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FURTHER INFORMATION

Ref. Application: SD22A/0339

Erect 1074sq.m or 204.20KWP of photovoltaic panels on the roof of existing commercial building, in cafe / restaurant and 4 retail / commercial, with all associated site works.

A Chara,
South Dublin County Council

Please find enclosed the Glint and Glare assessment (6 copies) in support of the above Planning Permission Application of Lidl Ireland GMBH, Commercial Building-Lidl Complex, Main Road, Tallaght, Dublin 24.

FURTHER INFORMATION
It is considered that the proposed development accords with the policies and objectives of South Dublin County Council, as set out in the South Dublin County Council Development Plan 2016 – 2022, and subject to the condition(s) set out hereunder is thereby in accordance with the proper planning and sustainable development of the area.

In this regard, the applicant is requested to undertake a Glint and Glare study analysing the following:

Glint/Glare Assessment regarding Aviation.

Glint and Glare

Prior to the commencement of development and given the proximity of the development to Casement Aerodrome and Military Air Traffic Services the applicant shall submit to the Planning Authority for written agreement an aviation glint and glare report to assess any impact on Air Corps flight operations. Prior to submission of such report to the Planning Authority the applicant shall consult with and incorporate the requirements of Casement Aerodrome.
REASON: To ensure the protection of aviation safety.

If you have any queries, please do not hesitate to contact me by email elena.vazquez@enerpower.ie or by phone at 089 606 64 98.

Mise le meas,

Elena Vazquez c/o Enerpower

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Web Site: www.enerpower.ie VAT No. IE 6419788K Reg.No.399788

Aviation Glint and Glare Assessment

Lidl Ireland GMBH
Commercial Building-Lidl Complex
Main Road,
Tallaght, Dublin 24

SUNFLOWER SOLUTIONS

Disclaimer

MOVEO S.A. shall have no liability for any loss, damage, injury, claim, expense, cost or other consequence arising as a result of use or reliance upon any information contained in or omitted from this document.

Prepared For:

Prepared By:

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CONTENTS

1. EXECUTIVE SUMMARY

1.1. This Aviation Glint and Glare Assessment glint and glare assessment has been produced in response to South Dublin County Council request (**planning reference No. SD22A/0339**). This aviation glint and glare assessment has been undertaken in relation to the instalment of a solar array on a roof on lands approximately 6.3 km southeast of Casement Aerodrome.

1.2. There is no guidance or policy available across Ireland in relation to the assessment of Glint and Glare from Proposed Development. However, as identified by UK policy, it is recognised as a potential impact which needs to be considered for a proposed solar development.

1.3. A 30km study area is chosen for receptors. 4 aviation assets are located within 30km of the Proposed Development: Casement Aerodrome, Dublin Airport , Tallaght Hospital Helipad and Weston Airport. The receptor/s mentioned will require a detailed assessment due to the Proposed Development falling within their respective safeguarding buffer zones outlined in paragraph 4.19.

1.4. Geometric analysis was conducted for 12 runway approach paths, 8 helipad approach paths, and 4 Air Traffic Control Towers (ATCTs) at Dublin Airport, Weston Airport, Tallaght Hospital Helipad, and Casement Aerodrome.

1.5. The assessment concludes that:

- Casement Aerodrome: **No impact is predicted.**
- Dublin Airport: **No impact is predicted.**
- Tallaght Hospital Helipad: Green Glare (Low potential for after-image) was predicted at FP 13 and FP 16, which is an **acceptable impact** according to the FAA guidelines for the runways and can be deemed **not significant**.
- Weston Airport: **No impact is predicted.**

1.6. Overall impacts on aviation receptors are acceptable and not significant

2. INTRODUCTION

BACKGROUND

2.1. MOVEO S.A. has been appointed by (the "Applicant") to undertake a Glint and Glare Assessment for a proposed solar array development (the "Proposed Development") (**planning reference No. SD22A/0339**) on the roof of Proposed Solar Panels at Commercial Building-Lidl Complex, Main Road, Tallaght, Dublin 24 . This aviation glint and glare assessment has been undertaken in relation to the instalment of a solar array on a roof on lands approximately 6.3 km southeast of Casement Aerodrome. (the "Application Site").

2.2. Please see Appendix A for site Layout Map with PV Solar Panels.

DEVELOPMENT DESCRIPTION

2.3. The Proposed Development comprises a 1074.00 roof mounted solar array being installed on the roof of Proposed Solar Panels at Commercial Building-Lidl Complex, Main Road, Tallaght, Dublin 24.

SCOPE OF REPORT

2.4. Although there may be small amounts of glint and glare from the metal structures associated with the solar array, the main source of glint and glare will be from the panels themselves and this will be the focus of this assessment.

2.5. For the purpose of this report, the roofs will be treated as smooth glass with no anti-reflection coating to conform with a worst-case scenario assessment. Furthermore, the legislation and guidance that would be used for a similar size photovoltaic ("PV") solar farm will be used when assessing this development.

2.6. Solar panels are designed to absorb as much light as possible and not to reflect it. However, glint can be produced as a reflection of the sun from the surface of the solar PV panel. This can also be described as a momentary flash. This may be an issue due to visual impact and viewer distraction on ground-based receptors and on aviation.

2.7. Glare is significantly less intense in comparison to glint and can be described as a continuous source of bright light, relative to diffused lighting. This is not a direct reflection of the sun, but a reflection of the sky around the sun.

2.8. This report will concentrate on the impacts of glint and glare and their effects on aviation assets and will be supported with the following Appendices:

- APPENDIX A:
  - APPENDIX A: FIGURE 1 Site Layout Map
  - APPENDIX A: FIGURE 2 Existing and Proposed Solar PV panel Roof Plan
  - APPENDIX A: FIGURE 3 Proposed Solar PV Elevations
  - APPENDIX A: Figure 4 Ground Elevation Profile
  - APPENDIX A: FIGURE 5 Dublin Airport Chart
  - APPENDIX A: FIGURE 6 Weston Airport Chart
  - APPENDIX A: FIGURE 7 Casement Aerodrome Chart
- APPENDIX B: GLARE ANALYSIS REPORT RESULTS
- APPENDIX C: AVIATION RECEPTOR GLARE RESULTS
- APPENDIX D: SOLAR MODULE GLARE AND REFLECTANCE TECHNICAL MEMO

STATEMENT OF AUTHORITY

2.9. This Glint and Glare Assessment has been produced by MOVEO S.A. Founding Partner director Maria Florencia Garcia having completed an architecture degree in 2012. She has been working on various technical assessments including glint and glare reports for numerous solar farms in Ireland.

DEFINITIONS

2.10. This study examined the potential hazard and nuisance effects of glint and glare in relation to aviation-based receptors. The Federal Aviation Guidance (FAA) in their *"Technical Guidance for Evaluating Selected Solar Technologies on Airports"* [1] have defined the terms 'Glint' and 'Glare' as meaning;

- Glint – *"A momentary flash of bright light"*
- Glare – *"A continuous source of bright light" ií*

2.11. Glint and glare are essentially the unwanted reflection of sunlight from reflective surfaces. This study used a multi-step process of elimination to determine which receptors had the potential to experience the effects of glint and glare. It then examined, using a computer

[1] Harris, Miller, Miller & Hanson Inc. (November 2010). Technical Guidance for Evaluating Selected Solar Technologies on Airports; 3.1.2 Reflectivity. Technical Guidance for Evaluating Selected Solar Technologies on Airports. Available at: https://www.faa.gov/airports/environmental/policy_guidance/media/airport-solar-guide.pdf

generated geometric model, the times of the year and the times of the day such effects could occur. This is based on the relative angles between the sun, the panels, and the receptor throughout the year.

GENERAL NATURE OF REFLECTANCE FROM PHOTOVOLTAIC PANELS

2.12. In terms of reflectance, photovoltaic solar panels are not highly reflective surfaces. They are designed to absorb sunlight and not to reflect it. Nonetheless, photovoltaic panels have a flat polished surface, which omits 'specular' reflectance rather than a 'diffuse' reflectance, which would occur from a rough surface. Several studies have shown that photovoltaic panels (as opposed to Concentrated Solar Power) have similar reflectance characteristics to water,which is much lower than glass, steel, snow and white concrete by comparison (see **Appendix D** for details). Similar levels of reflectance can be found in rural environments from shed roofs and the lines of plastic mulch used in cropping. In terms of the potential for reflectance from photovoltaic panels to cause hazard and/ or nuisance effects, there have been several studies undertaken in respect of schemes in close proximity to airports. The most recent of these was compiled by the Solar Trade Association (STA) in April 2016 which used a number of case studies and expert opinions. The summary of this report states that "the STA does not believe that there is cause for concern in relation to the impact of glint and glare from solar PV on aviation and airports..."[2]

Time Zones / Datum's

2.13. Locations in this report were given in Eastings and Northings using the 'OSNI 1952 Irish National Grid' grid reference system unless otherwise stated. Ireland uses Irish Standard Time (IST, UTC+01:00) in the summer months and Greenwich Mean Time (UTC+0) in the winter period. For the purposes of this report all time references were in GMT, however if reference was made to a time which falls within the IST then this was outlined in the report.

[2]Solar Trade Association. (April 2016). Summary of evidence compiled by the Solar Trade Association to help inform the debate around permitted development for non - domestic solar PV in Scotland. Impact of solar PV on aviation and airports. Available at:
http://www.solar-trade.org.uk/wp-content/uploads/2016/04/STA-glint-and-glare-briefing-April-2016-v3.pdf

3. LEGISLATION AND GUIDANCE

PLANNING POLICY

3.1. The National Planning Framework (NPF) was adopted by the Irish Government on the 29th of May 2018. However, this policy document provides no current provision within the Irish authoPlanning System for the requirement of Glint and Glare Assessments to support applications for the installation of ground mounted solar PV systems. It is therefore considered appropriate to defer to extant policy guidance within the UK planning system; the National Planning Policy Guidance (NPPG) on Renewable and Low Carbon Energy2[3].

3.2. Paragraph 013 sets out planning considerations that relate to large scale ground-mounted solar PV farms. This determines that the deployment of large-scale solar farms can have a negative impact on the rural environment, particularly in undulating landscapes. However, the visual impact of a well-planned and well-screened solar farm can be properly addressed within the landscape if planned sensitively. Considerations to be taken into account by local planning authorities are;

- *"the proposal's visual impact, the effect on landscape of glint and glare and on neighbouring uses and aircraft safety;*
- *the extent to which there may be additional impacts if solar arrays follow the daily movement of the sun."*

INTERIM CAA GUIDANCE – SOLAR PHOTOVOLTAIC SYSTEMS (2010)

3.3. There is little guidance on the assessment of glint and glare from solar arrays with regards to aviation safety. The Civil Aviation Authority (CAA) has published interim guidance on 'Solar Photovoltaic Systems[4]', they also intend to undertake a review of the potential impacts of solar PV developments upon aviation, however this is yet to be published.

3.4. The interim guidance identifies the key safety issues with regards to aviation, including *"glare, dazzling pilots leading them to confuse reflections with aeronautical lights."* It is outlined that solar farm developers should be aware of the requirements to comply with

[3] NPPG Renewable and Low Carbon Energy. Available at: http://planningguidance.communities.gov.uk/blog/guidance/renewable-and-low-carbon-energy/particular-planning-considerations-for-hydropower-active-solar-technology-solar-farms-and-wind-turbines/#paragraph_012

[4] CAA (2010) Interim CAA Guidance – Solar Photovoltaic Systems. Available at: http://www.enstoneflyingclub.co.uk/files/caa_view_on_solar_panel_instalations.pdf?PHPSESSID=8900a41db8a205da84fca7bbc14eae69

the Air Navigation Order (ANO), published in 2009. In particular, developers should take cognisant of the following articles of the ANO[5], including:

- *"**Article 137** – Endangering safety of an aircraft – A person must not recklessly or negligently act in a manner likely to endanger an aircraft, or any person in an aircraft."*

- ***Article 221*** *- Lights liable to endanger – "A person must not exhibit in the United Kingdom any light which:*

  – a) by reason of its glare is liable to endanger aircraft taking off or from landing at an aerodrome; or

  – b) by reason of its liability to be mistaken for an aeronautical ground light liable to endanger aircraft"

- ***Article 222*** *– Lights which dazzle or distract – "A person must not in the United Kingdom direct or shine any light at any aircraft in flight so as to dazzle or distract the pilot of the aircraft."*

3.5. These Articles are considered within the assessment of glint and glare of the Proposed Development.

US FEDERAL AVIATION ADMINISTRATION POLICY

3.6. The US Federal Aviation Administration (FAA) in their Solar Guide (Federal Aviation Authority, 2010)[6] incorporates a chapter on the impact and assessment of glint from solar panels. It concludes that (although subject to revision):

"...evidence suggests that either significant glare is not occurring during times of operation or if glare is occurring, it is not a negative effect and is a minor part of the landscape to which pilots and tower personnel are exposed."

3.7. The current policy (Federal Register, 2013)[7] demands that an ocular impact assessment must be assessed at 1-minute intervals from when the sun rises above the horizon until the sun

[5] CAA (2015) Air Navigation: The Order and Regulations. Available at: http://publicapps.caa.co.uk/docs/33/CAP%20393%20Fourth%20edition%20Amendment%201%20April%202015.pdf

[6] FAA (2010), Technical Guidance for Evaluating Selected Solar Technologies on Airports. Available at: https://www.faa.gov/airports/environmental/policy_guidance/media/airport-solar-guide-print.pdf

[7] FAA (2013), Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports. Available at: https://www.federalregister.gov/documents/2013/10/23/2013-24729/interim-policy-faa-review-of-solar-energy-system-projects-on-federally-obligated-airports

sets below the horizon. Specifically, the developer must use the 'Solar Glare Hazard Analysis Tool' (SGHAT) tool specifically and reference its results as this was developed by the FAA and Sandia National Laboratories as a standard and approved methodology for assessing potential impacts on aviation interests, although it notes other assessment methods may be considered. The SGHAT tool has since been licensed to a private organisation who were also involved in its development and it is the software model used in this assessment.

