Grange Solar

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Tesco Extra Liffey Valley Roof-mount PV Installation

Glint and Glare Assessment

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04/05/2022

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1 Introduction

This assessment was completed in order to determine glint and glare levels for a roof-mount PV installation at Tesco Extra, Fonthill Road, Liffey Valley, Clondalkin, Co. Dublin. This installation is sized at approximately 340kW and covers the unobstructed sections of the roof, as shown below (Figure 1). This assessment is needed to evaluate glint and glare impacts at relevant surrounding receptors should the installation proceed. These relevant receptors include major roadways surrounding the installation and nearby aviation receptors such as airports, aerodromes and helicopter flight paths. These are chosen following the guidance provided by the Federal Aviation Authority (FAA), which has been adopted for use by the Irish Aviation Authority (IAA) [1].

Figure 1: Tesco Extra Liffey Valley Site Layout

2 Glint and Glare Assessment Guidance

Glint and glare are reflections of sunlight from reflective surfaces. Glint is defined as "a momentary flash of bright light", whereas glare is defined as "a continuous source of bright light" [1]. This study evaluated the potentially hazardous effects that the solar PV installation may have on the surrounding environment. These hazardous effects can be a "temporary visual interference that persists after the source of illumination has ceased" from glint and a "brief loss of vision" from glare [2] [1]. Glint comes as a result of specular sunlight reflections, whereas, glare comes as a result of diffused sunlight reflections, which are shown below (Figure 2) [1]. These effects are minimised through the use of modern solar PV modules which can use textured glass and anti-reflective coatings.

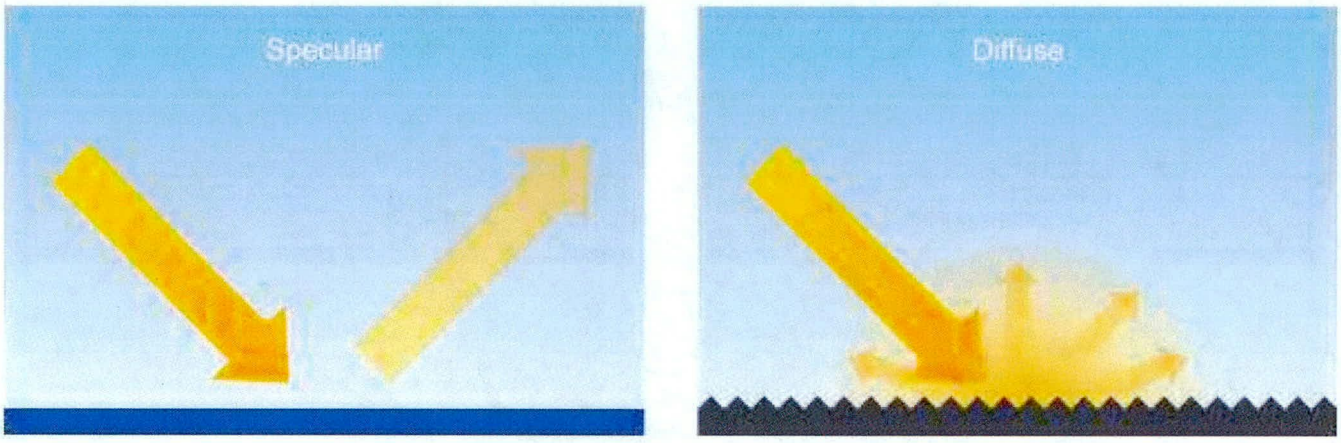


Figure 2: Sunlight Reflection Types

For the majority, glint and glare reflections from solar PV modules is of a similar level to water. This is due to solar modules being designed to absorb light and not to reflect it. The solar reflectance of solar modules is less than other commonly seen materials in urban environments such as Aluminium, steel and unpainted concrete, as seen below (Figure 3).

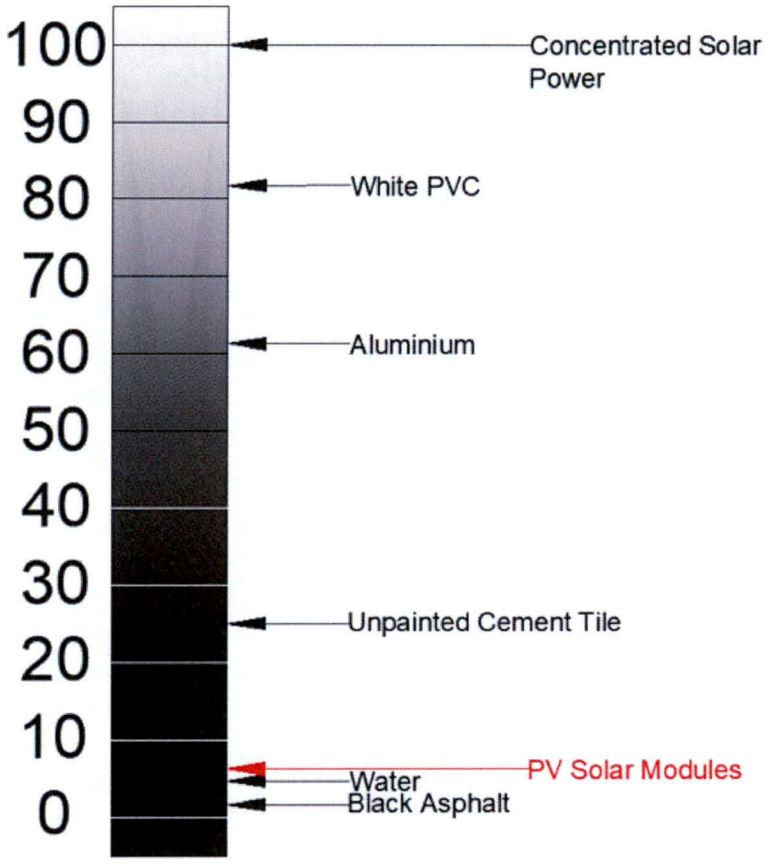


Figure 3: Typical Roof Material Solar Reflectance

2.1 Glint and Glare Assessment Scope

2.1.1 Assessment Methodology

The methodology used for this glint and glare assessment, and all similar assessments by Grange Solar, follows a standard procedure of steps;

1. Identify all relevant aviation receptors surrounding the planned installation: Grange solar uses a distance of 15km from the planned installation for glint and glare assessments. Any airports, aerodromes or helicopter landing pads which are situated 15km or less from the installation must be assessed. This approach is used as guidance provided by the DAA states that any solar PV installation within 15km of Dublin or Cork airports requires a glint and glare survey to be completed. In addition, the IAA states that consultation must take place for any installation within 10km of any other airport or aerodrome. For this, approaches by airplanes or helicopters to runways or landing pads and air traffic control towers must be assessed to ensure there is no effect from glint and glare to visibility.
2. Identify all relevant ground-based receptors surrounding the planned installation: Any major roads surrounding the installation, which the installation is visible to, should be identified and evaluated to ensure glint and glare have no effect.
3. Use an FAA approved Solar Glare Hazard Analysis Tool (SGHAT): This tool should be used to input the identified receptors and evaluate the effect glare may cause. Levels of glare on the receptors is measured by the tool throughout a year timeline and shown so further action can be taken.

4. Implement appropriate control measures: Following the analysis, any necessary control measures can be taken to mitigate the effects of glint and glare to the receptors. These control measures could include rotating the PV modules, removing glare producing PV modules or erecting screening between receptors and the installation. This ensures that the installation can be approved by the IAA.

2.1.2 Aviation Receptors

Due to the proximity of the planned PV installation to Dublin Airport, Casement Aerodrome, Weston Aerodrome and Tallaght Hospital, glint and glare from the planned PV installation is a potential issue for aviation in the area. Aviation receptors must be set out at the approaches to runways and helipads in the surrounding areas, as well as at any air traffic control towers. This comes as a result of guidance on the potential hazards that solar developments have upon aviation activities, prepared by the US Federal Aviation Authority (FAA). In accordance with this guidance, Solar Glare Hazards Analysis Tools (SGHAT) have been developed which can be used internationally as an online resource. For the assessment of these aviation receptors, a SGHAT tool has been used.

2.1.3 Ground Based Receptors

Due to the factors regarding this installation, glint and glare will cause no impact where ground-based receptors are concerned. These factors include the overall height of the building, at approximately 14m, onto which the PV modules will be installed, the 2m setback of the modules from the roof edge and the low tilt of the modules of 10 degrees, relative to the roof. These factors will ensure that the modules are not visible from the ground in the surrounding areas. In addition, due to the trajectory of the sun in Ireland, solar reflection from these modules will be due north for the most part. Although major roads such as the N4 and M50 run to the north and east of this installation respectively, any potential view from the ground is obstructed by the building itself, other industrial high-rise buildings, walls and trees. It can therefore be concluded that further consideration of glint and glare impacts to ground based receptors was unnecessary. Examples of this can be seen below (Figure 4) (Figure 5) (Figure 6) (Figure 7).

Figure 4: Image from Street level on the M50

Figure 5: Image From Street level on the M50 N4 Slip Road

Figure 6: Image From Street Level on the N4

Figure 7: Image From Street Level to the South of the Installation

3 Relevant Installation Parameters

The proposed installation is situated on the roof of Tesco Extra, Fonthill Rd, Liffey Valley, Clondalkin, Co. Dublin. This installation is situated approximately 12.5km southwest of Dublin Airport, 6km east of Weston Aerodrome, 6km North-East of Casement Aerodrome and 6km North of Tallaght Hospital, as shown below in (Figure 8). The installation is situated approximately 200m west of the M50 motorway and approximately 600m south of the N4. However, visibility to the modules from these major roads is obstructed by trees, walls and the building itself. The installation comprises of 844 modules, tilted at 10 degrees south. It is aligned at an azimuth of 179 degrees, as shown below (Figure 9).

