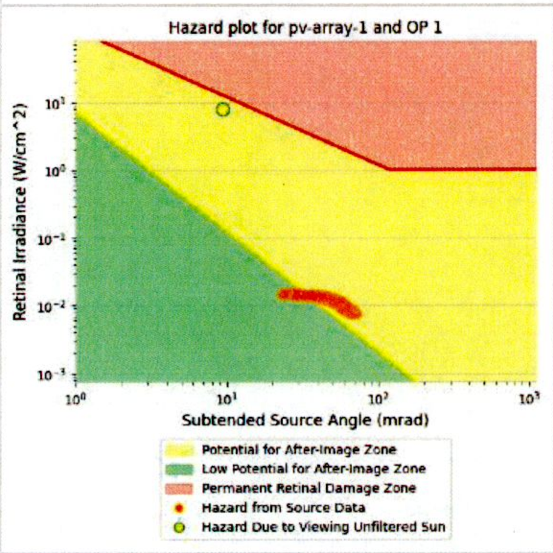
PV array is expected to produce the following glare for receptors at this location:

- 302 minutes of "green" glare with low potential to cause temporary after-image.
- 8,712 minutes of "yellow" glare with potential to cause temporary after-image.









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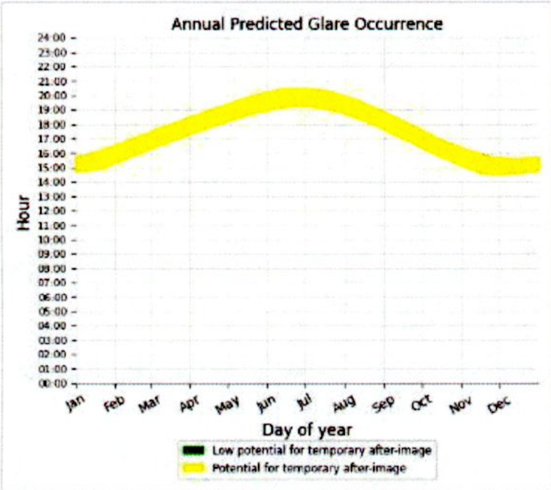
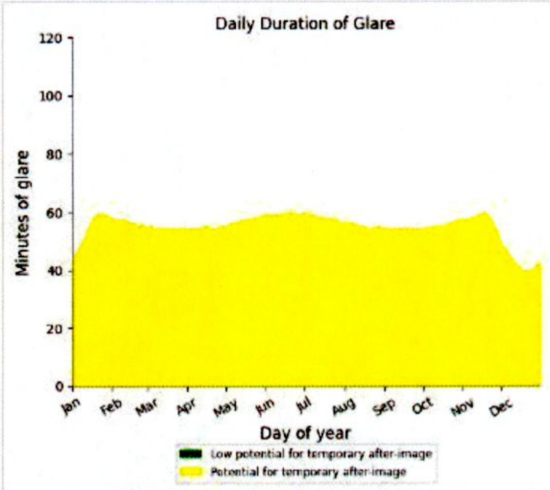
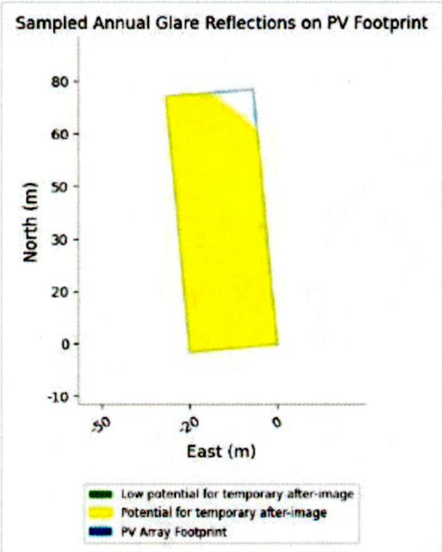
PV array 1 - OP Receptor (OP 2)

