ABSRACT
THE EFFECT OF SOLAR IRRADIANCE AND LOAD VARIATION ON THE PERFORMANCE OF A 12-VOLT 400 WP OFF-GRID SOLAR POWER SYSTEM

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The increasing demand for electrical energy has driven innovation in the use of renewable energy sources, one of which is the off-grid Solar Power Plant (PLTS) with a capacity of 400 WP. This study aims to analyze the influence of solar irradiance and load variations on the performance of a 12-volt monocrystalline-based PLTS system. The method employed is field experimentation, conducted over a five-day period under varying solar irradiance levels (793–1,216 W/m²) and electrical loads (100–500 watts), with observations on the efficiency of solar panels, inverters, MPPT controllers, and 12V VRLA battery capacity. The results show that panel efficiency increased from 14.4% to 15.84% as irradiance rose, while higher loads enhanced inverter efficiency up to over 93%. However, high loads may accelerate battery capacity degradation if not supported by sufficient sunlight. PLTS efficiency also improved, reaching up to 14,34% at the highest irradiance level. Therefore, an optimal combination of solar intensity and proper load management is crucial for enhancing the efficiency and durability of off-grid PLTS systems, supporting the sustainable utilization of renewable energy in Indonesia.

Keywords: off-grid solar power, solar irradiance, electrical load, efficiency, renewable energy.