

**ABSTRAK**  
**Efisiensi Total Sistem PLTS 400 WP Off-Grid Parallel Terhadap**  
**Pemakaian Listrik Pengaruh Sudut Kemiringan Panel**  
***Polycrystalline dan Irradiance***

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Meningkatnya konsumsi listrik nasional memicu kebutuhan mendesak akan pemanfaatan energi terbarukan, salah satunya melalui Pembangkit Listrik Tenaga Surya (PLTS). Walaupun Indonesia memiliki potensi radiasi surya yang melimpah, kinerja operasional PLTS sangat dipengaruhi oleh variabel lingkungan dan teknis, seperti intensitas cahaya (*irradiance*) dan sudut kemiringan panel surya. Penelitian ini bertujuan menganalisis konfigurasi sudut kemiringan panel surya optimal dan pengaruh *irradiance* terhadap efisiensi daya sistem PLTS *off-grid* paralel berkapasitas 400 Wp. Metode penelitian dilakukan dengan merancang, membangun, dan menguji sistem menggunakan empat panel jenis *polycrystalline*, MPPT, baterai VRLA, serta inverter dengan beban konstan 300 watt. Pengujian menerapkan variasi sudut kemiringan 0°, 8°, 16°, 24°, dan 32° pada pukul 09.00–13.00 WIB. Hasil penelitian menunjukkan sudut kemiringan panel berpengaruh berbanding terbalik terhadap performa akibat Hukum Kosinus Pencahayaannya (*Lambert's Cosine Law*). Konfigurasi terbaik diraih pada sudut 0° (horizontal) dengan *irradiance* maksimum 1.168,00 W/m<sup>2</sup>, yang menghasilkan efisiensi panel 12,40 %, daya output MPPT 346,95 watt, kapasitas baterai 97%, dan efisiensi total sistem tertinggi 10,19 %. Sebaliknya, performa terendah terjadi pada sudut ekstrem 32° dengan *irradiance* 420,00 W/m<sup>2</sup>, menghasilkan efisiensi panel 6,58 % dan efisiensi total 5,35 %. Selisih efisiensi tersebut mengindikasikan adanya akumulasi kehilangan energi (*power losses*) pada komponen elektronika daya dan transfer elektrokimia baterai.

Kata Kunci: *PLTS Off-Grid, Sudut Kemiringan, Irradiance, Polycrystalline, Efisiensi Daya.*

## ABSTRACT

### ***Total System Efficiency of 400 WP Off-Grid Parallel PLTS Against the Influence of Electricity Consumption of Polycrystalline Panel Tilt Angle and Irradiance***

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*The increasing national electricity consumption triggers an urgent need for the utilization of renewable energy, one of which is through Solar Power Plants (PLTS). Although Indonesia has abundant solar radiation potential, the operational performance of PLTS is highly influenced by environmental and technical variables, such as light intensity (irradiance) and the tilt angle of the solar panels. This study aims to analyze the optimal solar panel tilt angle configuration and the effect of irradiance on the power efficiency of a 400 Wp parallel off-grid PLTS system. The research method involved designing, building, and testing a system utilizing four polycrystalline panels, an MPPT, a VRLA battery, and an inverter under a constant 300-watt load. Testing varied the tilt angles at 0°, 8°, 16°, 24°, and 32° from 09:00 to 13:00 WIB. The results indicated that the panel tilt angle is inversely proportional to system performance due to Lambert's Cosine Law. The best configuration was achieved at a 0° angle (horizontal) with a maximum irradiance of 1.168,00 W/m<sup>2</sup>, yielding a panel efficiency of 12,40 %, MPPT output power of 346,95 watts, battery capacity of 97%, and the highest total system efficiency of 10,19 %. Conversely, the lowest performance occurred at an extreme 32° angle with 420.00 W/m<sup>2</sup> irradiance, resulting in a panel efficiency of 6,58 % and a total efficiency of 5,35 %. The efficiency discrepancy indicates accumulated power losses within power electronic components and the electrochemical battery transfer.*

**Keywords:** *Off-Grid PLTS, Tilt Angle, Irradiance, Polycrystalline, Power Efficiency.*