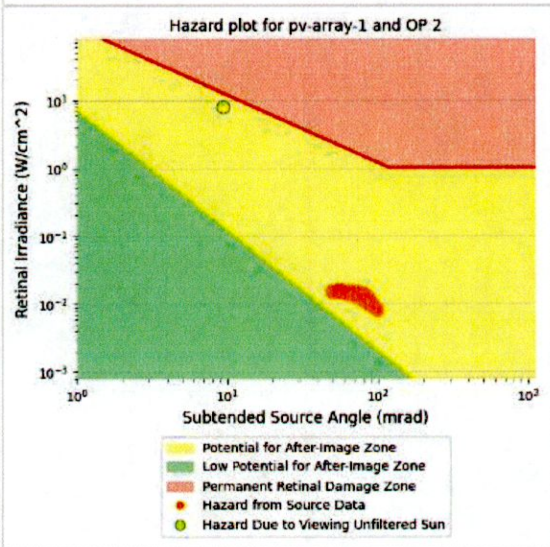
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 19,932 minutes of "yellow" glare with potential to cause temporary after-image.





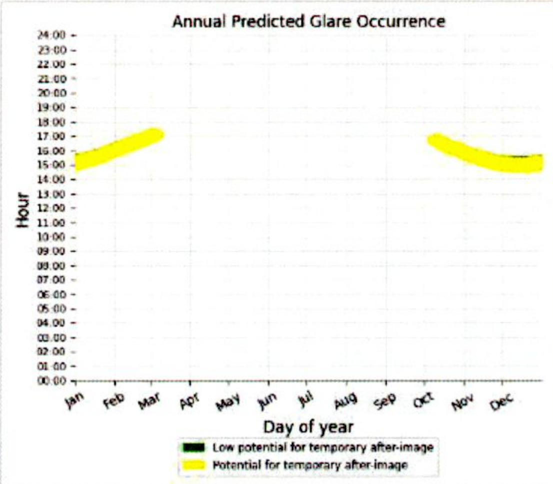


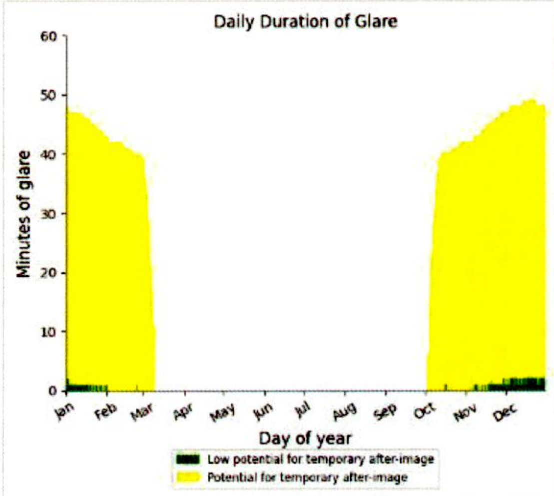


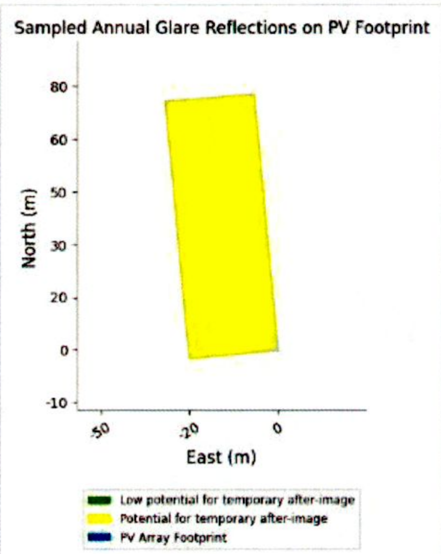
PV array 1 - OP Receptor (OP 3)

