Introduction

Bifacial solar panels are photovoltaic (PV) devices that can absorb light on both the front and rear of the panel to produce electricity.

Bifacial PV market is growing quickly, from 10% in 2020 to 35% in 2025. The spectrum of the light incident on a solar panel is important to for its performance. Understanding this spectrum is a significant challenge particularly for rear side irradiance on bifacial modules.

This work establishes a methodology to do spectral irradiance and albedo simulations for bifacial PV and validates it with field data for two sensors with different spectral sensitivities. An analysis to estimate the contribution of ground reflected irradiance to total rear irradiance is also presented.

Test Site

The test field modeled is the 75 kW Bifacial Experimental Single-Axis Tracking (BEST) field located on the campus of the National Renewable Energy Laboratory (NREL). Weather data from the Solar Radiation Research Laboratory was used.

Two rear irradiance sensors with different spectral sensitivities were modeled and compared with their recorded values. The CM11 sensor (broadband) is mounted on the eastern edge of row 3 and the LiCor (Ebg = 1.1um) sensor is mounted on the western edge.

Figure 1 (a) 75kW bifacial single-axis tracked field in Golden, CO (b) Location of the sensors being modeled in the module’s plane CM11 (West, broadband) and LiCor (East, narrowband)

Methodology

• Raytracing (bifacial_radiance) was used to compare non-spectral simulations and spectral simulations, and their impact on rear irradiance modeling.

• SMARTS2 was used to generate the spectral DNI, DHI, and spectral ground reflectance data for the raytracing. These were scaled by field measurements of DNI, DHI (Fig. 2), such that the integral of the spectra is equal to the measured values.

• Spectral albedo was scaled such that the weighted average of the spectral reflectance, with the GHI spectrum as the weight, equaled the measured value.

• An estimated-spectral rear irradiance can be obtained by doing a non-spectral simulation where the weighted albedo is calculated such that:

\[ \frac{R(\lambda)}{GHI(\lambda)} \times \frac{\delta \lambda}{R(\lambda)} \times \frac{\delta \lambda}{GHI(\lambda)} \]

Results

• Non-spectral simulations have an RMSE of 12-13% with measured data.

• Full spectral modeling provides more accuracy for non-broadband sensors such as the LiCor pyranometer. Minimal improvement is seen for broadband sensors.

• The estimated-spectral rear irradiance method proposed obtains a comparable improvement in rear irradiance to the spectral simulations but takes roughly 0.005% of the time.

Conclusion and Future Work

• Accounting for spectral effects is important when modeling sensors and PV cells with non-broadband sensitivities, for this work decreasing RMSE from 13% to 8-11%.

• Using estimated-spectral irradiance simulations can provide similar results to those obtained through full spectral simulations in less time.

• Further validation of the spectral simulations should be done using a spectrophotometer to measure rear spectral irradiance for the BEST field.