

ABSTRAK

Meikel Eduardo Girsang: Perancangan dan Analisis Ekonomi Sistem PLTS dalam Memenuhi Kebutuhan Suplai Daya Listrik pada Bukit Gajah Bobok Kabupaten Karo. Skripsi. Fakultas Teknik Universitas Negeri Medan, 2025.

Bukit Gajah Bobok di Kabupaten Karo merupakan kawasan wisata yang hingga kini belum memperoleh akses jaringan listrik dari PLN. Kondisi tersebut menyebabkan kebutuhan energi listrik masih sepenuhnya bergantung pada generator berbahan bakar fosil yang menimbulkan berbagai permasalahan, seperti tingginya biaya operasional, ketergantungan pada ketersediaan bahan bakar, serta dampak negatif berupa kebisingan dan pencemaran lingkungan. Oleh karena itu, penelitian ini bertujuan untuk merancang sistem Pembangkit Listrik Tenaga Surya (PLTS) off-grid sebagai alternatif penyediaan energi listrik yang lebih handal, efisien, dan ramah lingkungan, sekaligus menganalisis aspek keekonomian dari sistem yang diusulkan.

Metodologi penelitian mencakup studi literatur, survei lapangan, serta pengumpulan data beban listrik. Berdasarkan hasil pengukuran, kebutuhan beban listrik harian terpasang sebesar 6,354 kWh dengan proyeksi peningkatan hingga 19,128 kWh per hari. Selain itu, intensitas iradiasi matahari rata-rata di lokasi penelitian tercatat 4,63 kWh/m²/hari. Perancangan sistem dilakukan melalui penentuan kapasitas panel surya, baterai, dan inverter, yang kemudian disimulasikan menggunakan perangkat lunak HOMER Pro.

Hasil perancangan menunjukkan konfigurasi PLTS dengan panel surya monokristalin 375 Wp sebanyak 18 unit (kapasitas total 6,60 kWp), baterai Lithium LiFePO₄ berkapasitas 4,8 kWh sebanyak 5 unit, serta inverter hybrid Growatt 3 kW. Sistem ini dirancang dengan masa operasi 20 tahun, faktor derating 85%, dan efisiensi baterai 95%. Berdasarkan simulasi, PLTS mampu menghasilkan suplai energi rata-rata 24,8 kWh/hari yang sesuai dengan profil beban.

Dari sisi ekonomi, diperoleh nilai *Cost of Energy* (CoE) sebesar Rp 2.247/kWh, lebih rendah dibandingkan generator berbahan bakar fosil, dengan total biaya *Net Present Cost* (NPC) sebesar Rp 202.000.000. Analisis sensitivitas terhadap variasi suku bunga 6%–7,5% menunjukkan bahwa kenaikan suku bunga meningkatkan CoE, namun menurunkan NPC, sedangkan biaya operasional relatif stabil.

Dengan demikian, penerapan PLTS off-grid di Bukit Gajah Bobok layak diterapkan sebagai solusi ekonomis dan berkelanjutan dalam pemenuhan kebutuhan energi listrik kawasan wisata tersebut.

Kata kunci: PLTS, HOMER Pro, energi surya, biaya energi listrik, analisis sensitivitas

ABSTRACT

M. E. Girsang, "Design and Economic Analysis of a Solar Power Plant (PLTS) System to Meet the Electricity Supply Needs at Bukit Gajah Bobok, Karo Regency," Undergraduate Thesis, Faculty of Engineering, State University of Medan, 2025

Bukit Gajah Bobok, located in Karo Regency, is a tourist area that has not yet obtained access to the PLN electricity grid. As a result, electricity demand still relies entirely on fossil fuel generators, which cause several issues such as high operational costs, dependence on fuel availability, as well as negative impacts including noise and environmental pollution. Therefore, this study aims to design an off-grid Solar Power Plant (PLTS) as an alternative energy supply that is more reliable, efficient, and environmentally friendly, while also analyzing the economic feasibility of the proposed system.

The research methodology includes literature studies, field surveys, and data collection of electricity demand. The installed daily load was recorded at 6.354 kWh, with projected growth reaching 19.125 kWh per day. In addition, the average solar irradiation intensity at the study site was measured at 4.63 kWh/m²/day. System design was carried out through the determination of solar panel, battery, and inverter capacities, which were then simulated using HOMER Pro software.

The design results indicate that the PLTS configuration consists of 18 units of monocrystalline solar panels rated at 375 Wp (total capacity of 6.60 kWp), five units of Lithium LiFePO₄ batteries with 4.8 kWh each, and one Growatt 3 kW hybrid inverter. The system was designed for a 20-year operation period, with a derating factor of 85% and battery efficiency of 95%. Simulation results show that the PLTS can produce an average energy supply of 24.8 kWh/day, which meets the projected load profile.

From an economic perspective, the system achieves a Cost of Energy (CoE) of Rp 2,247/kWh, lower than the current generator-based system, with a total Net Present Cost (NPC) of Rp 202,000,000. Sensitivity analysis with interest rate variations of 6%–7.5% indicates that higher rates increase CoE but reduce NPC, while operational costs remain relatively stable.

Thus, the implementation of the off-grid PLTS at Bukit Gajah Bobok is considered feasible, economical, and sustainable for meeting electricity needs in the area.

Keywords: *Solar PV system, HOMER Pro, solar energy, electricity cost, sensitivity analysis*