Australian Government
Australian Renewable Energy Agency

ARENA

# Lessons Learnt

## Lessons Learnt Report: *Output loss analysis for bifacial modules by rear surface non-uniform irradiance*

***Project Name:*** *Photovoltaic Modules for the Australian Environment (PV-MATE)*

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| **Knowledge Category:** | Technical |
| **Knowledge Type:** | Technology |
| **Technology Type:** | Solar PV |
| **State/Territory:** | Canberra ACT, Adelaide ACT |

## Key learning

We have used the developed cell current mismatch tool to simulate the relative power loss of a tilted, ground mounted bifacial module due to non-uniform irradiance on the rear surface. Based on the measurements of irradiance at three locations at the top, middle and the bottom of a 45° tilted module, mounted on our rooftop platform, for average albedo of 22.7%, the irradiance at the rear bottom is 30.3% lower than the top on average over a day. The resultant power loss due to the variation of rear irradiance has been calculated to be in the range of 0.12% and 0.3%. This calculated power loss is low, considering the severity setup for non-uniform rear irradiance.

## Implications for future projects

We have investigated the variation of rear irradiance regarding to module tilt angle, elevation and solar position. The cell current simulation allows to better predict the power output of a bifacial module operating in-field with mounting and albedo information. The bifacial model takes cell IV properties and environmental data as input and therefore can be implemented with other cell-to-module (CTM) components to predict the overall power of a bifacial module with certain configurations and operating environment.

## Knowledge gap

Being able to absorb light from the rear surface, bifacial modules tend to have higher power output compared to conventional mono-facial modules. However, to estimate the power of a bifacial in the field is more complicated as the rear irradiance from ground reflection depends on the module position and several environmental factors. Most current bifacial module outdoor simulation models assume uniform irradiance at the rear. We have measured and modelled the magnitude of these errors. We have proposed a model to take consideration of the non-uniformity of rear surface irradiance to improve the accuracy of bifacial module power output simulation in the field.

# Background

## Objectives or project requirements

The goal of the project is to analyse the impact of rear irradiance gradient on the bifacial module power output. To achieve a realistic simulation results, output simulation is to be carried out with rear irradiance data measured in practical PV module operating environment.

## Process undertaken

We made 8 reference cells to measure the irradiance data at different locations of a tilted PV module at the front and rear surface as shown in Fig. 1. Irradiance data, presented in Fig. 2, was recorded over a cloudy day with 5-second incident between every two measurements. The front irradiance was approximately identical at three locations while the rear irradiance deviated significantly. Therefore, we computed the irradiance gradient at the rear using interpolation of the data, and use the irradiance gradient to scale the $I_{sc}$ of cells according to their positions. Using the cell current mismatch calculator developed in another project, we then calculated the relative power loss of an imaginary 60-cell bifacial module with reference to the amount of extra power received from rear irradiance. The module specifications are based on commercial modules while all cells within the module are assumed to be identical. The power loss is plotted in Fig. 3 over a day with a resolution of 5 seconds along with the albedo ratio.

