Monte Carlo simulation for comparison of single axis tracking and east west mounting systems

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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 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 ay 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, based on the number of E-W (120 modules) or SAT (84 modules) systems is performed and the results passed to the Monte Carlo process.

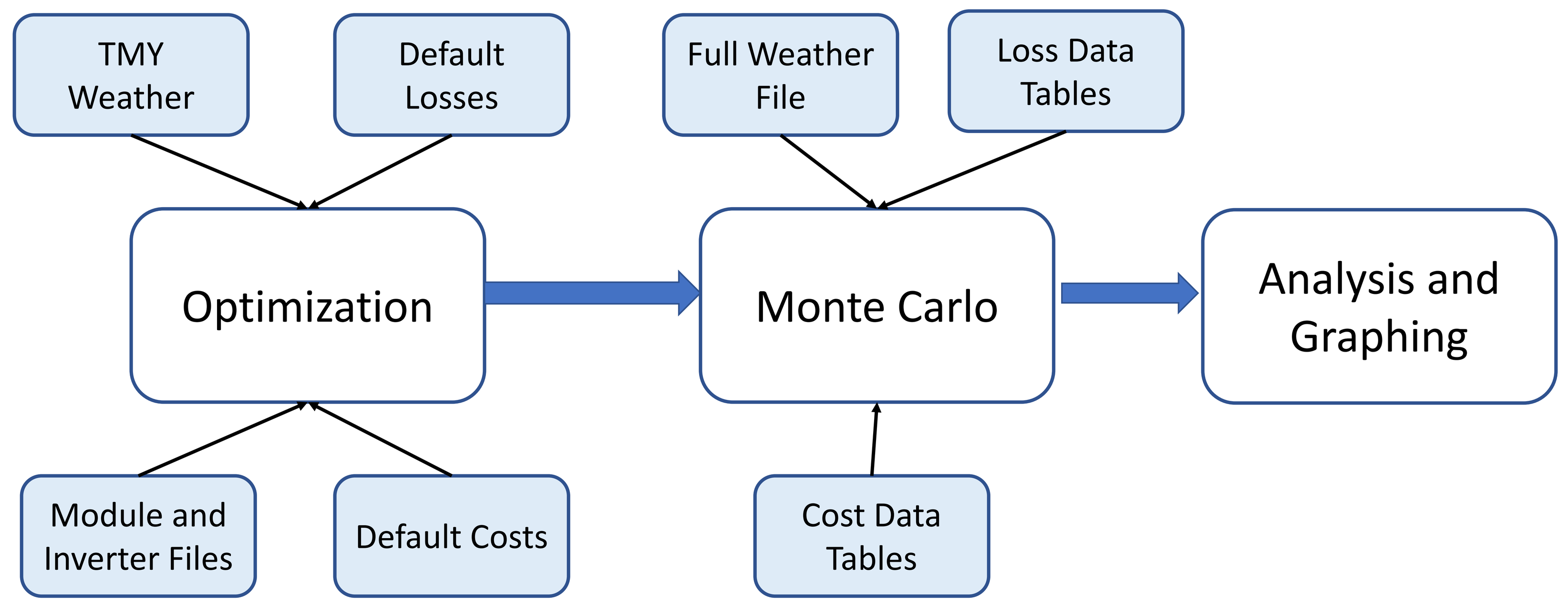

Figure 1: Block Diagram of Simulation Processes

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 for this poster) 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]. For this poster we considered 2.55 m^2 modules with Wp ratings of 550 W, 575 W and 600 W, with a price premium applied for higher efficiencies.