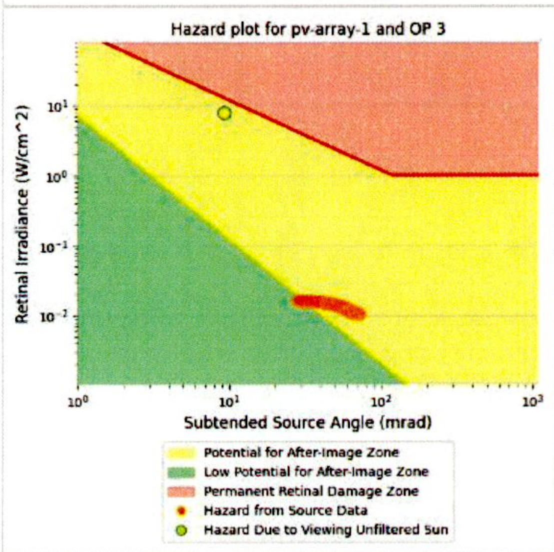
PV array is expected to produce the following glare for receptors at this location:

- 102 minutes of "green" glare with low potential to cause temporary after-image.
- 6,490 minutes of "yellow" glare with potential to cause temporary after-image.









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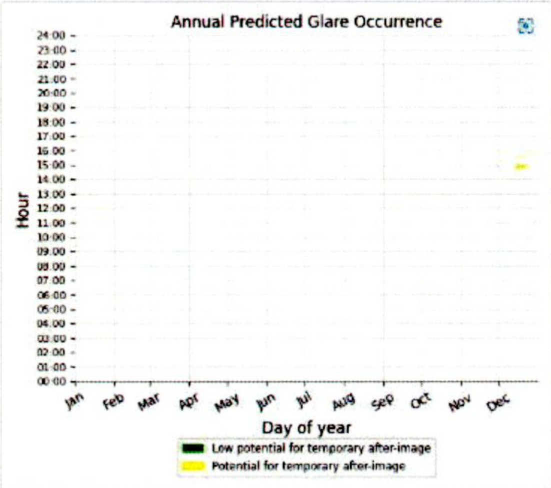
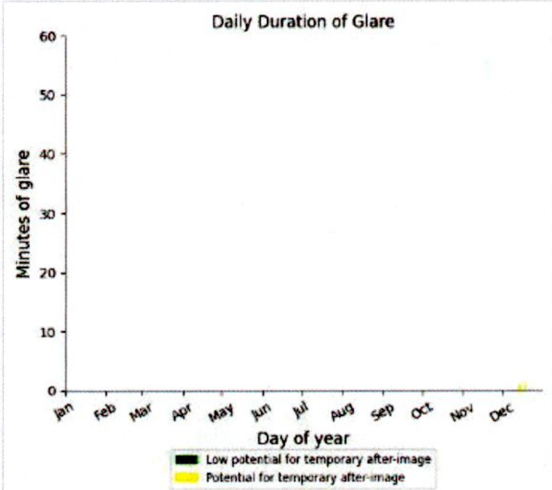
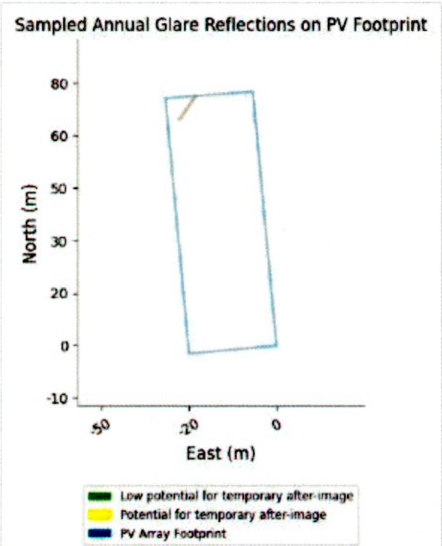
PV array 1 - OP Receptor (OP 4)

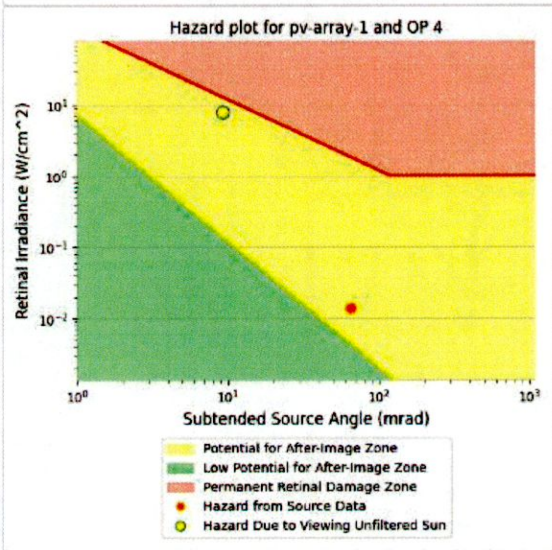
PV array is expected to produce the following glare for receptors at this location:

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





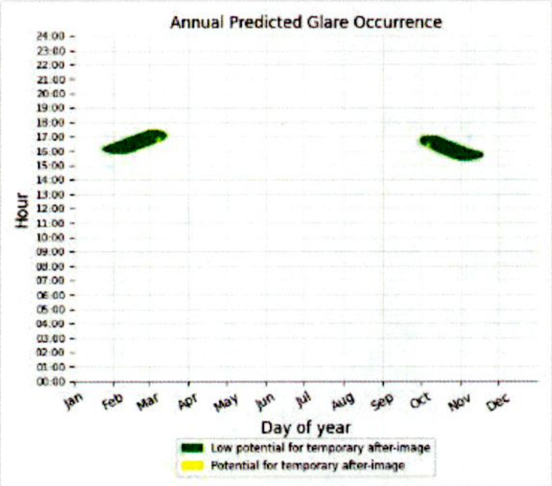


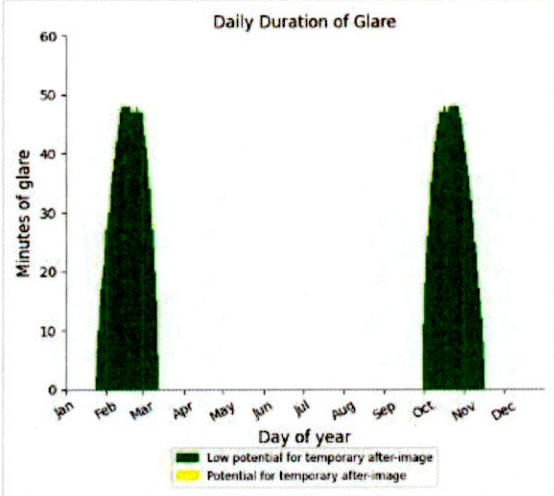


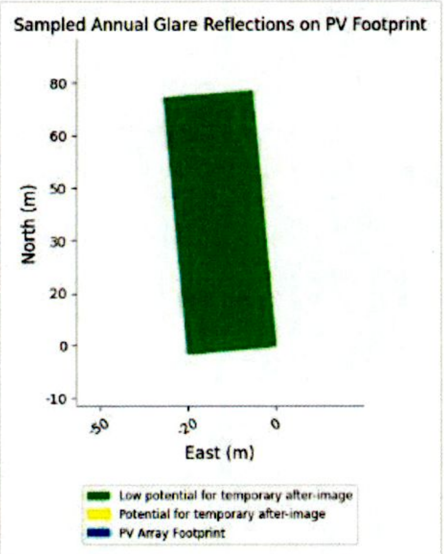
PV array 1 - OP Receptor (OP 5)

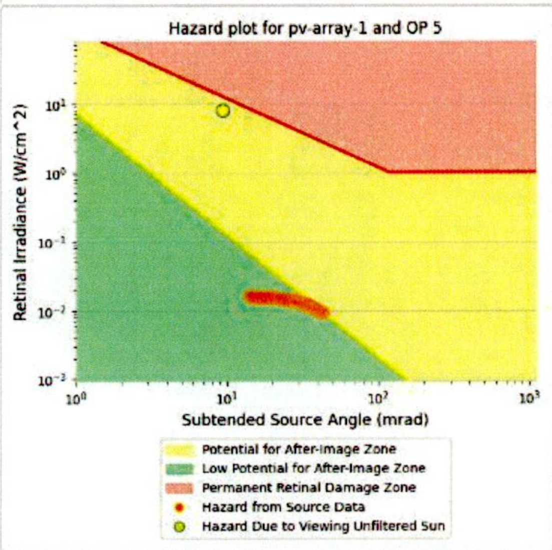
PV array is expected to produce the following glare for receptors at this location:

- 3,361 minutes of "green" glare with low potential to cause temporary after-image.
- 4 minutes of "yellow" glare with potential to cause temporary after-image.