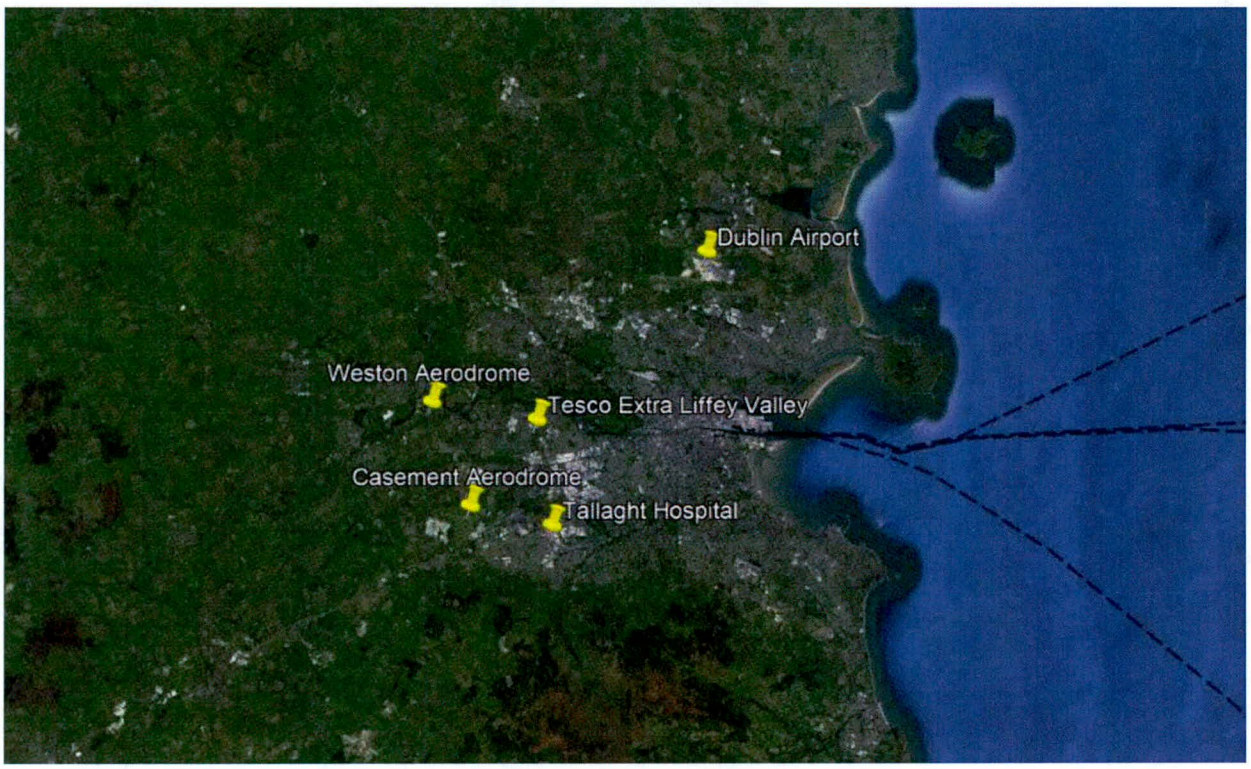


Figure 8: Surrounding Aviation Receptors

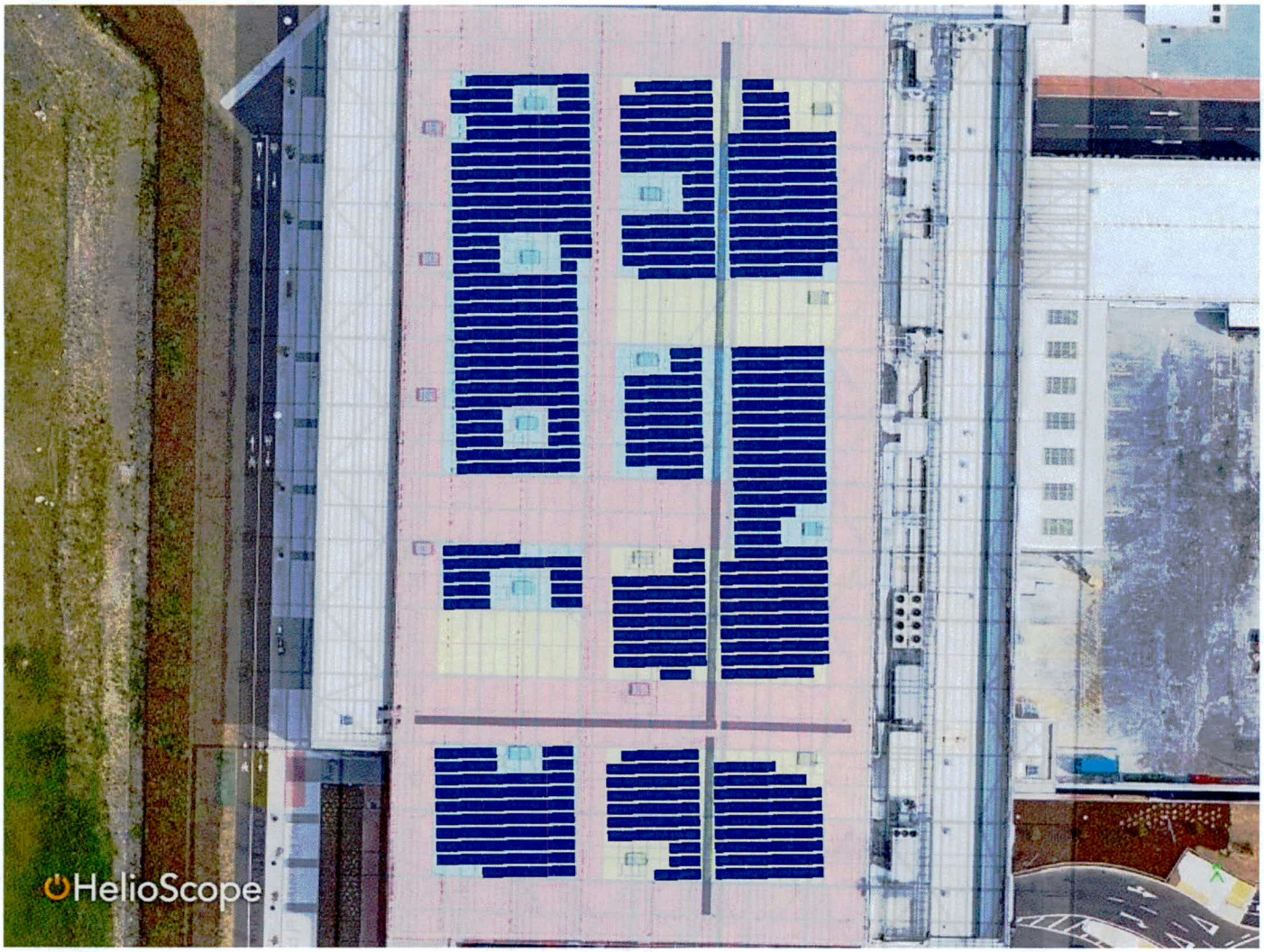


Figure 9: Installation Layout

3.1.1 Relevant Receptor Indication

The following are the relevant receptors for the planned solar PV installation at Tesco Extra, Fonthill Rd, Liffey Valley, Clondalkin, Co. Dublin;

1. Dublin Airport:

Dublin Airport is situated approximately 12.7km north-east of the installation. With 2 runways currently in service: 10/28 and 16/34. A 3rd runway is currently under construction which will run parallel to runway 10/28, to the north. These will be indicated as 10N/28N. 2-mile flight path receptors were used for the approach to each side of these runways. This airport has two functioning air traffic control towers. The first of which is situated approximately 1km to the west of the main control building. This has a structural elevation of approximately 21.9m. The second of which is situated at approximately 140m northwest of the first and has a structural elevation of 75.6m. Point receptors were used for these control towers, using the appropriate heights. An indication of these receptors is shown below (Figure 10). The results for these receptors are shown in Appendix A.