3.8. Crucially, the policy provides a quantitative threshold which is lacking in the UK guidance. This outlines that a development will not automatically receive an objection on glint grounds if low intensity glint is visible to pilots on final approach. In other words, low intensity glint with a low potential to form a temporary after-image would be considered acceptable under US guidance. Due to the lack of legislation and guidance within the UK, this US document has been utilised as guidance for this report.

3.9. The FAA guidance states that for a solar PV (and therefore any reflective surface) development to obtain FAA approval or to receive no objection, the following two criteria must be met:

- No potential for glint or glare in the existing or planned Air Traffic Control Tower (ATCT); and
- No potential for glare (glint) or "low potential for after-image" along the final approach path for any existing or future runway landing thresholds (including planned or interim phases), as shown by the approved layout plan (ALP). The final approach path is defined as 2 miles from 50 feet above the landing threshold using a standard 3-degree glide path.

3.10. The geometric analysis included later in this report, which defines the extent and time at which glint and glare may occur, is required by the FAA as the methodology to be used when assessing glint and glare impacts on aviation receptors. This report follows the methodology required by the FAA as it offers the most robust assessment method currently available.

THE SOUTH DUBLIN COUNTY COUNCIL DEVELOPMENT PLAN

3.11. The South Dublin County Development Plan 2022-2028 was made on 22nd June 2022 and came into effect on 3rd August 2022.

3.12. The South Dublin County Development Plan sets out the framework to guide future development with the focus placed on the places we live, the places we work, and how we interact and move between these places while protecting our environment. The aim is to progress to a more sustainable development pattern for South Dublin in the immediate and long-term future up to 2040 and beyond.

3.13. Chapter 10's introduction reads:

'The '2021 Climate Action Plan' represents the Government's all of society approach, aimed at enabling Ireland to meet the EU targets to reduce carbon emissions by 51 per cent between 2021 and 2030, and lays the foundations for achieving net zero carbon emissions by 2050. Within that context South Dublin County Council through its strategic County Development Plan seeks to exceed those targets or meet them earlier, creating reliable, robust and efficient energy systems which enable growth across all sectors, and which supports the future development of the County. In line with the LGMAs Delivering on Climate Action 2030, the Council will continue to make every effort to increase energy efficiency and unlock renewable energy potential in the County. '

3.14. In the same chapter, the E7 solar power policy states one of the objectives:

' Promote the development of solar energy infrastructure in the County, including the building of integrated and commercial-scale solar projects subject to a viability assessment and environmental safeguards including the protection of natural or built heritage features, biodiversity and views and prospects.'

4. METHODOLOGY

4.1. A desk-based assessment was undertaken to identify when and where glint and glare may be visible at aviation receptors within the vicinity of the Proposed Development, throughout the day and the year.

SUN POSITION AND REFLECTION MODEL

Sun Data Model

4.2. The calculations in the solar position calculator are based on equations from Astronomical Algorithms[8]. The sunrise and sunset results are theoretically accurate to within a minute for locations between +/- 72° latitude, and within 10 minutes outside of those latitudes. However, due to variations in atmospheric composition, temperature, pressure, and conditions, observed values may vary from calculations.

Solar Reflection Model

4.3. The position of the sun is calculated at one-minute intervals of a typical year, in this instance the year assessed is 2022.

4.4. To determine if a reflection will reach a receptor, the following variables are required:

- Sun position;
- Observer location; and
- Tilt, orientation, and extent of the modules in the solar array.

4.5. The model assumes that the azimuth and horizontal angle of the sun is the same across the whole solar farm. This is considered acceptable due to the distance of the sun from the Proposed Development and the miniscule differences in location of the sun over the Proposed Development.

4.6. Once the position of the sun is known for each time interval, a vector reflection equation determines the reflected sun vector, based on the normal vector of the solar array panels.

This assumes that the angle of reflection is equal to the angle of incidence reflected across a normal plane. In this instance, the plane being the vector which the solar panels are facing.

[8] Jean Meeus, Astronomical Algorithms (Second Edition), 1999

4.7. On knowing the vector of the solar reflection, the azimuth is calculated and the horizontal reflection from multiple points within the solar farm. These are then compared with the azimuth and horizontal angle of the receptor from the solar farm to determine if it is within range to receive solar reflections.

4.8. The solar reflection in the model is considered to be specular as a worst-case scenario. In practice, the light from the sun will not be fully reflected as solar panels are designed to absorb light rather than reflect it. The previous text and **Appendix D** outline the reflective properties of solar glass and compares it to other reflective surfaces. Although the exact figures in this report are not conclusive, it is included as a visual guide and it agrees with most other reports, in that solar glass has less reflective properties than other types of glass and that the amount of reflective energy decreases as the angle of incidence decreases.

4.9. Most modern panels have a slight surface texture which should have a small effect on diffusing the solar radiation further; although, this has not been modelled to conform with the worst-case scenario assessment.

Determination of Ocular Impact

4.10. The software used for this assessment is based on the Sandia Laboratories Solar Glare Hazard Analysis Tool (SGHAT). This tool is specifically mentioned in the FAA guidance as the software which should be used in this type of assessment.

4.11. Determination of the ocular impact requires knowledge of the direct normal irradiance, PV module reflectance, size and orientation of the array, optical properties of the PV module, and ocular parameters. These values are used to determine the retinal irradiance and subtended source angle used in the ocular hazard plot.

4.12. The ocular impact[9] of viewed glare can be classified into three levels based on the retinal irradiance and subtended source angle: low potential for after-image (green), potential for after-image (yellow), and potential for permanent eye damage (red).

4.13. Green glare can be ignored when looking at ground based and some aviation receptors. Green glare does not cause temporary flash blindness and happens at an instant with very slight disturbance. As per FAA guidelines mitigation is only required for green glare when affecting an Air Traffic Control Tower, but not for when affecting pilots. Therefore, it can be assumed that green glare is acceptable for ground-based receptors.

[9] Ho, C.K., C.M. Ghanbari, and R.B. Diver, 2011, Methodology to Assess Potential Glint and Glare Hazards From Concentrating Solar Power Plants: Analytical Models and Experimental Validation, Journal of Solar Energy Engineering-Transactions of the Asme, 133(3).

4.14. The subtended source angle represents the size of the glare viewed by an observer, while the retinal irradiance determines the amount of energy impacting the retina of the observer. Larger source angles can result in glare of high intensity, even if the retinal irradiance is low.

Relevant Parameters of the Proposed Development

4.15. For an easier understanding, solar panels have been grouped into 1 figure(PV1) as shown in figure 1 (same figure is in Appendix A in a larger scale).

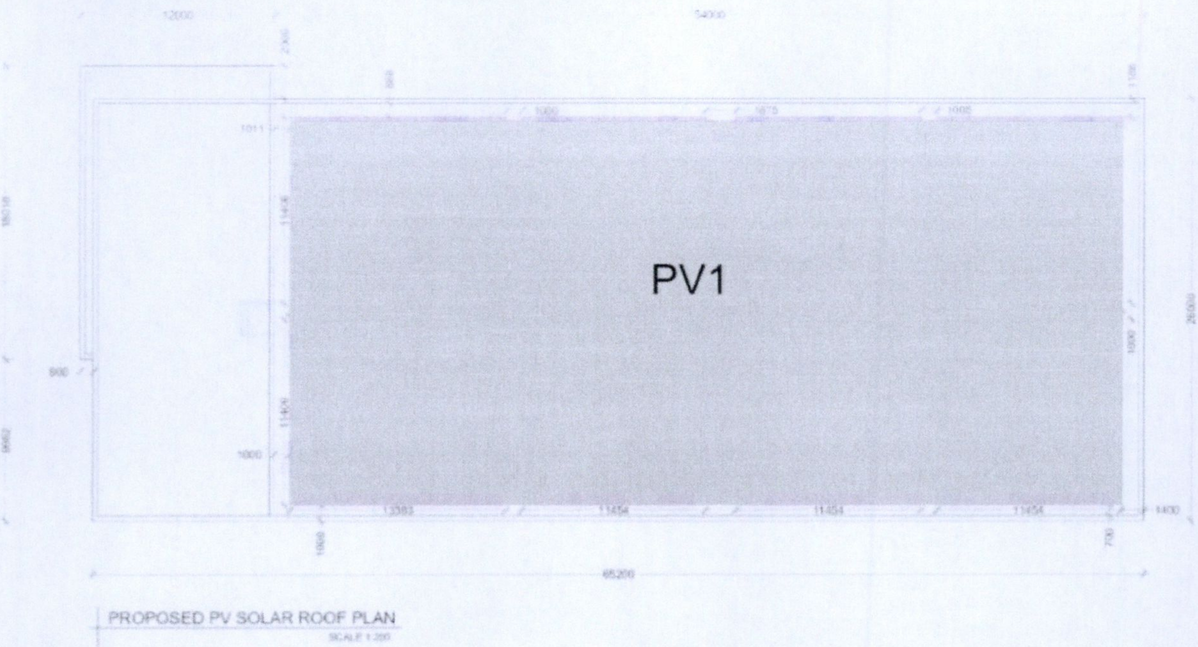


figure 1

4.16. The photovoltaic (PV) panels are oriented in different directions as seen in the box below (to align with the undulation of the roof and will remain in a fixed position throughout the day and during the year (i.e. they will not rotate to track the movement of the sun). The panels will be the panels will be analysed considering the following conditions:

NAME	ORIENTATION	TILT	AREA
PV1	164.0	3	1074.00

4.17. The maximum height of the building is 6.10 m, so this will be the height that is used to determine the worst-case scenario for potential glint and glare.

IDENTIFICATION OF RECEPTORS

Aviation

4.18. Glint is only considered to be an issue with regards to aviation safety when the solar development lies within proximity to a runway, particularly when the aircraft is descending to land. En-route activities are not considered an issue as the flight will most likely be at a higher altitude than the solar reflection.

4.19. Should a solar development be proposed within the safeguarded zone of an aerodrome, a full geometric study may be required (depending on the orientation from the Proposed Development) which would determine if there is potential for glint and glare at key locations, most likely on the descent to land. This assessment has been produced in response to The South Dublin County Council's request for a glint and glare assessment to be undertaken.

4.20. Buffer zones to identify aviation assets vary depending on the safeguarding criteria of that asset. All aerodromes within 30km will be identified, however generally the detailed assessments are only required within: 20km for large international aerodromes, 10km for military aerodromes and 5km for small aerodromes.

MAGNITUDE OF IMPACT

Moving Receptors (Aviation)

Approach Paths

4.21. Each final approach path which has the potential to receive glint is assessed using the Solar Glare Hazard Analysis Tool (SGHAT) model. The model assumes an approach bearing on the runway centreline, a 3-degree glide path with the origin 50ft (15.24m) above the runway threshold.

4.22. The computer model considers the pilot's field of view. The azimuthal field of view ("AFOV") or horizontal field of view ("HFOV") as it is sometimes referred to, refers to the extents of the pilot's horizontal field of view measured in degrees left and right from directly in front of the cockpit. The vertical field of view ("VFOV") refers to the extent of the pilot's vertical field of view measured in degrees from directly in front of the cockpit. The HFOV is modelled at 90 degrees left and right from the front of the cockpit whilst the VFOV is modelled at 30 degrees.

4.23. The FAA guidance states that there should be no potential for glare or "low potential for after image" at any existing or future planned runway landing thresholds in order for the proposed Development to be acceptable.

Air Traffic Control Tower (ATCT)

4.24. An air traffic controller uses the visual control room to monitor and direct aircraft on the ground, approaching and departing the aerodrome. It is essential that air traffic controllers have a clear and unobstructed view of aviation activity. The key areas on an aerodrome are the views towards the runway thresholds, taxiways, and aircraft bays.

4.25. The FAA guidance states that no solar reflection towards the ATCT should be produced by a proposed solar development, however this should be assessed on a site by site basis and will depend on the operations at a particular aerodrome.

4.26. In order to determine the impact on the ATCT, the location and height of the tower will need to be fed into the SGHAT model and where there is a potential for 'low potential for After Image' or more, then mitigation measures will be required.

ASSESSMENT LIMITATIONS

4.27. Below is a list of assumptions and limitations of the model and methods used within this report:

- The model does not consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc;
- The model does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results;
- Due to variations in atmospheric composition, temperature, pressure and conditions, observed values may vary slightly from calculated positions; and
- The model does not account for the effects of diffraction; however, buffers are applied as a factor of safety.

5. BASELINE CONDITIONS

Aviation Receptors

5.1. Aerodromes within 30km of the proposed solar development can be found in Table **5-1**.

Table 5-1: Airfields within 20km of the Proposed Development

Airfield	Distance (km)	Use
Casement Aerodrome	6.64	Aerodrome
Dublin Airport	16.05	Airport
Tallaght Hospital Helipad	1.48	Helipad
Weston Airport	11.4	Airport
Ballyboughal Aerodrome	25.69	Aerodrome
Gowran Grange Aerodrome	22.18	Aerodrome
Dolly's Grove Airfield	19.73	Airfield
Millicent Airfield	22.16	Airfield
Ellistown Airstrip	28.57	Airstrip
Moyglare Airfield	22.89	Airfield

5.2. The Proposed Development is located within the safeguarding buffer zones of aviation assets. Casement Aerodrome, Dublin Airport, Tallaght Hospital Helipad and Weston Airport, require a detailed assessment.

5.3. As Ballyboughal Aerodrome, Gowran Grange Aerodrome, Dolly's Grove Airfield, Millicent Airfield, Ellistown Airstrip, Moyglare Airfield are not large and does not fall within 5km of the Proposed Development, there is no need for a detailed assessment. This is in accordance with what was outlined in the methodology chapter above.

Tallaght Hospital Helipad

5.4. Tallaght Hospital Helipad is used primarily by the hospital for the transportation of patients into the hospital. Due to the random nature at which a helicopter can approach a helipad, all directions will be assessed in detail. Each direction that is mentioned in **Table 5-2** is the direction in which the helicopter will approach the helipad from. I.e. North will mean that the helicopter is travelling from north to south

Table 5-2: Tallaght Hospital Helipad Approach paths

Helipad Approach	Bearing (°)
North	180.00
Northeast	225.00
East	270.00
Southeast	315.00
South	360.00
Southwest	045.00
West	090.00
Northwest	135.00

5.5. Each direction will be assessed as a 2-mile flight path to ensure that every possible approach into the helipad can be assessed.