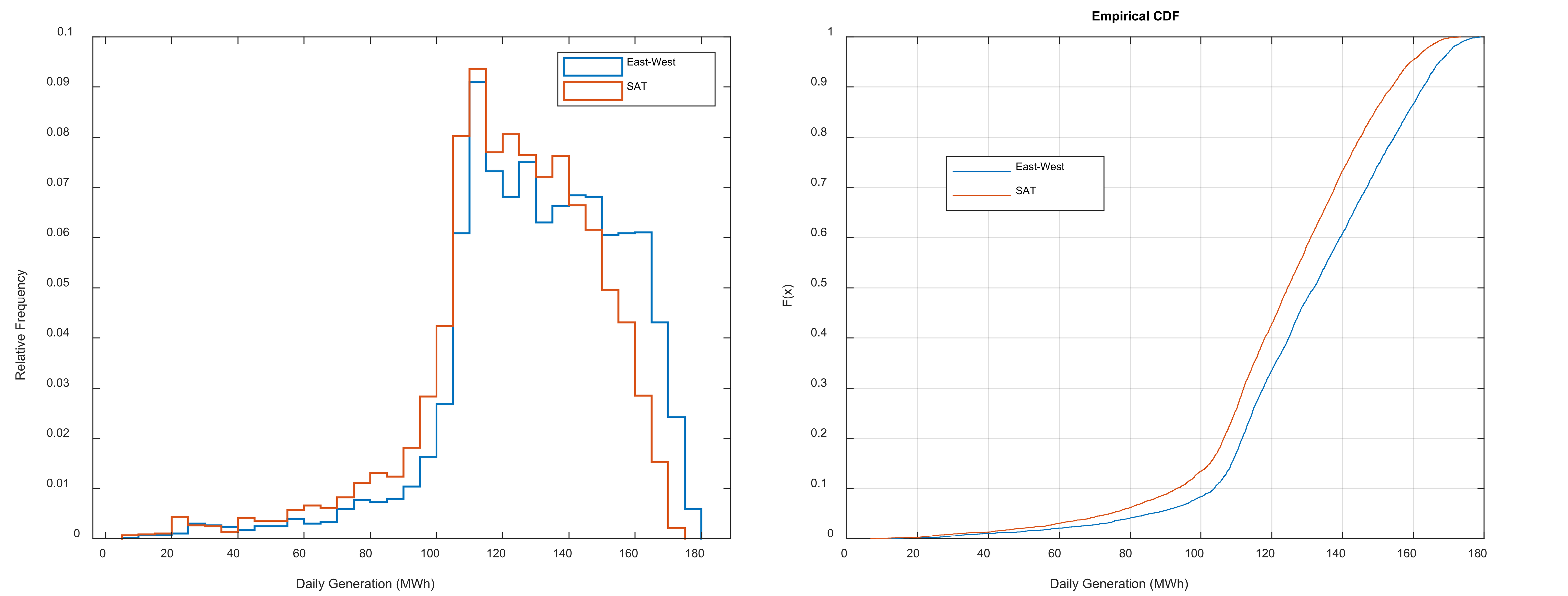

Figure 2: A) Histogram of daily generation for SAT and E-W systems using 600 W modules simulated over 15 years of satellite data. B) Cumulative Distribution function for the data in A).

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 E-W and SAT systems using 600W modules, both sized to produce 30 GWh yearly using the TMY file. The significantly lower number of days with output <100 MWh for E-W 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, resulting in a 4% difference in total output.

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 the price premium applied. 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.

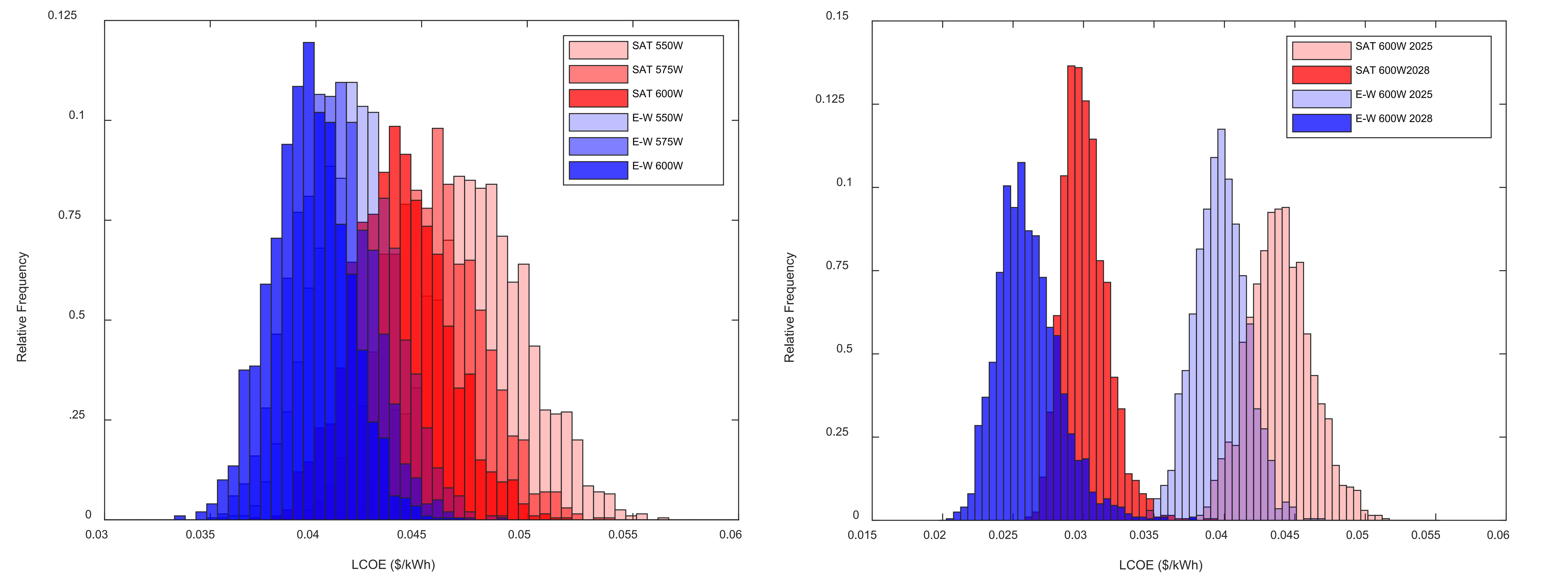

Figure 3: A) LCOE histogram for SAT and E-W systems in 2025 with 550, 575 and 600 W modules. B) LCOE histogram for SAT and E-W systems with 600 W modules in 2025 and 2028.