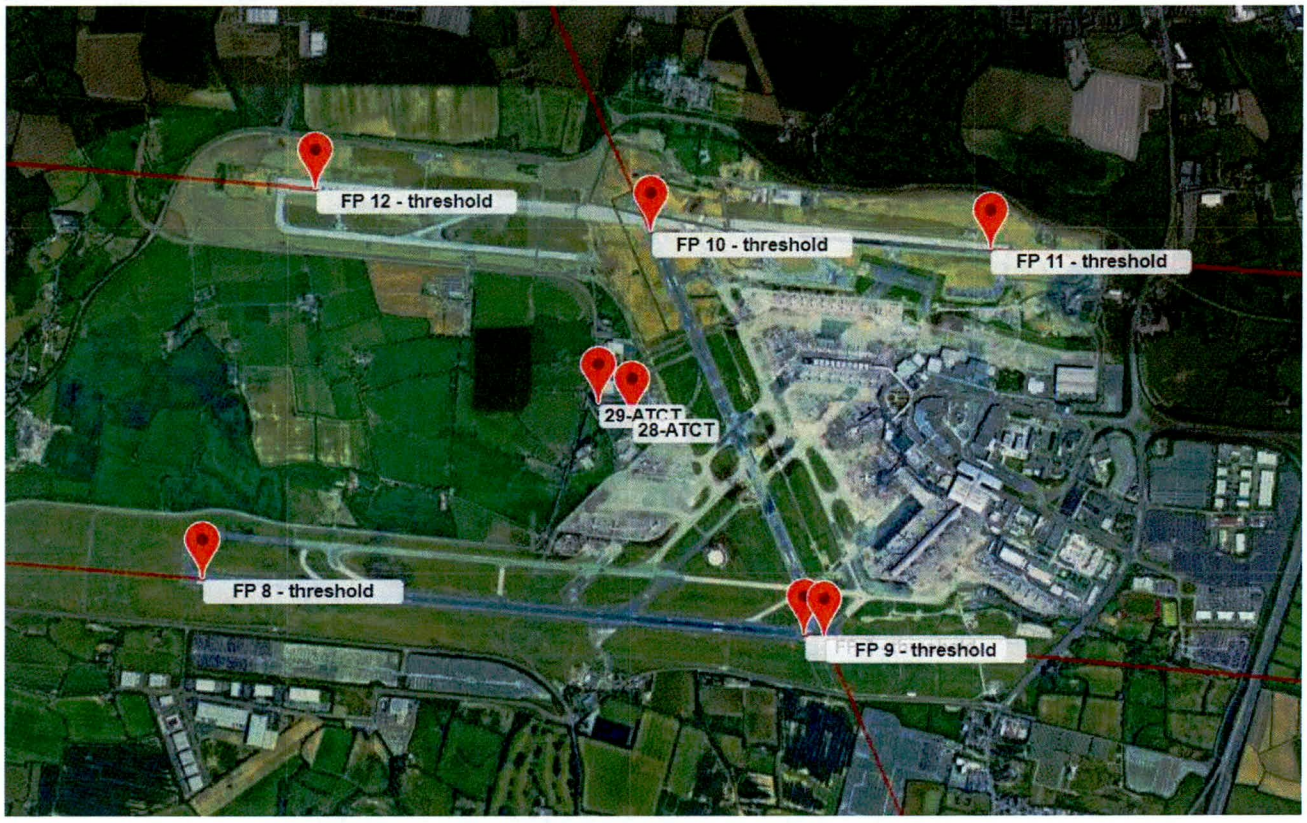


Figure 10: Aviation Receptor Indication at Dublin Airport

2. Casement Aerodrome:

Casement Aerodrome is situated 6km south-west of the installation. It uses two operational runways: 05/23 and 11/29. 2-mile flight path receptors were used for the approach to each side of these runways. The air traffic control tower for this aerodrome is situated approximately 200m south of the hangar buildings and has a structural elevation of approximately 9m. An indication of these receptors can be seen below (Figure 11) and the results for these can be seen in Appendix A.

Figure 11: Aviation Receptors at Casement Aerodrome

3. Weston Aerodrome:

Weston Aerodrome is situated 6km west of the installation. It uses one operational runways: 05/25. 2-mile flight path receptors were used for the approach to each side of this runway. The air traffic control tower for this aerodrome is situated approximately 50m southwest of the hangar building and has a structural elevation of approximately 15m. An indication of these receptors can be seen below (Figure 12) and the results for these can be seen in Appendix A.

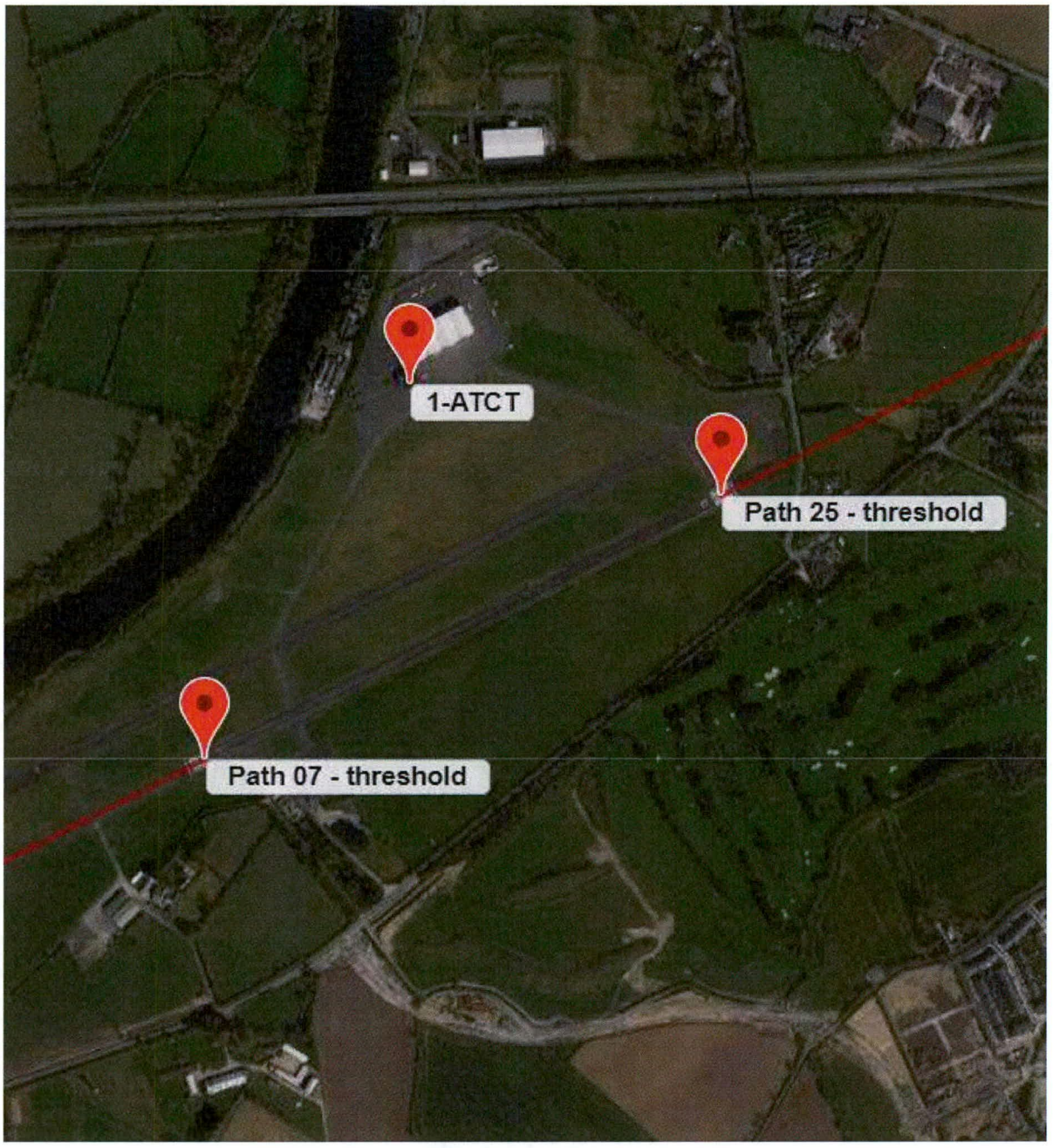


Figure 12: Aviation Receptors at Weston Aerodrome

4. Tallaght Hospital:

Tallaght Hospital is situated approximately 6km south of the installation. The hospital has a helicopter pad which is frequently used for the transport of patients. Point receptors were used for the approaches to this. These were spaced at 500m in all cardinal directions (N, NE, E, SE, etc.) These receptors were evaluated at increments of 30m to a maximum of 180m above the helipad. This will cover all possible approaches to the helipad. An indication of these receptors is shown below (Figure 13) and the results for these can be seen in Appendix A and B.

