INTISARI

Meningkatnya kebutuhan energi mendorong transisi menuju energi bersih, yang mengakibatkan peningkatan penetrasi EBT seperti PLTS dan PLTB. Namun, sifat intermiten PLTS dan PLTB menyebabkan pemborosan energi karena sistem jaringan listrik belum mampu memanfaatkannya secara optimal. Penelitian ini mengkaji optimasi ukuran dan lokasi BESS NMC dalam sistem jaringan listrik yang terintegrasi dengan PLTS dan PLTB. Optimasi dilakukan dengan metode DC OPF menggunakan pendekatan MIQCP untuk meminimalkan biaya operasional sistem. Simulasi dilakukan pada IEEE RTS 24 *bus system* dengan berbagai tingkat penetrasi PLTS dan PLTB untuk menilai dampak integrasi BESS NMC. Hasil penelitian menunjukkan bahwa integrasi BESS NMC yang optimal mampu meningkatkan efisiensi sistem dengan mengurangi *curtailment power* dari pembangkit PLTS dan PLTB, serta menurunkan biaya operasional. Pada penetrasi 10%, BESS NMC berhasil menghilangkan *loss of load* dan *curtailment power*, sehingga menurunkan total biaya operasional harian sebesar 49,58%. Pada penetrasi 25% dan 50%, BESS NMC mampu menurunkan total biaya operasional harian sebesar 1,25% dan 3,85%. Pada penetrasi tinggi sebesar 75%, BESS NMC mampu menurunkan total biaya operasional harian sebesar 13,35%. Penelitian ini menunjukkan potensi BESS NMC dalam mendukung transisi energi bersih melalui integrasi PLTS dan PLTB yang lebih optimal dan efisien.

Kata kunci : Energi Baru Terbarukan, *Battery Energy Storage System*, *Lithium Nickel Manganese Cobalt Oxide*, *Optimal Power Flow*, *Mixed-Integer Quadratically Constrained Programming*

ABSTRACT

Increasing energy demand is driving the transition towards clean energy, resulting in increased penetration of variable renewable energy (VRE) such as solar power plants and wind power plants. However, the intermittent nature of VRE causes energy waste because the electricity grid system has not been able to utilise it optimally. This research examines the optimisation of the size and location of BESS NMC in a power grid system integrated with solar power plants and wind farms. Optimisation is carried out with the DC OPF method using the MIQCP approach to minimise system operating costs. Simulations were conducted on a IEEE RTS 24-bus system under varying levels of renewable penetration to assess the impact of BESS NMC integration. The results show that the optimal integration of BESS NMC is able to improve system efficiency by reducing the curtailment power from solar and wind farms, as well as lowering operating costs. At 10% renewable penetration, BESS NMC successfully eliminates loss of load and curtailment power, thereby reducing the total daily operating cost by 49.58%. At 25% and 50% penetration, BESS NMC was able to reduce total daily operating costs by 1.25% and 3.85%. At a high penetration of 75%, BESS NMC was able to reduce total daily operating costs by 13.35%. This research demonstrates the potential of BESS NMC in supporting clean energy transition through more optimised and efficient renewable energy integration.

Keywords : *Variable Renewable Energy*, *Battery Energy Storage System*, *Lithium Nickel Manganese Cobalt Oxide*, *Optimal Power Flow*, *Mixed-Integer Quadratically Constrained Programming*