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Evaluating the Field of View: Quantifying How the Location of a Solar Reflection Impacts a Road User

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THE EFFECT OF A ROAD USER EXPERIENCING A SOLAR REFLECTION

Overview

When a proposed solar photovoltaic (PV) development is located near to a road, it can lead to concerns with respect to the potential impact upon road safety due to glint and glare. This is especially the case if it is a road with fast moving traffic and/or high traffic densities, which are typically national and major national roads.

Consequently, ensuring that glint and glare will not have a significant impact upon surrounding road users is paramount for developers when seeking planning permission.

Impact Significance of a Road User Experiencing a Solar Reflection

If a solar reflection is experienced by a road user along a major national, national, or regional road, it does not instantly result in a significant impact upon safety. Many factors should be taken into consideration to determine the overall impact significance and mitigation requirement, such as:

- The level of screening (whether the solar reflection is visible);
- The location of the reflecting panel relative to a road user's direction of travel;
- The separation distance between the reflecting panels and the receptor location; and
- The extent to which effects coincide with direct sunlight.

The process to determine the impact significance and mitigation requirement is set out in Pager Power's glint and glare guidance document[1]. In the first instance, it should be determined whether a solar reflection is visible to a road user. If there is no visibility of the solar reflection, no impacts are possible.

Where a solar reflection is visible to a road user, the direction of the reflection panel relative to the road user's main field of view (FOV) should be determined because any solar reflections that are considered outside of the road users' main FOV are no longer considered significant.

It is therefore important that the specific location of the solar reflection that is considered outside the main FOV is defined so that the impact significance can be consistently determined.

THE VISUAL FIELD (FIELD OF VISION)

Overview

The visual field, or field of vision, is the portion of space in which objects are visible at the same moment during steady fixation of gaze in one direction[2]. Whilst the visual field spans approximately 220 degrees, visual acuity (the ability to discern colours, shapes, and details) is not uniform across the whole visual field.

Central vision is where visual acuity is the highest and makes up just a small arc of the visual field. It is used when reading, driving, and seeing pictures and faces. Peripheral vision, therefore, occurs outside of the point of fixation and makes up most of the visual field. Visual acuity is greatly reduced in the peripheral vision whereby colours, shapes, and details become difficult to discern[3].

A visual representation of the visual field is shown in Figure 1 below[4].

