Probabilistic modelling for technology comparison: Comparing Single-Axis Trackers and East-West mounting systems

Phillip Hamer[1], Nathan Chang[1,2], Baran Yildiz[1], Anna Bruce[1] and Bram Hoex[1]

[1]School of Photovoltaic and Renewable Energy Engineering, UNSW Sydney, Sydney, NSW, Australia
[2]5B, Mascot, NSW, Australia
p.hamer@unsw.edu.au

Abstract

The past decade has seen the use of single axis trackers (SAT) become increasingly dominant for utility scale PV installations. This has been driven by the increased yield per module (still the most expensive component of most systems) and more recently by the increase in bifacial gain. More recently a number of east-west mounting systems such as the PEG system and the 5B Maverick have gained attention. This is largely driven by the continued reduction in module and inverter costs and the increased significance of other system costs such as land acquisition and on-site labour. In this study we describe a tool based on Monte Carlo simulation to identify key decision factors between the use of single axis tracking and east-west mounting systems for GW scale installations in Northern Australia.

Methods

The simulation package was developed in python and currently uses the pvlib library[1] for simulation of PV output. Cost data is entered and accessed by means of an Airtable database. There are three main processes for a set of simulations, as shown in Figure 1. In the first step a specified selection of scenarios are ‘optimized’ to allow for a fair comparison. This optimization can be performed in order to achieve a specific yearly output, maximize the Net Present Value or simply simulate a set number of systems. A simple grid search, to determine the optimal number of E-W (120 modules) or SAT (84 modules) systems is performed and the results passed to the Monte Carlo process.

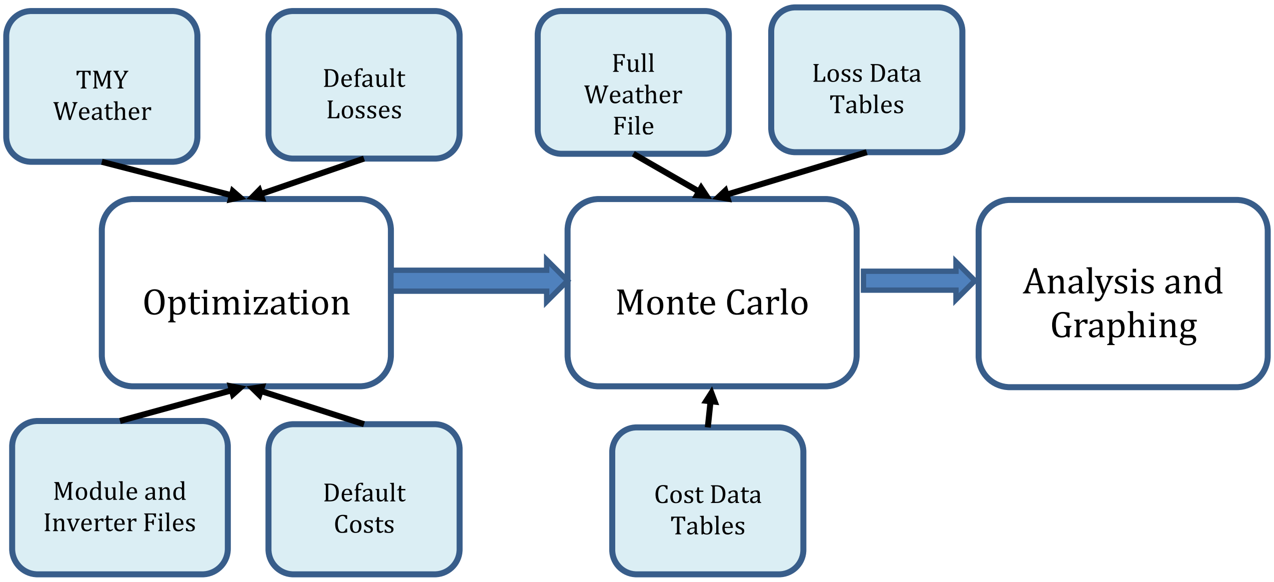

Figure 1: Block Diagram of Simulation Processes

The Monte Carlo process generates datatables from given ranges for system losses and costs. In addition the full weather file (15 years in the case simulated here) is used to generate random pv_out timeseries for the project life for each iteration. This allows calculation of kWh generated, revenue received and system costs for each iteration.

One important goal of this project was to simulate how these scenarios might change in future years. In order to do this ‘Future” modules were added to our module database based on the expected module efficiencies and parameters from the ITRPV roadmap[2].