# Supporting information

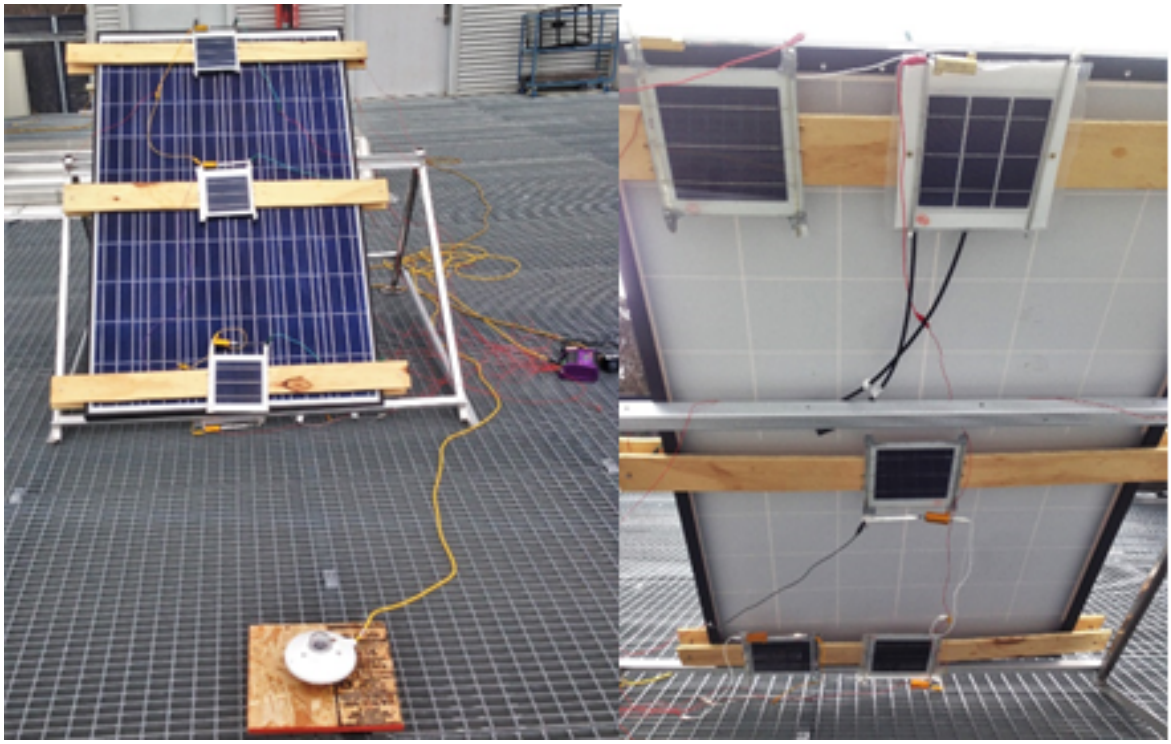

Figure. 1. Experiment setup of study on irradiance distribution on PV module's front and rear surface.

