UNIVERSITI TEKNOLOGI MARA

ACTUAL AND SIMULATED PERFORMANCE OF GRID-CONNECTED PHOTOVOLTAIC SYSTEMS WITH ASSESSMENT OF THERMAL LOSS IN TROPICAL RAINFOREST CLIMATE

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ABSTRACT

The escalation of photovoltaic (PV) system installations has led to the development of PV software simulation tools, which are valuable for optimizing the design of PV systems.. However, one common issue related to simulation is the accuracy of the simulation with respect to the actual system performance. It is crucial to evaluate the accuracy of these simulations concerning the actual system performance. Analysis on several retrofitted grid-connected PV (GCPV) systems using PVsyst software also highlighted the significance of thermal loss (T_{loss}) as the major system loss, which reached up to 14%. Nevertheless, the comparison between the actual and simulated T_{loss} for GCPV system is still very limited, particularly in Tropical Rainforest Climate of Malaysia. Therefore, this study presents the evaluation on the design configuration of the actual installed and PVsyst simulated, comparison of the actual and PVsyst simulation technical performance and estimation of the discrepancy between actual and PVsyst simulated thermal loss of three GCPV systems in Malaysia. The results showed similarity between the simulated design configurations and the actual installed systems. The technical performances of systems A, B, and C were evaluated for the year 2019, considering seven parameters: DC energy generated (E_A), AC energy generated (E_{out}), Array yield (Y_A), final yield (Y_f), reference yield (Y_r), performance ratio (PR), capacity factor (CF). The results demonstrated a generally good agreement between the simulated and actual values for annual E_A, E_{out}, Y_A, Y_f, Y_r, CF with the Mean Bias Error (MBE)being less than 10% for all parameters. However, it is worth noting that the simulated annual PR exhibited the most significant inaccuracy. The MBE between the actual and simulated values for PR was -7.9%, -13.7%, and -11.4% for systems A, B, and C, respectively. The discrepancy can be attributed to an overestimation of losses declared in the PVsyst simulation, leading to the inaccuracy of the simulation results. Another potential factor contributing to the underprediction of PR is likely the T_{loss}, which the actual values for system A, B and C were found to be 8%, 6%, and 6.4%, respectively. On the other hand, the simulated T_{loss} obtained for systems A, B, and C were 11.7%, 11.7%, and 11.5%, respectively. When comparing the simulated T_{loss} to the actual T_{loss}, the results revealed that the simulated values were consistently higher for all three systems, with a deviation of 3.7%, 5.8%, and 5.1% for systems A, B, and C, respectively. This study has successfully compared the actual and PVsyst simulated T_{loss}, leading to the proposal of further modifications to the field T_{loss} based on the type of mounting in PVsyst simulations.

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CHAPTER 1
INTRODUCTION

1.1 Research Background

Malaysia possesses a geographically advantageous location for the generation of solar energy, primarily due to its proximity to the equator (Shafie et al., 2011). This strategic positioning allows the country to receive substantial solar irradiance, ranging from 1,575 kWh/m^2 to 1,812 kWh/m^2, which is comparable to the regional average of 1,500 kWh/m^2 to 2,000 kWh/m^2 observed in Southeast Asia (SEDA, 2021)

The exceptional solar potential in Malaysia has rendered it as an ideal location for solar energy generation, with various types of solar photovoltaic (PV) installations available, including rooftop, ground-mounted, and floating solar PV. This high solar irradiance, increase the potential for solar PV installations in Malaysia particularly grid-connected PV (GCPV) with an estimated 42 GW of rooftop solar PV resource availability from 4.6 million buildings and 43 university campuses, while ground-mounted solar PV has the highest solar potential in Malaysia at 210 GW. Additionally, floating solar PV has an estimated 16.6 GW of resource potential available in Malaysia, covering 17 hydroelectric plants and 62 reservoir dams that make up 2,944 km^2 of total water surface area (SEDA, 2021)

The rise in PV system installations within Malaysia has led to an increased utilization of commercial PV software simulation tools. These tools play a crucial role in optimizing the design and performance of photovoltaic systems, ensuring their maximum efficiency and effectiveness (González-Peña et al., 2021; Umar et al., 2018). Various software applications such as PVsyst, HOMER, MATLAB, and others have been employed for simulation and analysis purposes (Al-Waeli et al., 2018; Dondariya et al., 2018; Duman & Güler, 2020). These studies commonly analyze parameters including energy production, reference, array and final yield, performance ratio, capacity factor, system efficiency, and system losses (Allouhi et al., 2016; Ameur et al., 2020; Attari et al., 2016; Dondariya et al., 2018; Duman & Güler, 2020; Emziane & Al Ali, 2015; Omar & Mahmoud, 2018; te Heesen et al., 2019).This study aims to compare the actual and simulated technical performance parameters of three GCPV systems in Malaysia and subsequently estimate the discrepancies in thermal loss between the actual