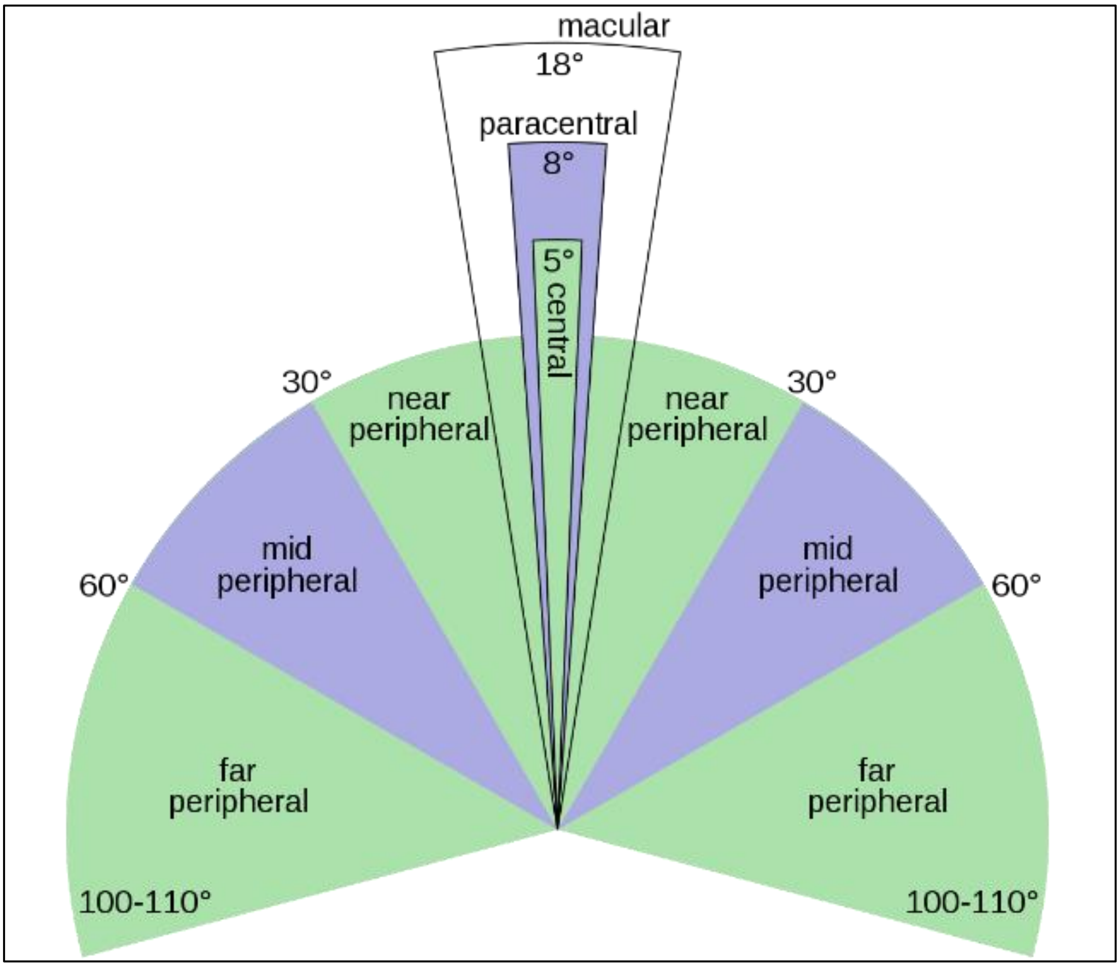

Figure 1 *Visual field*

Importance of the Visual Field to a Road User

A road user must constantly be gathering information of their surroundings in order to safely navigate in a vehicle. To do this, a road user's eyes must frequently move so that the central vision can focus on various locations to gain as much understanding of their surroundings as possible (e.g., reading the road ahead or scanning for hazards). However, given that many of the key regions are almost directly in front of them (e.g., lane positioning, ensuring safe distance to the vehicle ahead, looking at upcoming road conditions or traffic lights), it is likely that a driver will spend most of their time looking at, or close to, their direction of travel.

It is therefore most reasonable to use the road user's direction of travel as the default point of fixation and the centre of the visual field when assessing the impact of glare at different locations relative to the road user.

Effect of Light on Visual Field

Resources pertaining to the effect of light upon the visual field are sparse and Pager Power has not been able to identify specific studies related to the effect of sunlight, other forms of light, or visual distractions from different parts of the visual field in general, or for road users.

Based on the available resources found to date, the location in which glare should not be considered a concern cannot be determined based on the visual field alone.

WHAT LOCATION OF GLARE IS CURRENTLY CONSIDERED A CONCERN?

Overview

To inform this whitepaper, the Highway Code and Highways England resources were examined to find any background on the visual field and the effect of glare at different locations relative to a road user. There is, however, a lack of guidance and resources pertaining to this topic.

As a result, the most relevant guidance and resources from related sectors, such as railway and aviation, have been examined and compared to determine the appropriate FOV when assessing glint and glare for a road user.

The Federal Aviation Administration (FAA)

'Evaluation of the of Glare as a Hazard for General Aviation Pilots on Final Approach'[5] is a report sponsored by the FAA and undertaken by Sandia National Laboratories. The report simulated glare originating from different locations and lasting various times towards pilots on approach to determine the impairment caused by glare.

During the approach phase of each flight, glare was simulated from one of four possible angles (0, 25, 50, and 90 degrees left of straight ahead). The glare was simulated using halogen lamps that, under the lighting conditions of the Sandia National Laboratories lab, approximated the visual effect of solar glare.