Casement Aerodrome

5.6. Casement Aerodrome (ICAO code EIME) is designated as a Military Aerodrome. It is located approximately 7NM (13 km) southwest of the city of Dublin. For the Casement Aerodrome Chart **See Figure 7: Appendix A.**

5.7. The elevation of the aerodrome at the Aerodrome Reference Point (ARP) is 319ft (97.23m). It has two asphalt strip runways, details of which are given in Table **5-3**.

Table 5-3: Runways at Casement Aerodrome

Runway Designation	True Bearing (°)	Length (m)	Width (m)
04	040.93	1462	45
10	101.93	1828	45
22	220.93	1462	45
28	281.93	1828	45

5.8. The threshold locations and heights of the runways at Casement Aerodrome are given in **Table 5-4.**

Table 5-4: Runway Threshold Locations and Heights

Runway Designation	Threshold Latitude	Threshold Longitude	Height AOD (m)
04	53° 17′ 36.90″ N	006° 27′ 13.73″ W	96.93
10	53° 18′ 16.88″ N	006° 28′ 07.75″ W	97.23
22	53° 18′ 12.63″ N	006° 26′ 22.02″ W	92.66
28	53° 18′ 05.85″ N	006° 26′ 40.68″ W	96.01

5.9. The Airfield Reference Point (ARP) is located at the midpoint of the main runway. The actual location of the ARP is given in Table **5-5**. This table also shows the location and height of the ATCT.

5.10. The overall height above local ground level of the Control Tower Building has been estimated as 15m using photographs of the installation as a guide and referencing them to everyday objects.

Table 5-5: Casement Aerodrome Airfield Reference Point

	Latitude	Longitude	Eastings	Northings
ARP	53° 18′ 11″ N	006° 27′ 19″ W	103277	387719
ATCT	53° 18′ 20″ N	006° 26′ 30″ W	104192	387932

Weston Airport

5.11. Weston Airport (ICAO code EIWT) is designated as a Civil Aerodrome. It is located approximately 8NM (14.82 km) west of the city of Dublin. For the Weston Airport Chart **See Figure 6: Appendix A.**

5.12. The elevation of the aerodrome at the Aerodrome Reference Point (ARP) is 155ft (47.24m). It has two asphalt strip runways, details of which are given in **Table 5-6**.

Table 5-6: Runways at Weston Airport

Runway Designation	True Bearing (°)	Length (m)	Width (m)
07	063.30	924	24
25	243.27	924	25

5.13. The threshold locations and heights of the runways at Weston Airport are given in Table **5-7**.

Table 5-7: Runway Threshold Locations and Heights

Runway Designation	Threshold Latitude	Threshold Longitude	Height AOD (m)
07	53° 21′ 01.48″ N	006° 29′ 40.17″ W	47.24
25	53° 21′ 15.03″ N	006° 28′ 55.66″ W	46.33

5.14. The Airfield Reference Point (ARP) is located at the midpoint of the main runway. The actual location of the ARP is given in **Table 5-8**. This table also shows the location and height of the ATCT.

5.15. The overall height above local ground level of the Control Tower Building has been estimated as 15m using photographs of the installation as a guide and referencing them to everyday objects.

5.16. The ground height at the base of the Control Tower Building has been estimated as 49.7m AOD using google earth.

Table 5-8: Weston Aerodrome Airfield Reference Point

	Latitude	Longitude	Eastings	Northings
ARP	53° 21′ 08″ N	006° 29′ 17″ W	101420	393329
ATCT	53° 21′ 20″ N	006° 29′ 22″ W	101370	393704

Dublin Airport

5.17. Dublin Airport (ICAO code EIDW) is designated as an International Civil Aerodrome. It is located approximately 5.3NM (10 km) north of the city of Dublin, Ireland. For the Dublin Airport Aerodrome Chart **See Figure 5: Appendix A.**

5.18. The elevation of the aerodrome at the Aerodrome Reference Point (ARP) is 242ft (73.76m). It has four asphalt strip runways, details of which are given in **Table 5-9**.

5.19. Work has already been finalised on the construction of a new ATCT at Dublin Airport. The new tower is required in order to provide clear sightlines to the planned parallel Northern Runway (which will be designated 10L and 28R, with the existing 10-28 runway being re-designated 10R and 28L). The new runway and ATCT, as well as all the existing ones have been considered in this assessment.

Table 5-9: Runways at Dublin Airport

Runway Designation	True Bearing (°)	Length (m)	Width (m)
10L	095.24	3,110	45
10R	095.24	2,637	45
28L	275.27	2,637	45
28R	275.27	3,110	45
16	156.58	2,072	61
34	336.59	2,072	61

5.20. The threshold locations and heights of the runways at Dublin Airport are given in **Table 5-10**.

Table 5-10: Runway Threshold Locations and Heights

Runway Designation	Threshold Latitude	Threshold Longitude	Height AOD (m)
10L	53° 26′ 13.811″ N	006° 16′ 49.010″ W	71.94
10R	53° 25′ 20.75″ N	006° 17′ 24.27″ W	73.76
28L	53° 25′ 12.94″ N	006° 15′ 02.08″ W	61.57
28R	53° 26′ 6.191″ N	006° 14′ 45.479″ W	63.44
16	53° 26′ 13.16″ N	006° 15′ 43.12″ W	66.14
34	53° 25′ 11.66″ N	006° 14′ 58.54″ W	61.57

5.21. The Airfield Reference Point (ARP) is located at the midpoint of the main runway. The actual location of the ARP is given in **Table 5-11**. This table also shows the locations of the old and new ATCTs.

5.22. The overall height above local ground level of the old ATCT is 22m and the new ATCT is going to be 86.9m tall.

Table 5-11: Dublin Airport Airfield Reference Point

	Latitude	Longitude	Eastings	Northings
ATCT(New)	53° 25′ 44″ N	006° 15′ 52″ W	116820	400930
ATCT	53° 25′ 42″ N	006° 15′ 43″ W	116983	400858
ARP	53° 25′ 17″ N	006° 16′ 12″ W	116402	400118

6. IMPACT ASSESSMENT

6.1. Following the methodology outlined earlier in this report, geometrical analysis comparing the azimuth and horizontal angle of the receptors from the Proposed Development and the solar reflection was conducted. Although this assessment did not consider obstructions such as intervening vegetation and buildings, discussion on the potentially impacted receptors is provided where necessary.

AVIATION RECEPTORS

6.2. Table **6-1** shows a summary of the modelling results for each of the runway approach paths as well at the ATCT whilst the detailed results and ocular impact charts can be viewed in **Appendix C**.

Table 6-1: Summary of Component Glare Results

Runway Approach	Results: Predicted reflection times (GMT)		Glare Type			Remarks
	am	pm				
FP 1 Casement Aerodrome	-	-	-	-	-	No impact predicted
FP 2 Casement Aerodrome	-	-	-	-	-	No impact predicted
FP 3 Casement Aerodrome	-	-	-	-	-	No impact predicted
FP 4 Casement Aerodrome	-	-	-	-	-	No impact predicted
FP 5 Dublin Airport	-	-	-	-	-	No impact predicted
FP 6 Dublin Airport	-	-	-	-	-	No impact predicted
FP 7 Dublin Airport	-	-	-	-	-	No impact predicted
FP 8 Dublin Airport	-	-	-	-	-	No impact predicted
FP 9 Dublin Airport	-	-	-	-	-	No impact predicted
FP 10 Dublin Airport	-	-	-	-	-	No impact predicted
FP 11 Tallaght Hospital Helipad	-	-	-	-	-	No impact predicted
FP 12 Tallaght Hospital Helipad	-	-	-	-	-	No impact predicted
FP 13 Tallaght Hospital Helipad	-	14:00 to 18:00	High	-	-	Green Glare

FP 14 Tallaght Hospital Helipad	-	-	-	-	-	No impact predicted
FP 15 Tallaght Hospital Helipad	-	-	-	-	-	No impact predicted
FP 16 Tallaght Hospital Helipad	-	13:00 to 14:00	Low	-	-	Green Glare
FP 17 Tallaght Hospital Helipad	-	-	-	-	-	No impact predicted
FP 18 Tallaght Hospital Helipad	-	-	-	-	-	No impact predicted
FP 19 Weston Airport	-	-	-	-	-	No impact predicted
FP 20 Weston Airport	-	-	-	-	-	No impact predicted
OP 1 Dublin Old Tower	-	-	-	-	-	No impact predicted
OP 2 Dublin New Tower	-	-	-	-	-	No impact predicted
OP 3 Casement	-	-	-	-	-	No impact predicted
OP 4 Weston	-	-	-	-	-	No impact predicted

6.3. As can be seen in Table **6-1** , only green glare is expected to impact the runways,at FP 13 and FP 16 at Tallaght Hospital Helipad . Green glare is described as 'Low Potential for After Image' which is an **acceptable impact** when pilots are approaching runways/helipads, according to the FAA guidance. The impact on approach at those runways is therefore deemed as **not significant**.

No glare is expected on the rest of the runways and in any of the ATCT.Therefore, the impacts can be reduced to **None** and **Not Significant**.

6.4. It must be emphasised at this point that all results, whether from FAA endorsed SGHAT software or our own proprietary software, are theoretical by default, in that they assume that the sun is always shining and at full intensity. The results do not account for climate and inherent weather patterns that occur across the island of Ireland. According to the Met Eireann website (https://www.met.ie/), the monthly averages of daily duration of sunshine are approximately **44% of daylight hours** in the vicinity of the site. While we cannot correlate the exact periods of sunlight with our predicted periods of potential glare, it is clear that the figures for the periods and duration of glare listed in this report are conservative and would likely be subject to a substantial reduction in reality. Therefore, the impact is reduced to **None** and **not significant**.

6.5. Ireland normally gets between 1100 and 1600 hours of sunshine each year. The sunniest months are May and June. During these months, sunshine duration averages between 5 and 6.5 hours per day over most of the country. The extreme southeast gets the most sunshine, averaging over 7 hours a day in early summer. Therefore, the impacts can be reduced to **None** and **Not Significant**.

6.6. It is important to note that the user manual for Sandia National Laboratories SGHAT states "SGHAT does not consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc." hence it is likely that impacts will be far lower than predicted due to intervening screening. Therefore, the impacts can be reduced to **None** and **Not Significant**.

7. SUMMARY

7.1. This Aviation Glint and Glare Assessment glint and glare assessment has been produced in response to South Dublin County Council request (**planning reference No. SD22A/0339**). This aviation glint and glare assessment has been undertaken in relation to the instalment of a solar array on a roof on lands approximately 6.3 km southeast of Casement Aerodrome.

7.2. There is no guidance or policy available across Ireland in relation to the assessment of glint and glare from Proposed Development. However, as identified by UK policy, it is recognised as a potential impact which needs to be considered for a proposed solar development.

7.3. A 30km study area is chosen for receptors.4 aviation assets are located within 30km of the Proposed Development: Casement Aerodrome, Dublin Airport , Tallaght Hospital Helipad and Weston Airport. The receptor/s mentioned will require a detailed assessment due to the Proposed Development falling within their respective safeguarding buffer zones outlined in paragraph 4.19.

7.4. Geometric analysis was conducted for 12 runway approach paths, 8 helipad approach paths, and 4 Air Traffic Control Towers (ATCTs) at Dublin Airport, Weston Airport, Tallaght Hospital Helipad, and Casement Aerodrome.

7.5. The assessment concludes that:

- Casement Aerodrome: **No impact is predicted.**
- Dublin Airport: **No impact is predicted.**
- Tallaght Hospital Helipad: Green Glare (Low potential for after-image) was predicted at FP 13 and FP 16, which is an **acceptable impact** according to the FAA guidelines for the runways and can be deemed **not significant**.
- Weston Airport: **No impact is predicted.**

7.6. Overall impacts on aviation receptors are **acceptable and not significant.**

8. APPENDICES

APPENDIX A: FIGURES

- APPENDIX A: FIGURE 1 Site Layout Map
- APPENDIX A: FIGURE 2 Existing and Proposed Solar PV panel Roof Plan
- APPENDIX A: FIGURE 3 Proposed Solar PV Elevations
- APPENDIX A: Figure 4 Ground Elevation Profile
- APPENDIX A: FIGURE 5 Dublin Airport Chart
- APPENDIX A: FIGURE 6 Weston Airport Chart
- APPENDIX A: FIGURE 7 Casement Aerodrome Chart