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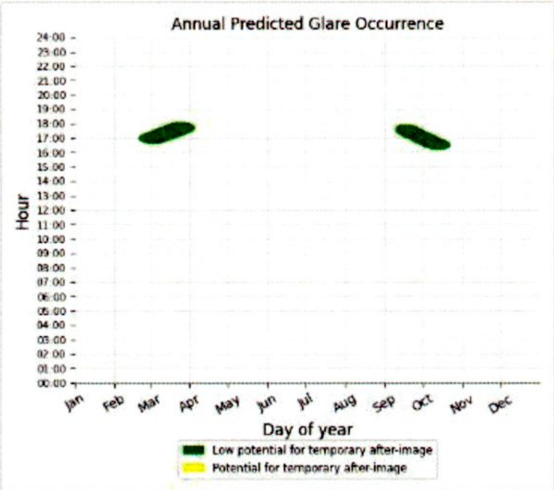
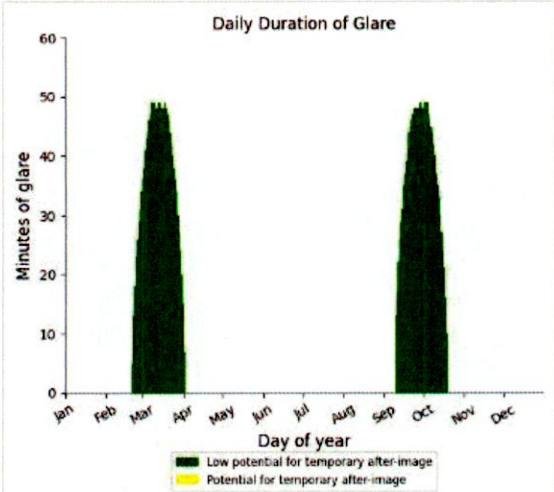
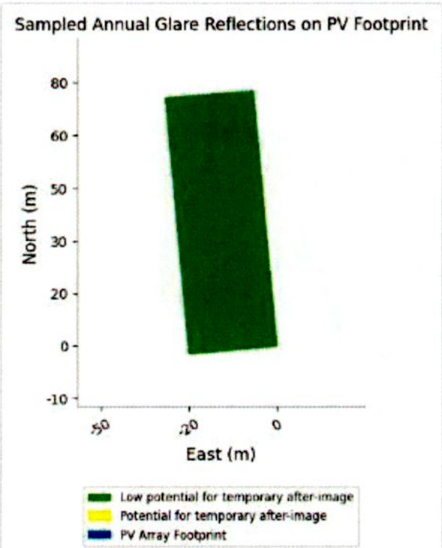
PV array 1 - OP Receptor (OP 6)

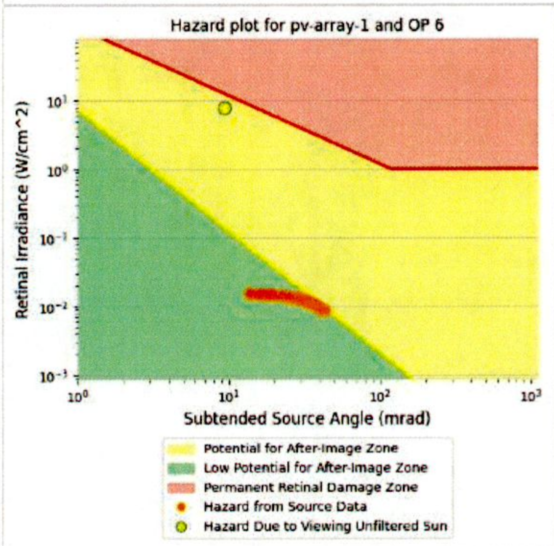
PV array is expected to produce the following glare for receptors at this location:

- 3,007 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





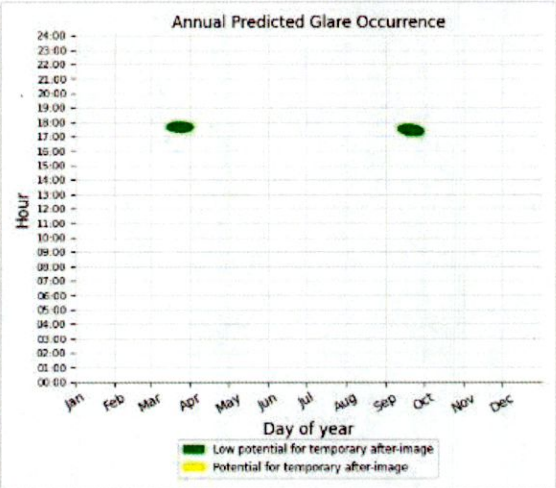


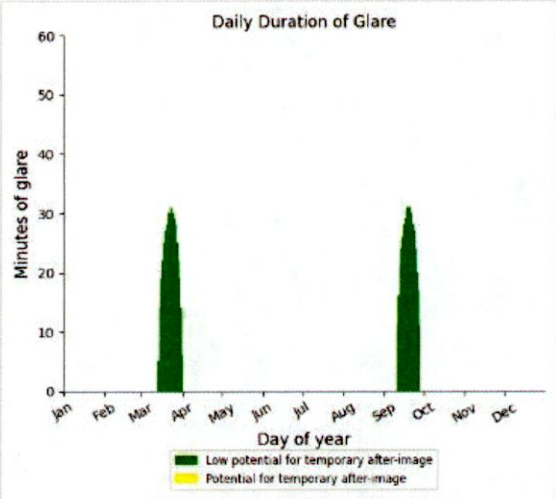


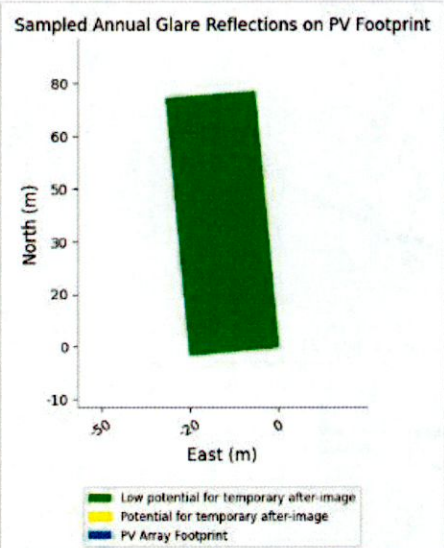
PV array 1 - OP Receptor (8-ATCT)

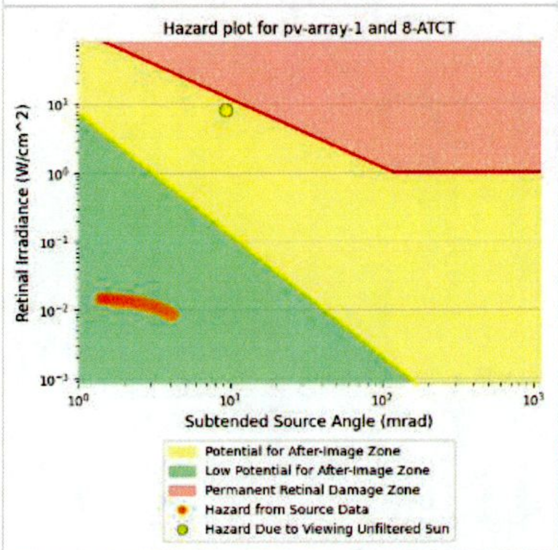
PV array is expected to produce the following glare for receptors at this location:

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









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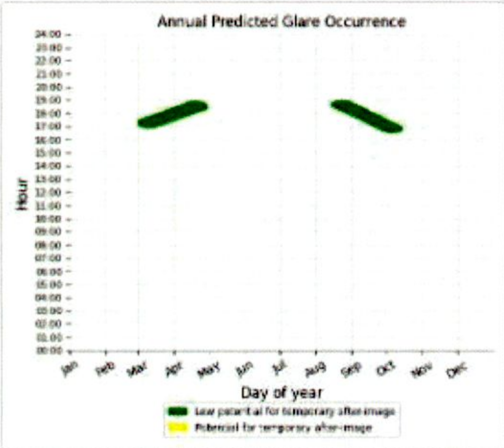
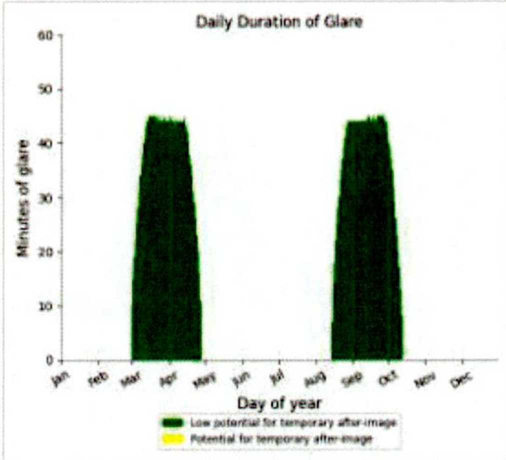
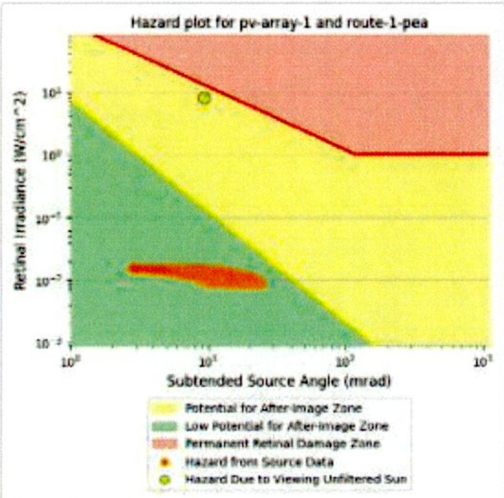
PV array 1 - Route Receptor (Route 1 Peamount Road)

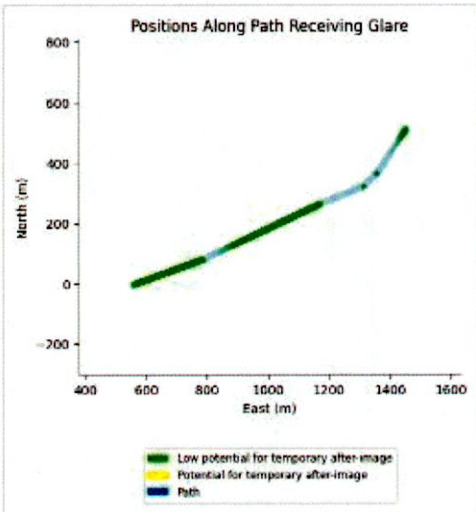
PV array is expected to produce the following glare for receptors at this location:

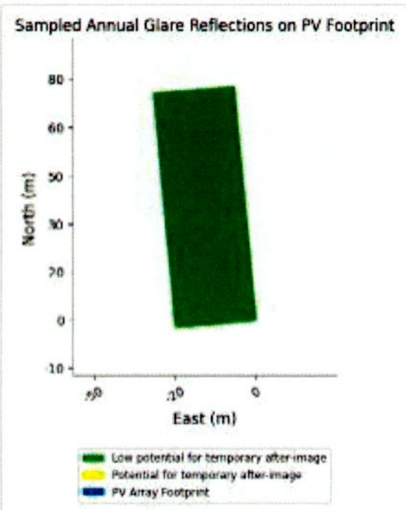
- 4,385 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.