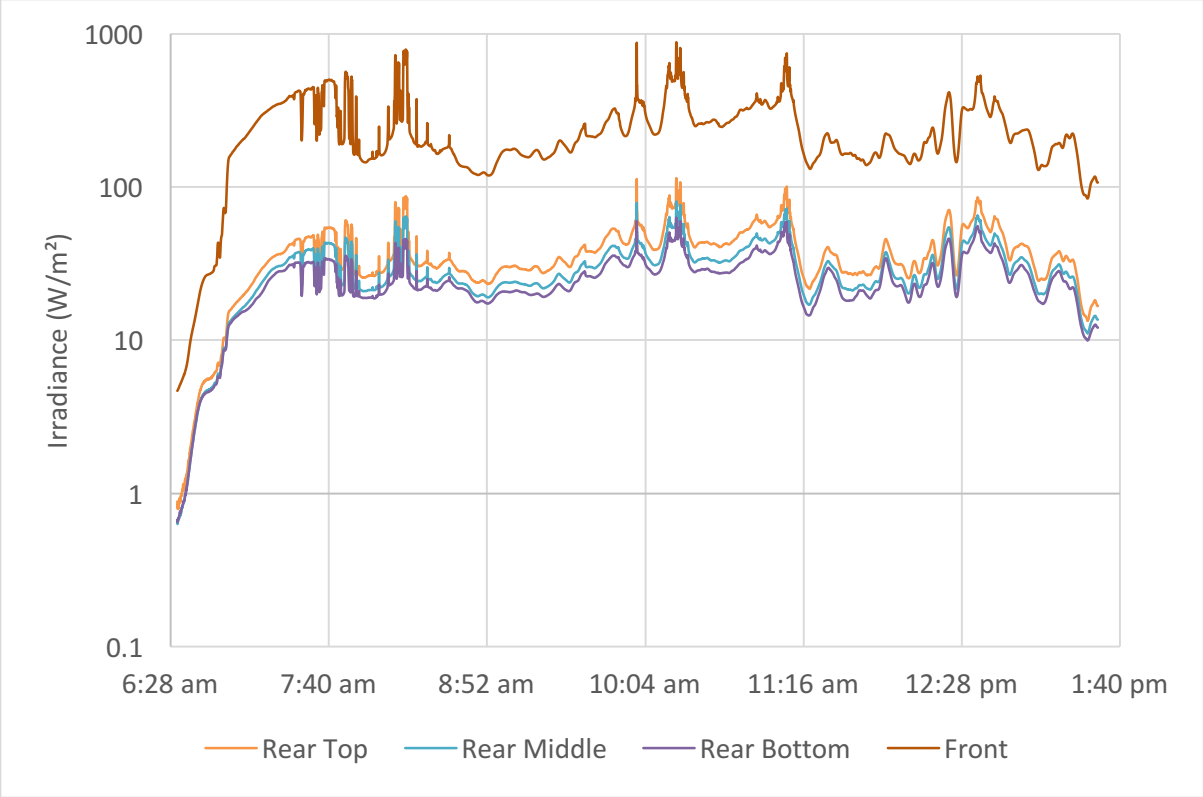


Figure. 2. Experiment setup of study on irradiance distribution on PV module's front and rear surface.

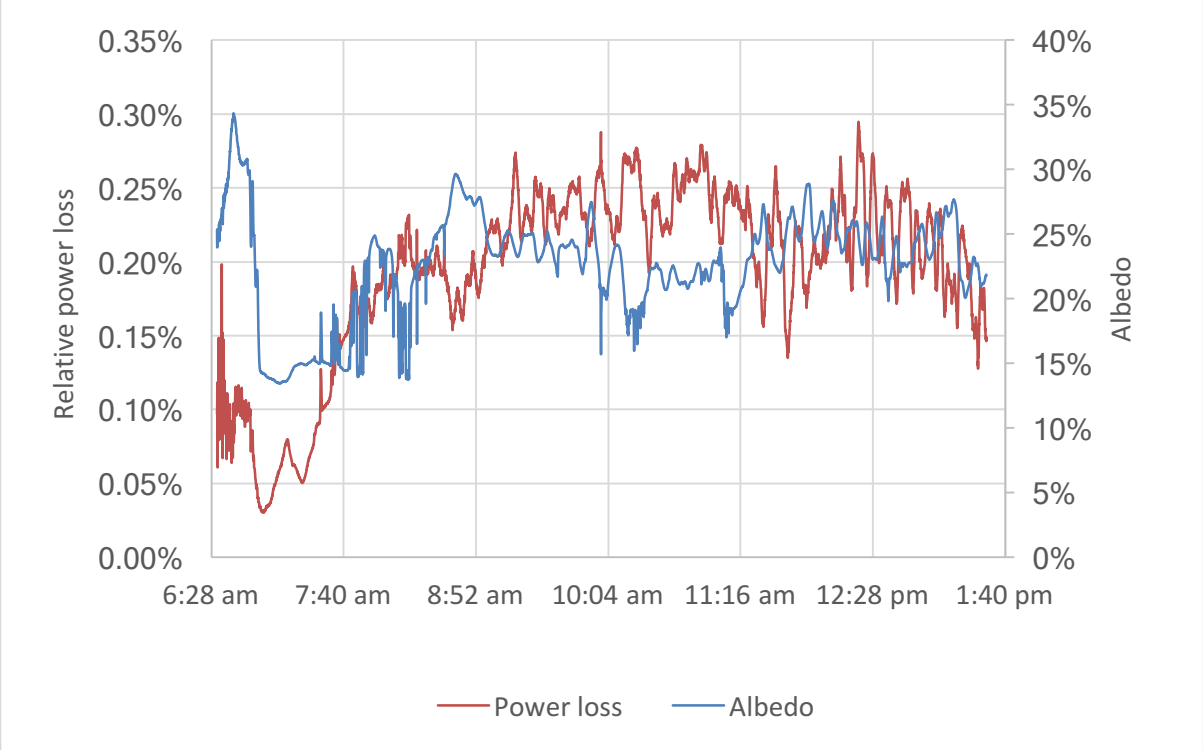


Figure. 3. Simulated mismatch power loss for a 60-cell (10×6) bifacial module with 3 strings. Rear surface irradiance is based on interpolation from three locations, and front surface irradiance is based on measurements.