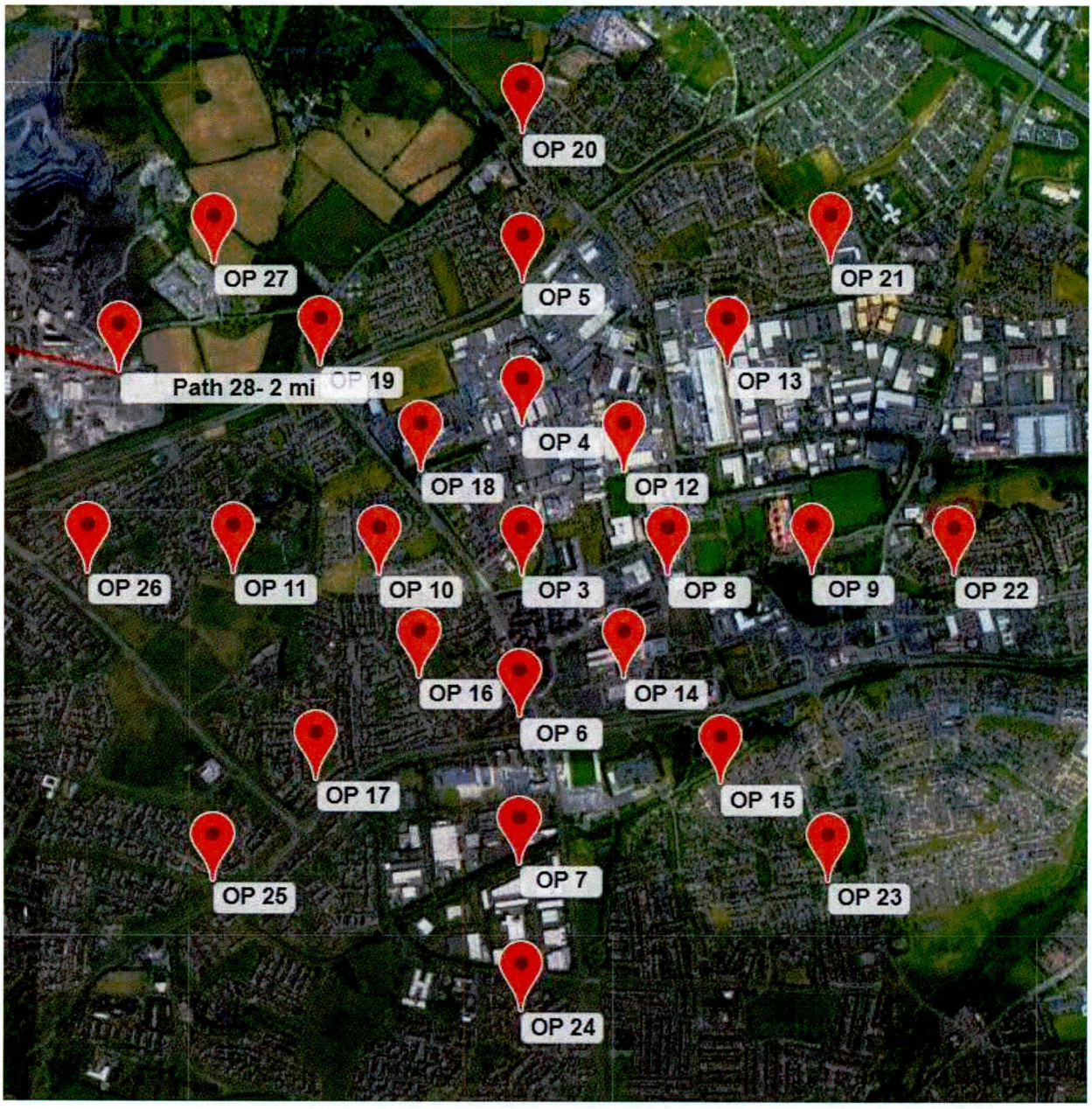


Figure 13: Helipad Receptor Locations at Tallaght Hospital

An indication of the points used for the SGHAT analysis can be seen on the table below (Table 1).

Point Identification	Indication
CA 04-22	Casement Aerodrome Runway 04/22
CA 10-28	Casement Aerodrome Runway 10/28
CA 22-04	Casement Aerodrome Runway 22/04
CA 28-10	Casement Aerodrome Runway 28/10
DA 10-28	Dublin Airport Runway 10/28
DA 10N-28N	Dublin Airport Proposed Runway 10/28
DA 16-34	Dublin Airport Runway 16/34
DA 28-10	Dublin Airport Runway 28/10
DA 28N-10N	Dublin Airport Proposed Runway 28/10
DA 34-16	Dublin Airport Runway 34/16
WA 07-25	Weston Aerodrome Runway 07/25
WA 25-07	Weston Aerodrome Runway 25/07
1-ATCT	Weston Aerodrome Air Traffic Control Tower
2-ATCT	Casement Aerodrome Air Traffic Control Tower
OP 3	Tallaght Hospital Helipad Location
OP 4	500m North
OP 5	1km North
OP 6	500m South
OP 7	1km South
OP 8	500m East
OP 9	1km East

Point Identification	Indication
OP 10	500m West
OP 11	1km West
OP 12	500m North-East
OP 13	1km North-East
OP 14	500m South-East
OP 15	1km South-East
OP 16	500m South-West
OP 17	1km South-West
OP 18	500m North-West
OP 19	1km North-West
OP 20	1.5km North
OP 21	1.5km North-East
OP 22	1.5km East
OP 23	1.5km South-East
OP 24	1.5km South
OP 25	1.5km South-West
OP 26	1.5km West
OP 27	1.5km North-West
28-ATCT	Dublin Airport 21.9m Air Traffic Control Tower
29-ATCT	Dublin Airport 75.6m Air Traffic Control Tower

Table 1: Receptor Point Indication

4 Results of Glint and Glare Assessment at Receptors

In order to assess the effects of glint and glare of the Installation at Tesco Extra, Fonthill Rd, Liffey Valley, Clondalkin, Co. Dublin, a Solar Glare Hazard Analysis Tool (SGHAT) was used. This tool is used to due the current lack of guidance in Ireland to glint and glare effects. However, the tool is endorsed by the Federal Aviation Authority (FAA) as "the standard for measuring the ocular impact of any proposed solar energy system on a federally- obligated airport". It is regarded as the accepted standard by aviation authorities when evaluating glint and glare upon aviation receptors. The SGHAT results of this assessment can be seen in Appendix A and B.

The level of magnitude of glint and glare which this report is designed to are outlined in the FAA's interim policy [2] which states "to obtain FAA approval to revise an airport layout plan to depict a solar installation and/or a "no objection" to a Notice of Proposed Construction From 7460-1, the airport sponsor will be required to demonstrate that the proposed solar energy system meets the following standards:

- No potential for glint and glare in the existing or planned Airport Traffic Control Tower (ATCT) cab, and
- No "potential for after-image" (Yellow) glare or worse, along the final approach path for any existing landing threshold or future landing thresholds (including any planned interim phases of the landing thresholds) as shown on the current FAA-approved Airport Layout Plan (ALP). The final approach path is defined as two (2) miles from fifty (50) feet above the landing threshold using a standard three (3) degree glidepath."

Therefore, the specifications for this evaluation were no glare to air traffic control towers and a maximum of "low potential for after-image", or green, glare on approaches to runways or helipads. Any potential for after-image or potential, yellow, for permanent eye damage, red, glare is not acceptable. The SGHAT analyses the impact of glare over a calendar year for each minute that the sun is above the horizon. It analyses this using a solar glare ocular hazard plot, shown below (Figure 14), which give the level of glare for each minute that the sun is visible.

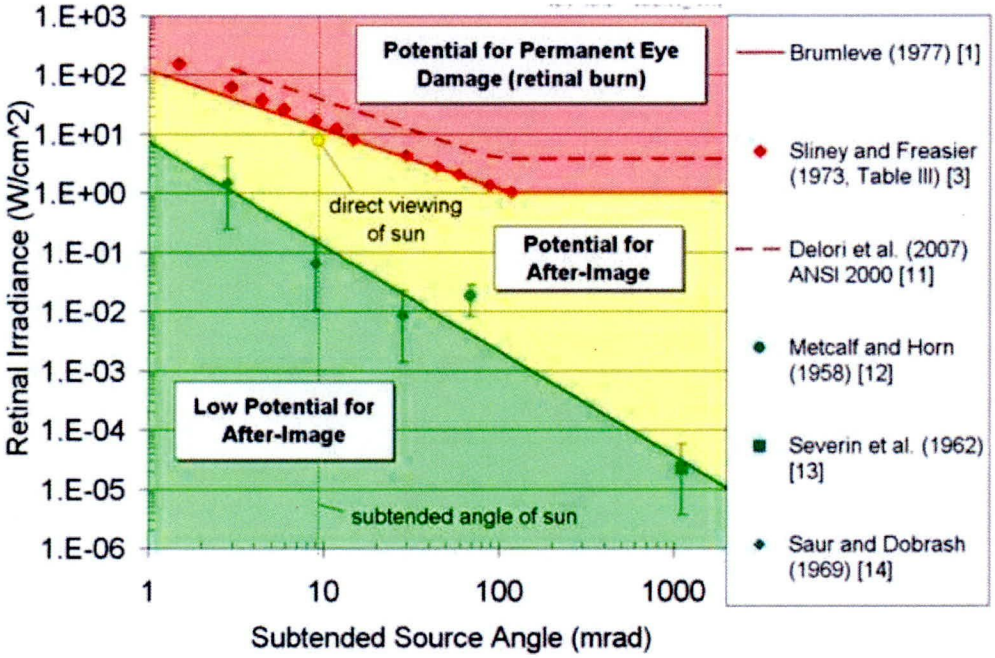


Figure 14: Solar Glare Ocular Hazard Plot

4.1 SGHAT Results

1. Dublin Airport: Results from SGHAT indicate that the is no potential for any glare type to the approaches to any of Dublin Airports Runways. In addition, there is no potential for any glare type to either air traffic control towers at Dublin Airport. This is shown in Appendix A.
2. Casement Aerodrome: Results from SGHAT indicate the potential for "green glare" or glare with a "low potential for temporary after image" to occur along the approach to the 10/28 runway from the west side. There is no potential for glare of any type to occur to the other runway approaches or to the air traffic control tower. This is shown in Appendix A.
3. Weston Aerodrome: Results from SGHAT indicate the potential for "green glare" or glare with a "low potential for temporary after image" to occur along the approach to the 07/25 runway from the west side. There is no potential for glare of any type to occur to the other runway approach or to the air traffic control tower. This is shown in Appendix A.
4. Tallaght Hospital Helipad: Results from SGHAT indicate no potential for any glare type to occur at any point. This represents no glare type to occur to the approach to the helipad from any direction.

5 Glint and Glare Assessment Conclusion

The results from using the SGHAT for the planned solar PV installation at Tesco Extra, Fonthill Road, Liffey Valley, Clondalkin, Co. Dublin show that there is no potential for hazardous effects due to glare at any of the receptors considered. The only glare detected was "low potential for after-image", or green, glare along one runway approach at Casement and Weston aerodromes. However, this level of glare is considered acceptable for runway approaches. Therefore, no further mitigation measure are needed and the installation falls within a suitable range for landing activities.

6 References

[1] M. Lawrance and P. W. Magnotta, "Technical Guidance for Evaluating Selected Solar Technologies on Airports," Federal Aviation Administration, Washington D.C., 2018.

[2] Federal Aviation Administration, "JO 7400.2N - Procedures for Handling Airspace Matters," U.S. Department of Transportation, Washington D.C., 2021.