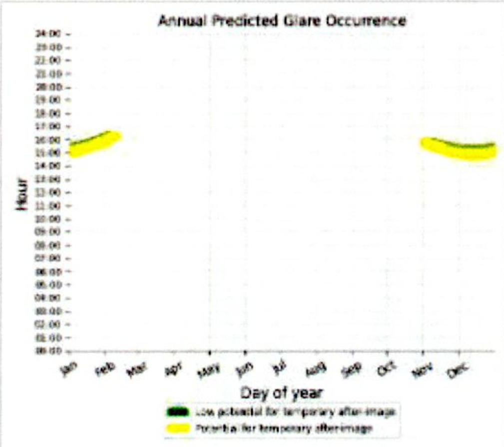


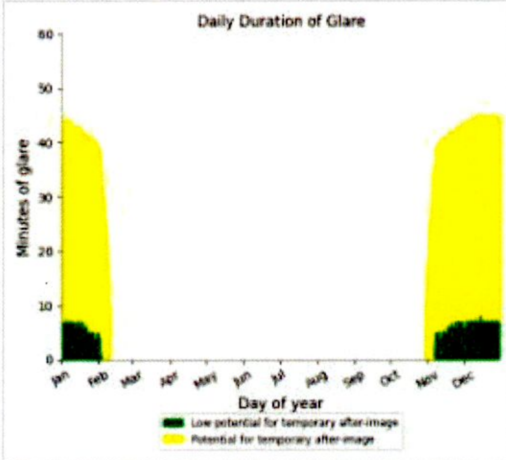


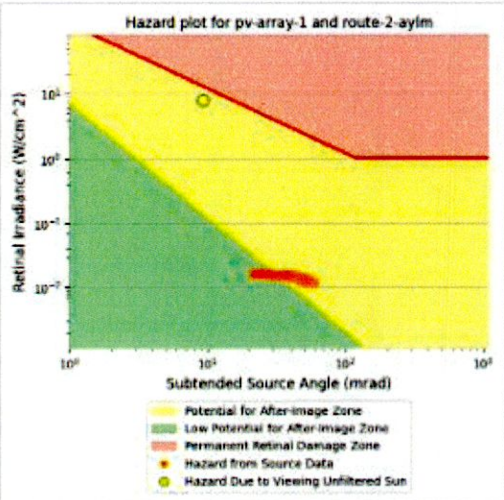
PV array 1 - Route Receptor (Route 2 Aylmer Road)

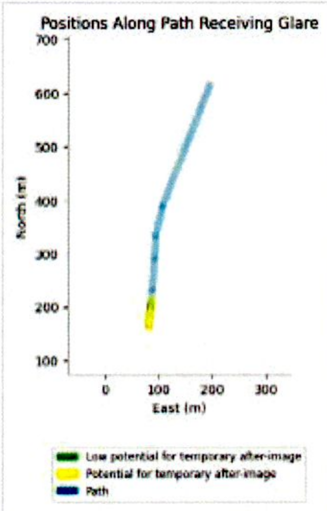
PV array is expected to produce the following glare for receptors at this location:

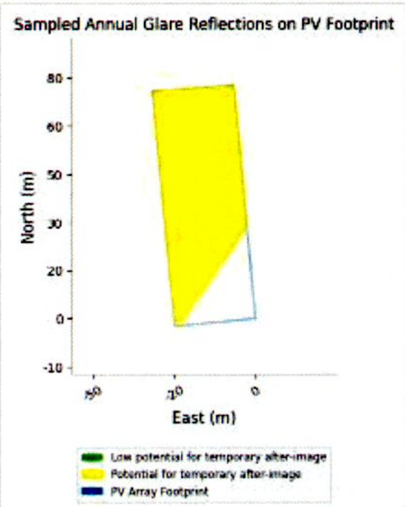
- 551 minutes of "green" glare with low potential to cause temporary after-image.
- 3,570 minutes of "yellow" glare with potential to cause temporary after-image.











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PV array 1 - Route Receptor (Route 3 Athgoe-Main street)

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

- 5,221 minutes of "green" glare with low potential to cause temporary after-image.
- 3,875 minutes of "yellow" glare with potential to cause temporary after-image.