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ENERGY YIELD AND MONTHLY PERFORMANCE ANALYSIS OF A LARGE-SCALE PHOTOVOLTAIC SYSTEM USING ENERGY PERFORMANCE INDEX

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Abstract:
This study aims to evaluate the level of energy generation efficiency and monthly operating performance of large-scale photovoltaic systems using the Energy Performance Index (EPI) approach. This approach is used to overcome the industry's reliance on irradiation data alone, which is insufficient to identify performance degradation caused by internal technical factors of the system. The analysis of this study is based on actual operational data obtained from a large-scale solar plant with a capacity of 31 MWp for the period January to December 2023. The EPI calculation method is developed based on a derating factor model that considers the effects of module temperature, inverter efficiency, power loss in the cable, module surface contamination, and system degradation. Monthly analysis is then used to link EPI values to possible causes of system failure or performance degradation. The results show that recorded EPI values fell below the 0.90 performance threshold throughout the study period, with the largest deviations occurring in February (-18.24%), attributed to inverter failure and October (-16.32%), attributed to system efficiency degradation. By July, in contrast, recorded the best performance with an EPI of 0.893 despite only moderate irradiation input. These findings demonstrate that EPI captures

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performance deviations more sensitively and completely than irradiation-based assessment alone. The main contribution of this study is therefore a validated EPI-based framework that can serve as a standard metric for monthly performance monitoring, predictive maintenance planning, and long-term operational optimization of PV farms in Malaysia.

Keywords:
Photovoltaic system, energy performance index, monthly performance, large-scale solar farms, predictive maintenance

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