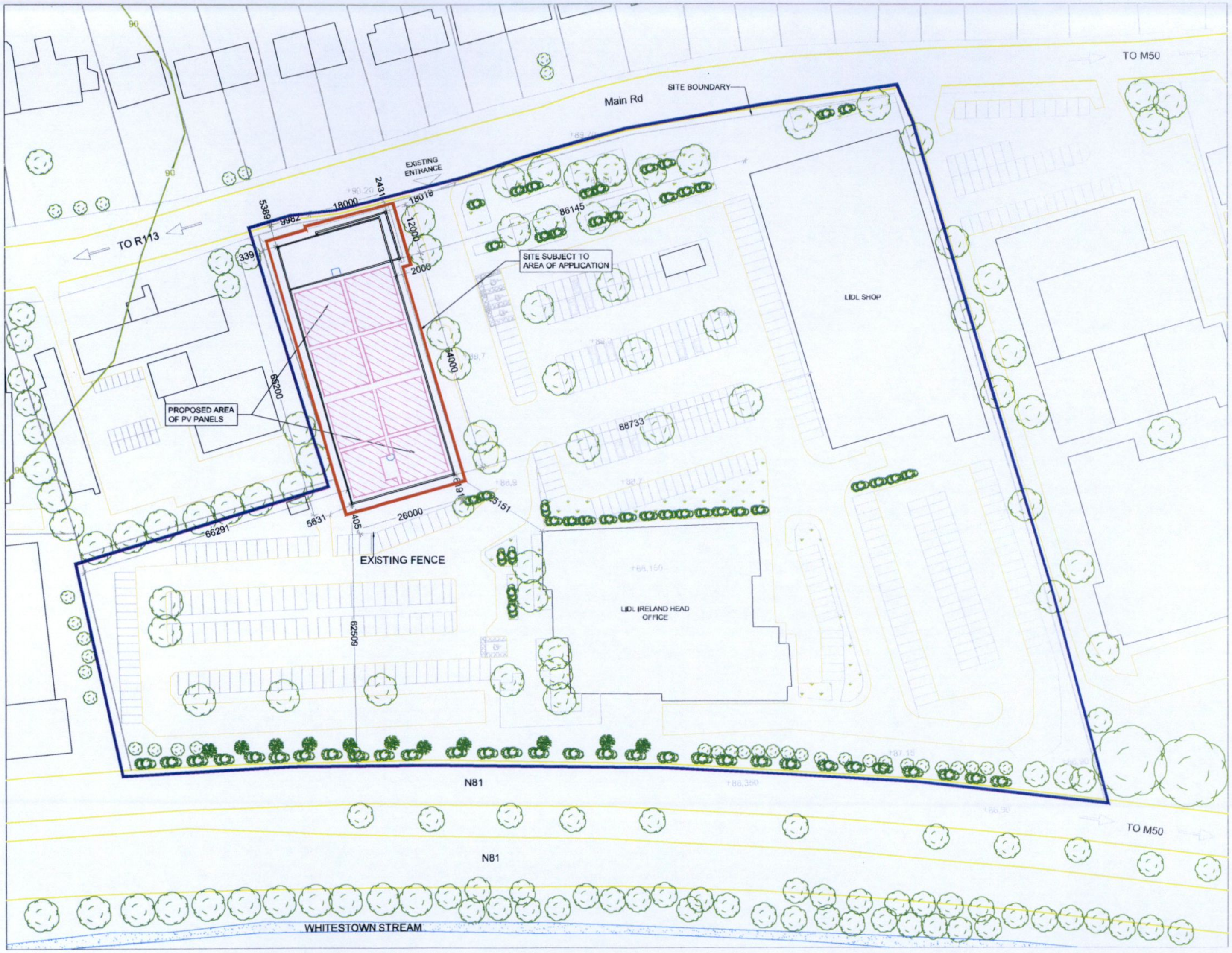
APPENDIX B: GLARE ANALYSIS REPORT RESULTS

APPENDIX C: AVIATION RECEPTOR GLARE RESULTS

APPENDIX D: SOLAR MODULE GLARE AND REFLECTANCE TECHNICAL MEMO

MOVEO S.A.

APPENDIX A: FIGURE 1 SITE LAYOUT MAP



Site subject to planning application outlined in solid RED.	
Adjacent lands under the control of the applicant outlined in BLUE.	
Stream outlined in BLUE	
Waysleaves outlined in YELLOW.	

	Grass
	Trees
	Small Shrubs. Boundary. Natural fence
	Big Shrubs. Boundary. Natural fence

N
W E
S

Grid Reference: O 09769 27646

X(Easting): 309769
Y(Northing): 227646

Centre Point Coordinates (ITM):

X(ITM) : 709711
Y(ITM) : 727671

JOB : Proposed Solar Panels at Commercial Building-Lidl Complex, Main Rd, Tallaght, Dublin 24

CLIENT: Lidl Ireland GMBH

TITLE: Site Layout Plan.

PLAN No.: 02

SCALE: 1:500@A1

Rev A Rev A 18/07/2022
Drawing by Elena Vazquez

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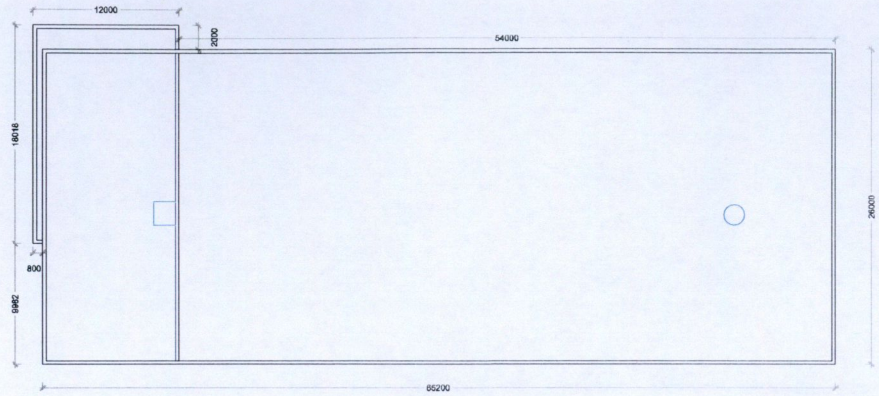
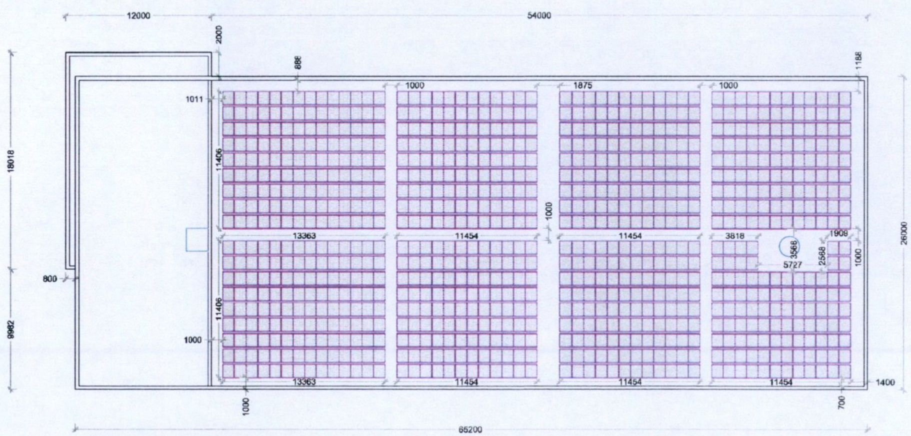
APPENDIX A: FIGURE 2 EXISTING AND PROPOSED SOLAR PV PANEL ROOF PLAN



EXISTING ROOF PLAN
SCALE 1:200



PROPOSED PV SOLAR ROOF PLAN
SCALE 1:200

*** or Similar Panels

JOB :	Proposed Solar Panels at Commercial Building-Lidl Complex, Main Rd, Tallaght, Dublin 24
CLIENT:	Lidl Ireland GMBH
TITLE:	Existing Roof Plan and Proposed PV Solar Roof Plan
PLAN No.:	04
SCALE:	1:200@A1

Rev A 18/07/2022
Drawing by Elena Vazquez

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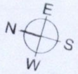
3. This drawing is to be read in conjunction with all revelant structural, services and architectural drawings, specifications and schedules.
4. All dimension are in millimeters and levels in meters unless note otherwise.

TOTAL PANELS = 444 panels

444 Panels x 460 Wp = 204.2 kWp



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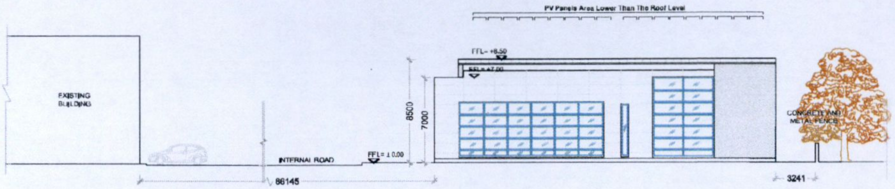
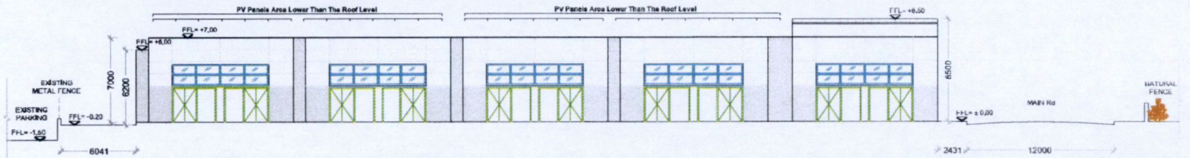
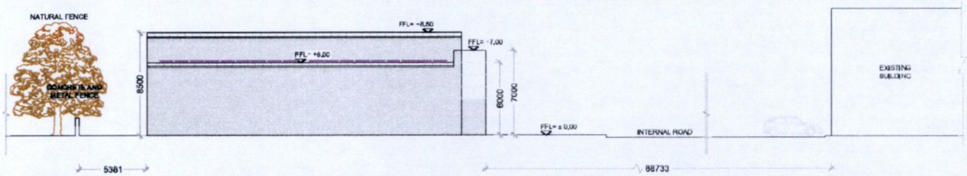
APPENDIX A: FIGURE 3 PROPOSED SOLAR PV ELEVATIONS



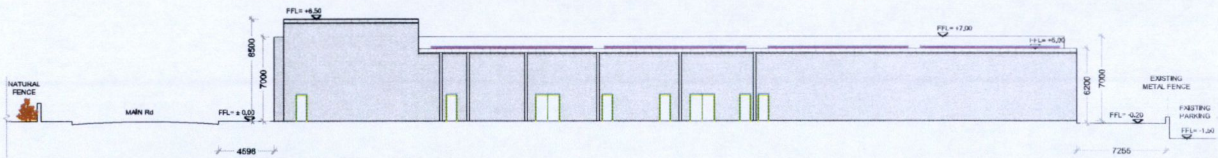
PROPOSED SOLAR PV NORTH ELEVATION
SCALE 1:200



PROPOSED SOLAR PV EAST ELEVATION
SCALE 1:200

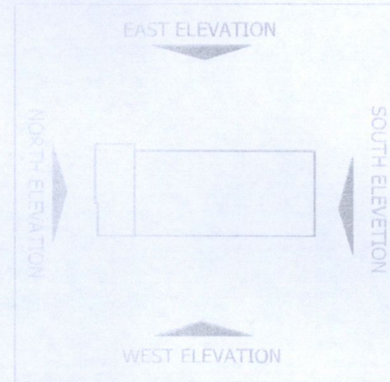


PROPOSED SOLAR PV SOUTH ELEVATION
SCALE 1:200



PROPOSED SOLAR PV WEST ELEVATION
SCALE 1:200

KEY PLAN
SCALE : NTS



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4. All dimension are in millimeters and levels in meters unless note otherwise.

JOB :	Proposed Solar Panels at Commercial Building-Lidl Complex, Main Rd, Tallaght, Dublin 24
CLIENT:	Lidl Ireland GMBH
TITLE:	Proposed PV Solar Elevations Plan
PLAN No.:	06
SCALE:	1:200@A1

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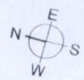

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Appendix A: Figure 5 Ground Elevation Profile

ELEVATION PROFILE BETWEEN PROPOSED DEVELOPMENT AND CASEMENT AERODROME ATCT

High Point

Proposed Development

Casement Aerodrome ATCT

Appendix A: Figure 5 Ground Elevation Profile

ELEVATION PROFILE BETWEEN PROPOSED DEVELOPMENT AND DUBLIN AIRPORT OLD ATCT

High Point

Proposed Development

Dublin Airport Old ATCT

Appendix A: Figure 5 Ground Elevation Profile

ELEVATION PROFILE BETWEEN PROPOSED DEVELOPMENT AND DUBLIN AIRPORT NEW ATCT

High Point

Proposed Development

Dublin Airport New ATCT

Appendix A: Figure 5 Ground Elevation Profile

ELEVATION PROFILE BETWEEN PROPOSED DEVELOPMENT AND WESTON AIRPORT ATCT

High Point

Proposed Development

Newton Airport ATCT

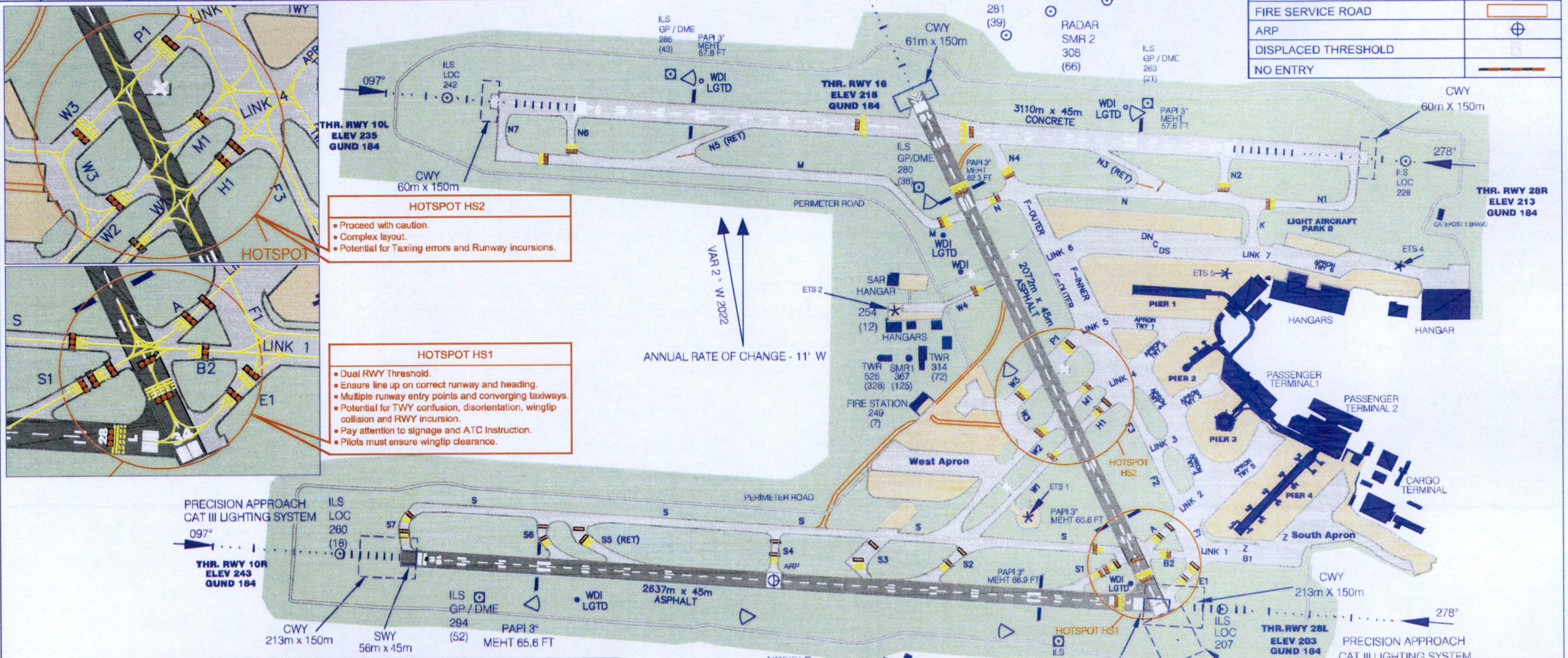
APPENDIX A: FIGURE 5 DUBLIN AIRPORT CHART

AERODROME CHART - ICAO	53 25 17 N 006 16 12 W ELEV 243 FT	TWR 118.600MHz ATIS 124.530 GND 121.800MHz CLEARANCE DELIVERY 122.985 GND 125.885MHz