[3] Federal Aviation Authority (FAA), "Review of Solar Energy System Projects on Federally Obligated Airports," *Department of Transportation - Federal Aviation Authority Interm Policy,* vol. 78, no. 205, pp. 63276 - 63279, 2013.

APPENDIX A:

SGHAT Results

All ATCT Receptors

All Runway Approach Receptors

Helipad Approach Receptors at 0m Elevation

FORGESOLAR GLARE ANALYSIS

Project: **Tesco Liffey Valley Roofmount PV**
Site configuration: **Roofmount PV**
Analysis conducted by Cormac Connell (cormac.connell@grange-solar.com) at 23:06 on 03 Jun, 2022.

U.S. FAA 2013 Policy Adherence

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

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

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

COMPONENT	STATUS	DESCRIPTION
Analysis parameters	PASS	Analysis time interval and eye characteristics used are acceptable
2-mile flight path(s)	PASS	Flight path receptor(s) do not receive yellow glare
ATCT(s)	PASS	Receptor(s) marked as ATCT do not receive glare

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

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

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

SITE CONFIGURATION

Analysis Parameters

DNI: peaks at 1,000.0 W/m^2
Time interval: 1 min
Ocular transmission coefficient: 0.5
Pupil diameter: 0.002 m
Eye focal length: 0.017 m
Sun subtended angle: 9.3 mrad
Site Config ID: 68580.12116
Methodology: V2

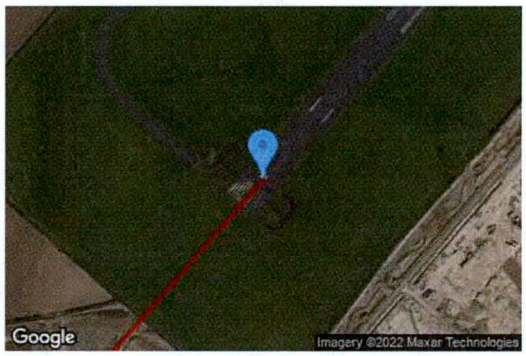
PV Array(s)

Name: PV array 1
Axis tracking: Fixed (no rotation)
Tilt: 10.0°
Orientation: 179.0°
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.350943	-6.389650	66.00	14.00	80.00
2	53.350936	-6.388961	66.00	14.00	80.00
3	53.350080	-6.388990	66.00	14.00	80.00
4	53.350093	-6.389668	66.00	14.00	80.00

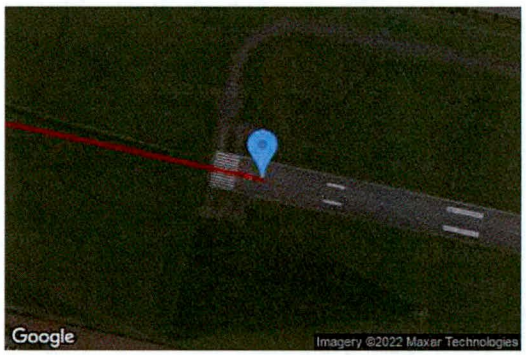
Flight Path Receptor(s)

Name: CA 04-22
Description:
Threshold height: 15 m
Direction: 41.1°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°



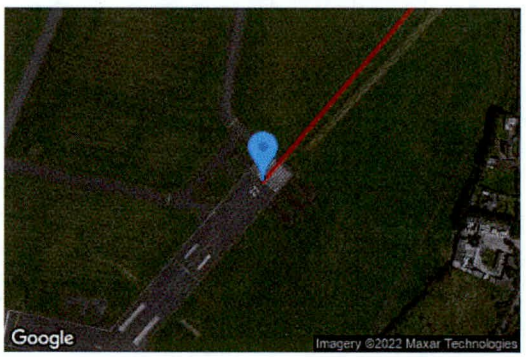
Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.293916	-6.453318	98.17	15.24	113.41
Two-mile	53.272125	-6.485147	153.94	128.15	282.09

Name: CA 10-28
Description:
Threshold height: 15 m
Direction: 102.3°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.304566	-6.467797	86.61	15.24	101.85
Two-mile	53.310730	-6.515124	72.81	197.72	270.53

Name: CA 22-04
Description:
Threshold height: 15 m
Direction: 220.5°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.303270	-6.439806	93.36	15.24	108.60
Two-mile	53.325255	-6.408347	63.58	213.71	277.28

Name: CA 28-10
Description:
Threshold height: 15 m
Direction: 282.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.301684	-6.445028	96.06	15.24	111.30
Two-mile	53.295698	-6.397640	106.17	173.81	279.99

Name: DA 10-28
Description:
Threshold height: 15 m
Direction: 94.7°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.422414	-6.289618	74.08	15.24	89.32
Two-mile	53.424798	-6.338028	81.19	176.82	258.00

Name: DA 10N-28N
Description:
Threshold height: 15 m
Direction: 94.7°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.437218	-6.282378	73.10	15.24	88.34
Two-mile	53.439602	-6.330804	78.04	178.98	257.03

Name: DA 16-34
Description:
Threshold height: 15 m
Direction: 156.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.435555	-6.260936	66.16	15.24	81.40
Two-mile	53.461974	-6.280677	67.39	182.70	250.09

Name: DA 28-10
Description:
Threshold height: 15 m
Direction: 275.4°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.420294	-6.251060	61.98	15.24	77.22
Two-mile	53.417553	-6.202706	41.61	204.30	245.90

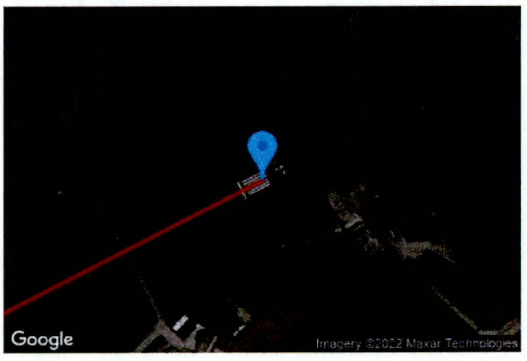
Name: DA 28N-10N
Description:
Threshold height: 15 m
Direction: 274.6°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.434890	-6.239219	66.90	15.24	82.14
Two-mile	53.432571	-6.190786	33.04	217.79	250.83

Name: DA 34-16
Description:
Threshold height: 15 m
Direction: 336.7°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

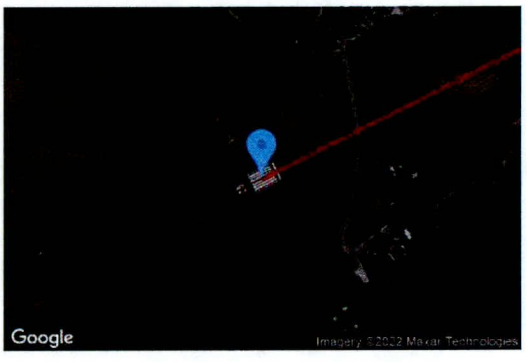
Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.420163	-6.249748	62.26	15.24	77.50
Two-mile	53.393604	-6.230551	48.94	197.24	246.18

Name: WA 07-25
Description:
Threshold height: 15 m
Direction: 62.9°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.350541	-6.494097	47.61	15.24	62.85
Two-mile	53.337383	-6.537278	52.88	178.66	231.54

Name: WA 25-07
Description:
Threshold height: 15 m
Direction: 243.3°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

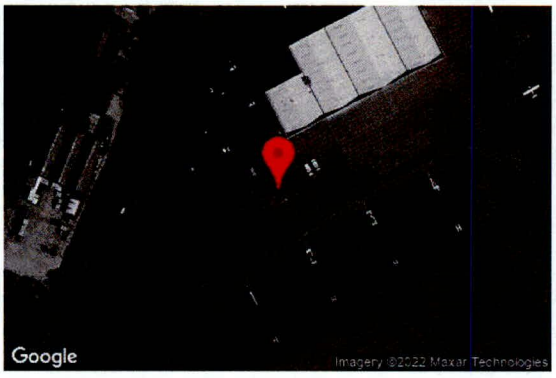


Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.354096	-6.482412	46.75	15.24	61.99
Two-mile	53.367096	-6.439093	29.55	201.12	230.67

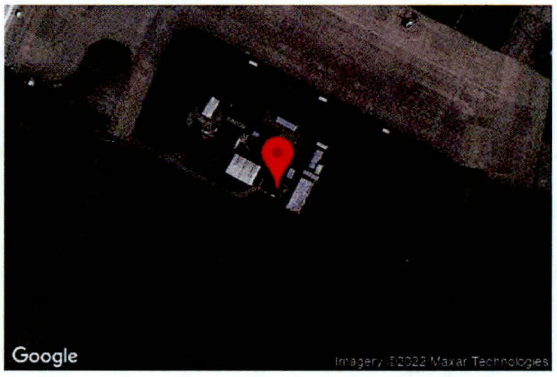
Discrete Observation Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	53.355569	-6.489432	49.66	15.00
2-ATCT	2	53.305504	-6.441789	93.54	9.00
OP 3	3	53.289503	-6.376776	103.75	0.00
OP 4	4	53.294037	-6.376815	104.09	0.00
OP 5	5	53.298492	-6.376794	104.05	0.00
OP 6	6	53.285054	-6.376866	101.57	0.00
OP 7	7	53.280491	-6.376896	98.94	0.00
OP 8	8	53.289509	-6.369274	100.48	0.00
OP 9	9	53.289544	-6.361742	96.31	0.00
OP 10	10	53.289510	-6.384211	108.20	0.00
OP 11	11	53.289518	-6.391710	107.34	0.00
OP 12	12	53.292678	-6.371512	100.18	0.00
OP 13	13	53.295880	-6.366117	94.69	0.00
OP 14	14	53.286315	-6.371496	99.49	0.00
OP 15	15	53.283042	-6.366522	93.87	0.00
OP 16	16	53.286329	-6.382116	107.21	0.00
OP 17	17	53.283136	-6.387412	106.66	0.00
OP 18	18	53.292644	-6.382036	106.94	0.00
OP 19	19	53.295906	-6.387304	110.42	0.00
OP 20	20	53.303015	-6.376800	97.95	0.00
OP 21	21	53.299100	-6.360788	88.91	0.00
OP 22	22	53.289502	-6.354357	88.65	0.00
OP 23	23	53.279976	-6.360930	101.35	0.00
OP 24	24	53.276006	-6.376774	104.61	0.00
OP 25	25	53.279996	-6.392722	108.37	0.00
OP 26	26	53.289516	-6.399241	108.91	0.00
OP 27	27	53.299038	-6.392723	115.98	0.00
28-ATCT	28	53.428530	-6.262162	65.62	21.90
29-ATCT	29	53.429054	-6.264262	65.32	75.60