Results

One of immediate observations from the comparison of SAT and E-W systems was that the use of TMY for the optimisation process led to issues once the full weather file was considered. Figure 2 presents a histogram and the associated cumulative distribution function of the daily total outputs (DC) for MAV and SAT systems using 600W modules, both sized to produce 30 GWh yearly using the TMY file. The significantly reduced number of days with output <100 MWh for E-W systems reflects lower output days having a higher fraction of diffuse light, for which the ~33% increase in panel area for the E-W system is more important than the trackers ability to capture direct light. Less expected was the higher output of E-W systems on the days with highest insolation. The combination of these two effects resulted in a 4% difference in total output over the simulated life of the system, meaning that the E-W system is somewhat “oversized”. The better approach is to optimize for NPV since this takes into account trade-offs between the cost of installing additional systems, the loss of excess generation and the opportunity to generate revenue on days with low insolation. It could also be extended to consider the impact on high-value electrified assets such as hydrogen electrolysers or enormous submarine cables.

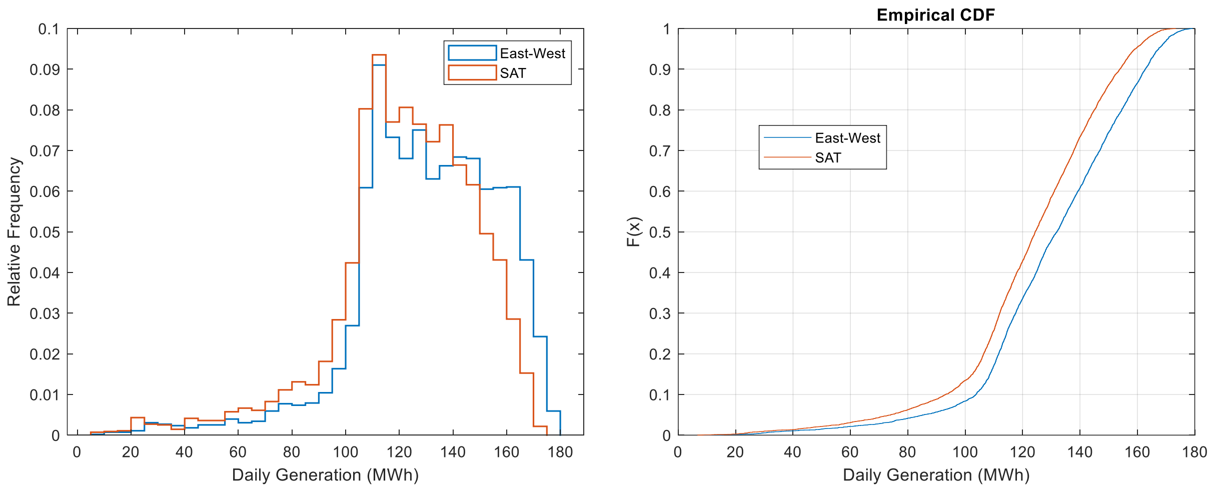

Figure 2: Histogram and Cumulative Distribution Function for daily generation of MAV (E-W) and SAT systems with the same total output based on TMY data.

Figure 3 presents the Monte Carlo outputs for LCOE for SAT and E-W systems in 2025 for module ratings of 550, 575 and 600 W. Based on our input costs used the E-W systems generally outperformed the SAT’s. The SAT systems did exhibit a greater dependence on module efficiency, whereas the E-W systems were more sensitive to any price premium for higher module efficiency. We can also use the tool to evaluate how these comparisons might be expected to evolve into the future as module (and other) costs decrease.

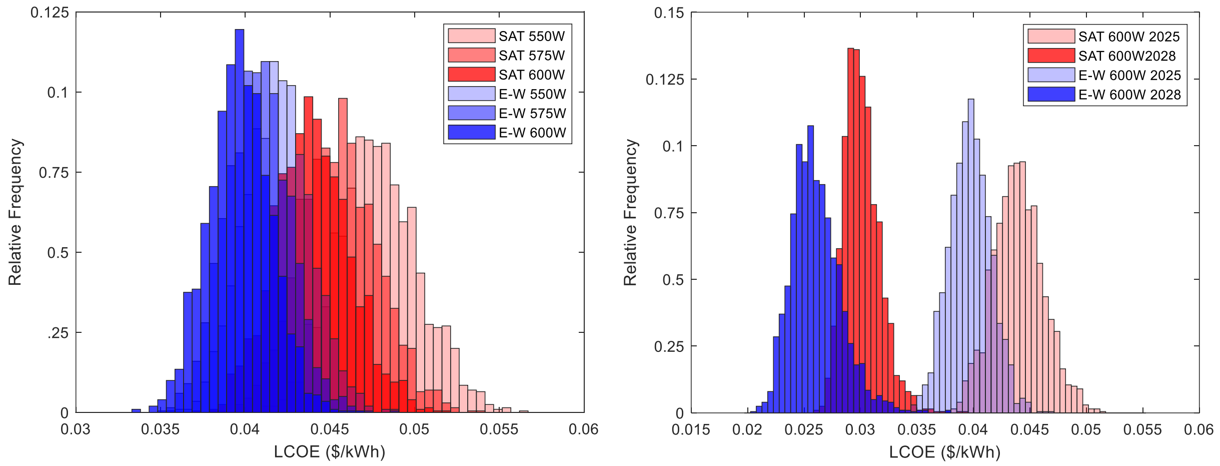

Figure 3: A) LCOE histogram for SAT and E-W systems in 2025 with 550, 575 and 600 W modules. B) LCOE histogram for SAT and E-W systems with 600 W modules in 2025 and 2028.

