INTISARI

Kebutuhan energi nasional pada 2023 mencapai 288,44 TWh dengan 66,44% berasal dari sumber tak terbarukan. Kontrasnya, potensi energi terbarukan Indonesia seperti surya 3.294,4 GWp dan angin 154,9 GWp, pemanfaatannya masih di bawah 1%. Penelitian ini merancang dan membangun sistem Pembangkit Listrik Tenaga Hybrid (PLTH) menggunakan *inverter Low Frequency Transformer* (LFT) untuk meningkatkan stabilitas dan keandalan. Kinerja *inverter* LFT berbasis *driver* EGS002 ini diuji secara komparatif dengan *inverter* komersial *High Frequency Transformer* (HFT) dan jaringan PLN, meliputi pengujian tanpa beban, beban resistif, dan beban induktif, serta stabilitas.

Hasil pengujian menunjukkan adanya *trade-off* performa. Pada beban resistif, *inverter* HFT lebih efisien dengan rata-rata sebesar 83,93%, sedangkan rata-rata efisiensi *inverter* LFT sebesar 69,39%. Akan tetapi, *inverter* LFT menunjukkan stabilitas tegangan *output* yang jauh lebih baik dengan fluktuasi hanya 0,2V, berbeda signifikan dengan fluktuasi HFT sebesar 3,5V. LFT menunjukkan keunggulan yang nyata saat diuji dengan beban induktif yang berat. Efisiensi LFT menjadi lebih tinggi dengan rata-rata sebesar 81% dan mampu mempertahankan kualitas daya setara PLN. *Inverter* HFT gagal total setelah enam menit akibat *overheat* saat dibebani tiga motor. *Inverter* LFT secara konsisten menghasilkan frekuensi 49,99 Hz dan gelombang sinus murni. Sistem pendingin juga terbukti sangat efektif dengan perbedaan sebesar 15°C lebih dingin dari HFT pada kondisi pendinginan maksimal. Pada kondisi suhu tinggi, penurunan tegangan *output* pada *inverter* LFT sangat rendah hanya 3,7V, sedangkan pada *inverter* HFT mencapai 14,2V. Sistem *Automatic Transfer Switch* (ATS) terbukti andal dalam melakukan perpindahan daya otomatis antara *inverter* dan PLN pada seluruh skenario pengujian, termasuk kondisi prioritas, *failover*, dan *recovery*.

Kata kunci: Inverter Transformator Frekuensi Rendah, Pembangkit Listrik Tenaga Hybrid (PLTH), Stabilitas, Kualitas Daya, Efisiensi

ABSTRACT

National energy demand in 2023 reached 288.44 TWh, with 66.44% derived from non-renewable sources. In contrast, Indonesia's vast renewable energy potential, including a solar potential of 3,294.4 GWp and a wind potential of 154.9 GWp, remains under 1% utilized. This research details the design and construction of a Hybrid Power Generation System (PLTH) using a Low-Frequency Transformer (LFT) inverter to enhance stability and reliability. The performance of this EGS002-based driver LFT inverter was comparatively tested against a commercial High-Frequency Transformer (HFT) inverter and the public grid, encompassing no-load, resistive load, inductive load, and stability tests.

The test results indicate a performance trade-off. Under a resistive load, the HFT inverter was more efficient with an average efficiency of 83.93%, whereas the LFT inverter's average efficiency was 69.39%. However, the LFT inverter exhibited far superior output voltage stability with a fluctuation of only 0.2V, a significant difference from the HFT's 3.5V fluctuation. LFT showed a significant advantage under heavy inductive load. Its efficiency increased to an average of 81% and it successfully maintained grid-equivalent power quality. The HFT inverter experienced a total failure after six minutes due to overheating when loaded with three motors. The LFT consistently produced a 49.99 Hz frequency and a pure sine wave. The cooling system also proved highly effective, maintaining a temperature 15°C cooler than the HFT at maximum cooling conditions. Under high-temperature conditions, the output voltage drop on the LFT inverter was very low at only 3.7V, whereas the HFT's reached 14.2V. The Automatic Transfer Switch (ATS) system proved reliable in performing automatic power transfers between the inverter and the public grid across all test scenarios, including priority, failover, and recovery conditions.

Keywords: Low Frequency Transformer Inverter, Hybrid Power Generation, Stability, Power Quality, Efficiency