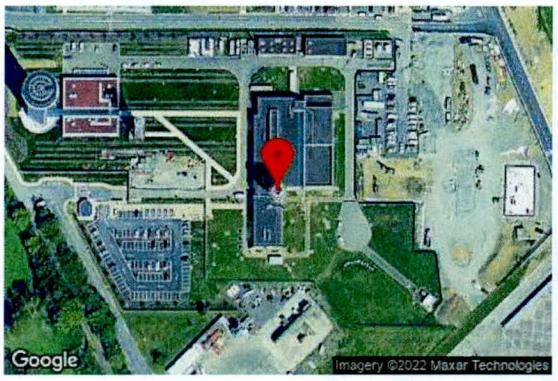
Map image of 1-ATCT



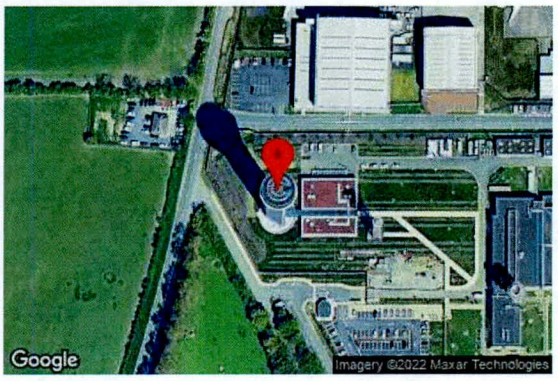
Map image of 2-ATCT



Map image of 28-ATCT



Map image of 29-ATCT



GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt (°)	Orient (°)	"Green" Glare min	"Yellow" Glare min	Energy kWh
PV array 1	10.0	179.0	1,679	0	-

Total annual glare received by each receptor

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
CA 04-22	0	0
CA 10-28	932	0
CA 22-04	0	0
CA 28-10	0	0
DA 10-28	0	0
DA 10N-28N	0	0
DA 16-34	0	0
DA 28-10	0	0
DA 28N-10N	0	0
DA 34-16	0	0
WA 07-25	747	0
WA 25-07	0	0
1-ATCT	0	0
2-ATCT	0	0
OP 3	0	0
OP 4	0	0
OP 5	0	0
OP 6	0	0
OP 7	0	0
OP 8	0	0
OP 9	0	0
OP 10	0	0
OP 11	0	0
OP 12	0	0
OP 13	0	0
OP 14	0	0
OP 15	0	0
OP 16	0	0
OP 17	0	0
OP 18	0	0
OP 19	0	0

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
OP 20	0	0
OP 21	0	0
OP 22	0	0
OP 23	0	0
OP 24	0	0
OP 25	0	0
OP 26	0	0
OP 27	0	0
28-ATCT	0	0
29-ATCT	0	0

Results for: PV array 1

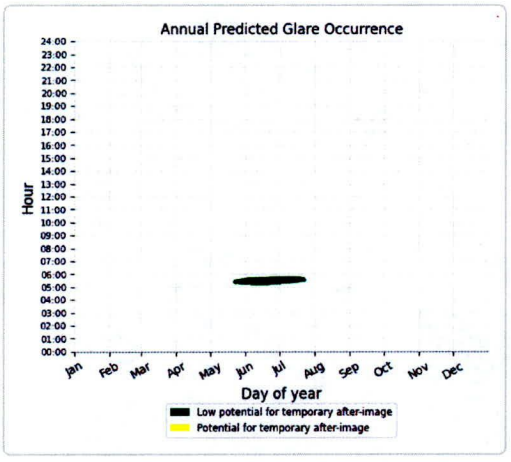
Receptor	Green Glare (min)	Yellow Glare (min)
CA 04-22	0	0
CA 10-28	932	0
CA 22-04	0	0
CA 28-10	0	0
DA 10-28	0	0
DA 10N-28N	0	0
DA 16-34	0	0
DA 28-10	0	0
DA 28N-10N	0	0
DA 34-16	0	0
WA 07-25	747	0
WA 25-07	0	0
1-ATCT	0	0
2-ATCT	0	0
OP 3	0	0
OP 4	0	0
OP 5	0	0
OP 6	0	0
OP 7	0	0
OP 8	0	0
OP 9	0	0
OP 10	0	0
OP 11	0	0
OP 12	0	0
OP 13	0	0
OP 14	0	0
OP 15	0	0
OP 16	0	0
OP 17	0	0
OP 18	0	0
OP 19	0	0
OP 20	0	0
OP 21	0	0
OP 22	0	0
OP 23	0	0
OP 24	0	0
OP 25	0	0
OP 26	0	0
OP 27	0	0
28-ATCT	0	0
29-ATCT	0	0

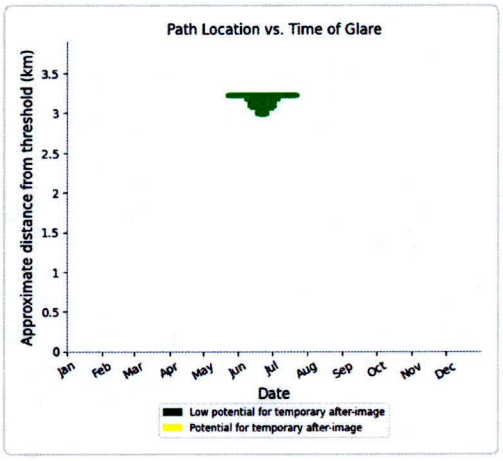
Flight Path: CA 04-22

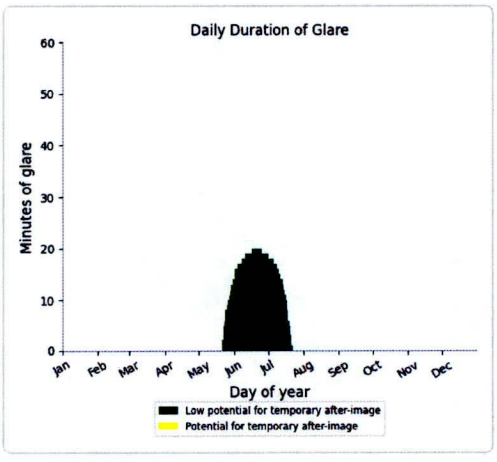
0 minutes of yellow glare
0 minutes of green glare

Flight Path: CA 10-28

0 minutes of yellow glare
932 minutes of green glare







Flight Path: CA 22-04

0 minutes of yellow glare
0 minutes of green glare

Flight Path: CA 28-10

0 minutes of yellow glare
0 minutes of green glare

Flight Path: DA 10-28

0 minutes of yellow glare
0 minutes of green glare

Flight Path: DA 10N-28N

0 minutes of yellow glare
0 minutes of green glare

Flight Path: DA 16-34

0 minutes of yellow glare
0 minutes of green glare

Flight Path: DA 28-10

0 minutes of yellow glare
0 minutes of green glare

Flight Path: DA 28N-10N

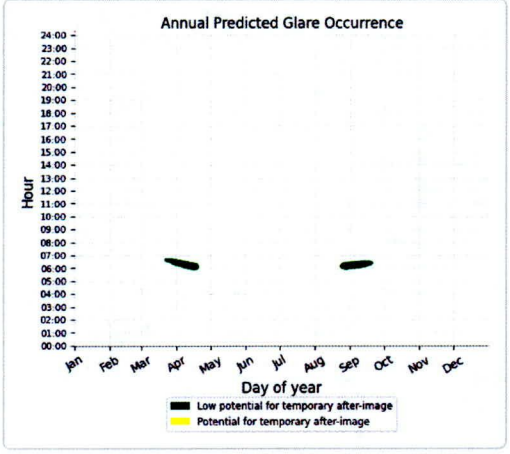
0 minutes of yellow glare
0 minutes of green glare