The most interesting application of the tool is to examine what drives the differences in output, such as LCOE, form 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 (Lower -> higher labour costs) and the module $/Wp. E-W systems are clearly advantaged by lower module costs and by higher onsite labour costs (due to their relatively easier deployment).

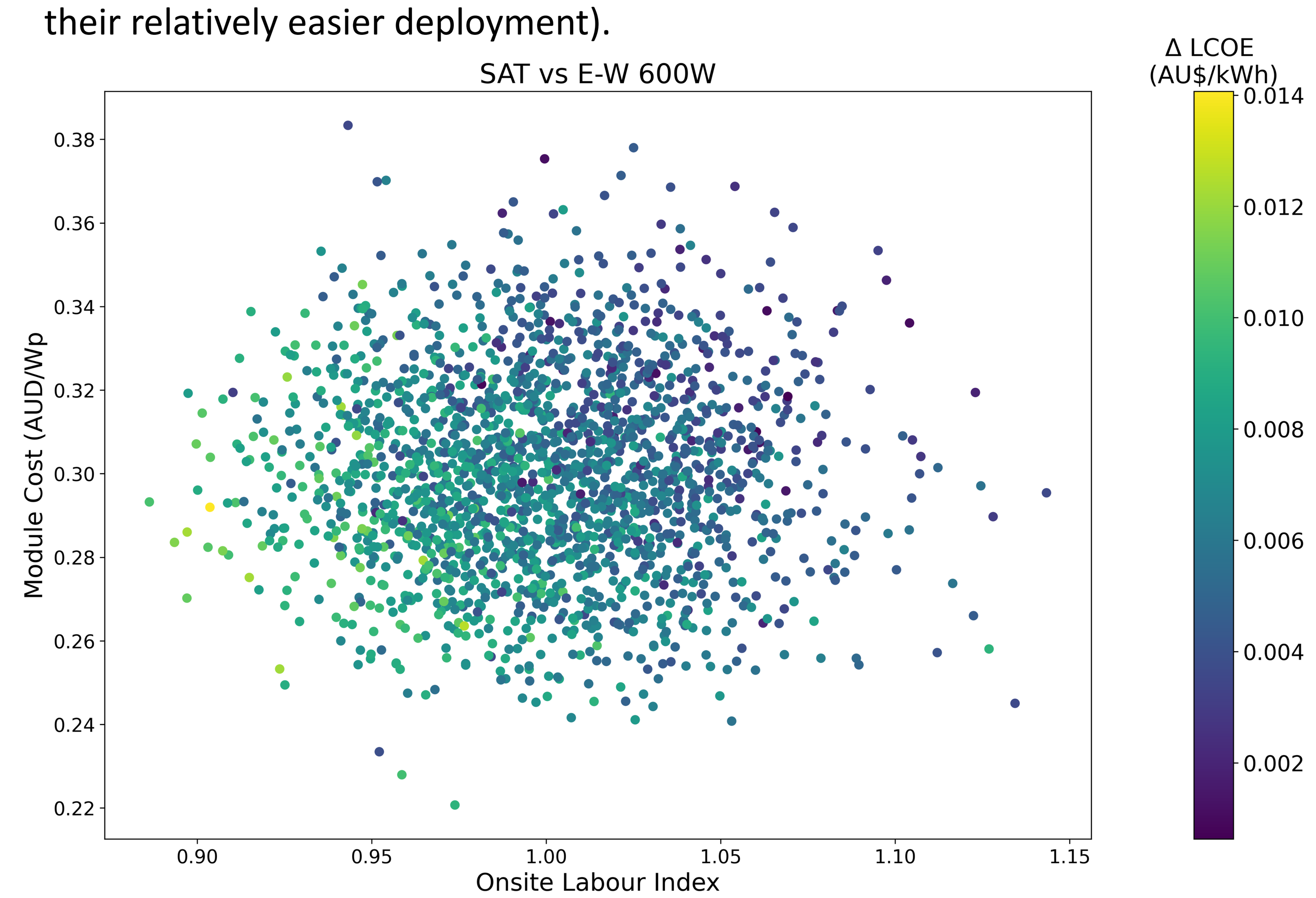

Figure 4: 2-D scatter plot of ΔLCOE for an E-W system compared to a SAT system using 600 W modules.

Further Work

This work formed part of a pilot project at UNSW. Going forward we are collaborating with 5B, Sun Cable and PVLighthouse to improve simulation of the 5B Maverick system, with a particular focus on improved pv_out simulation accuracy using SunSolve Yield and a focus on O&M costs.

References

[1] William F. Holmgren, Clifford W. Hansen, and Mark A. Mikofski. "pvlib python: a python package for modeling solar energy systems." Journal of Open Source Software, 3(29), 884, (2018). https://doi.org/10.21105/joss.00884

[2] ITRPV (International Technology Roadmap for Photovoltaic) 2022. VDMA. https://www.vdma.org/international-technology-roadmap-photovoltaic.

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