Subjective measures of impairment were recorded for each condition by the 20 participants using a questionnaire. Following each simulation, the pilots were asked to rate their experience through three questions and possible responses (on a 5-point rating scale). The questions were as follows:

- Rate the degree of impairment from the simulated glare on your ability to fly the plane.
- Rate the degree of impairment from the simulated glare on your ability to read your instruments.
- How similar was the simulated glare to actual glare you have observed while flying, if applicable?

Using several statistical tests, the report concluded that the presence of glare was associated with the most impairment in the pilot's ability to see their instruments and to fly their aeroplane when the glare was straight ahead, as well as slightly to the side. These results considered simultaneously suggest that any sources of glare at an airport may be potentially mitigated if the angle of the glare is greater than 25 degrees from the approach bearing. The report therefore recommends that a solar installation at an airport is positioned such that it is not straight ahead of pilots or within 25 degrees of straight ahead during final approach.

This trial is the basis for which the FAA has defined 50 degrees to be the appropriate location for which glare should not be considered an issue. At first glance, the recommendation that solar developments are located further than 25 degrees from the approach bearing may appear to contradict the 50 degrees that has ultimately been used by the FAA. However, the simulation methodology and results has caused a window in which the effects of glint and glare on a pilot are unknown. In other words, it is unclear where within 25- and 50-degrees glare starts to impair the pilot's ability to see their instruments or fly the plane.

Therefore, it is understood that the FAA has used 50 degrees as it has been proven by the results of the investigation that glare at this location is not significant, and any value lower than this has not been proven to be so. This is a conservative approach, which is important when considering the potential safety implications of glint and glare for aviation.

Network Rail

The 'Signal Sighting Assessment Requirements'[6] document produced by Network Rail sets out the signal sighting assessment process that is used to confirm compatibility of lineside signalling system assets with train operations (signal sighting).

In the document, similarly to 'The Visual Field' section earlier in this whitepaper, the visual field is defined in the context of central and peripheral regions, with the central field being the area that provides detailed information. The central vision is defined as extending from the central point (0 degrees) to approximately 30 degrees at each eye, with the peripheral field extending from this point to the edge of the visual field.

The document then states that research has shown train drivers search for signs or signals towards the centre of the field of vision, implying that that signs and signals (lights) get harder to identify the further they are from the central field of vision. Although this is not specifically related to the position of glare relative to a train driver, the document suggests that glare within the peripheral field does not have as high an impact upon a train driver as glare within the central vision.

It has therefore been concluded by Pager Power that Network Rail considers glare outside of 30 degrees of the direction of travel to be outside the main field of view, and therefore not significant towards train drivers.

WHERE SHOULD GLARE NOT BE CONSIDERED A CONCERN?

Overall Conclusion

Considering the review of the most relavant resources and literature, a definitive location which glare is not considered a concern has not been conlusively determined and agreed. However, it is easy to recognise that the location in which glare should not be considered a concern is between 30 and 50 degrees outside of the road users direction of travel.

To determine a nominal value that is consistent with reputable guidance on the topic, professional judgement, evaluation of both literature, and a comparison to the real world application with respect to a road user must be considered. Therefore, the following points are applicable:

- The FAA simulation relates specifically to distraction caused by glint and glare upon the pilot whereas the Network Rail document does not relate specifcally to glint and glare;
- The gaps in the results of the FAA simulation means that it is not possible to deduce where the most accurate location is based on the current evidence (somewhere between 25 degrees and 50 degrees);
- A road user is far more likely to be turning their head under normal driving conditions compared to a train driver travelling along a track.

It is therefore concluded that glare experienced outside of 50 degrees either side of the direction of travel should not be considered a significant concern for a road user. This is based on a conservative approach because the current guidance and studies have not found sufficient evidence to reduce the location closer to the central point.

The resulting main FOV that is considered appropriate for a road user is 100 degrees centered on the direction of travel (50 degrees either side of straight ahead).

Next Steps

Given the lack of research and studies found based on the literature review, further studies and investigations could be undertaken with specific focus on the effects of glint and glare upon a road user, with the aim of finding a more precise and appropriate value. This can be undertaken by Pager Power in the future with the support of Highways England, relevant stakeholders, researchers, or experts in this field.

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