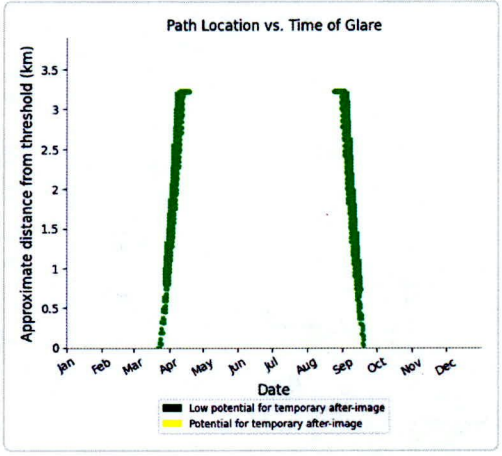
Flight Path: DA 34-16

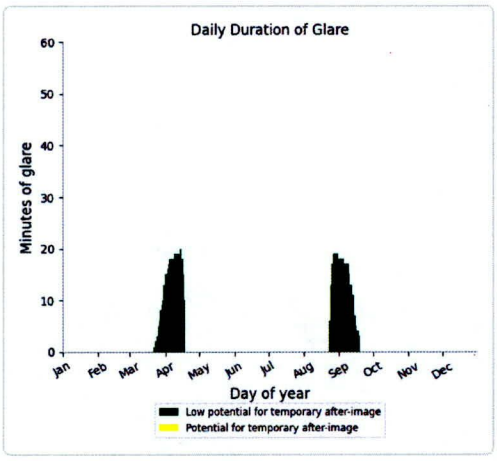
0 minutes of yellow glare
0 minutes of green glare

Flight Path: WA 07-25

0 minutes of yellow glare
747 minutes of green glare







Flight Path: WA 25-07

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: 1-ATCT

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: 2-ATCT

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 5

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 6

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 7

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 8

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 9

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 10

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 11

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 12

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 13

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 14

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 15

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 16

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 17

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 18

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 19

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 20

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 21

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 22

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 23

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 24

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 25

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 26

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 27

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: 28-ATCT

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: 29-ATCT

0 minutes of yellow glare
0 minutes of green glare

Assumptions

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

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APPENDIX B:

SGHAT Results

Helipad Approach Receptors at 30m Elevation

Helipad Approach Receptors at 60m Elevation

Helipad Approach Receptors at 90m Elevation

Helipad Approach Receptors at 120m Elevation

Helipad Approach Receptors at 150m Elevation

Helipad Approach Receptors at 180m Elevation

FORGESOLAR GLARE ANALYSIS

Project: **Tesco Liffey Valley Roofmount PV**
Site configuration: **Roofmount PV Installation Helipad**
Analysis conducted by Cormac Connell (cormac.connell@grange-solar.com) at 22:48 on 03 Jun, 2022.

U.S. FAA 2013 Policy Adherence

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

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

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

COMPONENT	STATUS	DESCRIPTION
Analysis parameters	PASS	Analysis time interval and eye characteristics used are acceptable
2-mile flight path(s)	N/A	No flight paths analyzed
ATCT(s)	N/A	No ATCT receptors designated

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

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

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

SITE CONFIGURATION

Analysis Parameters

DNI: peaks at 1,000.0 W/m^2
Time interval: 1 min
Ocular transmission coefficient: 0.5
Pupil diameter: 0.002 m
Eye focal length: 0.017 m
Sun subtended angle: 9.3 mrad
Site Config ID: 70169.12116
Methodology: V2

PV Array(s)

Name: PV array 1
Axis tracking: Fixed (no rotation)
Tilt: 10.0°
Orientation: 179.0°
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.350943	-6.389650	66.00	14.00	80.00
2	53.350936	-6.388961	66.00	14.00	80.00
3	53.350080	-6.388990	66.00	14.00	80.00
4	53.350093	-6.389668	66.00	14.00	80.00

Discrete Observation Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	53.289503	-6.376776	103.75	30.00
OP 2	2	53.294037	-6.376815	104.09	30.00
OP 3	3	53.298492	-6.376794	104.05	30.00
OP 4	4	53.285054	-6.376866	101.57	30.00
OP 5	5	53.280491	-6.376896	98.94	30.00
OP 6	6	53.289509	-6.369274	100.48	30.00
OP 7	7	53.289544	-6.361742	96.31	30.00
OP 8	8	53.289510	-6.384211	108.20	30.00
OP 9	9	53.289518	-6.391710	107.34	30.00
OP 10	10	53.292678	-6.371512	100.18	30.00
OP 11	11	53.295880	-6.366117	94.69	30.00
OP 12	12	53.286315	-6.371496	99.49	30.00
OP 13	13	53.283042	-6.366522	93.87	30.00
OP 14	14	53.286329	-6.382116	107.21	30.00
OP 15	15	53.283136	-6.387412	106.66	30.00
OP 16	16	53.292644	-6.382036	106.94	30.00
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OP 19	19	53.299100	-6.360788	88.91	30.00
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OP 22	22	53.276006	-6.376774	104.61	30.00
OP 23	23	53.279996	-6.392722	108.37	30.00
OP 24	24	53.289516	-6.399241	108.91	30.00
OP 25	25	53.299038	-6.392723	115.98	30.00

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt (°)	Orient (°)	"Green" Glare min	"Yellow" Glare min	Energy kWh
PV array 1	10.0	179.0	0	0	-

Total annual glare received by each receptor

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
OP 1	0	0
OP 2	0	0
OP 3	0	0
OP 4	0	0
OP 5	0	0
OP 6	0	0
OP 7	0	0
OP 8	0	0
OP 9	0	0
OP 10	0	0
OP 11	0	0
OP 12	0	0
OP 13	0	0
OP 14	0	0
OP 15	0	0
OP 16	0	0
OP 17	0	0
OP 18	0	0
OP 19	0	0
OP 20	0	0
OP 21	0	0
OP 22	0	0
OP 23	0	0
OP 24	0	0
OP 25	0	0

Results for: PV array 1

Receptor	Green Glare (min)	Yellow Glare (min)
OP 1	0	0
OP 2	0	0
OP 3	0	0
OP 4	0	0
OP 5	0	0
OP 6	0	0
OP 7	0	0
OP 8	0	0
OP 9	0	0
OP 10	0	0
OP 11	0	0
OP 12	0	0
OP 13	0	0
OP 14	0	0
OP 15	0	0
OP 16	0	0
OP 17	0	0
OP 18	0	0
OP 19	0	0
OP 20	0	0
OP 21	0	0
OP 22	0	0
OP 23	0	0
OP 24	0	0
OP 25	0	0

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 5

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 6

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 7

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 8

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 9

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 10

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 11

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 12

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 13

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 14

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 15

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 16

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 17

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 18

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 19

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 20

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 21

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 22

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 23

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 24

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 25

0 minutes of yellow glare
0 minutes of green glare

Assumptions

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OP 7	7	53.289544	-6.361742	96.31	60.00
OP 8	8	53.289510	-6.384211	108.20	60.00
OP 9	9	53.289518	-6.391710	107.34	60.00
OP 10	10	53.292678	-6.371512	100.18	60.00
OP 11	11	53.295880	-6.366117	94.69	60.00
OP 12	12	53.286315	-6.371496	99.49	60.00
OP 13	13	53.283042	-6.366522	93.87	60.00
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OP 22	22	53.276006	-6.376774	104.61	60.00
OP 23	23	53.279996	-6.392722	108.37	60.00
OP 24	24	53.289516	-6.399241	108.91	60.00
OP 25	25	53.299038	-6.392723	115.98	60.00

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt (°)	Orient (°)	"Green" Glare min	"Yellow" Glare min	Energy kWh
PV array 1	10.0	179.0	0	0	-

Total annual glare received by each receptor

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
OP 1	0	0
OP 2	0	0
OP 3	0	0
OP 4	0	0
OP 5	0	0
OP 6	0	0
OP 7	0	0
OP 8	0	0
OP 9	0	0
OP 10	0	0
OP 11	0	0
OP 12	0	0
OP 13	0	0
OP 14	0	0
OP 15	0	0
OP 16	0	0
OP 17	0	0
OP 18	0	0
OP 19	0	0
OP 20	0	0
OP 21	0	0
OP 22	0	0
OP 23	0	0
OP 24	0	0
OP 25	0	0

Results for: PV array 1

Receptor	Green Glare (min)	Yellow Glare (min)
OP 1	0	0
OP 2	0	0
OP 3	0	0
OP 4	0	0
OP 5	0	0
OP 6	0	0
OP 7	0	0
OP 8	0	0
OP 9	0	0
OP 10	0	0
OP 11	0	0
OP 12	0	0
OP 13	0	0
OP 14	0	0
OP 15	0	0
OP 16	0	0
OP 17	0	0
OP 18	0	0
OP 19	0	0
OP 20	0	0
OP 21	0	0
OP 22	0	0
OP 23	0	0
OP 24	0	0
OP 25	0	0

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 5

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 6

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 7

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 8

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 9

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 10

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 11

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 12

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 13

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 14

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 15

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 16

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 17

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 18

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 19

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 20

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 21

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 22

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 23

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 24

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 25

0 minutes of yellow glare
0 minutes of green glare

Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
"Yellow" glare is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
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Discrete Observation Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	53.289503	-6.376776	103.75	90.00
OP 2	2	53.294037	-6.376815	104.09	90.00
OP 3	3	53.298492	-6.376794	104.05	90.00
OP 4	4	53.285054	-6.376866	101.57	90.00
OP 5	5	53.280491	-6.376896	98.94	90.00
OP 6	6	53.289509	-6.369274	100.48	90.00
OP 7	7	53.289544	-6.361742	96.31	90.00
OP 8	8	53.289510	-6.384211	108.20	90.00
OP 9	9	53.289518	-6.391710	107.34	90.00
OP 10	10	53.292678	-6.371512	100.18	90.00
OP 11	11	53.295880	-6.366117	94.69	90.00
OP 12	12	53.286315	-6.371496	99.49	90.00
OP 13	13	53.283042	-6.366522	93.87	90.00
OP 14	14	53.286329	-6.382116	107.21	90.00
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OP 19	19	53.299100	-6.360788	88.91	90.00
OP 20	20	53.289502	-6.354357	88.65	90.00
OP 21	21	53.279976	-6.360930	101.35	90.00
OP 22	22	53.276006	-6.376774	104.61	90.00
OP 23	23	53.279996	-6.392722	108.37	90.00
OP 24	24	53.289516	-6.399241	108.91	90.00
OP 25	25	53.299038	-6.392723	115.98	90.00

