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**OPTIMISASI KONFIGURASI SISTEM ISOLATED HYBRID MICROGRID BERBASIS SIMULASI DENGAN METODE
MULTI-OBJECTIVE PARTICLE SWARM OPTIMIZATION (MOPSO)**
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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

INTISARI

Perangkat lunak optimisasi seperti HOMER Pro banyak digunakan dalam perancangan sistem *hybrid microgrid*. Namun, optimisasi yang digunakan masih berfokus pada minimisasi biaya sehingga aspek keandalan sistem, pemanfaatan energi terbarukan, dan *curtailment* belum dipertimbangkan secara simultan sebagai fungsi objektif. Penelitian ini mengembangkan algoritma *Multi-Objective Particle Swarm Optimization* (MOPSO) berbasis Python sebagai alternatif metode optimisasi yang mampu menentukan konfigurasi pembangkit *hybrid* dengan mempertimbangkan empat fungsi objektif, yaitu minimalisasi *Cost of Energy* (COE), minimalisasi *Loss of Load Probability* (LOLP), maksimalisasi *Renewable Fraction* (RF), dan minimalisasi *curtailment*, serta merepresentasikan kondisi aset eksisting. Kinerja algoritma divalidasi melalui 20 kali pengujian *robustness* menggunakan *test data* dan dibandingkan dengan perangkat lunak HOMER Pro. Hasil validasi menunjukkan bahwa algoritma memiliki konsistensi yang baik dengan koefisien variasi COE sebesar 1,16%, deviasi 0,003%, serta menghasilkan *Unmet Load* dan LOLP sebesar 0% pada seluruh simulasi. Dibandingkan dengan HOMER Pro, algoritma menghasilkan solusi yang lebih baik dengan COE sebesar \$0,231/kWh dan RF sebesar 100%, sedangkan *HOMER Pro* menghasilkan COE sebesar \$0,252/kWh dan RF sebesar 100%. Konfigurasi optimal terdiri atas PLTS sebesar 156,9 kWDC dan penambahan BESS menjadi 1.556 kWh (2 *string*), dengan NPC sebesar \$1.018.201 selama 25 tahun. Penelitian ini memberikan kontribusi melalui pengembangan algoritma MOPSO yang mempertimbangkan kondisi aset eksisting dan empat fungsi objektif secara simultan, sehingga dapat menjadi alternatif pendekatan dalam perencanaan dan pengembangan sistem *hybrid microgrid* yang lebih andal dan efisien.

Kata kunci: *Multi-Objective Particle Swarm Optimization*, *hybrid microgrid*, energi terbarukan, HOMER Pro, *Cost of Energy*.

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ABSTRACT

Hybrid microgrid optimization software such as *HOMER Pro* is widely used for hybrid microgrid system design. However, its optimization process primarily focuses on cost minimization, while system reliability, renewable energy utilization, and energy curtailment are not simultaneously considered as objective functions. This study develops a Python-based *Multi-Objective Particle Swarm Optimization* (MOPSO) algorithm as an alternative optimization approach capable of determining the optimal hybrid generation configuration by simultaneously considering four objective functions: minimizing the *Cost of Energy* (COE), minimizing the *Loss of Load Probability* (LOLP), maximizing the *Renewable Fraction* (RF), and minimizing energy curtailment, while also representing existing asset conditions. The algorithm was validated through 20 robustness tests using test data and compared with *HOMER Pro*. The validation results demonstrate that the proposed algorithm exhibits good consistency, with a COE coefficient of variation of 1.16%, a deviation of 0.003%, and zero *Unmet Load* and LOLP in all simulations. Compared with *HOMER Pro*, the proposed algorithm achieved a lower COE of \$0.231/kWh while maintaining an RF of 100%, whereas *HOMER Pro* produced a COE of \$0.252/kWh with the same RF. The optimal configuration consisted of a 156.9 kWDC photovoltaic system and an additional battery energy storage system (BESS) capacity of 1,556 kWh (2 strings), resulting in a *Net Present Cost* (NPC) of \$1,018,201 over a 25-year project lifetime. This study contributes by developing an MOPSO-based optimization algorithm that simultaneously considers existing asset conditions and four objective functions, providing an alternative approach for planning and developing more reliable and cost-effective hybrid microgrid systems.

Key words: Multi-Objective Particle Swarm Optimization, hybrid microgrid, renewable energy, HOMER Pro, Cost of Energy.