RWY	DIRECTION	THR		BEARING STRENGTH
10R	97°	53 25 20.75 N	006 17 24.27 W	PCN 92/R/B/W/T
28L	278°	53 25 12.94 N	006 15 02.08 W	
16	159°	53 26 13.16 N	006 15 43.12 W	PCN 84/R/B/W/T
34	339°	53 25 11.66 N	006 14 58.54 W	
10L	97°	53 26 13.79 N	006 16 50.22 W	PCN 114/R/C/W/T
28R	278°	53 26 06.73 N	006 14 41.87 W	

CONSULT NOTAM FOR LATEST INFORMATION — **DUBLIN AIRPORT/ IRELAND**

LEGEND	
RVR	
DISUSED PAVEMENT	
STOPBAR	
RUNWAY HOLDING POSITION MARKINGS	
HOT SPOT	
CLEARWAY	
STOPWAY	
ENGINE TEST SITE, ETS	
FIRE SERVICE ROAD	
ARP	
DISPLACED THRESHOLD	
NO ENTRY	



NOTE 1	RWY 10R/28L IS PROVIDED WITH 7.5M WIDE ASPHALT SHOULDERS
NOTE 2	RWY 10L/28R IS PROVIDED WITH 7.5M WIDE CONCRETE SHOULDERS
NOTE 3	ALL TAXIWAYS 23M WIDE EXCEPT TWY W4: 15M, LINK 1: 33M, LINK 2: 65M, LINK 3: 42M, LINK 4: 73M, B1, B2 AND N1: 24M, S5: 30M, F1, M1 AND W2: 25M, N2: 27M, N6: 26M, N7: 25M.
NOTE 4	TAXIWAYS S5, N3, AND N5 ARE THE ONLY RAPID EXIT TAXIWAYS (RET) AT DUBLIN AIRPORT
NOTE 5	BEARINGS ARE MAGNETIC
NOTE 6	LINEAR DIMENSION IN METRES
NOTE 7	ELEVATIONS IN FEET AMSL
NOTE 8	HEIGHT IN FEET ABOVE AERODROME ELEVATION SHOWN IN BRACKETS

CHANGES: New Northern Runway, New Note 2 and Note 3 revised along with old Note 8 removed and New Legend.

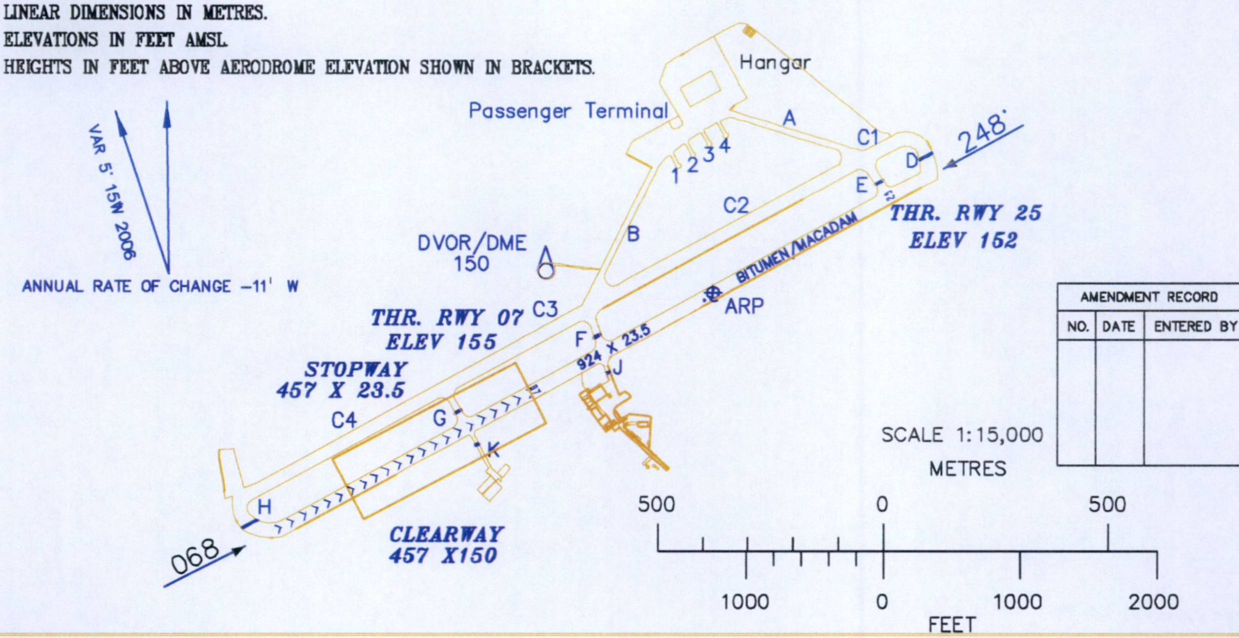
APPENDIX A: FIGURE 6 WESTON AIRPORT CHART

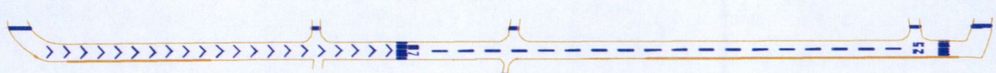
AERODROME CHART - ICAO	53 21 08.25 N 006 29 17.92 W	ELEV 155FT	TWR 122.4 GND 119.425 ATIS 118.875	CONSULT NOTAM FOR LATEST INFORMATION	WESTON AIRPORT/ DUBLIN

RWY	DIRECTION	THR		BEARING STRENGTH
07	068°	53 21 01.48 N	006 29 40.17 W	PCN 45/F/A/W/T
25	248°	53 21 15.03 N	006 28 55.66 W	

LEGEND	
HELICOPTER STANDS	1
RUNWAY HOLDING POSITION MARKING	

BEARINGS ARE MAGNETIC.
LINEAR DIMENSIONS IN METRES.
ELEVATIONS IN FEET AMSL.
HEIGHTS IN FEET ABOVE AERODROME ELEVATION SHOWN IN BRACKETS.





MARKING AIDS RUNWAY 07/25

NIL

LIGHTING AIDS RUNWAY 07/25

Helicopter Stand	Latitude	Longitude	Max Wingspan	Max Length	Conditions
01	53 21 17.18 N	006 29 22.05 W			
02	53 21 17.96 N	006 29 20.18 W			
03	53 21 18.67 N	006 29 18.25 W			
04	53 21 19.31 N	006 29 16.26 W			

NOTE 1: TAXIWAY AND APRON : PCN 45/F/A/W/T.
NOTE 2: TAXIWAY C1, C2, C3 AND C4: 30M WIDE.
NOTE 3: TAXIWAY A, B, D, E, F, G, H AND J: 16M WIDE.
NOTE 4: TAXIWAY K: 7M WIDE.

CHANGES: *NEW ARP COORDINATES; NEW THRESHOLD COORDINATES FOR RUNWAY 25 AND 07; NEW THRESHOLD ELEVATION RUNWAY 07*

APPENDIX A: FIGURE 7 CASEMENT AERODROME CHART

AERODROME CHART ICAO N 53°18'10.77" W 006°27'19.46" ELEV 319ft

TWR 123.500
GND 121.755
ATIS 122.805

CONSULT NOTAM FOR LATEST INFORMATION

BALDONNEL/CASEMENT

RWY	DIRECTION	THR	BEARING STRENGTH
04	044°	N 53°17'36.90" W 006°27'13.73"	PCN 46/F/D/W/T
10	105°	N 53°18'16.88" W 006°28'07.75"	PCN 52/F/D/W/T
22	224°	N 53°18'12.63" W 006°26'22.02"	PCN 46/F/D/W/T
28	285°	N 53°18'05.85" W 006°26'40.68"	PCN 52/F/D/W/T

BEARINGS ARE MAGNETIC.

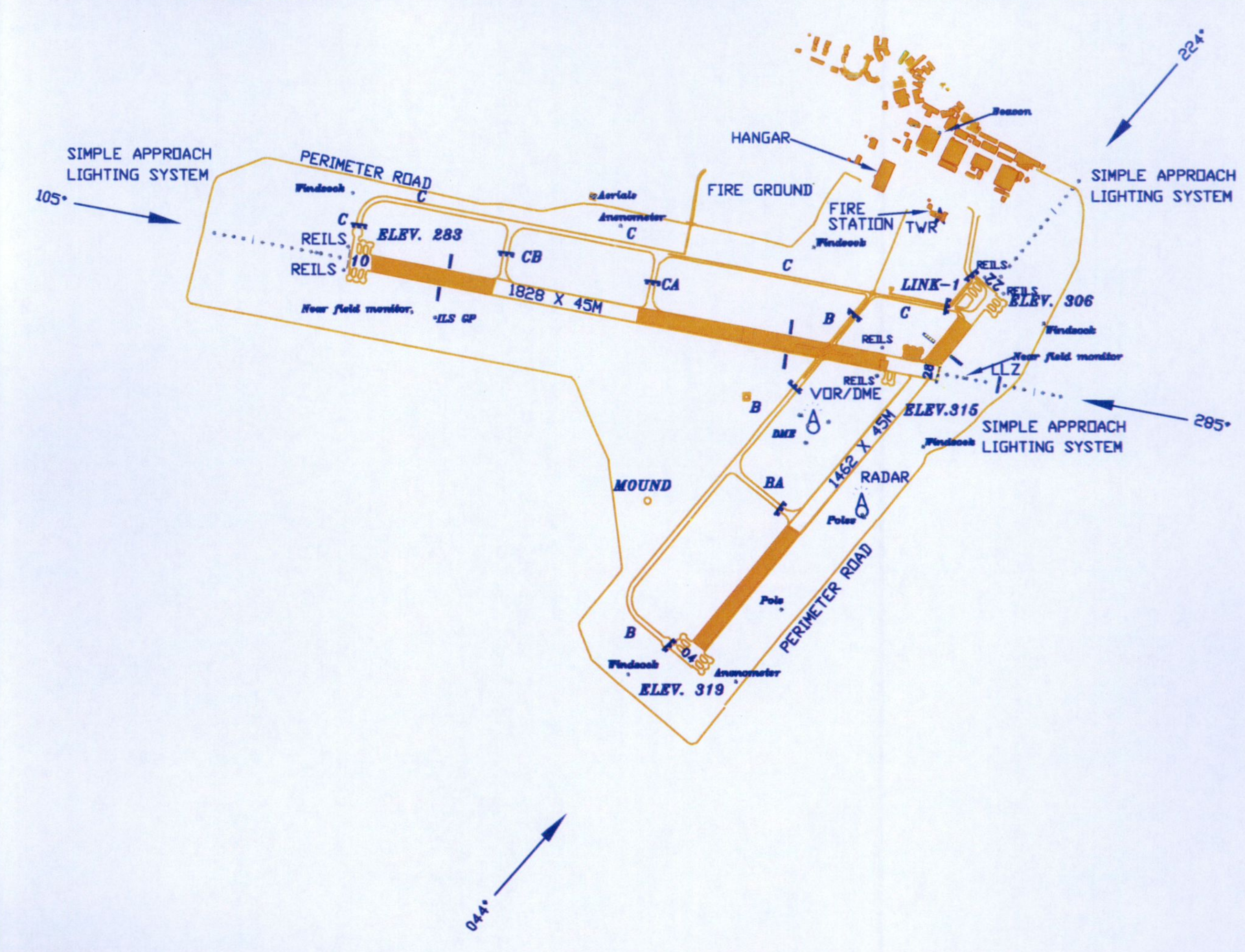
ELEVATIONS SHOWN IN FEET AMSL.

HEIGHTS IN FEET ABOVE AERODROME ELEVATION SHOWN IN BRACKETS.

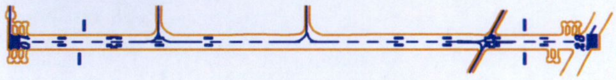
LINEAR DIMENSIONS IN METRES.

VAR 3° W 2019

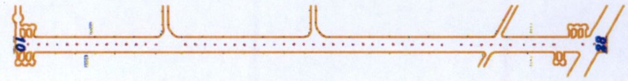
ANNUAL RATE OF CHANGE -11' W



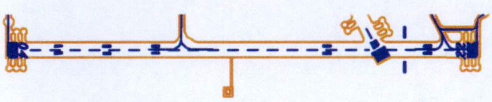
MARKING AIDS RWY 10/28



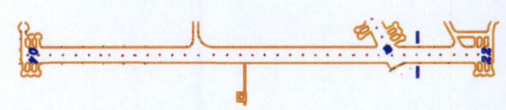
LIGHTING AIDS RWY 10/28



MARKING AIDS RWY 04/22



LIGHTING AIDS RWY 04/22



CHANGES : MAGNETIC VARIATION, BEARINGS, RUNWAY DESIGNATORS AND FREQUENCIES.

