MER-498 – MECHANICAL ENGINEERING –2022

Enhancing Bifacial PV Efficiency With the Addition of a Rear Side Reflector

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Introduction

Bifacial photovoltaics are an expanding sector of solar electricity production, predicted to account for half of the PV market in 5 years. Bifacial panels collect solar energy on the front and back sides of the module. This increases the energy production by around 10% to 30% over a typical mono facial panel, which only collects sunlight on the front. When a reflector is added to face the backside of a collector, the set-up can then be enhanced to increase the bifacial gain (BG):

$$Bifacial\ Gain = \frac{Rear\ Energy}{Front\ Energy}$$

Solar cells were calibrated against a pyranometer and used to measure the solar insolation. The solar irradiance, W/m^2, was plotted against the voltage output of each individual cell. The voltage of each cell could then be correlated to the pyranometer W/m^2 to get calibration factors for each individual cell. The cells were set up to represent to rear side of a bifacial collector, in both indoor and outdoor tests (Figs. 2 and 3). A numerical model developed previously [1] was also used to determine the incident energy on both

Experimental Setup

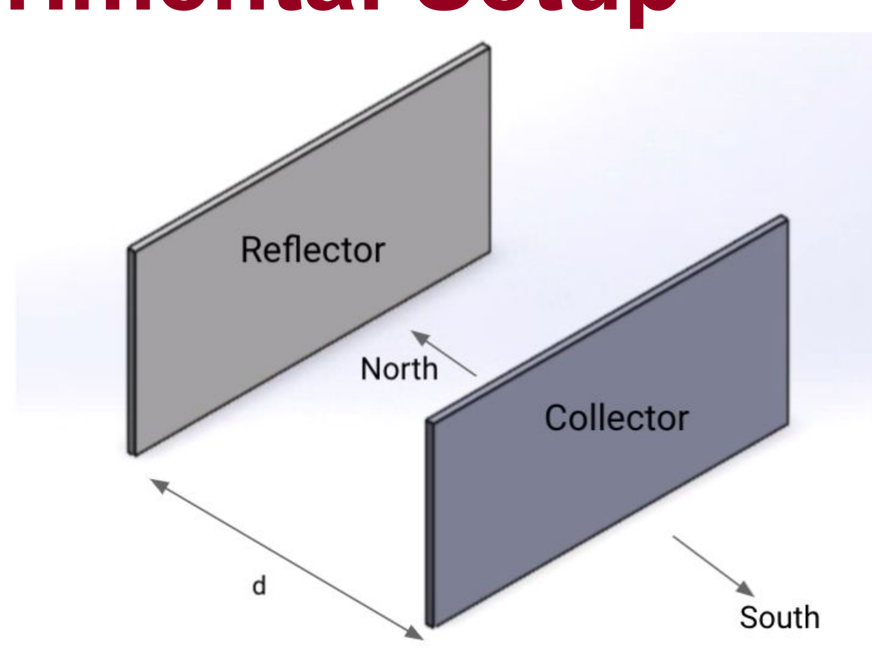

Figure 1: General Setup with sun from the south

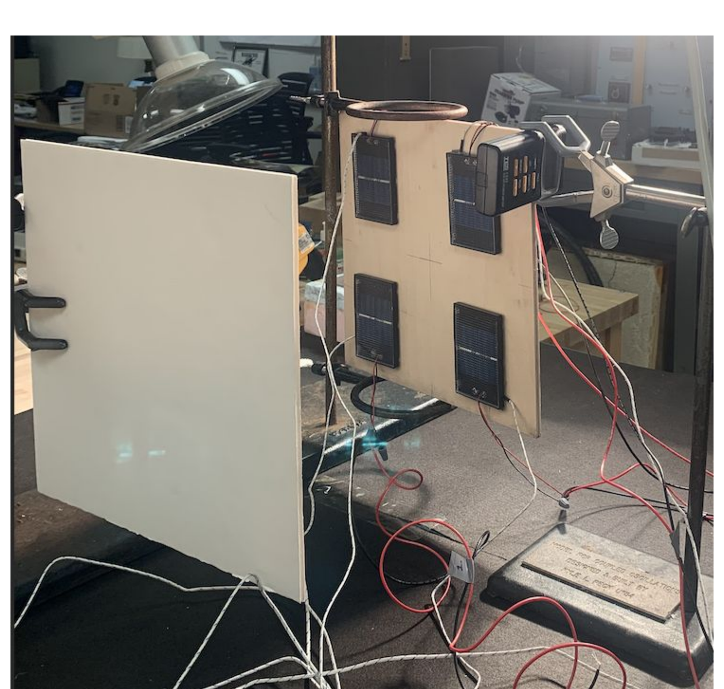

Figure 2: Indoor Setup

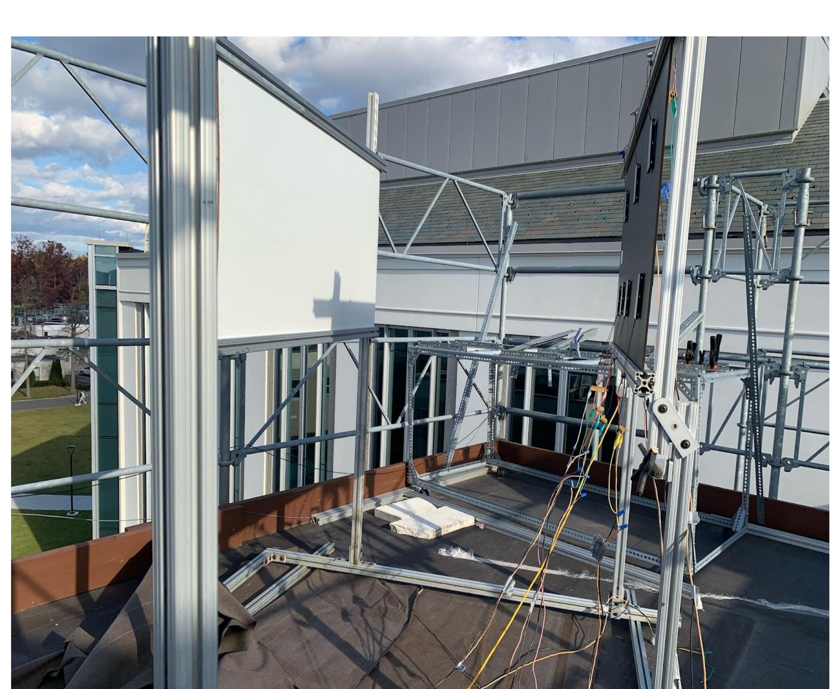

Figure 3: Outdoor Setup

Research Goals

- ➢ Design and conduct experiments to study the effects of different geometric parameters of a reflector-enhanced bifacial collector
- ➢ Compare experimental data with results from a numerical model.

Results

White-Diffuse Rear-Side Reflector:

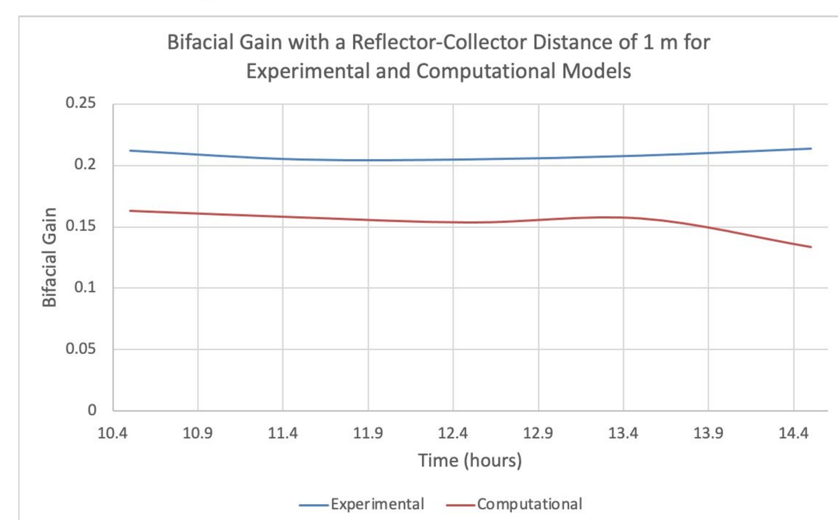

Figure 4: Outdoor experimental vs. computational over time for 1 m separation.

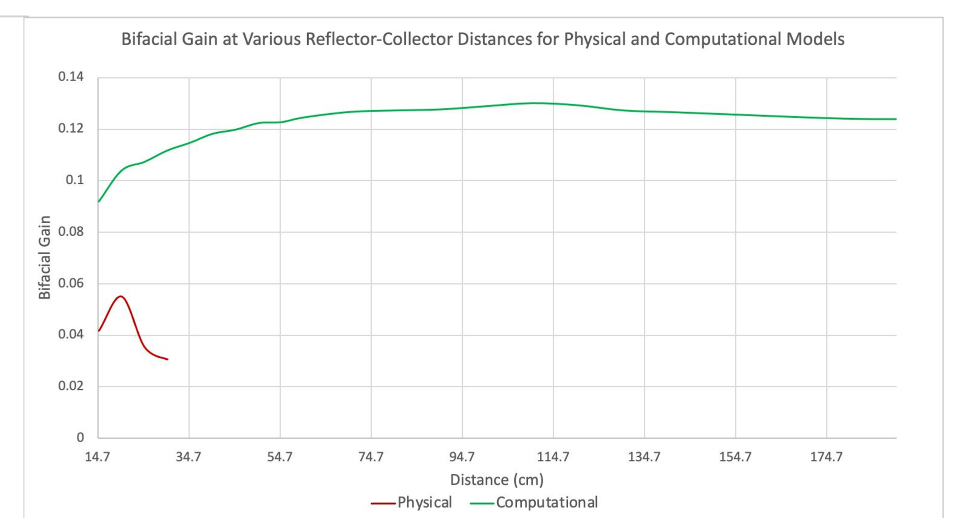

Figure 5: Indoor experimental vs. computational at different separation distances.

- Optimal separation distance around 1 m based on the outdoor experimental setup, resulting in a significant power gain of 20% (4).
- A peak bifacial gain can be seen at a specific reflector-collector distance. 20 cm. for the indoor model, and 110 cm for the computational model. While this discrepancy is somewhat high, both models display similar behavior, climbing to a maximum power gain then dropping off. Due to difference in sun vs. lamps and the scale.

Nonuniformity between rows of cells:

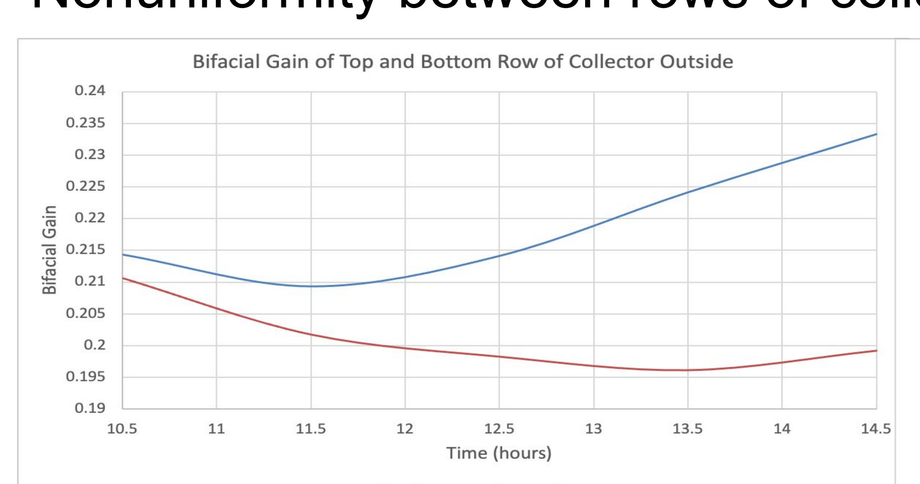

Figure 6: Nonuniformity between top and bottom rows of cells over time for outdoor tests.

