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Reflectance of Solar Innova PV Modules

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1. Introduction and Motivation.

A photovoltaic (PV) system does correspond to a large area of glass and metal surface oriented in a single direction. Due to potential dazzle or glare effects, it may therefore seem to constitute a risk when constructed near an airport, a railroad track, or a road, or it could become a nuisance for neighbors when placed near a residential neighborhood.

PV modules, like those manufactured by Solar Innova, indeed reflect part of the energy they receive from the sun, just as any other object or material. However, the PV modules are specifically designed to absorb sunlight instead of reflecting it. This is, for instance, achieved by using glass with a special texturing or even an "anti-reflective" (AR) coating for some module types.

Nevertheless, analyzing the reflectance of PV modules in detail is a meaningful way to quantify the risk of dazzle or glare. Clearly, in this context only the specular component of the visual portion of the reflected light is relevant. The purpose of this technical bulletin is to show that the reflectance of Solar Innova PV modules is low and comparable to that of other common surfaces.

2. Laboratory Measurements.

At an independent laboratory, hemispherical spectral reflectance measurements were performed in accordance with ASTM Standard Test Method E903 with a PerkinElmer Lambda 950 Spectrophotometer utilizing an integrating sphere. Results were obtained for spectral reflection near normal incidence (8°) and as a function of wavelength within the visible range of the solar spectrum.

This was done for the distinct material layer structures typical of Solar Innova PV Modules (i.e., aluminum frame, glass over encapsulation and back sheet, glass over encapsulation and silicon surface of the solar cell, and glass over encapsulation and metallization of the solar cell).

3. Calculation of Module Reflectance Values.

Using these laboratory measurements, a weighted average over the area of a given module type and the visible wavelength range of 410 nm to 720 nm of the solar spectrum at air mass 1.5 could be determined. Table 1 shows the results for Solar Innova PV modules using a front glass cover with AR coating and table 2 contains the corresponding data for Solar Innova PV modules without AR coating.

Module Series	Glass Thickness (mm)	Anti-Reflective Coating	Average Specular Reflectance
SI-ESF-M-M156-60 SI-ESF-M-P156-60	3.2	Yes	2.5 %
SI-ESF-M-M156-72 SI-ESF-M-P156-72	3.2	Yes	2.6 %

Table 1: Average specular reflectance for Solar Innova PV modules with AR coating.

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Module Series	Glass Thickness (mm)	Anti-Reflective Coating	Average Specular Reflectance
SI-ESF-M-M156-72	4.0	No	4.0 %
SI-ESF-M-P156-72			
SI-ESF-M-M156-60	3.2	No	4.6 %
SI-ESF-M-P156-60			
SI-ESF-M-M125-96	3.2	No	4.6 %
SI-ESF-M-M125-72			

Table 2: Average specular reflectance for Solar Innova PV modules without AR coating.

4. Summary and Conclusion.

Material	Reflectance
Aluminum Roof	74 %
Water	5 %
PV Module without ARC	4.0-4.6 %
Black Asphalt	3 %
PV Module with ARC	2.5-2.6 %

Reflectance measurements from an independent laboratory were used to obtain an average specular re-flectance for different types of Solar Innova PV modules. These results are reported in Tables 1 and 2 for modules with and without anti-reflective coating on the front glass, respectively.

To put these results into perspec-tive, Table 3 shows reflectance values for some common surface materials (source: www.landsat.org, www.gsfc.nasa.gov) in comparison to the results obtained for Solar Innova PV modules.

The reflectance of the PV modules is comparable to that of water or black asphalt. It can therefore be concluded, that Solar Innova PV modules are unlikely to constitute an unusually high risk for dazzle or glare.

It is nevertheless important to emphasize that the intensity of light reflected from a PV module surface depends on the amount of sunlight reaching the surface and will therefore vary based on, among others, geographic location, time of year, cloud cover, and PV module orientation. A full analysis to assess the potential impact of reflectance will therefore depend on the specific project site and system design. This is, for instance, detailed in the "Airport Solar Guide" of the U.S. Federal Aviation Association (available at www.faa.gov). The reflectance values provided in this bulletin can be used as input data for such more detailed site specific assessments.

For more information on the reflectance of Yingli Solar PV modules, please contact us at info@ygee.eu.