

ABSTRAK

SALMAN NUSADA BASIR, Analisis Efisiensi dan Kontinuitas Suplai Daya pada Sistem Pembangkit Listrik *Hybrid* PLTS – PLTPH untuk Beban Penerangan.
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Keterbatasan akses listrik dan karakteristik sumber energi terbarukan yang berubah menjadi tantangan dalam penyediaan energi pada wilayah terpencil. Penelitian ini bertujuan menganalisis kinerja PLTS, kinerja dan efisiensi PLTPH, kinerja sistem hybrid PLTS-PLTPH, serta kemampuan energi yang dihasilkan untuk memenuhi kebutuhan beban penerangan. Pengujian dilakukan secara eksperimental di laboratorium menggunakan prototipe sistem hybrid PLTS-PLTPH yang dianalisis pada empat kelompok pengujian, yaitu PLTS, PLTPH, hybrid, dan beban LED. PLTS diuji selama tujuh hari pada pukul 07.00-17.00 dengan 77 titik pengamatan. PLTPH diuji selama tujuh hari pada pukul 18.00-03.00 dengan 70 titik pengamatan pada debit tetap 15,60 L/menit dan head 1,20 m. Hasil pengujian menunjukkan PLTS menghasilkan daya rata-rata 16,069 W, daya maksimum 27,36 W, energi rata-rata 172,75 Wh/hari, dan tingkat pemanfaatan daya puncak 91,20% terhadap kapasitas nominal panel 30 Wp. PLTPH menghasilkan daya rata-rata 2,278 W, daya maksimum 2,40 W, energi rata-rata 20,49 Wh/malam, koefisien variasi daya 3,46%, dan efisiensi rata-rata 74,50%. Pada kondisi hybrid, daya rata-rata sebesar 18,347 W dengan kontribusi relatif PLTS 87,58% dan PLTPH 12,42%, sedangkan energi gabungan sebesar 193,24 Wh/periode. Beban LED 5 W selama 12 jam membutuhkan energi 60 Wh. Energi PLTS dan hybrid lebih besar daripada kebutuhan tersebut, sedangkan energi PLTPH belum mencukupi apabila digunakan sendiri. Pada perhitungan beban, energi baterai awal 90 Wh masih tersisa 55,40 Wh pada akhir periode setelah memperhitungkan konsumsi beban dan tambahan energi PLTPH sesuai data yang digunakan. Hasil penelitian menunjukkan bahwa pada kondisi prototipe yang diuji, PLTS menjadi sumber utama, PLTPH berperan sebagai sumber pendukung, dan kombinasi keduanya mampu menyediakan energi yang mencukupi kebutuhan beban penerangan 5 W selama periode analisis.

Kata kunci: Sistem *Hybrid*, PLTPH, PLTS, Efisiensi Energi, Kontinuitas Daya

ABSTRACT

SALMAN NUSADA BASIR, Analysis of Efficiency and Power Supply Continuity in a Hybrid Solar PV–Pico-Hydro Power System for Lighting Loads.

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Limited access to electricity and the variable characteristics of renewable energy resources remain challenges for energy supply in remote areas. This study analyzes the performance of the solar photovoltaic (PV) subsystem, the performance and efficiency of the pico-hydro subsystem, the performance of the hybrid PV-pico-hydro system, and the ability of the generated energy to meet a lighting load. Laboratory experiments were conducted using a hybrid PV-pico-hydro prototype and were grouped into four tests: PV, pico-hydro, hybrid operation, and a 5 W LED load. The PV system was tested for seven days from 07:00 to 17:00, producing 77 observations. The pico-hydro system was tested for seven days from 18:00 to 03:00, producing 70 observations at a constant flow rate of 15.60 L/min and a 1.20 m head. The PV system produced an average power of 16.069 W, a maximum power of 27.36 W, an average energy of 172.75 Wh/day, and a peak power utilization of 91.20% relative to the 30 Wp panel rating. The pico-hydro system produced an average power of 2.278 W, a maximum power of 2.40 W, an average energy of 20.49 Wh/night, a power coefficient of variation of 3.46%, and an average efficiency of 74.50%. Under hybrid operation, the average power was 18.347 W, with relative contributions of 87.58% from PV and 12.42% from pico-hydro, while the combined energy was 193.24 Wh per test period. A 5 W LED operated for 12 hours requires 60 Wh. The energy provided by the PV and hybrid conditions exceeded this requirement, whereas the pico-hydro subsystem alone was insufficient. In the load-energy calculation, the battery energy decreased from an initial 90 Wh to 55.40 Wh at the end of the period after accounting for load consumption and the pico-hydro energy contribution according to the data used. The results show that, under the tested prototype conditions, PV acts as the main source, pico-hydro as a supporting source, and their combination provides sufficient energy for the 5 W lighting load during the analyzed period.

Keyword: *energy efficiency, hybrid system, pico-hydro power, power continuity, solar photovoltaic system.*