APPENDIX B: GLARE ANALYSIS REPORT RESULTS

FORGESOLAR GLARE ANALYSIS

Project: **LIDL HQ**
Site configuration: **Lidl HQ**

Created 31 Oct, 2022
Updated 30 Nov, 2022
Time-step 1 minute
Timezone offset UTC0
Site ID 78547.13927
Category 100 to 500 kW
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

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

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	6.0	72.0	11,451	190.8	0	0.0	-

Total annual glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
FP 10 Dublin Airport	0	0.0	0	0.0
FP 11 Tallaght Hospital Helipad	0	0.0	0	0.0
FP 12 Tallaght Hospital Helipad	0	0.0	0	0.0
FP 13 Tallaght Hospital Helipad	9,845	164.1	0	0.0
FP 14 Tallaght Hospital Helipad	0	0.0	0	0.0
FP 15 Tallaght Hospital Helipad	0	0.0	0	0.0
FP 16 Tallaght Hospital Helipad	1,606	26.8	0	0.0
FP 17 Tallaght Hospital Helipad	0	0.0	0	0.0
FP 18 Tallaght Hospital Helipad	0	0.0	0	0.0

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
FP 19 Weston Airport	0	0.0	0	0.0
FP 1 Casement Aerodrome	0	0.0	0	0.0
FP 20 Weston Airport	0	0.0	0	0.0
FP 2 Casement Aerodrome	0	0.0	0	0.0
FP 3 Casement Aerodrome	0	0.0	0	0.0
FP 4 Casement Aerodrome	0	0.0	0	0.0
FP 5 Dublin Airport	0	0.0	0	0.0
FP 6 Dublin Airport	0	0.0	0	0.0
FP 7 Dublin Airport	0	0.0	0	0.0
FP 8 Dublin Airport	0	0.0	0	0.0
FP 9 Dublin Airport	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0
2-ATCT	0	0.0	0	0.0
3-ATCT	0	0.0	0	0.0
4-ATCT	0	0.0	0	0.0

Component Data

PV Arrays

Name: PV array 1
Axis tracking: Fixed (no rotation)
Tilt: 6.0°
Orientation: 72.0°
Rated power: -
Panel material: Smooth glass without 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	53.288141	-6.354770	89.00	6.10	95.10
2	53.287717	-6.354563	89.00	6.10	95.10
3	53.287775	-6.354244	89.00	6.00	95.00
4	53.288194	-6.354453	89.00	6.00	95.00

Flight Path Receptors

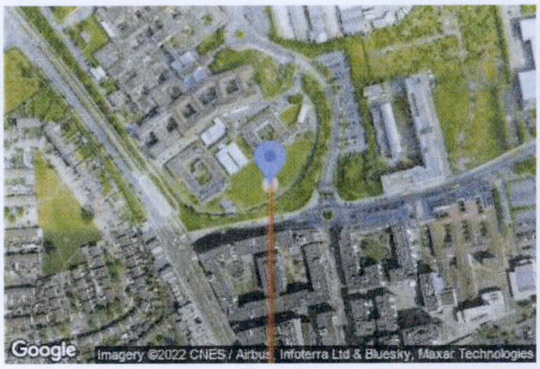
Name: FP 10 Dublin Airport
Description:
Threshold height: 15 m
Direction: 273.7°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.434950	-6.238379	67.85	15.24	83.09
Two-mile	53.433064	-6.189893	30.46	221.31	251.77

Name: FP 11 Tallagnt Hospital Helipad
Description:
Threshold height: 15 m
Direction: 180.0°
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	53.289505	-6.376774	103.75	15.24	118.99
Two-mile	53.318417	-6.376774	80.39	207.29	287.68

Name: FP 12 Tallagnt Hospital Helipad
Description:
Threshold height: 15 m
Direction: 0.0°
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	53.289507	-6.376774	103.74	15.24	118.98
Two-mile	53.260594	-6.376774	161.85	125.82	287.67

Name: FP 13 Tallaght Hospital Helipad
Description:
Threshold height: 15 m
Direction: 270.0°
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	53.289504	-6.376774	103.75	15.24	118.99
Two-mile	53.289504	-6.328350	67.99	219.68	287.68

Name: FP 14 Tallaght Hospital Helipad
Description:
Threshold height: 15 m
Direction: 90.0°
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	53.289505	-6.376774	103.75	15.24	118.99
Two-mile	53.289505	-6.425198	110.02	177.66	287.68

Name: FP 15 Tallaght Hospital Helipad
Description:
Threshold height: 15 m
Direction: 135.0°
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	53.289506	-6.376774	103.74	15.24	118.98
Two-mile	53.309950	-6.411015	80.98	206.69	287.67

Name: FP 16 Tallaght Hospital Helipad
Description:
Threshold height: 15 m
Direction: 225.0°
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	53.289515	-6.376801	103.73	15.24	118.97
Two-mile	53.309960	-6.342560	67.00	220.66	287.66

Name: FP 17 Tallaght Hospital Helipad
Description:
Threshold height: 15 m
Direction: 315.0°
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	53.289502	-6.376790	103.75	15.24	118.99
Two-mile	53.269058	-6.342549	100.17	187.51	287.68

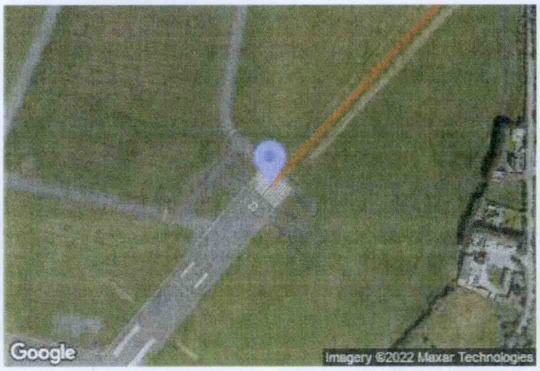
Name: FP 18 Tallaght Hospital Helipad
Description:
Threshold height: 15 m
Direction: 45.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.289509	-6.376801	103.74	15.24	118.98
Two-mile	53.269064	-6.411042	207.37	80.29	287.66

Name: FP 19 Weston Airport
Description:
Threshold height: 15 m
Direction: 242.0°
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	53.354099	-6.482412	46.75	15.24	61.99
Two-mile	53.367672	-6.439592	46.48	184.19	230.67

Name: FP 1 Casement Aerodrome
Description:
Threshold height: 15 m
Direction: 223.0°
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	53.303379	-6.439652	93.36	15.24	108.60
Two-mile	53.324527	-6.406623	64.73	212.56	277.29

Name: FP 20 Weston Airport
Description:
Threshold height: 15 m
Direction: 62.0°
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	53.350521	-6.494185	47.62	15.24	62.86
Two-mile	53.336947	-6.537002	53.81	177.74	231.54

Name: FP 2 Casement Aerodrome
Description:
Threshold height: 15 m
Direction: 41.6°
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	53.293763	-6.453577	98.42	15.24	113.66
Two-mile	53.272159	-6.485762	153.15	129.19	282.34

Name: FP 3 Casement Aerodrome
Description:
Threshold height: 15 m
Direction: 281.4°
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	53.301680	-6.444955	96.05	15.24	111.29
Two-mile	53.295970	-6.397471	110.94	169.03	279.97

Name: FP 4 Casement Aerodrome
Description:
Threshold height: 15 m
Direction: 102.1°
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	53.304656	-6.468483	86.24	15.24	101.48
Two-mile	53.310707	-6.515852	73.38	196.78	270.16

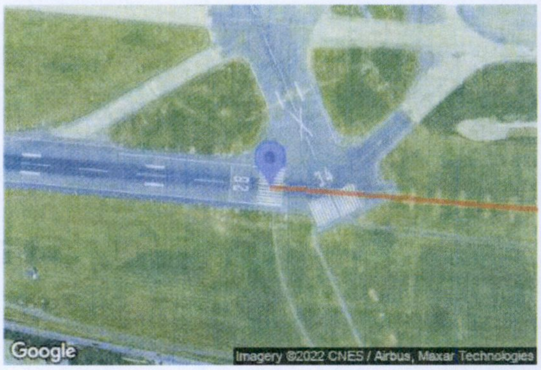
Name: FP 5 Dublin Airport
Description:
Threshold height: 15 m
Direction: 335.3°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.420131	-6.249752	62.26	15.24	77.50
Two-mile	53.393857	-6.229478	49.35	196.83	246.18

Name: FP 6 Dublin Airport
Description:
Threshold height: 15 m
Direction: 155.3°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

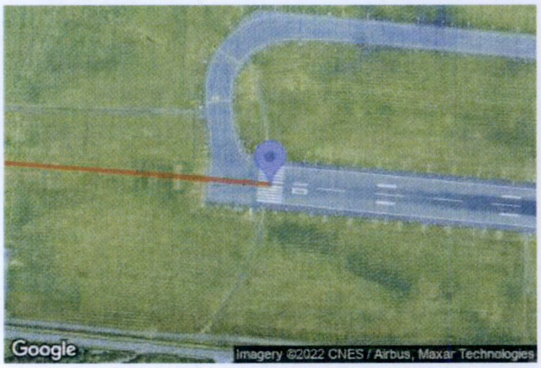
Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.435510	-6.260902	66.11	15.24	81.35
Two-mile	53.461786	-6.281176	67.97	182.07	250.03

Name: FP 7 Dublin Airport
Description:
Threshold height: 15 m
Direction: 274.8°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°



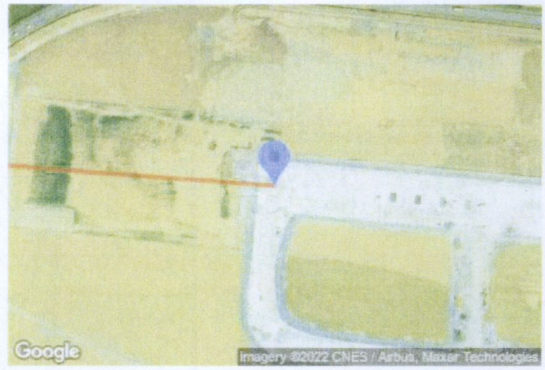
Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.420287	-6.250889	61.99	15.24	77.23
Two-mile	53.417842	-6.202491	41.99	203.93	245.92

Name: FP 8 Dublin Airport
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	53.422425	-6.289760	74.08	15.24	89.32
Two-mile	53.424784	-6.338173	81.31	176.69	258.01

Name: FP 9 Dublin Airport
Description:
Threshold height: 15 m
Direction: 94.1°
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	53.437395	-6.284538	72.92	15.24	88.16
Two-mile	53.439467	-6.333005	77.90	178.95	256.85

Discrete Observation Point Receptors

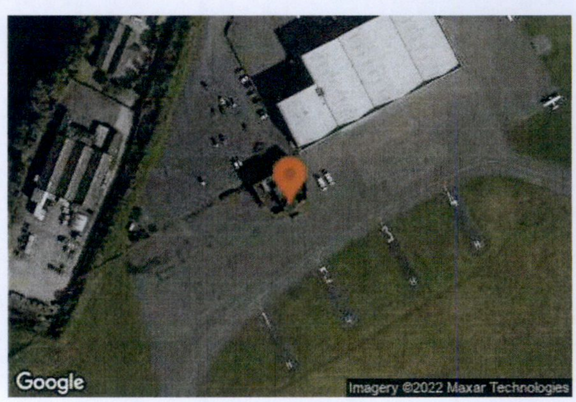
Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	53.428537	-6.262170	65.65	22.00
2-ATCT	2	53.429072	-6.264267	65.35	87.00
3-ATCT	3	53.305505	-6.441801	93.47	15.00
4-ATCT	4	53.355570	-6.489439	49.67	15.00

Map image of 1-ATCT

Map image of 2-ATCT

Map image of 3-ATCT

Map image of 4-ATCT



Glare Analysis Results

Summary of Results

Glare with low potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	6.0	72.0	11,451	190.8	0	0.0	-

Total annual glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
FP 10 Dublin Airport	0	0.0	0	0.0
FP 11 Tallaght Hospital Helipad	0	0.0	0	0.0
FP 12 Tallaght Hospital Helipad	0	0.0	0	0.0
FP 13 Tallaght Hospital Helipad	9,845	164.1	0	0.0
FP 14 Tallaght Hospital Helipad	0	0.0	0	0.0
FP 15 Tallaght Hospital Helipad	0	0.0	0	0.0
FP 16 Tallaght Hospital Helipad	1,606	26.8	0	0.0
FP 17 Tallaght Hospital Helipad	0	0.0	0	0.0
FP 18 Tallaght Hospital Helipad	0	0.0	0	0.0
FP 19 Weston Airport	0	0.0	0	0.0
FP 1 Casement Aerodrome	0	0.0	0	0.0
FP 20 Weston Airport	0	0.0	0	0.0
FP 2 Casement Aerodrome	0	0.0	0	0.0
FP 3 Casement Aerodrome	0	0.0	0	0.0
FP 4 Casement Aerodrome	0	0.0	0	0.0
FP 5 Dublin Airport	0	0.0	0	0.0
FP 6 Dublin Airport	0	0.0	0	0.0
FP 7 Dublin Airport	0	0.0	0	0.0
FP 8 Dublin Airport	0	0.0	0	0.0
FP 9 Dublin Airport	0	0.0	0	0.0

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
1-ATCT	0	0.0	0	0.0
2-ATCT	0	0.0	0	0.0
3-ATCT	0	0.0	0	0.0
4-ATCT	0	0.0	0	0.0

PV: PV array 1 low potential for temporary after-image

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
FP 13 Tallaght Hospital Helipad	9,845	164.1	0	0.0
FP 16 Tallaght Hospital Helipad	1,606	26.8	0	0.0
FP 10 Dublin Airport	0	0.0	0	0.0
FP 11 Tallaght Hospital Helipad	0	0.0	0	0.0
FP 12 Tallaght Hospital Helipad	0	0.0	0	0.0
FP 14 Tallaght Hospital Helipad	0	0.0	0	0.0
FP 15 Tallaght Hospital Helipad	0	0.0	0	0.0
FP 17 Tallaght Hospital Helipad	0	0.0	0	0.0
FP 18 Tallaght Hospital Helipad	0	0.0	0	0.0
FP 19 Weston Airport	0	0.0	0	0.0
FP 1 Casement Aerodrome	0	0.0	0	0.0
FP 20 Weston Airport	0	0.0	0	0.0
FP 2 Casement Aerodrome	0	0.0	0	0.0
FP 3 Casement Aerodrome	0	0.0	0	0.0
FP 4 Casement Aerodrome	0	0.0	0	0.0
FP 5 Dublin Airport	0	0.0	0	0.0
FP 6 Dublin Airport	0	0.0	0	0.0
FP 7 Dublin Airport	0	0.0	0	0.0
FP 8 Dublin Airport	0	0.0	0	0.0
FP 9 Dublin Airport	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0
2-ATCT	0	0.0	0	0.0
3-ATCT	0	0.0	0	0.0