The most interesting application of the tool is to examine what drives the differences in output, such as LCOE, from the variable inputs. Figure 4 depicts the difference in LCOE between a SAT and an E-W system and its correlation to the onsite labour index and the module $/Wp. In all cases the SAT system has a higher LCOE but the difference is greater (yellow/green points) when modules costs are lower and onsite labour costs are higher. This is because such systems use more modules to achieve the same energy yield, but have vastly reduced usage of onsite labour.

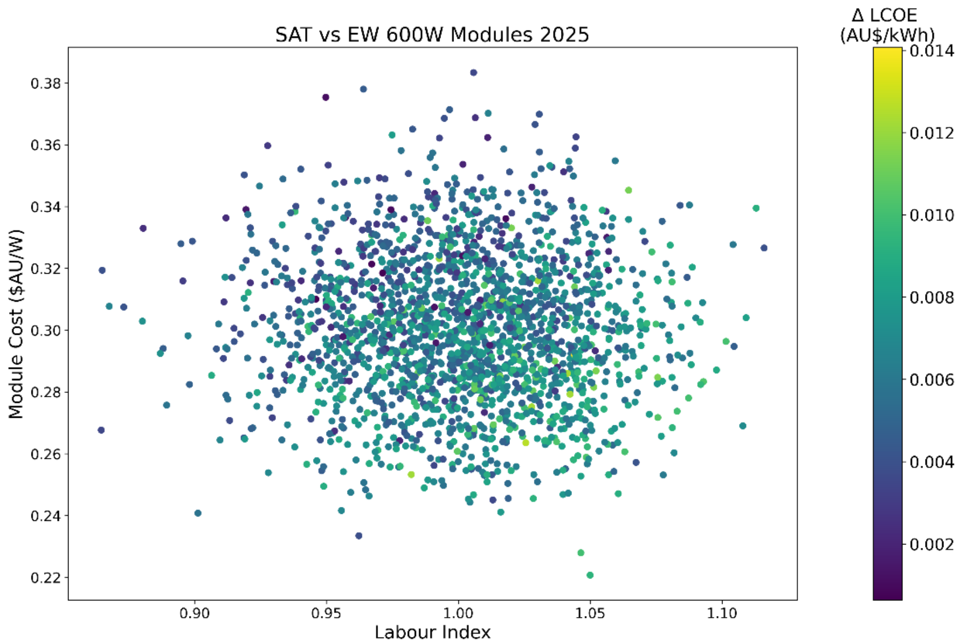

Figure 4: : 2-D scatter plot of ΔLCOE for an E-W system compared to a SAT system using 600 W modules.

Further Work

The tool described in this abstract is now being expanded through the ARENA TRAC project “Optimal O&M-strategy and LCOE-modelling for Ground-mounted PV. As part of this the pvlib energy yield simulations are being replaced with higher accuracy outputs from SunSolve yield[3], while the system loss models are also being updated with improved thermal and degradation models.

Acknowledgements

The authors would like to acknowledge support from the Australian Renewable Energy Agency (ARENA) through the project “Optimal O&M-Strategy and LCOE-Modelling for Ground-Mounted PV”

, as well as the Australian Centre for Advanced Photovoltaics. The Australian Government, through ARENA, is supporting Australian research and development in solar photovoltaic and solar thermal technologies to help solar power become cost competitive with other energy sources. The views expressed herein are not necessarily the views of the Australian Government, and the Australian Government does not accept responsibility for any information or advice contained herein.

References

[1] W. F. Holmgren, C. W. Hansen, and M. A. Mikofski, ‘pvlib python: a python package for modeling solar energy systems’, *J Open Source Softw*, vol. 3, no. 29, p. 884, Sep. 2018, doi: 10.21105/joss.00884.

[2] ‘Photovoltaic Equipment International Technology Roadmap for Photovoltaic (ITRPV) 2022 Results’, 2023.

[3] K. R. McIntosh, M. D. Abbott, B. A. Sudbury, and J. Meydbray, ‘Mismatch Loss in Bifacial Modules Due to Nonuniform Illumination in 1-D Tracking Systems’, *IEEE J Photovolt*, vol. 9, no. 6, pp. 1504–1512, Nov. 2019, doi: 10.1109/JPHOTOV.2019.2937217.