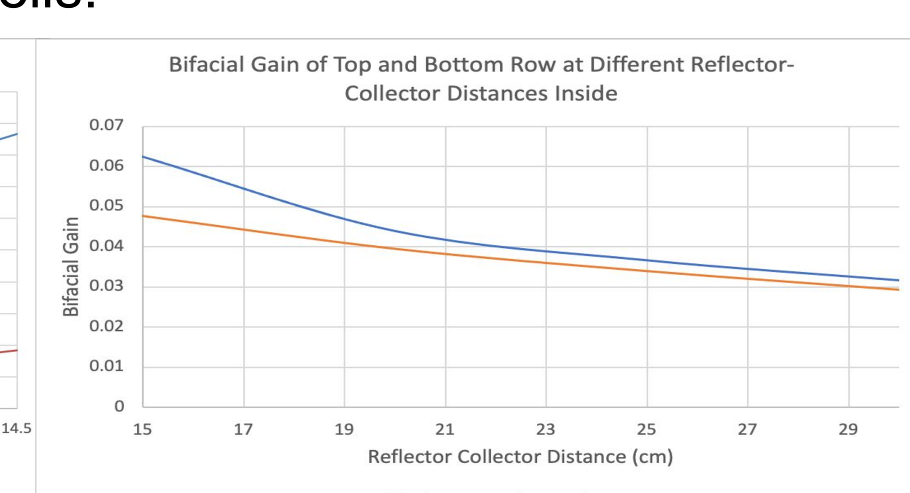

Figure 7: Nonuniformity between top and bottom rows of cells at different distances for indoor tests.

- As the incidence angle of the reflected sunlight changes over time, a greater disparity between the output of the top vs. bottom row occurs (Fig. 6).
- As the reflector is moved closer less diffuse light can reach the refector and collector (Fig. 7). [2].
- More tests could be conducted to see how the nonuniformity caused by a rear side reflector affects the overall power output of the entire module.

Background

- Bifacial photovoltaic cells have been studied since the 1960s.
- Addition of a rear-side reflector can be a simple and cost-effective method to produce a significant power increase.
- Geometric factors can influence this increase: reflector-collector separation distance, tilt angle, reflector-collector height above ground, reflector and ground albedo.
- Many different farm array geometries have been studied previously: vertical, optimally tilted, east-west and north-south orientations, etc.
- Sunlight has two components: beam and diffuse- Diffuse sunlight is any light that is scattered; most of the light that is captured on the rear side comes from direct and reflected diffuse light.

Conclusions

- ❖ Power gain of 20% for a 1m rear side reflector-collector distance, matches data gathered over the Summer of 2021.
- ❖ Nonuniformity between the rows as reflector moves closer, due to a lower view factor. There is an optimal distance where BG peaks.

References

[1] Rueter, M., Dobosz, M. and Wilk, R.D. "A Study of Reflector Enhanced Bifacial PV," Proceedings of SOLAR 2021: Empowering a Sustainable Future, American Solar Energy Society *College, Boulder, CO.*

[2] Lim, Y. S., Lo, C. K., Kee, S. Y., Ewe, H. T., and Faidz, A. R., 2013, "Design and evaluation of passive concentrator and reflector systems for bifacial solar panel on a highly cloudy region – A case study for Malaysia", Renewable Energy, 63, pp. 415-425.

Acknowledgements

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