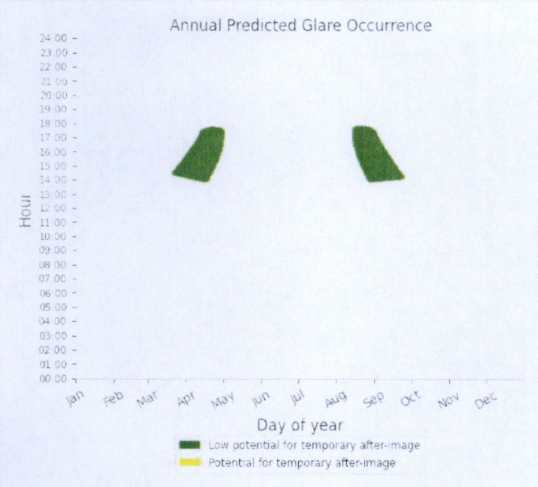
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
4-ATCT	0	0.0	0	0.0

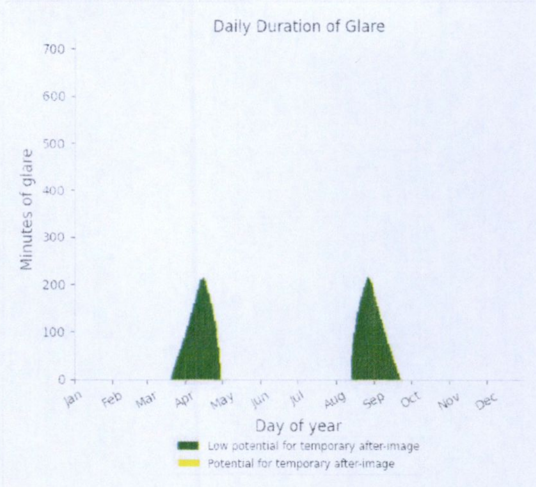
PV array 1 and FP 13 Tallaght Hospital Helipad

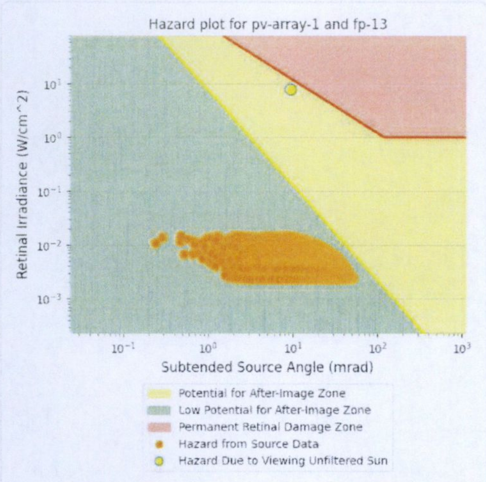
Receptor type: 2-mile Flight Path

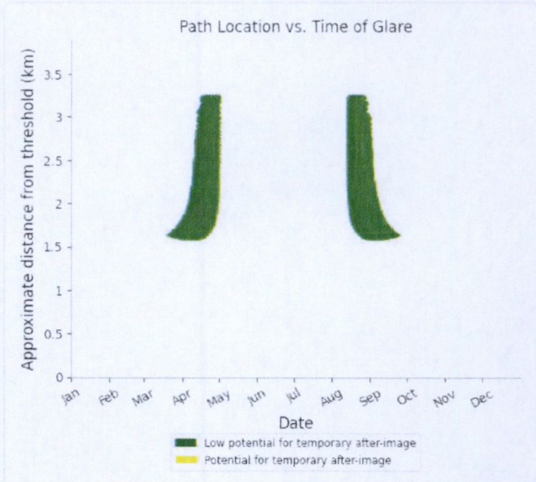
0 minutes of yellow glare

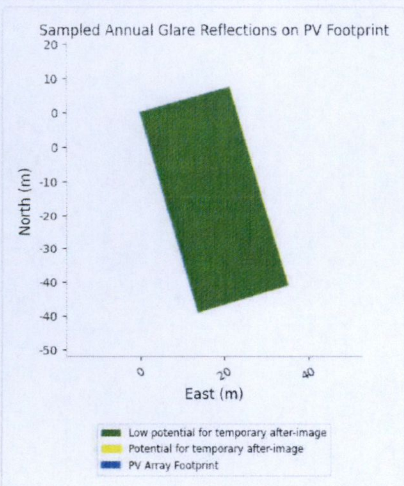
9,845 minutes of green glare

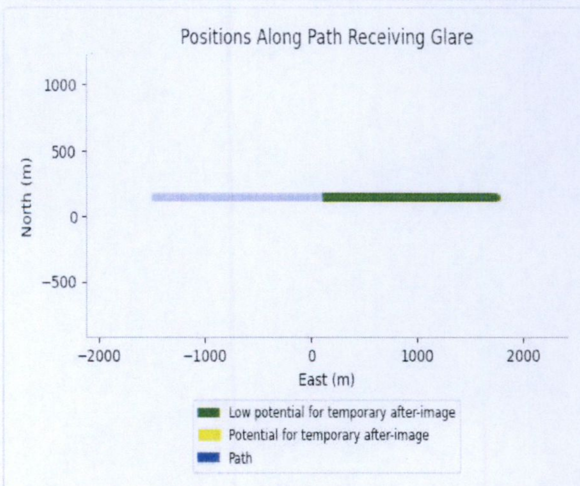










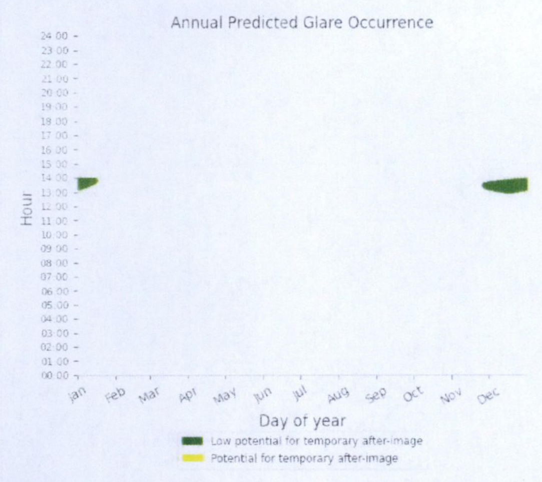


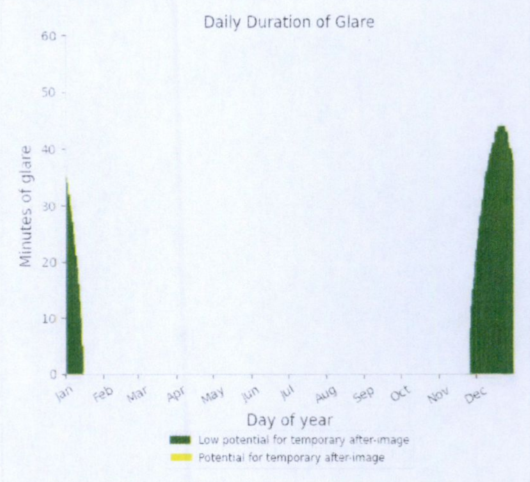
PV array 1 and FP 16 Tallaght Hospital Helipad

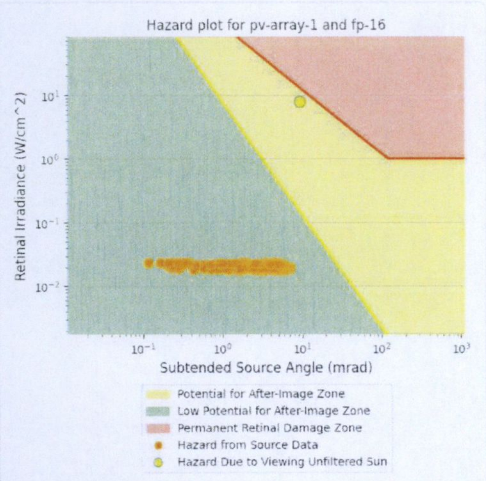
Receptor type: 2-mile Flight Path

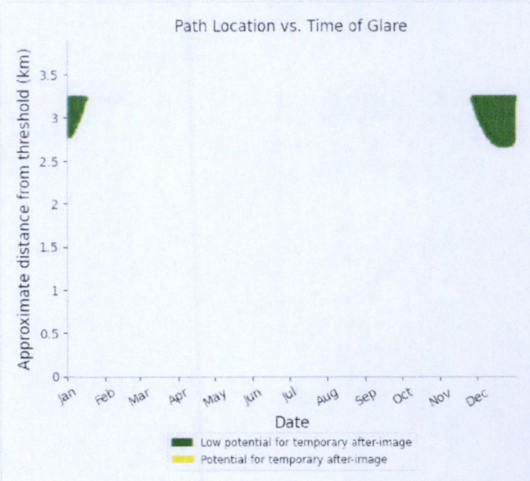
0 minutes of yellow glare

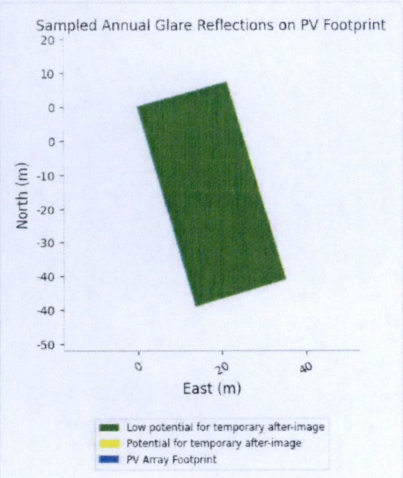
1,606 minutes of green glare

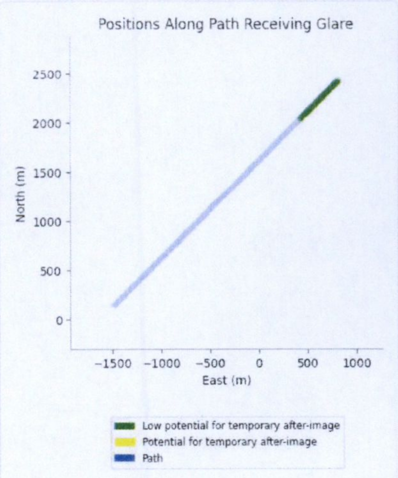












PV array 1 and FP 10 Dublin Airport

Receptor type: 2-mile Flight Path
No glare found

PV array 1 and FP 11 Tallaght Hospital Helipad

Receptor type: 2-mile Flight Path
No glare found

PV array 1 and FP 12 Tallaght Hospital Helipad

Receptor type: 2-mile Flight Path
No glare found

PV array 1 and FP 14 Tallaght Hospital Helipad

Receptor type: 2-mile Flight Path
No glare found

PV array 1 and FP 15 Tallaght Hospital Helipad

Receptor type: 2-mile Flight Path
No glare found

PV array 1 and FP 17 Tallaght Hospital Helipad

Receptor type: 2-mile Flight Path
No glare found

PV array 1 and FP 18 Tallaght Hospital Helipad

Receptor type: 2-mile Flight Path
No glare found

PV array 1 and FP 19 Weston Airport

Receptor type: 2-mile Flight Path
No glare found

PV array 1 and FP 1 Casement Aerodrome

Receptor type: 2-mile Flight Path
No glare found

PV array 1 and FP 20 Weston Airport

Receptor type: 2-mile Flight Path
No glare found

PV array 1 and FP 2 Casement Aerodrome

Receptor type: 2-mile Flight Path
No glare found

PV array 1 and FP 3 Casement Aerodrome

Receptor type: 2-mile Flight Path
No glare found

PV array 1 and FP 4 Casement Aerodrome

Receptor type: 2-mile Flight Path
No glare found

PV array 1 and FP 5 Dublin Airport

Receptor type: 2-mile Flight Path
No glare found

PV array 1 and FP 6 Dublin Airport

Receptor type: 2-mile Flight Path
No glare found

PV array 1 and FP 7 Dublin Airport

Receptor type: 2-mile Flight Path
No glare found

PV array 1 and FP 8 Dublin Airport

Receptor type: 2-mile Flight Path

No glare found

PV array 1 and FP 9 Dublin Airport

Receptor type: 2-mile Flight Path

No glare found

PV array 1 and 1-ATCT

Receptor type: Observation Point

No glare found

PV array 1 and 2-ATCT

Receptor type: Observation Point

No glare found

PV array 1 and 3-ATCT

Receptor type: Observation Point

No glare found

PV array 1 and 4-ATCT

Receptor type: Observation Point

No glare found

Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
"Yellow" glare is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. However, we have validated our models against several systems, including a PV array causing glare to the air-traffic control tower at Manchester-Boston Regional Airport and several sites in Albuquerque, and the tool accurately predicted the occurrence and intensity of glare at different times and days of the year.
Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare. This primarily affects V1 analyses of path receptors.
Random number computations are utilized by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result. This limitation primarily affects analyses of Observation Point receptors, including ATCTs. Note that the SGHAT/ForgeSolar methodology has always relied on an analytical, qualitative approach to accurately determine the overall hazard (i.e. green vs. yellow) of expected glare on an annual basis.
The analysis does not automatically consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc.
The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
The variable direct normal irradiance (DNI) feature (if selected) scales the user-prescribed peak DNI using a typical clear-day irradiance profile. This profile has a lower DNI in the mornings and evenings and a maximum at solar noon. The scaling uses a clear-day irradiance profile based on a normalized time relative to sunrise, solar noon, and sunset, which are prescribed by a sun-position algorithm and the latitude and longitude obtained from Google maps. The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors.
The ocular hazard predicted by the tool depends on a number of environmental, optical, and human factors, which can be uncertain. We provide input fields and typical ranges of values for these factors so that the user can vary these parameters to see if they have an impact on the results. The speed of SGHAT allows expedited sensitivity and parametric analyses.
The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid based on aggregated research data. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Refer to the Help page at **www.forgesolar.com/help/** for assumptions and limitations not listed here.