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt (°)	Orient (°)	"Green" Glare min	"Yellow" Glare min	Energy kWh
PV array 1	10.0	179.0	0	0	-

Total annual glare received by each receptor

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
OP 1	0	0
OP 2	0	0
OP 3	0	0
OP 4	0	0
OP 5	0	0
OP 6	0	0
OP 7	0	0
OP 8	0	0
OP 9	0	0
OP 10	0	0
OP 11	0	0
OP 12	0	0
OP 13	0	0
OP 14	0	0
OP 15	0	0
OP 16	0	0
OP 17	0	0
OP 18	0	0
OP 19	0	0
OP 20	0	0
OP 21	0	0
OP 22	0	0
OP 23	0	0
OP 24	0	0
OP 25	0	0

Results for: PV array 1

Receptor	Green Glare (min)	Yellow Glare (min)
OP 1	0	0
OP 2	0	0
OP 3	0	0
OP 4	0	0
OP 5	0	0
OP 6	0	0
OP 7	0	0
OP 8	0	0
OP 9	0	0
OP 10	0	0
OP 11	0	0
OP 12	0	0
OP 13	0	0
OP 14	0	0
OP 15	0	0
OP 16	0	0
OP 17	0	0
OP 18	0	0
OP 19	0	0
OP 20	0	0
OP 21	0	0
OP 22	0	0
OP 23	0	0
OP 24	0	0
OP 25	0	0

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 5

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 6

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 7

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 8

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 9

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 10

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 11

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 12

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 13

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 14

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 15

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 16

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 17

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 18

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 19

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 20

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 21

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 22

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 23

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 24

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 25

0 minutes of yellow glare
0 minutes of green glare

Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
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OP 6	6	53.289509	-6.369274	100.48	120.00
OP 7	7	53.289544	-6.361742	96.31	120.00
OP 8	8	53.289510	-6.384211	108.20	120.00
OP 9	9	53.289518	-6.391710	107.34	120.00
OP 10	10	53.292678	-6.371512	100.18	120.00
OP 11	11	53.295880	-6.366117	94.69	120.00
OP 12	12	53.286315	-6.371496	99.49	120.00
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OP 19	19	53.299100	-6.360788	88.91	120.00
OP 20	20	53.289502	-6.354357	88.65	120.00
OP 21	21	53.279976	-6.360930	101.35	120.00
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OP 23	23	53.279996	-6.392722	108.37	120.00
OP 24	24	53.289516	-6.399241	108.91	120.00
OP 25	25	53.299038	-6.392723	115.98	120.00

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt (°)	Orient (°)	"Green" Glare min	"Yellow" Glare min	Energy kWh
PV array 1	10.0	179.0	0	0	-

Total annual glare received by each receptor

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
OP 1	0	0
OP 2	0	0
OP 3	0	0
OP 4	0	0
OP 5	0	0
OP 6	0	0
OP 7	0	0
OP 8	0	0
OP 9	0	0
OP 10	0	0
OP 11	0	0
OP 12	0	0
OP 13	0	0
OP 14	0	0
OP 15	0	0
OP 16	0	0
OP 17	0	0
OP 18	0	0
OP 19	0	0
OP 20	0	0
OP 21	0	0
OP 22	0	0
OP 23	0	0
OP 24	0	0
OP 25	0	0

Results for: PV array 1

Receptor	Green Glare (min)	Yellow Glare (min)
OP 1	0	0
OP 2	0	0
OP 3	0	0
OP 4	0	0
OP 5	0	0
OP 6	0	0
OP 7	0	0
OP 8	0	0
OP 9	0	0
OP 10	0	0
OP 11	0	0
OP 12	0	0
OP 13	0	0
OP 14	0	0
OP 15	0	0
OP 16	0	0
OP 17	0	0
OP 18	0	0
OP 19	0	0
OP 20	0	0
OP 21	0	0
OP 22	0	0
OP 23	0	0
OP 24	0	0
OP 25	0	0

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 5

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 6

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 7

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 8

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 9

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 10

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 11

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 12

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 13

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 14

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 15

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 16

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 17

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 18

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 19

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 20

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 21

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 22

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 23

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 24

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 25

0 minutes of yellow glare
0 minutes of green glare

Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
"Yellow" glare is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
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OP 9	9	53.289518	-6.391710	107.34	150.00
OP 10	10	53.292678	-6.371512	100.18	150.00
OP 11	11	53.295880	-6.366117	94.69	150.00
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OP 24	24	53.289516	-6.399241	108.91	150.00
OP 25	25	53.299038	-6.392723	115.98	150.00

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt (°)	Orient (°)	"Green" Glare min	"Yellow" Glare min	Energy kWh
PV array 1	10.0	179.0	0	0	-

Total annual glare received by each receptor

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
OP 1	0	0
OP 2	0	0
OP 3	0	0
OP 4	0	0
OP 5	0	0
OP 6	0	0
OP 7	0	0
OP 8	0	0
OP 9	0	0
OP 10	0	0
OP 11	0	0
OP 12	0	0
OP 13	0	0
OP 14	0	0
OP 15	0	0
OP 16	0	0
OP 17	0	0
OP 18	0	0
OP 19	0	0
OP 20	0	0
OP 21	0	0
OP 22	0	0
OP 23	0	0
OP 24	0	0
OP 25	0	0

Results for: PV array 1

Receptor	Green Glare (min)	Yellow Glare (min)
OP 1	0	0
OP 2	0	0
OP 3	0	0
OP 4	0	0
OP 5	0	0
OP 6	0	0
OP 7	0	0
OP 8	0	0
OP 9	0	0
OP 10	0	0
OP 11	0	0
OP 12	0	0
OP 13	0	0
OP 14	0	0
OP 15	0	0
OP 16	0	0
OP 17	0	0
OP 18	0	0
OP 19	0	0
OP 20	0	0
OP 21	0	0
OP 22	0	0
OP 23	0	0
OP 24	0	0
OP 25	0	0

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 5

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 6

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 7

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 8

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 9

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 10

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 11

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 12

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 13

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 14

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 15

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 16

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 17

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 18

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 19

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 20

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 21

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 22

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 23

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 24

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 25

0 minutes of yellow glare
0 minutes of green glare

Assumptions

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OP 3	3	53.298492	-6.376794	104.05	180.00
OP 4	4	53.285054	-6.376866	101.57	180.00
OP 5	5	53.280491	-6.376896	98.94	180.00
OP 6	6	53.289509	-6.369274	100.48	180.00
OP 7	7	53.289544	-6.361742	96.31	180.00
OP 8	8	53.289510	-6.384211	108.20	180.00
OP 9	9	53.289518	-6.391710	107.34	180.00
OP 10	10	53.292678	-6.371512	100.18	180.00
OP 11	11	53.295880	-6.366117	94.69	180.00
OP 12	12	53.286315	-6.371496	99.49	180.00
OP 13	13	53.283042	-6.366522	93.87	180.00
OP 14	14	53.286329	-6.382116	107.21	180.00
OP 15	15	53.283136	-6.387412	106.66	180.00
OP 16	16	53.292644	-6.382036	106.94	180.00
OP 17	17	53.295906	-6.387304	110.42	180.00
OP 18	18	53.303015	-6.376800	97.95	180.00
OP 19	19	53.299100	-6.360788	88.91	180.00
OP 20	20	53.289502	-6.354357	88.65	180.00
OP 21	21	53.279976	-6.360930	101.35	180.00
OP 22	22	53.276006	-6.376774	104.61	180.00
OP 23	23	53.279996	-6.392722	108.37	180.00
OP 24	24	53.289516	-6.399241	108.91	180.00
OP 25	25	53.299038	-6.392723	115.98	180.00

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt (°)	Orient (°)	"Green" Glare min	"Yellow" Glare min	Energy kWh
PV array 1	10.0	179.0	0	0	-

Total annual glare received by each receptor

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
OP 1	0	0
OP 2	0	0
OP 3	0	0
OP 4	0	0
OP 5	0	0
OP 6	0	0
OP 7	0	0
OP 8	0	0
OP 9	0	0
OP 10	0	0
OP 11	0	0
OP 12	0	0
OP 13	0	0
OP 14	0	0
OP 15	0	0
OP 16	0	0
OP 17	0	0
OP 18	0	0
OP 19	0	0
OP 20	0	0
OP 21	0	0
OP 22	0	0
OP 23	0	0
OP 24	0	0
OP 25	0	0

Results for: PV array 1

Receptor	Green Glare (min)	Yellow Glare (min)
OP 1	0	0
OP 2	0	0
OP 3	0	0
OP 4	0	0
OP 5	0	0
OP 6	0	0
OP 7	0	0
OP 8	0	0
OP 9	0	0
OP 10	0	0
OP 11	0	0
OP 12	0	0
OP 13	0	0
OP 14	0	0
OP 15	0	0
OP 16	0	0
OP 17	0	0
OP 18	0	0
OP 19	0	0
OP 20	0	0
OP 21	0	0
OP 22	0	0
OP 23	0	0
OP 24	0	0
OP 25	0	0

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 5

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 6

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 7

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 8

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 9

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 10

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 11

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 12

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 13

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 14

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 15

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 16

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 17

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 18

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 19

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 20

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 21

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 22

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 23

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 24

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 25

0 minutes of yellow glare
0 minutes of green glare

Assumptions

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

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