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

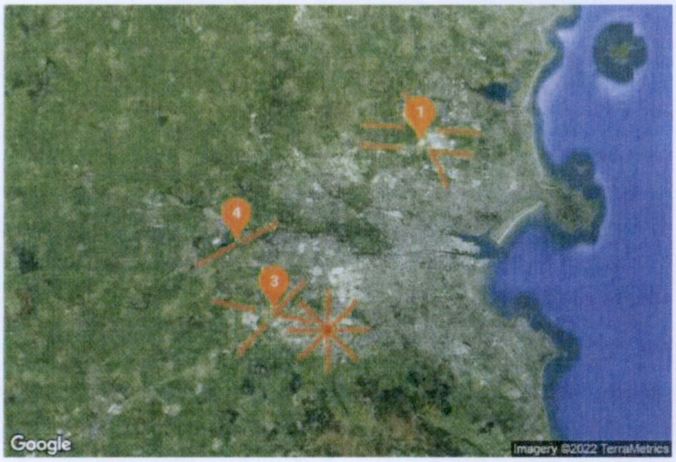
- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

APPENDIX C: AVIATION RECEPTOR GLARE RESULTS

FORGESOLAR GLARE ANALYSIS

Project: **LIDL HQ**
Site configuration: **Lidl HQ**

Created 31 Oct, 2022
Updated 30 Nov, 2022
Time-step 1 minute
Timezone offset UTC0
Site ID 78547.13927
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)	PASS	Receptor(s) marked as ATCT do not receive glare

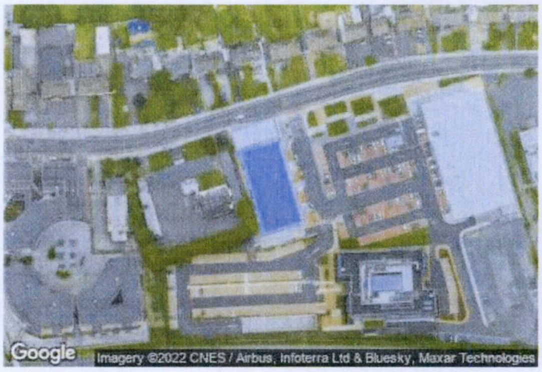
The referenced policy can be read at https://www.federalregister.gov/d/2021-09862

Component Data

This report includes results for PV arrays and Observation Point ("OP") receptors marked as ATCTs. Components that are not pertinent to the policy, such as routes, flight paths, and vertical surfaces, are excluded.

PV Arrays

Name: PV array 1
Axis tracking: Fixed (no rotation)
Tilt: 6.0°
Orientation: 72.0°
Rated power: -
Panel material: Smooth glass without 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	53.288141	-6.354770	89.00	6.10	95.10
2	53.287717	-6.354563	89.00	6.10	95.10
3	53.287775	-6.354244	89.00	6.00	95.00
4	53.288194	-6.354453	89.00	6.00	95.00

Observation Point ATCT Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	53.428537	-6.262170	65.65	22.00
2-ATCT	2	53.429072	-6.264267	65.35	87.00
3-ATCT	3	53.305505	-6.441801	93.47	15.00
4-ATCT	4	53.355570	-6.489439	49.67	15.00

Map image of 1-ATCT

Map image of 2-ATCT

Map image of 3-ATCT

Map image of 4-ATCT

Glare Analysis Results

Summary of Results No glare predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	6.0	72.0	0	0.0	0	0.0	-

Total annual glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
1-ATCT	0	0.0	0	0.0
2-ATCT	0	0.0	0	0.0
3-ATCT	0	0.0	0	0.0
4-ATCT	0	0.0	0	0.0

PV: PV array 1

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
1-ATCT	0	0.0	0	0.0
2-ATCT	0	0.0	0	0.0
3-ATCT	0	0.0	0	0.0
4-ATCT	0	0.0	0	0.0

PV array 1 and 1-ATCT

Receptor type: ATCT Observation Point

No glare found

PV array 1 and 2-ATCT

Receptor type: ATCT Observation Point

No glare found

PV array 1 and 3-ATCT

Receptor type: ATCT Observation Point

No glare found

PV array 1 and 4-ATCT

Receptor type: ATCT Observation Point

No glare found

Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
"Yellow" glare is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. However, we have validated our models against several systems, including a PV array causing glare to the air-traffic control tower at Manchester-Boston Regional Airport and several sites in Albuquerque, and the tool accurately predicted the occurrence and intensity of glare at different times and days of the year.
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Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Refer to the Help page at **www.forgesolar.com/help/** for assumptions and limitations not listed here.

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

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

APPENDIX D: SOLAR MODULE GLARE AND REFLECTANCE TECHNICAL MEMO

SUNPOWER

Technical Notification

TITLE: SunPower Solar Module Glare and Reflectance
AUTHORS: Technical Support
APPLICATION: Residential/ Commercial
SCOPE: SunPower Modules

SUMMARY:

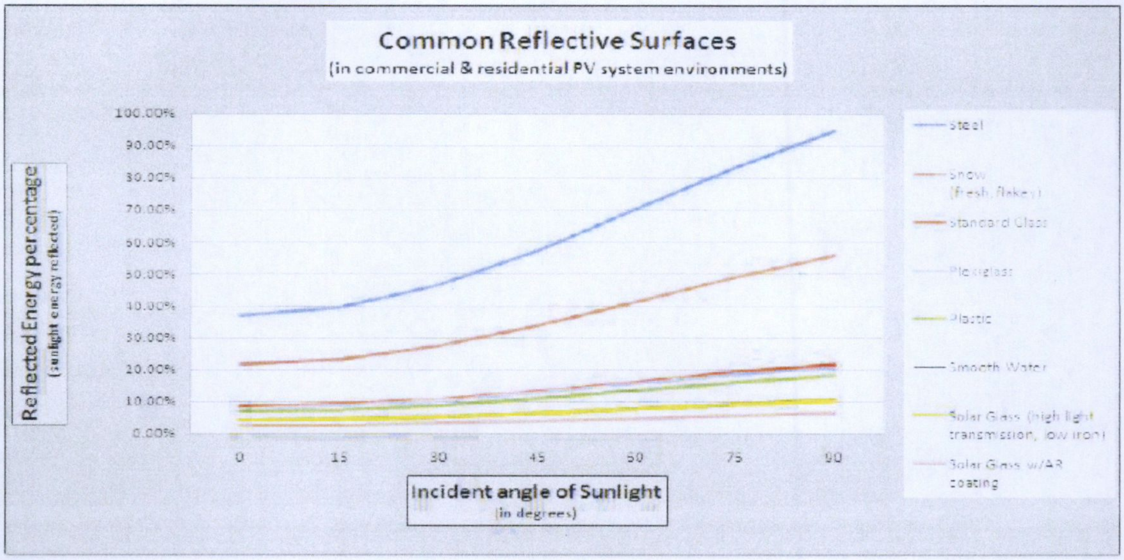
The objective of this document is to increase awareness concerning the possible glare and reflectance impact of PV Systems on their surrounding environment.

The glare and reflectance levels from a given PV system are decisively lower than the glare and reflectance generated by the standard glass and other common reflective surfaces in the environments surrounding the given PV system. Concerning random glare and reflectance observed from the air: SunPower has several large projects installed near airports or on air force bases. Each of these large projects has passed FAA or Air Force standards and all projects have been determined as "No Hazard to Air Navigation". Although the possible glare and reflectance from PV systems are at safe levels and are usually decisively lower than other standard residential and commercial reflective surfaces, SunPower suggests that customers and installers discuss any possible concerns with the neighbors/cohabitants near the planned PV system installation.

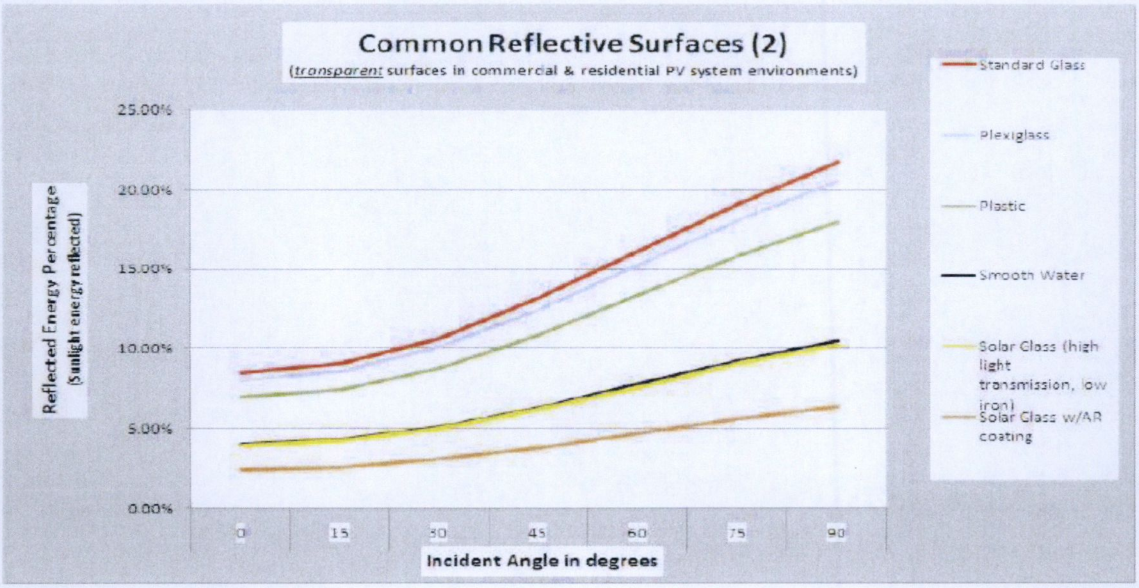
DETAILED EXPLANATION:

In general, since the whole concept of efficient solar power is to absorb as much light as possible while reflecting as little light as possible, standard solar module produces less glare and reflectance than standard window glass. This is pointed out very well in US Patent #6359212 which explains the differences in the refraction and reflection of solar module glass versus standard window glass. Solar modules use "high-transmission, low iron glass" which absorbs more light, producing small amounts of glare and reflectance than normal glass.

In the graph below, we show the reflected energy percentages of sunlight, of some common residential and commercial surfaces. The legend and the graph lists the items from top to bottom in order of the highest percentage of reflected energy.



It should be noted that the reflected energy percentage of Solar Glass is far below that of a standard glass and more on the level of smooth water. Also, below are the ratios of the common reflective surfaces:



Light beam physics resolves that the least amount of light is reflected when the beam is the normal, in other words, least light energy is reflected when the beam is at 0 degrees to the normal. The chart below is a result of light beam physics calculations:

Common Reflective Surfaces (in surrounding environments for PV systems)		Incident angle in degrees						
		0	15	30	45	60	75	90
Material Reflectivity (percent of incident light reflected)	Steel	36.73%	39.22%	46.34%	57.11%	70.02%	83.15%	94.40%
	Snow (fresh, flakey)	21.65%	25.09%	27.29%	33.65%	41.25%	48.96%	55.59%
	Standard Glass	8.44%	9.01%	10.65%	13.12%	16.09%	19.10%	21.69%
	Plexiglass	8.00%	8.54%	10.09%	12.44%	15.25%	18.11%	20.56%
	Plastic	6.99%	7.46%	8.82%	10.87%	13.33%	15.83%	17.97%
	Smooth Water	4.07%	4.35%	5.14%	6.33%	7.76%	9.22%	10.47%
	Solar Glass (high light transmission, low iron)	3.99%	4.26%	5.03%	6.20%	7.61%	9.03%	10.26%
	Solar Glass w/AR coating	2.47%	2.64%	3.12%	3.84%	4.71%	5.59%	6.35%

(Note: Index of refraction values may vary slightly depending on suppliers and reference documentation. The values for the above calculations are averages or single values obtained from the list of references for this document).

Important reference – "Stipples glass": In addition to the superior refractive/reflective properties of solar glass versus standard glass, SunPower uses stippled solar glass for our modules. Stippled glass is used with high powered telescopes and powerful beacons and lights. The basic concept behind stippling is for the surfaces of the glass to be textured with small types of indentations. As a result, stippling allows more light energy to be channeled/ transmitted through the glass while diffusing the reflected light energy. This concept is why the reflection of off a SunPower solar module will look hazy and less-defined than the reflection from standard glass, this occurs because the stippled SunPower glass is transmitting a larger percentage of light to the solar cell while breaking up the intensity of the reflected light energy.

SUMMARY/ACTION REQUIRED:

The studies, data and light beam physics behind the charts and graphs prove beyond a reasonable doubt that solar glass has less glare and reflectance than standard glass. The figures also make it clear that the difference is very decisive between solar glass and other common residential/commercial glasses. In addition, not to be lost in the standard light/glass equations and calculations, the SunPower solar glass is stippled and has a very photon-absorbent solar cell attached to the back side, contributing two additional factors which results in even less light energy being reflected.

REGIONAL CONTACTS:

****

EU Toll Free number: SunPower Technical Support, **00800–SUNPOWER (00800–78676937)**

- **For inquiries by e-mail, please use**:
  - Spain: SunPower – Soporte Técnico España: soportetecnico@sunpowercorp.com
  - Germany: SunPower – Technischer Support: technischersupport@sunpowercorp.com
  - Italy: SunPower – Servizio Tecnico Italia: serviziotecnico@sunpowercorp.com
  - France: SunPower – Support Technique France: supporttechnique@sunpowercorp.com

USA Toll Free number: SunPower Technical Support, **1-800–SUNPOWER (786-76937)**

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Korea – SPK (SunPower Korea) contact number: **(02) 3453-0941**

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